



Point of Safe Return Minimums...How Low Can You Go?

GRADUATE RESEARCH PAPER

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GRP

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### **Abstract**

The Department of Defense (DOD) has supported the United States Antarctic Program (USAP) and the National Science Foundation (NSF) for over 60 years in Antarctica. Missions flown in support of Operation Deep Freeze (ODF) require specially qualified aircrew operating under guidance specific to only this operation. The aircraft are meticulously maintained and specially prepared to operate in this harsh climate. The LC-130 is modified with skis which allow it to deliver cargo and personnel to the remote skiways throughout the continent. This aircraft excels at the intra-theater mission in Antarctica and has been the backbone of ODF for over 40 years. The aircraft also performs inter-theater airlift between Christchurch, New Zealand and McMurdo Station, Antarctica when the C-17 is not available.

The C-17 normally performs the inter-theater mission because of its capability to fly longer distances and deliver more cargo than the LC-130. However, neither aircraft can fly this mission without regulations and procedures specific to ODF. The aircrews flying this mission are required to calculate a Point of Safe Return (PSR) prior to each flight. This calculation determines how far the aircraft can fly enroute to McMurdo then return to Christchurch while maintaining required fuel reserves. Aircrews receive an updated weather forecast as they approach the PSR which determines whether or not they can continue to McMurdo or “boomerang” back to Christchurch.

LC-130 aircrews currently require a McMurdo weather forecast at the PSR of a cloud height of 500 feet and a visibility of 3 miles at their McMurdo estimated time of arrival plus 2 hours in order to continue forward with their mission (U.S. Air Force,

2014). The LC-130 weather minimums required to continue past the PSR have never been statistically analyzed. However, the C-17 PSR weather minimums have been analyzed to determine their best weather criteria to continue past the PSR and they are different than the LC-130. Joint Task Force-Support Forces Antarctica (JTF-SFA) requested a similar analysis for the LC-130.

The analysis used only missions that departed or arrived in the McMurdo area from 2008-2015 to capture only the missions that were affected by McMurdo weather using a PSR of 500/2 in order to compare the results with the C-17 analysis. The data was extracted from the Polar Mission Summary (PMS) database which was made available by the 109th Airlift Wing. The analysis showed that 17% of LC-130 McMurdo missions were affected by weather which is lower than the C-17 mission delay percentage of 23% (PACAF/A9, 2013).

The weather observed in the McMurdo area from 2009-2015 was then analyzed in order to find the percentage of time the location experienced weather at specific levels. These percentages and their differences were used to predict the percentage of missions affected by weather if the PSR weather minimums were changed. This data was also filtered to determine if there was a “best time of day” to conduct operations in the McMurdo area.

This paper concluded that changing the PSR weather minimum for the LC-130 does not significantly decrease the amount of missions affected by weather. It also validated the assumptions made in the C-17 analysis. Lastly, it concluded that the worst time of day to conduct aircraft operations in the McMurdo Area is from 1201-1800 Zulu.

## **Acknowledgments**

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Bret Echard

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# **Point of Safe Return Minimums...How Low Can You Go?**

## **I. Introduction**

### **Background, Motivation and Problem Statement**

The United States Antarctic Program (USAP) is a division of the National Science Foundation (NSF) and conducts scientific research in Antarctica. The USAP website describes Antarctica as the coldest, windiest, driest and harshest continent on the planet. Ice covers 98% of the continent and the average elevation is 6,500 feet. ODF personnel must live and work in the conditions while supporting the NSF (USAP, 2014). Aircrew operate at airfields only a few feet above sea level as well as airfields over 8,000 feet above sea level that requires skis. The Southern Ocean surrounds the continent rendering it only accessible via air or sea. Austral winter temperatures routinely fall below -50° Fahrenheit and winds can exceed 100 knots (USAP, 2014). The conditions require meticulous planning and precautions to ensure safety while attempting to maximize effectiveness. Efficiencies are extremely hard to gain in this environment. The austral winter brings over 4 months of darkness while the summer offers continuous daylight for over 4 months (USAP, 2014). The characteristics of Antarctica pose some of the most challenging obstacles for everyone involved in ODF starting at the planning stages throughout execution.

The Department of Defense (DOD) has supported the USAP and NSF in Antarctica since the early 1950's. The support agreements, command relationships and responsibilities have been updated several times throughout the years but the overall objectives of Operation Deep Freeze (ODF) have remained constant. Scientific research

has always been the number one priority for all ODF participants despite the challenges posed by the harsh Antarctic weather.

These unique challenges demand innovation in order to continue scientific research on the most remote continent on the planet. The LC-130 and its unique capabilities are a prime example of how innovative ideas led to a single aircraft with the ability to provide both inter and intra-theater airlift for the entire continent, if needed. This aircraft has the ability to land on snow, ice and normal runways in the same mission. It can also perform airdrop to austere scientific stations without a landing zone (LZ) or skiway. The 109th Airlift Wing (AW), Stratton Air National Guard (ANG) Base, New York operates the LC-130 and forms the 139th Expeditionary Airlift Squadron while deployed in support of ODF. While the aircraft excels at intra-theater missions its capabilities are limited when performing inter-theater airlift missions.

The flight from Christchurch, New Zealand to McMurdo Station, Antarctica is considered an inter-theater flight and is normally accomplished by the C-17 due to the distance. Flying this mission is the equivalent of flying from Seattle to Philadelphia except Antarctica offers few additional landing alternates for aircrew when the weather deteriorates below approach minimums. This requires all aircrew to carry enough fuel to divert back to Christchurch at a pre-determined point if the weather at McMurdo deteriorates below specific weather minimums for different aircraft. The C-17's pre-determined point normally lies within 30 minutes of McMurdo which allows aircrew to receive an extremely accurate forecast. However, the aircraft does not remain in theater for the entire austral summer.

When the C-17 is unavailable, the LC-130 executes the inter-theater mission. When this happens, the LC-130 is taken away from its primary intra-theater role which can prolong the amount of time the LC-130 remains in Antarctica. The austral winter normally dictates when LC-130 flights must stop for the season, not the amount of undelivered cargo. Therefore this inter-theater flight must be executed efficiently and safely so the LC-130 can return to McMurdo, continue the intra-theater mission and keep ODF on schedule.

This flight requires special procedures and meticulous fuel planning to ensure safety. These requirements may reduce the LC-130's allowable cabin load (ACL). Appendix B explains the tradeoff between fuel and cargo. For example, an LC-130 typically burns around 5,000 pounds of fuel per hour at cruise altitude. Based on Appendix B and the typical fuel burn rate, each additional hour of flight reduces the ACL by about 5,000 pounds. A normal inter-theater flight between Christchurch and McMurdo takes about 8 hours which forces the LC-130 to carry less than 12,000 pounds of cargo. Weather conditions at McMurdo coupled with enroute winds at cruising altitude dictate the amount of required fuel and help aircrews determine the Point of Safe Return (PSR).

Air Force Instruction (AFI) 11-2C-130V3 109 AW Supplement defines this as the commit point beyond which return to the point of departure (or alternate) is no longer an option. Currently, LC-130 crews have several criteria which must be met prior to crossing the PSR which is normally 3 or more hours away from McMurdo. This large amount of time between forecast and arrival time allows weather conditions to drastically change before the aircraft lands at McMurdo.

A “blown forecast” may require crews to perform an Emergency Whiteout Landing in the McMurdo area due to the lack of viable alternates if weather deteriorates after crossing the PSR. Appendix A shows the approach procedure for this emergency landing near Williams Field (NZWD). This emergency procedure is the last option and is similar to ditching the aircraft in the snow. According to Colonel Gary James, DOD Liaison to National Science Foundation, around 1-2 of these emergency landings happen each year. Also, 2-3 “boomerang” flights occur where crews approach the PSR, then return to Christchurch based on updated McMurdo forecasts or other criteria that has not been met in Appendix B (James, 2015).

The 109 AW Supplement dictates that the forecasted prevailing weather must be 500 foot ceiling and 3 miles visibility or lowest published minimums for a suitable approach, whichever is higher, for estimated time of arrival (ETA) plus 2 hours to continue past the PSR. The PSR weather minimums were updated this past year based on inputs from a working group and experiences gained from past seasons. Lieutenant Colonel Herdrick, former 139 Expeditionary Airlift Squadron Commander, wrote:

“Regarding PSR minimums, they have remained constant (500-2 for ETA + 2 hours) since the NYANG took over the mission from the Navy in 1999. Last season, we had two whiteout lands on missions from Christchurch to McMurdo and several other "close-calls" and decided to establish a working group reevaluate all of our weather minimums (not just proceed past PSR). We worked closely with SPAWAR to understand their limitations. Included in the working group was our OG/CC, OSS/CC, AS/CC, Wing Safety, OGV, Tactics, and Antarctic Operations. The conclusion of that working group was to raise the proceed past PSR minimums to 500-3 for ETA +2 hours and to include TEMPO weather above the lowest suitable approach minimums for ETA plus 2 hours.” (Herdrick, 2016)

Finding the most effective PSR weather minimum is worthless if weather forecasts are unreliable or if the airfield is busiest during times when McMurdo area weather is historically bad.

McMurdo business hours mirror the hours when Christchurch operates to minimize operations throughout the night in New Zealand. Unfortunately, this time period coincides with a satellite blackout period when weather forecasting coverage is unavailable. This period can last up to 10 hours and normally occurs between 0900-1500 local time (James, 2015). Weather forecasters must rely on current observations and experience to predict the weather for inbound crews who may still be 3 hours away from landing in the McMurdo area. This can literally create the perfect storm for aircrews and forecasters when deciding to continue past the PSR or boomerang back to Christchurch.

Weather data along with LC-130 operational data has not been analyzed to see if the PSR weather minimum could potentially be reduced while maintaining the current level of safety and avoid emergency whiteout landings. A safe reduction in weather minimums backed up by historical data to continue past the PSR would increase mission effectiveness by reducing weather delays and diverts.

### **Research Objectives**

The first objective of this research is to analyze the last six years of weather data to find the percentage of weather observations at different cloud heights measured in feet above ground level (AGL) and visibility distances measured in meters and converted to miles. The Joint Task Force-Support Forces Antarctica (JTF-SFA) suggested an analysis of the cloud heights (in feet) 1500, 1000, 800, 500 and 400. The suggested visibility (in

miles) distances are 1.5, 2, 2.5 and 3. The analysis will show how often McMurdo experienced weather at these levels and if there are any potential operational benefits to be gained by changing the weather minimums required to continue past the current PSR of 500 feet and 3 miles.

The second objective is to determine if there is a time period that historically has better weather for ODF planners to exploit. The cloud height and visibility results will be filtered to form 4 separate time periods. The findings could potentially change the normal McMurdo operating hours along with the current PSR weather minimums.

### **Research Question**

Will the weather data analysis show enough trends to change the PSR minimums or allow planners to target a specific time of day for McMurdo arrivals and departures?

### **Research Focus**

The focus of this research is to analyze weather observation data for the previous 6 years, provided by Space & Naval Warfare Systems Command (SPAWAR), at three McMurdo sites: McMurdo Station, Pegasus Field and Williams Field. The combined area is referred to as the McMurdo area. The operations data will analyze only McMurdo area departures and arrivals that were delayed, cancelled or aborted due to weather. This focus will help determine if the weather minimums required to continue past the PSR can be reduced and if the time period for the majority of LC-130 operations at McMurdo should be changed.

## **Assumptions/Limitations**

SPAWAR provided over 27,000 weather observations from 2009-2015. The analysis assumes this is a sufficient amount of observations to accurately and equally represent each day during this time period. The analysis also assumes that the observations accurately depict the weather and were measured using similar procedures with the proper equipment.

The analysis also assumes that all data retrieved from Polar Mission Summary (PMS) is complete and accurate. The data covers every LC-130 mission from November 2008- January 2015 and was input into the database by several different navigators who were part of the crews assigned to each mission. This database was used instead of Global Decision Support System II (GDSSII) because it includes every mission that was flown, delayed, cancelled and/or aborted and is maintained by the 139th Expeditionary Airlift Squadron (EAS). GDSSII does not always include missions that were aborted or cancelled.

Lastly, the analysis for the LC-130 assumes that the model developed by PACAF/A9 to determine C-17 weather minimums also applies to the LC-130 analysis. Specifically, the C-17 model assumes that a 1% change in the average actual weather leads to the same 1% change in the percentage of C-17 delays/aborts (PACAF/A9, 2013). The entire C-17 weather analysis can be seen in Appendix D.

A key limitation to this report is that it does not take into account the risks associated with lowering the PSR weather minimums. According to, Lieutenant Colonel Blair Herdrick “lowering PSR weather minimums decreases the chances of the actual weather being below these levels however it also increases the chances of being forced

into a whiteout landing” (Herdrick, 2016). Risk assessments are performed prior to every LC-130 mission by the aircrew and squadron leadership to ensure each mission is safely executed.

He also stated “there may be financial risks due to increased air aborts if launch minimums are reduced. A reduction in filing and takeoff weather minimums allows more crews to depart Christchurch and proceed towards the PSR only to return after they get an updated forecast near the PSR” (Herdrick, 2016).

### **Implications**

The implication of this study will provide JTF-SFA justification for selecting specific weather minimums required to safely proceed past the PSR and determine McMurdo operating times that have historically offered the best weather. The analysis using historical weather and operations data could safely decrease PSR minimums and weather delays. It could also change normal business hours at McMurdo to align its operations with better weather in order to increase effectiveness and efficiencies.

## **II. Literature Review**

### **History of Operation Deep Freeze**

Aviate, Navigate, Communicate...these three basic skills are the foundation of every aviator's tool box. Training flights and repetition sharpen these fundamental aviation skills and processes which most likely will be called upon during challenging situations. Simply aviating during the initial Operation DEEP FREEZE missions challenged even the most experienced pilots. Most never had the opportunity to navigate or communicate due to the unforgiving and austere environment but the lessons learned and initial processes formed the baseline for operations today. A brief history of ODF must be examined in order to better understand the process of how the LC-130 delivers airpower to ODF today in support of the National Science Foundation.

While ODF processes continue to evolve, the objectives of the NSF Antarctic Research Program have remained constant throughout the years. The current MOA between the DOD and NSF states:

The goal of the NSF Arctic Research Program is to gain a better understanding of the Earth's biological, geophysical, chemical, and socio-cultural processes, and the interactions of ocean, land, atmosphere, biological, and human systems (Wynne, 2007).

Simply put, scientific research is the goal of the NSF and all of its support agencies, not military operations. In fact, military operations are not allowed in Antarctica according to the Antarctic Treaty of 1959. The MOA clearly describes this restriction, the overall program and the Antarctic area which is south of 60 degrees south latitude, to include all ice shelves (DCJTF, 2014). The treaty states that "Antarctica shall be used for peaceful purposes only, and that there shall be prohibited, inter alia, any

measures of a military nature, such as the establishment of military bases and fortifications, the carrying out of military maneuvers, and the testing of any type of weapons. However, it does not prevent the use of military personnel or equipment for support of scientific research or for any other peaceful purposes” (DCJTF, 2014). This statement allows the NSF to utilize military aircraft and personnel to support its operations and continue research on the continent.

The treaty also ensures “that the continent will continue to be used for peaceful purposes only, foster cooperative research to contribute to the solution of regional and worldwide problems, protect the environment, and ensure equitable and wise use of living and non-living resources” (DCJTF, 2014). The United States cooperates with many other countries also conducting scientific research. The countries don’t necessarily share resources and personnel but they do rely on each other during contingencies and other times of necessity due to the scarce resources available on the continent.

The USAP assigned the NSF with the “overall management responsibility for planning, funding, and implementing the U.S. national program in Antarctica. The fundamental objective of the program is to maintain an active and influential U.S. presence in Antarctica” (Wynne, 2007). This objective helped define the roles and responsibilities of the DOD in ODF. Throughout the years the chain of command has changed to reflect current guidance and restrictions however the overall objectives of ODF have remained constant.

The objectives and responsibilities described in the MOA layout the guidelines for JTF-SFA and all of the supporting commands overseen by the Commander, U.S. Pacific Command (CDRUSPACOM). JTF-SFA is the backbone of the logistics support

to the NSF and includes: sealift, bulk fuel supply, airlift, seaport access, intelligence and cargo handling which have all drastically evolved since the Navy's first flight on the continent (Augustine, 2012).

On 19 December 1955 the United States (U.S.) Navy successfully completed the first landing in Antarctica by an aircraft which originated from a landmass outside of the continent. Four aircraft made the 14-hour flight with minimal communication capabilities, no instrument flight rule (IFR) approaches available at their destination and unreliable maps of the entire continent. This operation, named DEEP FREEZE I, was executed solely by the U.S. Navy and met all of its objectives but the harsh operating conditions also claimed two lives and two aircraft (Reed, 1995).

The DOD tasked this operation to the Navy for one year based on the service's experience in Antarctica to support the logistical requirements of the International Geophysical Year (IGY). Instead, the IGY lasted 3 years and over 60 years later ODF continues to grow (Butler, 1977). Today, the U.S. Air Force is the lead supporting agency to the National Science Foundation tasked by the Secretary of Defense and written in the Memorandum of Agreement between the Department of Defense and NSF below.

The Secretary of Defense, pursuant to Title 10 U.S.C. 113 and consistent with DOD Directive 5101.1 designated the Secretary of the Air Force as the DOD Executive Agent for the NSF (Wynne, 2007). This change and evolution of command relationships and responsibilities plays an important role in understanding current ODF processes and how the Antarctic conditions formed them.

These operating conditions also delayed the first U.S. Air Force C-124 missions into Antarctica. Finally on 21 October 1956, the first C-124 landed at McMurdo after flying 2,082 miles from its ODF staging base, Christchurch, New Zealand. These same C-124s then escorted Navy aircraft to the South Pole only 10 days later. They were loaded and rigged for emergency airdrop should other aircraft have issues in the -58 degree Fahrenheit temperatures (Wallwork & Wilcoxson, 2006). The austere and harsh environment demanded several layers of redundancy and innovation at all levels as well as multiple runways with different support requirements and capabilities used during different times of the year.

Major Miller describes the three main runways, in a 2001 Mobility Forum article, used by aircraft inbound from Christchurch, New Zealand prior to continuing further inland. He described McMurdo Station as a “NSF post on Ross Island located at the edge of the permanent ice shelf in McMurdo Sound. The ice runway at McMurdo is on the 'annual' ice about 3 miles offshore, and is designed for airplanes with wheels” (Miller, 2001). This ice shelf breaks up during the austral summer and forces aircraft operations to Williams Field where permanent ice is located. Moving airfields during peak season is a challenge regardless of location but performing this in Antarctica poses obvious unique challenges. Miller goes on to describe a third airfield, Pegasus, as a low-maintenance, unmanned airfield on the far side of the permanent ice that had been cleared for use by larger, wheeled aircraft such as the C-141, C-5, and C-17 (Miller, 2001). This airfield has slowly become the primary ODF airfield due to its low maintenance requirements and accessibility by larger aircraft.

Miller's description shows how basic airport infrastructure maintenance in Antarctica poses some of the greatest challenges for airfield managers. Many of these challenges only exist in Antarctica and require an extensive level of planning and innovation unseen anywhere else in the world. These airfields demand innovation during day to day operations coupled with leaders who understand the Antarctic challenges.

Senior leaders empowered the first ODF participants, which fueled innovation. For example, in 1972 the ODF Mission Commander (MC) approved a C-141 three-engine takeoff from McMurdo which normally requires Higher Headquarters (HHQ) approval. This allowed the aircraft to return to Christchurch where the appropriate maintenance was located and freed the aircraft from prolonged exposure to the cold which normally causes other issues. Three standing waivers for standard airdrop procedures were also in place which encouraged innovation (Wallwork & Wilcoxson, 2006).

Riggers could exceed the set parachute load limits and surpass established platform load ratings, if needed. Also, deployed ODF leadership served as the approval authority for all nonstandard aerial systems (including containers and slings) needed to deliver irregular items. (Wallwork & Wilcoxson, 2006). The standing waivers ensured the timely delivery of supplies throughout the continent. The culture allowed everyone involved in ODF to continuously develop new tactics, techniques and procedures (TTPs) still used today.

For example, in order to resupply every outpost on the continent with fuel, ODF riggers developed a method to drop four 55-gallon drums on a single A-22 bundle without damaging the drums. This TTP was extremely successful unless the strong

Antarctic winds continued to blow the parachutes where were still connected to the bundles on ground. The dragging and battering of the supplies rendered them useless in a matter of seconds after airdrops. To overcome this, ODF riggers devised disconnects that separated the bundles from the parachutes after the loads safely landed (Wallwork & Wilcoxson, 2006). This TTP quickly caught the attention of all MAF aircrew and is still used today on every airdrop that requires parachutes large enough to drag bundles across the ground. The Mobility Air Force (MAF) also used many of these TTPs on a daily basis in Iraq and Afghanistan to resupply many forward operating bases (FOB) which were inaccessible by ground.

Key senior leaders also noticed these innovative TTPs. Admiral Jerauld Wright, Commander in Chief of the Atlantic Fleet, said “I was amazed at the efficiency of the techniques used by the Air Force pilots. Colonel Ellen and his crew dropped ten tons of cargo including four dozen eggs without so much as breaking an egg” (Wallwork & Wilcoxson, 2006).

ODF also experienced challenges that were not overcome mostly due to the technology available at that time. For example, severe snow storms in Antarctica forced many McMurdo bound aircraft to divert back to Christchurch after reaching their point of safe return also known as a “boomerang” flight. This point allowed crews to get as close to McMurdo as possible while still guaranteeing enough fuel to safely return to Christchurch. However, this necessary precaution limited the amount of cargo each C-124 carried out of Christchurch. Aircrews experience these same challenges today and also must calculate a PSR on every mission prior to departure (JTF-SFA, 2015).

Another challenge that literally stopped all operations was communication black-outs caused by solar disturbances. During these periods all aircraft departures stopped which delayed ODF for several years. Ironically, the scientists supported by the MAF were studying this phenomenon (Wallwork & Wilcoxson, 2006). Satellite Communications (SATCOM) would eventually reduce this issue for all ODF participants. While new technologies continuously improved efficiencies in ODF, airpower and its unique capabilities have made the largest impacts to ODF.

In 1960, the Navy deployed ski-equipped C-130s to Antarctica and changed airlift TTPs on the continent forever. The first aircraft were simply C-130A models modified with skis, eight jet-assisted take-off (JATO) units and designated the C-130D. During this deployment, several C-130Ds landed at the South Pole at a maximum gross weight of 124,200 pounds due to weight bearing capacity of the snow packed runway. These aircraft boasted a 92% Mission Capable (MC) rate during their first deployment and began their ODF intra-theater airlift legacy (Wallwork & Wilcoxson, 2006).

The success of the C-130D eventually led to C-130E deployments in support of (ISO) of ODF in 1964. This same year funding limitations virtually eliminated airdrops and ski landings for the Air Force; while the Navy continued to support ODF with its fleet of ski-equipped C-130s. The lack of funding also delayed ski modifications for all Air Force C-130Es supporting ODF. Today they have all been replaced by the LC-130 (ski equipped) and are operated solely by the Air National Guard (ANG). These aircraft are variants of the Lockheed Martin C-130 H-2 and H-3 models currently flown all over the world as seen in Figure 1 performing a JATO (Wallwork & Wilcoxson, 2006).



**Figure 1. LC-130 Snow Takeoff** (Rejcek, 2008)

ODF 2015-16 marks the 55th year the C-130 has led the joint intra-theater airlift support in Antarctica. These aircraft fly to ski ways only accessible by aircraft with skis and provide everything those outposts need to survive, including fuel required to survive the long austral winters. Currently these intra-theater missions cannot be accomplished by larger jet engine aircraft.

ODF mission effectiveness improved in 1964 when the C-141A flew its first mission into McMurdo as the Air Force retired the C-124. It also became the first jet aircraft to land on the continent. Faster cruise speeds, increased cargo capacity and larger fuel loads gave planners and aircrew more flexibility when dealing with the unpredictable weather at McMurdo. The PSR shifted much closer to McMurdo and allowed aircrew to communicate directly with controllers on the ice (Wallwork & Wilcoxson, 2006). This new capability also increased efficiency and drove new TTPs for ODF.

Two capabilities introduced by the updated C-141B completely changed the Antarctic airdrop mission. This model increased the aircraft's payload by 3 pallets and

was aerial refueling (AR) capable. This allowed planners to stage missions out of Christchurch and overfly McMurdo thereby eliminating the risks associated with landing and shutting down engines. Planners could also resupply more locations via airdrop in one mission with the increased cargo capacity. The KC-135 and KC-10 now played an important role in ODF as they refueled the C-141B on most of these airdrop missions. However, the added capabilities of the C-141B also came with limitations.

The longer aircraft also weighed 7,000 pounds more which reduced the amount of cargo or fuel each mission could carry into McMurdo due to the weight limitations of the ice runway. Instead of reducing fuel and moving the PSR further away from McMurdo, planners decided to reduce the C-141B payload by 7,000 pounds. The C-141B couldn't carry a full payload because of the PSR restrictions, persistent weather and communication challenges seen in the joint operating area (JOA) (Wallwork & Wilcoxson, 2006). Planners could request AR to eliminate the PSR fuel constraints but the expensive capability was rarely used for airlift missions due to funding limitations.

The AR capability was used extensively during airdrop missions, initially known as Ice Drop, to support the NSF. However, the funding for airdrop missions did not come from the NSF. Instead, the Air Force used Joint Airborne/Air Transportability Training (JA/ATT) funds to execute airdrops and swap out crews during the austral winter. Senior leaders realized that MAF experiences and lessons learned during Ice Drop outweighed the costs required to execute these missions (Wallwork & Wilcoxson, 2006).

For example, these airdrops occurred during the winter months in Antarctica when the sun sets in June and doesn't reappear for several weeks. Recovering airdrop bundles was nearly impossible in the dark with no illumination and temperatures below

negative 55 degrees Fahrenheit. Riggers initially strapped normal flashlights to the bundles to aid ground parties with the recovery efforts. The flashlight batteries froze almost immediately after leaving the aircraft. Riggers eventually discovered that lights operated with lithium batteries normally operated long enough for the ground party to identify the bundles on the ground before the batteries froze (Wallwork & Wilcoxson, 2006).

The development of night vision goggles (NVG) and global positioning system (GPS) also improved effectiveness and changed TTPs during this time period. Aircrews could now see the ground and other terrain features at night which allowed them to fly at lower altitudes and improve airdrop accuracy. Also, GPS offered safer and more reliable navigation throughout the continent. Prior to GPS, aircraft headings could change up to 60 degrees without the aircraft making a single turn due to the magnetic variances near the South Pole (Wallwork & Wilcoxson, 2006).

These same TTPs developed over many Ice Drops allowed MAF aircrew to execute an unplanned, emergency airdrop mission using the C-141, KC-135 and KC-10 in 1999. During this mission, aircrew delivered critical medical supplies to a scientist stationed at the South Pole who had developed signs of breast cancer during the winter and could not be aeromedical evacuated (AE) until warmer temperatures returned (Sturkol, 1999). The scientist survived the winter and was evacuated after LC-130s were able to land at the South Pole.

Airlift capabilities and technologies continued to evolve and in 1989 the C-5 made its first appearance at McMurdo. It boasted a cargo capacity four times larger than the C-141. Again, the new capability brought new challenges which required new TTPs.

A site survey team determined that the ice could support the massive aircraft but recommended not turning the aircraft on the ground. The team feared that the heavy aircraft combined with turns would overstress the ice. The C-5 executed several ODF missions without incident for over 10 years (Wallwork & Wilcoxson, 2006). During this same period, ODF underwent the most organizational, aircraft and personnel changes since its inception in order to increase efficiencies which would also require new processes.

The DOD consolidated all LC-130 aircraft and operations within the ANG at the 109th Airlift Wing, Stratton ANG Base, New York by 1999. This decision also called for the Navy to inactivate its LC-130 squadron, VXE-6, who had performed this mission for over 40 years. The NSF also purchased three new LC-130s to enhance the 109th AW's LC-130 fleet which executed the first Air Force LC-130 deployment in 1996. The transition of responsibilities would take place over three phases and culminated in the signing of a new Memorandum of Agreement (MOA) in 1998 between the DOD and NSF (AW, 2014).

As discussed, this MOA between the DOD and NSF appointed the Secretary of the Air Force as the executive agent and U.S. Transportation Command (USTRANSOM) as the lead manager for logistics in ODF. This made the Air Force the lead service and led to several more changes within the ODF structure. The ANG provided a Colonel to act as the ODF Commander and increased the role of the 109th Airlift Wing and its LC-130 fleet. The ANG then activated a detachment at Christchurch to provide support and oversight for U.S. forces supporting ODF (Wallwork & Wilcoxson, 2006).

The Air Force Reserve had also been playing a key role in ODF during this time by supplying C-141Bs from the 62nd AW at McChord Air Force Base (AFB). McChord's new role played a large part in the future of the Air Force's support to ODF. In 1996, the Air Force designated McChord AFB as the principle strategic airlift provider for ODF with the retirement of the C-141 coming within the next few years (Office, 2012). This decision consolidated much of the inter-theater ODF experience at one location while the wing and Air Force transitioned to the C-17 (Wallwork & Wilcoxson, 2006).

This successful transition culminated in 1999 with the first ODF C-17 landing which would once again drive new TTPs and efficiencies. Most notably, the C-17 has 3 times the cargo capacity as the C-141. Figure 2 shows a C-17 flown by a reserve crew from McChord AFB landing on the ice at McMurdo.



**Figure 2. C-17 Ice Landing** (Schmidt, 2015)

In 2005, the C-141 flew its last ODF mission after nearly 40 years of delivering airpower to the continent. During this time, Pacific Command (PACOM) would also replace USTRANSCOM as the lead combatant command for ODF supporting the NSF (Wallwork & Wilcoxson, 2006).

### Current Operations

The NSF and DOD management policies, described by the current MOA, resolves a potential command structure issue between the two agencies. It states that “a civilian organization exercising funding control over operational military units is a departure from normal military command procedures and requires an exceptional amount of understanding and flexibility by all parties involved. It is recognized that OPCON, TACON and ADCON of assigned military units must remain at all times within DOD (Wynne, 2007). This statement defined the current DOD chain of command seen in Figure 3.

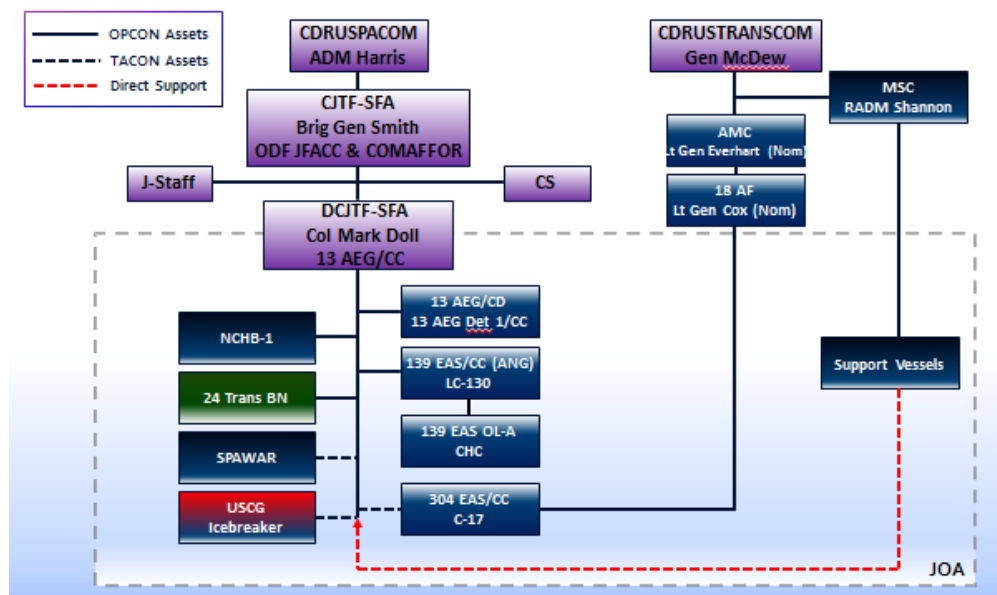


Figure 3. ODF Chain of Command (Schmidt, 2015)

The current goals, program descriptions, command structures and policies lay the foundation for key processes and procedures while aircraft capabilities shape specific phases of ODF. The Operations Order released by the Deputy Commander, JTF-SFA (DCJTF-SFA) describes the four phases of Operation DEEP FREEZE. To summarize, Phase I is the preparation phase which requires C-17 support to deliver essential personnel and equipment to McMurdo prior the main body arrival. This phase is mostly inter-continental flights. Phase II requires the LC-130 to resupply austere outposts while the C-17 continues its mission. This phase consists of mostly intra-continental flights and the C-17 support will eventually stop as the aircraft redeploys to its home station. This phase supplies posts with everything necessary to survive the austral winter after airlift support has stopped. Phase III involves vessel resupply operations at McMurdo. Phase IV is the redeployment phase which normally occurs in February or March. This phase must be completed before conditions become too harsh for aircraft operations to continue. Emergency winter airdrop operations are an option during contingencies or if aspects of certain phases were not completed (DCJTF, 2014).

During Phase II, C-17s normally redeploy to McChord while the LC-130s continue to support ODF for the entire austral summer. During this time, the LC-130s remain at McMurdo and primarily perform deep field resupply to locations only accessible by ski aircraft using the hub and spoke concept which is a common process for intra-theater aircraft. These aircraft also perform inter-theater airlift, if needed, between New Zealand and Antarctica while the C-17 is absent. These missions are typically 8 hours long and require the LC-130 to remain overnight (RON) outside of Antarctica and away from its primary hub airfield where the majority of its support assets reside. The

unpredictable weather conditions at McMurdo challenge all ODF participants and can delay the return of inter-theater LC-130 missions by several days. These delays cause a ripple effect which prolongs the overall delivery timeline of personnel and supplies to the remaining outposts in Antarctica, including the South Pole. Extending ODF into the austral winter increases risks to everyone and must be avoided.

During this past austral winter, a C-17 on a routine Special Assignment Airlift Mission (SAAM) landed at McMurdo. The planned mission called for the original C-17 crew to fly from Australia to Christchurch where they went into crew rest. During that time, a pre-positioned ice qualified crew flew the C-17 to McMurdo on NVGs. This new process continues the legacy of innovative thinking leading to leaner ODF processes (Grimsley, 2015).

### **Aircrew Procedures**

Other processes and guidelines must also be reviewed and potentially improved to gain efficiencies for the LC-130 especially while the C-17 is gone. Specifically, the McMurdo weather minimums required to continue past the PSR. Air Force Instruction (AFI) 11-2C-130V3 109AW Supplement defines the PSR for the LC-130 as “The PSR calculation determines the commit point beyond which return to the point of departure (or a suitable alternate) is no longer an option. Due to the austere nature of polar operations, aircrew should always consider their alternate/divert options and should determine a PSR when mission requirements dictate.” The AFI then goes on to show how to calculate a PSR as seen in Figure 2 below. The PSR is normally 3 or more hours away from McMurdo. This large time period requires accurate weather forecasts to avoid emergency whiteout landings.

$$\text{PSR} = \frac{(\frac{1}{2} \text{ Time})(\text{GS}_r)}{\text{TAS}}$$

$$\frac{1}{2} \text{ Time} = \frac{\text{T/O Fuel} - (\text{Reserve} + \text{Alternate (see note)} + \text{Approach} + \text{Landing Fuel})}{2}$$

**TAS** – Planned True Airspeed (Long Range Cruise, usually 270 KIAS)

**GS<sub>r</sub>**– Planned Ground Speed return (use the inverse of WF1)

**½ Time** – Half the amount of fuel available, converted to time, to take off from the departure point, fly to some point, and return to the departure point with exactly the required overhead fuel remaining. In the no-wind situation ½ Time equals PSR Time.

**PSR Time** – ETE to a point where a safe return is assured.

**Figure 4. PSR Calculations** (US Air Force., 2013)

AFI 11-2C-130V3 CH24 Annex B describes filing weather minimums and PSR procedures. It states that weather minimums require prevailing (not TEMPO) forecasted weather conditions. McMurdo must have a prevailing weather forecast of 1000/3 for estimated time of arrival (ETA) plus 2 hours as well as required McMurdo landing fuel reserves seen in Annex B. This annex requires 8,500 pounds of fuel at the initial penetration fix, 10,000 pounds if specific weather conditions are not met and 12,000 pounds if Pegasus is not a viable alternate landing airfield (US Air Force, 2014). These very specific requirements force in depth fuel planning throughout the mission by mission planners and aircrew based on extremely important weather forecasts from personnel based at McMurdo and the outlying posts.

Guidelines to continue past the PSR are different than the filing and departure guidelines. These procedures contain updated weather minimums required to continue

past the PSR which is lower than the weather required to file and depart for McMurdo. The lower weather minimums give aircrew and leadership additional flexibility during these inter-theater flights especially if weather deteriorates while aircrew are enroute to McMurdo. Additional restrictions require aircrew to obtain updated weather from a forecaster near the airfield in an effort to neutralize the added risk associated with the new lower weather minimums. The following PSR procedures from Annex B must be followed by aircrew to ensure safety and avoid an emergency whiteout landing.

### 3.5. PSR Procedures.

3.5.1. Proceed Past PSR Requirements. To proceed past PSR, the following criteria must be met:

- a) Updated McMurdo forecast obtained within 1 hour prior to crossing PSR (direct or indirect communications).
- b) Forecast prevailing 500 foot ceiling and 3 miles visibility or lowest published minimums for a suitable approach, whichever is higher, for ETA plus 2 hours.
- c) TEMPO weather above the lowest suitable approach minimums for ETA plus 2 hours.
- d) Weather observer in place at airfield.
- e) Operational aircraft radar and an operational #1 (pilot's) radar altimeter.

3.5.2. If the above conditions cannot be met, return to Christchurch. ACs and/or the 139EAS/CC have the authority to turn the aircraft back to Christchurch prior to PSR. While the weather to proceed past PSR is described in par. 3.5.1; TEMPO conditions, hourly observation trends, surface/horizon definition, weather satellite blackout periods, and SAR equipment availability shall be taken into consideration when determining to proceed past PSR. Weather conditions at potential divert fields such as the Ice Runway, Williams Field, Pegasus, and Mario Zucchelli Station should be considered in the decision process, however, the decision to proceed past PSR should be based upon the crew's expectation that conditions upon arrival at McMurdo will allow a safe landing at the primary airfield, without the need to divert (U.S. Air Force, 2014).

The required weather minimums are reduced to increase the chances of mission success assuming the other requirements are also met now that the aircraft is much closer to McMurdo. If the weather at McMurdo deteriorates after passing the PSR, aircrew may

be forced to perform an Emergency Whiteout Landing Procedure due to whiteout conditions based on the proximity of reliable alternates.

AFI 11-2C-130V3 CH24 Annex B defines a whiteout condition as “an optical phenomenon that occurs in uniformly overcast sky conditions over a snow covered surface” (US Air Force., 2013). This condition leads to dangerous flight conditions and potential flight attitudes at very low altitudes which have historically led to fatal crashes throughout the world. The ground and horizon are no longer distinguishable and flying in conditions like this can be compared to driving in a dense fog where nothing is visible past the hood of the car.

The resultant emergency procedure requires aircrew to land in the snow after flying an instrument approach with no visual cues to the ground throughout the procedure. The AFI 11-2C-130V3 109AW SUP defines a whiteout area as “a surveyed safe area that allows an instrument letdown and landing when planned recovery airfield is below safe landing weather minimums”. AFI-11-2C130V3 CH 24 ANNEX A contains the specific responsibilities for each crew member during this procedure and can be seen in Appendix E. This procedure is unique to ODF and puts aircrew in an extremely dangerous situation.

According to Lieutenant Colonel Herdrick, two whiteout landings occurred during the 2014-2015 season with several other “close calls”. He was a crew member on Skier 53 during a whiteout landing. The procedure requires the highest level of crew resource management and can be compared to “ditching the aircraft on the snow” (Herdrick, 2016). His entire description of a whiteout landing can be read in Appendix H.

To accomplish this procedure, the aircrew followed the USAP Instrument Approach Procedures produced annually by SPAWAR Office of Polar Programs. Pegasus and Williams Field both have TACAN and GPS approaches with an average approach minimum of 321 feet and 0.9 miles. If actual weather is below these minimums and aircrews are unable to make a normal landing they may be required to execute the Emergency Whiteout Landing approach procedure. The approach procedure is included in Appendix A.

However, the C-17 is not modified with skis and the crew cannot fly an airborne radar approach (ARA). The ARA is a self-contained approach that allows the navigator to provide approach inputs to the pilot in order to safely execute the instrument approach. An ARA for Skiway 07G at Williams Field can be seen in Appendix B. While not desirable, these capabilities coupled with proper training allow LC-130 crews to safely execute an emergency whiteout landing.

A C-17 emergency whiteout landing is an option but the aircraft would incur substantial damage and be extremely difficult if not impossible to recover. In 2012, JTF-SFA leadership requested that PACAF/A9 research and analyze weather and mission delays from 2007-2012 at McMurdo to determine if the C-17 PSR weather minimum could be lowered to increase C-17 mission effectiveness. At the time, the required weather for each mission was 1500 feet cloud height and 3 miles of visibility. On average, weather caused a delay or abort for 23% of McMurdo C-17 missions (PACAF/A9, 2013). The report was completed in 2013 using weather observed and recorded by SPAWAR.

JTF recommended keeping mission launch minima at 1500-3, but lowering PSR weather from 1500-3 to 1000-2, and lowering MCM departure weather from 1500-3 to 1000-2, adding a caveat of taking off from MCM with less than 1000-2 with MC concurrence based on ORM. Recommended a decision to go past PSR with weather of 1000-2 be restricted to a straight-in only approach. Note: JTF recommendation to lower the PSR and MCM takeoff minima was based on a 5-yr data call and analysis which predicted a increased mission success rate of the following per category vs. remaining at 1500-3. Data study was based on actual weather observed at MCM and provided to the 62AW for their consideration:

A.	1200-3;	0.1% increase
B.	1000-3;	0.1% increase
C.	1000-2.5;	2.1% increase
D.	1000-2;	3.5% increase
E.	800-2;	3.5% increase
F.	800-1.5;	3.6% increase
G.	500-2;	3.6% increase
H.	500-1.5;	3.7% increase

**Figure 5. C-17 ODF IFR Landing Minima Results (PACAF/A9, 2013)**

Based on the findings seen in Figure 5 from the “C-17 ODF IFR Landing Minima” paper, the JTF recommended that the PSR minimums be lowered from 1500-3 to 1000-2. According to the research conducted by PACAF/A9, this would correlate to a mission effectiveness increase of 3.5%. This also predicts a new C-17 mission delay percentage of 19.5% (equals 23% minus 3.5%). The other recommendations can also be seen in the excerpt below. The same study was not completed for the LC-130.

The Deputy Commander, JTF-SFA requested that a similar study be accomplished for the LC-130 to ensure that the current PSR weather minimums and normal business hours at McMurdo allow for the most effective LC-130 operations.

## Summary

ODF has seen many procedural changes and technological improvements throughout its history as well as challenges. The innovations developed by ODF

personnel throughout the years in response to these challenges have led to more effective and efficient operations in one of the most demanding environments on the planet. The processes and procedures that guide airlift operations must be continuously updated and improved upon in order to guarantee the safe, effective and efficient delivery of airpower to ODF.

## **II. Methodology**

### **Chapter Overview**

This section outlines a description of the data sources and the methods of analysis used to determine the percentage of LC-130 missions affected by McMurdo area weather. It also describes how the weather minimums required to continue past the PSR can be reduced and if there is a time of day that offers better weather to accomplish the majority of operations in the McMurdo area. All times are listed in Zulu. SPAWAR provided weather observations from McMurdo Station, Williams Field and Pegasus Fields, collectively known as the McMurdo area, from 2009-2015. The operations data containing the delays due to weather in the McMurdo area was extracted from Polar Mission Summary and compiled into a spreadsheet from 2008-2015.

### **Data Sources**

SPAWAR personnel observe and record weather for operations in the McMurdo area. They compiled the past 6 years of weather observation data into a single spreadsheet. Specifically, the weather data spans from November 2009 up to December 2015. The spreadsheet contains separate sheets for McMurdo Station, Pegasus Field and Williams field. Each sheet contains 37 columns of data but only the “visibility meters” and “cloud height feet 1” columns were required during this portion of the analysis. All rows begin with a date/time cell and contain other weather data such as: barometric pressure, temperature, winds, etc.

McMurdo Station contains 10,437 weather observations, Pegasus Field contains 13,726 and Williams Field contains 3,728. The spreadsheet contains a total of 27,897

weather observations for the McMurdo area in the last 6 years. These numbers were used to calculate the percentage of observations at specific levels which were displayed in a table for each location. The total percentage of weather observations in the McMurdo area was then found by totaling the observations for each location and calculating a percentage. These results are displayed in the following tables.

The date/time column coupled with the cloud height 1 and visibility meters columns was analyzed to determine if there was a specific time of day that historically offered better weather in the McMurdo area. The Zulu time periods were separated into 6-hour time periods from 0001-0600, 0601-1200, 1201-1800 and 1801-2400. This further separated the cloud height and visibility categories in order to compare the percentage of weather observations during these time blocks.

Lieutenant Colonel Herdrick provided operations data that he retrieved from Polar Mission Summary (PMS) which is an Access database used by all LC-130 crews to capture and record their information after each ODF successful and unsuccessful mission. He compiled all LC-130 flights from November 2008- March 2015 into a single spreadsheet that contained data for the entire timeframe. The spreadsheet contains every ODF mission flown or planned since November of 2008. The data was filtered based on season, delay, cancellation, abort and departure or arrival airfield to find the amount of flights into and out of McMurdo as well as the number of flights that were affected by weather in the McMurdo area. Data from the 2015-2016 season was not used because aircrews operated using a PSR weather minimum of 500/3. Including data from this season would invalidate the results due to the different PSRs.

## **Methods of Analysis**

The operations data from PMS was filtered to show only McMurdo arrivals and departures. These missions represented the total number of flights into and out of McMurdo for each season. The spreadsheet was then filtered again to display only missions that experienced a weather delay, cancellation or abort caused by McMurdo weather. These missions represented the total number of weather delays, cancellations and aborts experienced by LC-130 crews. The number of McMurdo area missions was recorded for each individual season and also totaled for the entire time period. The spreadsheet was then filtered to show only missions affected by weather in the McMurdo area. The number of missions affected by weather was divided by the total number of McMurdo missions to determine the percentage of missions affected by weather each season in the McMurdo area as well as the entire time period.

The cloud height and visibility columns were then analyzed to determine the percentage of time weather was at specific levels. These percentages were then graphically compared to determine if any weather trends could be found that favored a lower weather minimum to continue past the PSR. The cloud height analysis required an additional five columns to capture all weather observations in the following categories:  $\leq 400$ ,  $\leq 500$ ,  $\leq 800$ ,  $\leq 1000$  and  $\leq 1500$  feet. These specific levels were chosen based on inputs from JTF-SFA personnel. The data cells in each new column for every weather observation calculated and displayed a 1 or 0. A “1” showed that the weather observation was at or below the value of that column. Conversely, a “0” showed that the weather did not meet that criterion. For example, a weather observation of 500 feet would yield a 0 in the 400 column and a 1 in the 500, 800, 1000 and 1500 columns.

The columns were then summed to show the total number of observations at or below each cloud height category. These sums were then divided by the total number of weather observations to determine the percentage of observations at or below each criterion. This percentage directly correlates to the amount of time the McMurdo area experienced these cloud heights based on the assumption that the observations accurately depicted a full 24-hour period. The same process captured specific categories for the visibility observations.

The visibility column was first converted into miles by adding a column that simply divided the visibility meters column by 1,609 to convert the observations into miles. Then 4 additional columns were added to determine how many observations were at or below 1.5, 2, 2.5 and 3 miles. The cells in these columns also produced a “1” or “0” depending on the distance of the visibility observation. For example, a weather observation of 1.8 miles would yield a 0 in the 1.5 column and a 1 in the 2, 2.5 and 3 mile column. The columns were then summed and divided by the total number of observations to also determine the percentage of time the McMurdo area experienced weather at or below these visibility criteria. The cloud height and visibility percentage results were both captured on separate tables for each location and combined for a table containing the overall percentages for the McMurdo area.

Additional columns were added to determine if both cloud height and visibility for each day fell into the categories listed in Table 1. A “1” or “0” was calculated and summed to determine the percentage of time the weather was at each level. For example, if the weather observation was 1400 feet cloud height and 2.75 miles of visibility, the  $\leq 1500/3$  column displayed a “1” and all other columns displayed a “0”.

**Table 1. Weather Categories**

$\leq 1500/3$	$\leq 1200/3$	$\leq 1000/3$	$\leq 1000/2.5$	$\leq 1000/2$
$\leq 800/2$	$\leq 800/1.5$	$\leq 500/3$	$\leq 500/2.5$	$\leq 500/2$
$\leq 500/1.5$	$\leq 400/2$	$\leq 400/1.5$		

This data was then filtered using the 4 equal time periods to determine if there was a time of day that offered better weather for aircraft operations in the McMurdo area. Once filtered, the amount of observations and percentages were also captured on a table for each time period. These percentages were then compared to determine if there was a time period that offered better weather for operations in the McMurdo area. A smaller amount of low cloud height and low visibility observations during a time period would show this period offered better weather for operations.

## IV. Results

### McMurdo Area Flights Affected by Weather

Table 2 shows the total number of missions from November 2008 to March 2015 that included a McMurdo area departure or arrival sorted by season as well as the number of delays, cancellations or aborts due to McMurdo weather. The table also displays the totals of each category and finally the percentage of missions affected by McMurdo weather. The overall percentage of missions affected by McMurdo weather during this time period is 17%. This is exactly 6% less than the C-17 delay percentage of 23%.

**Table 2. McMurdo Area Weather Delays, Cancels and Aborts**

<b>Season</b>	<b>McMurdo msns</b>	<b>Delays</b>	<b>Cancels</b>	<b>Aborts</b>	<b>% Delays/Cancels/Aborts</b>
2008-2009	427	25	26	7	13.6%
2009-2010	489	27	70	15	22.9%
2010-2011	552	13	71	8	16.7%
2011-2012	481	13	52	7	15.0%
2012-2013	433	10	34	9	12.2%
2013-2014	424	15	77	8	23.6%
2014-2015	266	4	24	7	13.2%
<b>2008-2015</b>	<b>3072</b>	<b>107</b>	<b>354</b>	<b>61</b>	<b>17.0%</b>

### Cloud Height Observations

Table 3 shows the total number of cloud height observations at or below 400, 500, 800, 1000 and 1500 feet and the percentage of observations at and below these cloud

heights for McMurdo Station (NZCM), Pegasus Field (NZPG) and Williams Field (NZWD). The bottom of the table totals the observations for each location in the McMurdo area section and then shows the overall percentages. The total number of observations for each location is listed after the location identifier in the chart which was used to find the percentages for each location and the McMurdo area.

**Table 3. McMurdo Area Cloud Height Observations**

<b>NZCM - 10437</b>	<b>≤ 400 ft</b>	<b>≤ 500 ft</b>	<b>≤ 800 ft</b>	<b>≤ 1000 ft</b>	<b>≤ 1500 ft</b>
Total <	1671	1888	2183	3003	3760
% <	16.0%	18.1%	20.9%	28.8%	36.0%
<b>NZPG - 13726</b>	<b>≤ 400 ft</b>	<b>≤ 500 ft</b>	<b>≤ 800 ft</b>	<b>≤ 1000 ft</b>	<b>≤ 1500 ft</b>
Total <	1510	1898	2419	4091	5751
% <	11.0%	13.8%	17.6%	29.8%	41.9%
<b>NZWD - 3728</b>	<b>≤ 400 ft</b>	<b>≤ 500 ft</b>	<b>≤ 800 ft</b>	<b>≤ 1000 ft</b>	<b>≤ 1500 ft</b>
Total <	492	583	721	1218	1525
% <	13.2%	15.6%	19.3%	32.6%	40.8%
<b>McMurdo Area-27891</b>	<b>≤ 400 ft</b>	<b>≤ 500 ft</b>	<b>≤ 800 ft</b>	<b>≤ 1000 ft</b>	<b>≤ 1500 ft</b>
Total <	3673	4369	5323	8312	11036
% <	13.2%	15.7%	19.1%	29.8%	39.6%

The cloud height results show a reduction of 9.8% in observations from ≤1500 to ≤1000, another 11.7% reduction from ≤1000 to ≤800 and a 3.4% drop from ≤800 to ≤500. The observations drop only 2.5% below ≤500. This is important to note because the current ceiling requirement to continue past the PSR is also 500 feet. The range of the percentages from ≤400 to ≤1500 in the McMurdo area is 26.4%.

## Visibility Observations

Table 4 shows the total number of visibility observations at or below 1.5, 2, 2.5 and 3 miles, the percentage of observations at and below these visibilities for McMurdo Station (NZCM), Pegasus Field (NZPG) and Williams Field (NZWD). The bottom of the table totals the observations for each location in the McMurdo area section and then shows the overall percentages.

**Table 4. McMurdo Area Visibility Observations**

<b>NZCM - 10437</b>	<b>≤1.5 miles</b>	<b>≤2 miles</b>	<b>≤2.5 miles</b>	<b>≤3miles</b>
Total <	749	875	907	1055
% <	7.2%	8.4%	8.7%	10.1%
<b>NZPG - 13726</b>	<b>≤1.5 miles</b>	<b>≤2 miles</b>	<b>≤2.5 miles</b>	<b>≤3miles</b>
Total <	1122	1375	1436	1734
% <	8.2%	10.0%	10.5%	12.6%
<b>NZWD - 3728</b>	<b>≤1.5 miles</b>	<b>≤2 miles</b>	<b>≤2.5 miles</b>	<b>≤3miles</b>
Total <	333	418	455	543
% <	8.9%	11.2%	12.2%	14.5%
<b>McMurdo Area-27891</b>	<b>≤1.5 miles</b>	<b>≤2 miles</b>	<b>≤2.5 miles</b>	<b>≤3miles</b>
Total ≤	2204	2668	2798	3332
% ≤	7.9%	9.6%	10.0%	11.9%

The total number of observations for each location is listed after the location identifier in the chart which was used to find the percentages for each location and the McMurdo area. The results show a 1.9% reduction in observations between ≤3 to ≤2.0,

only a reduction of 0.4% from  $\leq 2.5$  to  $\leq 2$  followed by a reduction of 1.7% below  $\leq 2.0$ .  
 The range of the percentages from  $\leq 1.5$  to  $\leq 3$  is 4%.

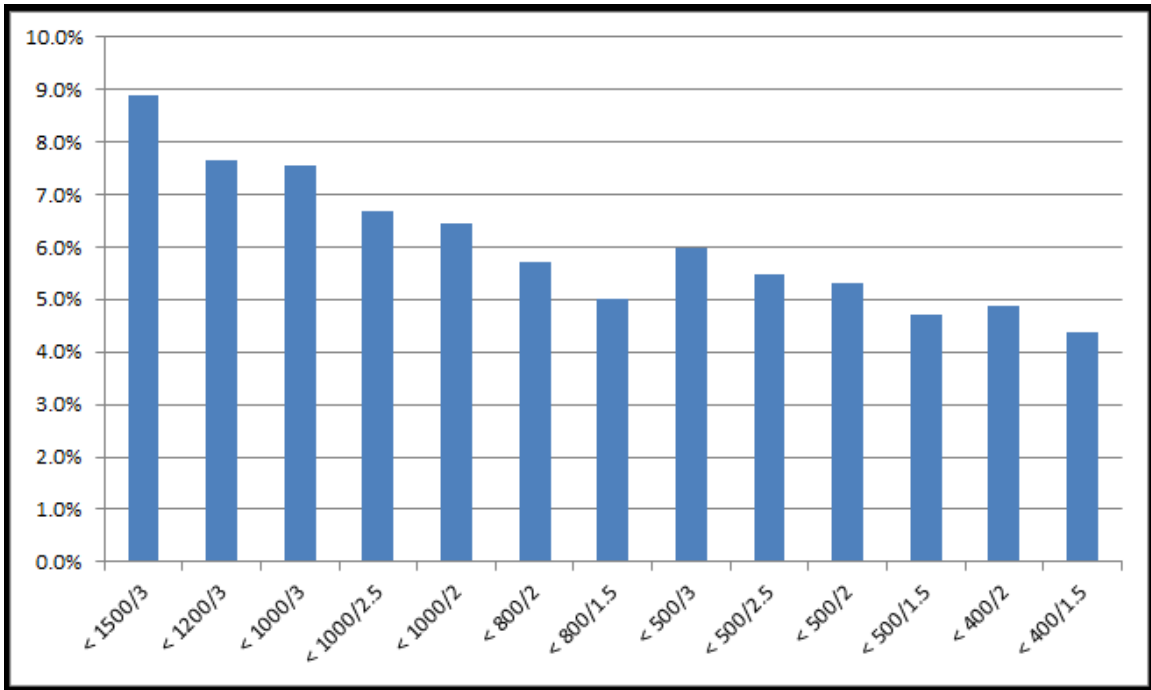
### Combined Cloud Height and Visibility Observations

Table 5 shows the percentage of time NZCM, NZPG, NZWD and the McMurdo area experienced cloud height and visibility in specific categories. There is a continuous drop in percentages from 1500/3 to 800/1.5 and then a rise of 1% at 500/3 which is the current weather required to continue past the PSR. The continuous reduction in percentages followed by an increase shows the current 500/3 PSR weather requirement would be more effective than an 800/2 requirement. For example, based on the C-17 model (1% change in weather equals 1% change in weather delays), changing the PSR weather minimums from 500/3 to 800/1.5 would change the current percentage of LC-130 missions effected by weather by 1% from 17% to 16%. However, the risks associated with a much smaller visibility requirement are not captured in this prediction. Note that the weather category of 500/2 was observed 5.3% of the time.

**Table 5. McMurdo Area Combined Cloud Height and Visibility Observations**

NZCM	$\leq 1500/3$	$\leq 1200/3$	$\leq 1000/3$	$\leq 1000/2.5$	$\leq 1000/2$	$\leq 800/2$	$\leq 800/1.5$	$\leq 500/3$	$\leq 500/2.5$	$\leq 500/2$	$\leq 500/1.5$	$\leq 400/2$	$\leq 400/1.5$
Total <	794	718	711	654	637	569	514	580	546	532	481	469	427
% <	7.6%	6.9%	6.8%	6.3%	6.1%	5.5%	4.9%	5.6%	5.2%	5.1%	4.6%	4.5%	4.1%
NZPG	$\leq 1500/3$	$\leq 1200/3$	$\leq 1000/3$	$\leq 1000/2.5$	$\leq 1000/2$	$\leq 800/2$	$\leq 800/1.5$	$\leq 500/3$	$\leq 500/2.5$	$\leq 500/2$	$\leq 500/1.5$	$\leq 400/2$	$\leq 400/1.5$
Total <	1291	1056	1033	888	864	737	640	780	695	678	592	629	557
% <	9.4%	7.7%	7.5%	6.5%	6.3%	5.4%	4.7%	5.7%	5.1%	4.9%	4.3%	4.6%	4.1%
NZWD	$\leq 1500/3$	$\leq 1200/3$	$\leq 1000/3$	$\leq 1000/2.5$	$\leq 1000/2$	$\leq 800/2$	$\leq 800/1.5$	$\leq 500/3$	$\leq 500/2.5$	$\leq 500/2$	$\leq 500/1.5$	$\leq 400/2$	$\leq 400/1.5$
Total <	396	362	361	324	302	285	248	313	289	271	239	267	235
% <	10.6%	9.7%	9.7%	8.7%	8.1%	7.6%	6.6%	8.4%	7.7%	7.3%	6.4%	7.2%	6.3%
McMurdo Area	$\leq 1500/3$	$\leq 1200/3$	$\leq 1000/3$	$\leq 1000/2.5$	$\leq 1000/2$	$\leq 800/2$	$\leq 800/1.5$	$\leq 500/3$	$\leq 500/2.5$	$\leq 500/2$	$\leq 500/1.5$	$\leq 400/2$	$\leq 400/1.5$
Total <	2481	2136	2105	1866	1803	1591	1402	1673	1530	1481	1312	1365	1219
% <	8.9%	7.7%	7.5%	6.7%	6.5%	5.7%	5.0%	6.0%	5.5%	5.3%	4.7%	4.9%	4.4%

Figure 6 graphically depicts the percentages shown in Table 5. The gradual decrease from 1500/3 to 800/1.5 followed by the increase at 500/3 becomes apparent and represents the ideal PSR weather minimum based on the percentage of McMurdo weather observations.



**Figure 6. Combined Cloud Height and Visibility Observation Graph**

### Time of Day Observations

Table 6 and 7 show the percentages of McMurdo Area weather observations for the Zulu time periods of 0001-0600, 0601-1200, 1201-1800 and 1801-2400. The same weather categories were used to analyze and compare the time periods. The data in Table 6 showed that the time period from 1201-1800 had the highest percentage of weather observations in every category which shows that this time period will most likely have

the worst weather. However, the best visibility time period cannot be determined by the historical weather data.

**Table 6. Visibility and Time**

<b>0001-0600</b>	<b>≤1.5 miles</b>	<b>≤2 miles</b>	<b>≤2.5 miles</b>	<b>≤3miles</b>
<b>Total ≤</b>	542	643	674	812
<b>% ≤</b>	7.3%	8.7%	9.1%	10.9%
<b>0601-1200</b>	<b>≤1.5 miles</b>	<b>≤2 miles</b>	<b>≤2.5 miles</b>	<b>≤3miles</b>
<b>Total ≤</b>	359	435	451	551
<b>% ≤</b>	7.0%	8.5%	8.8%	10.8%
<b>1201-1800</b>	<b>≤1.5 miles</b>	<b>≤2 miles</b>	<b>≤2.5 miles</b>	<b>≤3miles</b>
<b>Total ≤</b>	689	833	882	1033
<b>% ≤</b>	9.7%	11.8%	12.5%	14.6%
<b>1801-2400</b>	<b>≤1.5 miles</b>	<b>≤2 miles</b>	<b>≤2.5 miles</b>	<b>≤3miles</b>
<b>Total ≤</b>	576	713	746	880
<b>% ≤</b>	7.4%	9.1%	9.5%	11.2%

A similar trend was found in the historical cloud height data. The time period from 1201-1800 also had the highest percentage of cloud height weather observations in every category. McMurdo is Zulu plus 13 hours. Therefore, this time period equates to a 0101-0700 local time period. This showed that the time period historically had both the worst visibility and cloud height observations for the McMurdo area.

**Table 7. Cloud Height and Time**

<b>0001-0600</b>	<b>≤ 400</b>	<b>≤ 500</b>	<b>≤ 800</b>	<b>≤ 1000</b>	<b>≤ 1500</b>
<b>Total ≤</b>	805	953	1216	2139	2843
<b>% ≤</b>	10.9%	12.8%	16.4%	28.8%	38.3%
<b>0601-1200</b>	<b>≤ 400</b>	<b>≤ 500</b>	<b>≤ 800</b>	<b>≤ 1000</b>	<b>≤ 1500</b>
<b>Total ≤</b>	587	702	883	1468	2036
<b>% ≤</b>	11.5%	13.7%	17.2%	28.6%	39.7%
<b>1201-1800</b>	<b>≤ 400</b>	<b>≤ 500</b>	<b>≤ 800</b>	<b>≤ 1000</b>	<b>≤ 1500</b>
<b>Total ≤</b>	1135	1307	1543	2208	2980
<b>% ≤</b>	16.1%	18.5%	21.8%	31.2%	42.2%
<b>1801-2400</b>	<b>≤ 400</b>	<b>≤ 500</b>	<b>≤ 800</b>	<b>≤ 1000</b>	<b>≤ 1500</b>
<b>Total ≤</b>	1084	1334	1591	2349	2961
<b>% ≤</b>	13.9%	17.1%	20.3%	30.0%	37.8%

## V. Conclusions and Recommendations

The LC-130 had 6% fewer McMurdo missions affected by weather while using a PSR of 500/2 than the C-17. The difference stems from the lower LC-130 PSR weather minimum which increases their chances of continuing past their PSR and landing at McMurdo. The analysis of the data relied on the C-17 model that assumed for every 1% change in average weather there would also be a 1% change in weather delays if the PSR minimums were also changed to match that weather category. The C-17 study applied this assumption to recommend an ideal PSR weather minimum. The LC-130 analysis validated the C-17 model by applying the 1 to 1 rule to the LC-130 weather delay, cancel or abort percentage.

The C-17 was delayed 23% (+/- 3% due to weather variances) of the time while using 1500/3 as a PSR weather minimum. The LC-130 was delayed 17% of the time using 500/2 as a PSR weather minimum for the flights extracted from PMS. According to the C-17 model and the weather data analysis, a PSR minimum of 500/2 would decrease C-17 weather delays by 5.3%. This equates to a new C-17 weather delay percentage of 17.7%. That is only 0.7% more than the current LC-130 percentage rate of 17%. This comparison validates the model and proves that it can be applied to the LC-130 analysis.

Applying the model to the LC-130 percentages shows very small increases in successful missions when decreasing the current PSR weather minimum. Table 8 shows the new percentage of missions affected by weather with the associated PSR weather minimum increase or decrease.

**Table 8. Predicted LC-130 Missions Affected by Weather**

<b>McMurdo Area</b>	<b>&lt; 1500/3</b>	<b>&lt; 1200/3</b>	<b>&lt; 1000/3</b>	<b>&lt; 1000/2.5</b>	<b>&lt; 1000/2</b>	<b>&lt; 800/2</b>
<b>Predicted Cancel, Abort, Delay %</b>	<b>20.6%</b>	<b>19.3%</b>	<b>19.2%</b>	<b>18.4%</b>	<b>18.2%</b>	<b>17.4%</b>
<b>McMurdo Area</b>	<b>&lt; 800/1.5</b>	<b>&lt; 500/3</b>	<b>&lt; 500/2.5</b>	<b>&lt; 500/2</b>	<b>&lt; 500/1.5</b>	<b>&lt; 400/2</b>
<b>Predicted Cancel, Abort, Delay %</b>	<b>16.7%</b>	<b>17.7%</b>	<b>17.2%</b>	<b>17.0%</b>	<b>16.4%</b>	<b>16.6%</b>

It becomes apparent that adopting new PSR weather minimums also adds a certain level of risk which cannot be quantified in this research. For example, changing the PSR weather minimums from 500/3 to 800/1.5 decreases the percentage of missions affected by weather by 1% which is an improvement. However, JTF leadership also accepts additional risk by reducing the required visibility from 3 to 1.5 miles. This reduction requires an extremely accurate weather forecast and allows for only a 0.6 mile reduction in the actual weather. As discussed earlier, the average visibility required to perform approaches in the McMurdo area is 0.9 miles of visibility.

The analysis of the time periods showed similar patterns for three of the four periods but did not offer a best time for aircraft arrivals and departures. The percentages of the three time periods between 1801-1200 Zulu were all within 3% of each other in both the ceiling and visibility categories. Those similarities make it difficult to determine if there is a best time of day for operations. However, the time period of 1201-1800 Zulu showed a 3-4% increase in weather observations at or below each of the categories. Based on these percentages, this time period can be considered the worst time of day for McMurdo area aircraft departures and arrivals.

### **Recommendations for Action**

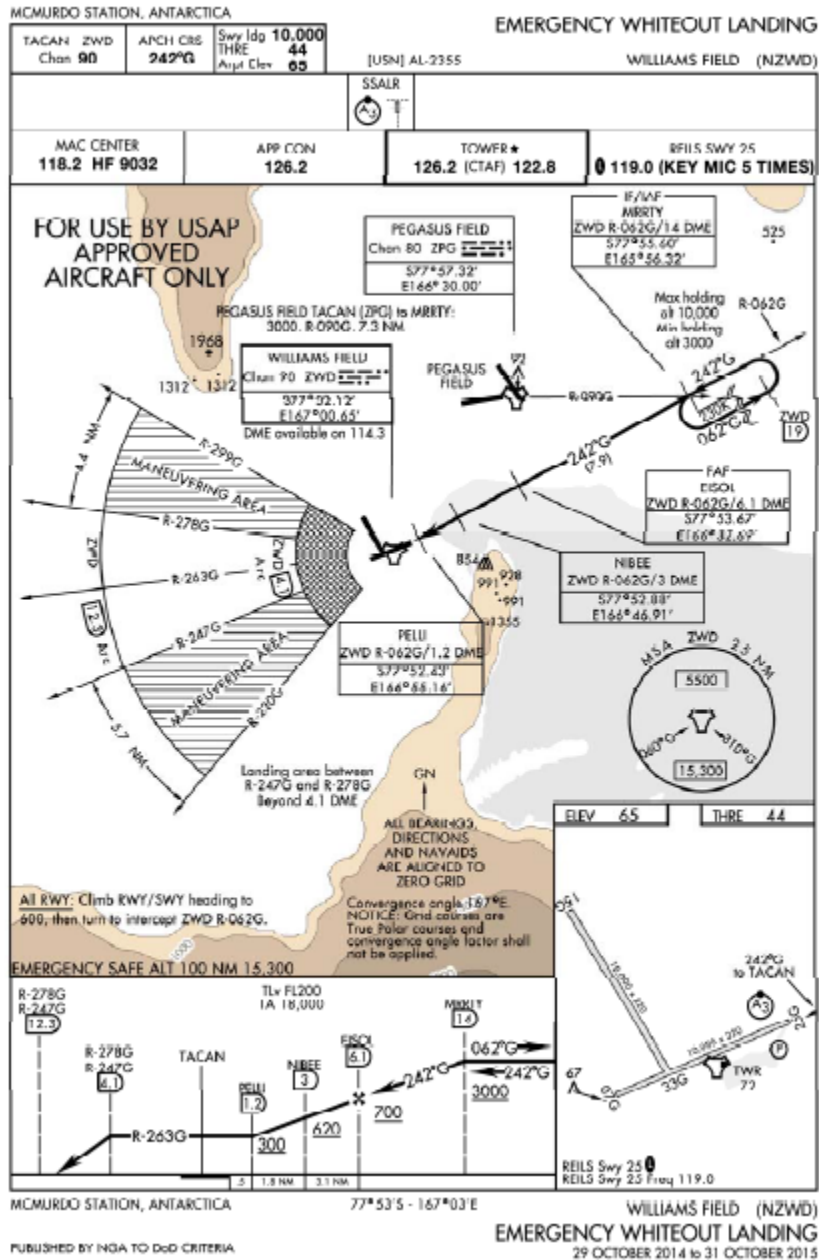
The results support no change in the current PSR weather requirement of 500/3. In fact, raising the PSR weather minimum from 500/2 to 500/3 this past season should only see an increase of 0.7% missions affected by weather. However, McMurdo arrival and departure time periods should be further discussed for future seasons to avoid the periods that have historically shown worse weather.

### **Recommendations for Future Research**

Weather observations compiled by trained personnel were used to conduct this research and determine if actual weather supported a reduction in weather minimums. A similar analysis that compares forecasted weather with observed weather could improve the forecasting abilities of SPAWAR personnel and potentially reduce weather minimums in the McMurdo area.

Also, the 2015-2016 ODF season marked the first time that JTF-SFA increased PSR weather minimums since the ANG assumed responsibility of this mission from the Navy. A future analysis of the observed weather for this season along with the percentage of missions affected by weather at this new PSR minimum may show the effectiveness of this PSR weather minimum.

## Appendix A: Emergency Whiteout Landing Approach



ACs can be put in a position where they must land below minimums or in the McMurdo Emergency Whiteout Landing Area. Landing below minimums and whiteout landings are emergency procedures. Crews will declare an emergency with ATC. When such a condition exists, ACs are authorized to commence an approach with weather reported below minimums to help them better judge their available options. If during this approach, they are able to make positive contact with the skiway markings and are in a safe position to land, they may do so. ACs exercising this option will set a bingo fuel that will allow them to execute a white-out landing with no less than 4,000 lbs total fuel upon completion of the whiteout landing.

*WARNING:* 4,000 lbs is the emergency fuel threshold. A landing should be accomplished prior to going below 4,000 lbs total fuel to ensure adequate fuel is available for landing and taxi.

4.7.9.1. Should unforecasted weather conditions cause ceiling and visibility to deteriorate upon arrival at McMurdo and all other means of approach/landing, holding, diverting, etc. have been considered and rejected, AFI 11-2C-130V3, Addenda A “White Out Landing Procedures” offers an effective means of landing the aircraft before aircraft fuel is completely exhausted. The following are additional considerations when executing a white out landing.

4.7.9.1.1. Reference Whiteout Landing Emergency Procedure in the USAP Instrument Approach Procedures.

4.7.9.1.2. Consider endurance/fuel remaining and declare minimum fuel with Mac Center when applicable.

4.7.9.1.3. At the completion of the last attempted instrument approach to land on a prepared surface execute a missed approach directly into the Emergency Whiteout Procedure.

*WARNING:* Comply with enroute altitude from the MAP to the Whiteout Area. Aircraft may need to climb before proceeding into the Whiteout Area. *CAUTION:* After a missed approach from the Ice Runway or Pegasus into the Whiteout area, confirm configuration (skis down) to prevent a skis up snow landing.

4.7.9.1.4. Once established in the Whiteout Area, position the aircraft to maximize the final descent distance so that the aircraft may land into the wind, with no drift, within surveyed area.

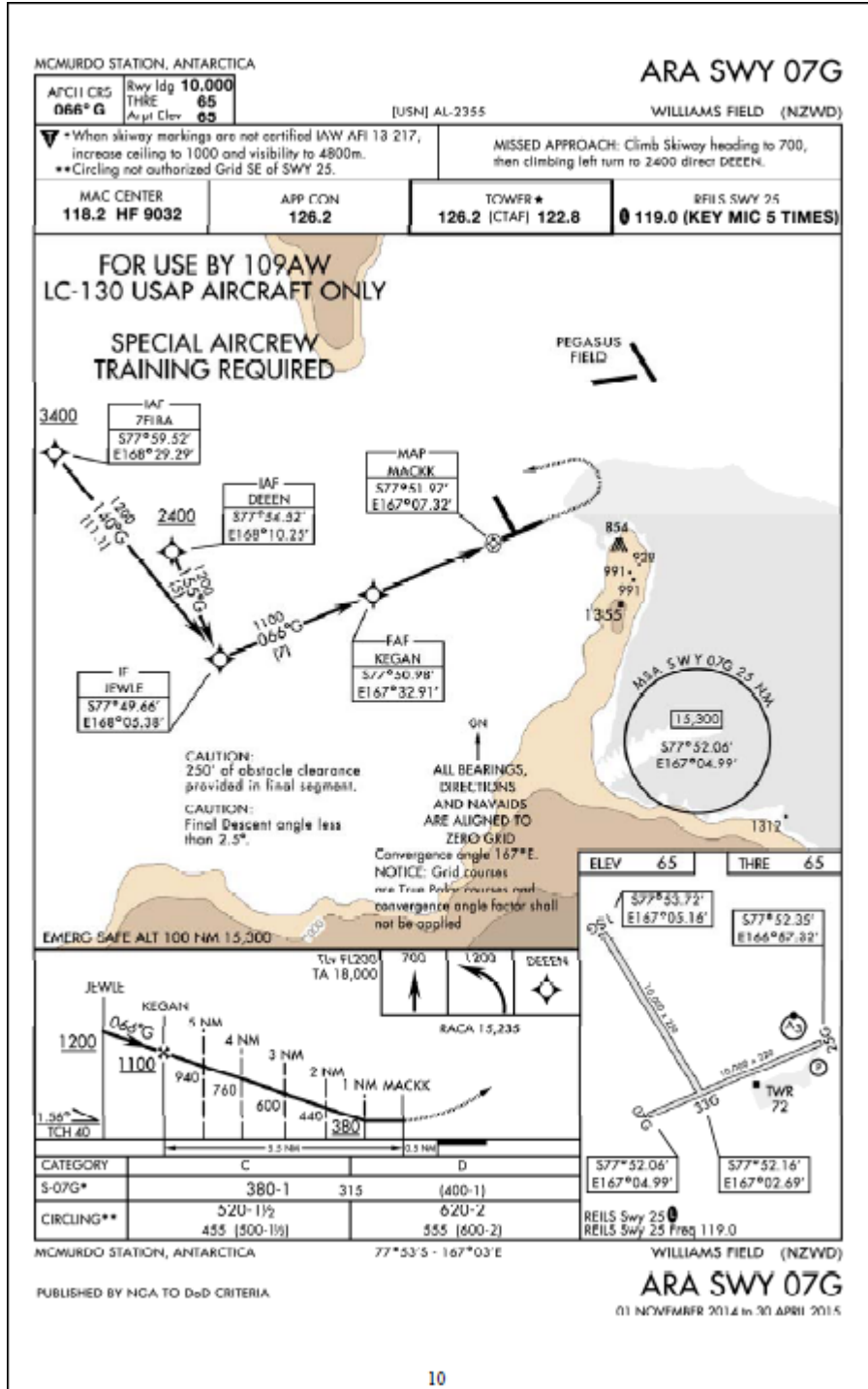
4.7.9.1.5. After landing, crews will call safe on snow with sector area to Raven Ops by any means available and state intentions. The necessity to taxi the aircraft is situational. If the PIC elects to taxi the aircraft, taxi to the Williams Field Skiway the most direct route, remaining inside the Whiteout Area as long as possible using DR, SCNS, TACAN and aircraft radar. Use extreme caution when taxiing due to possible ground hazards. If other aircraft are utilizing Williams Field remain clear of the skiway at all times to allow other aircraft to land.

*WARNING:* If other aircraft are utilizing the Whiteout Area, prior coordination needs to be accomplished to ensure de-confliction.

*WARNING:* There is no Missed Approach Procedure for a whiteout landing.

*WARNING:* Crevasse fields and quickly rising terrain exist outside the whiteout area.

## Appendix B. Williams Field ARA Example



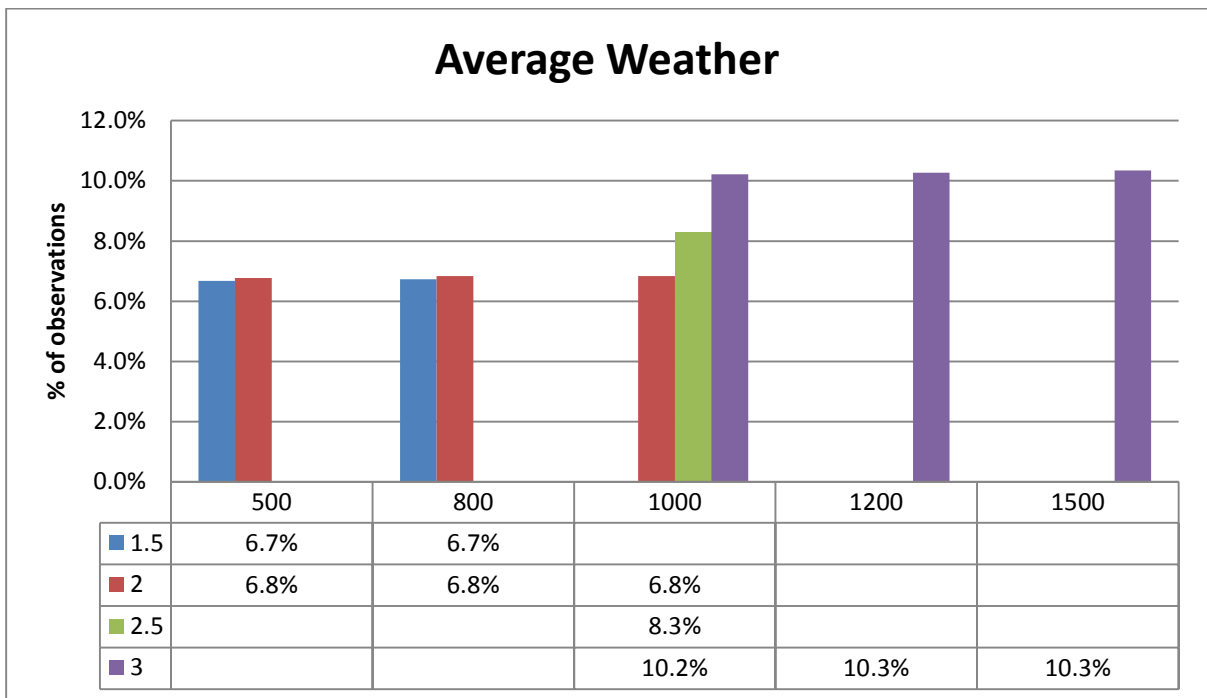


**Appendix D. C-17 Weather Analysis**

<b>C-17 Average Weather Delays/Aborts per Season*</b>
23%

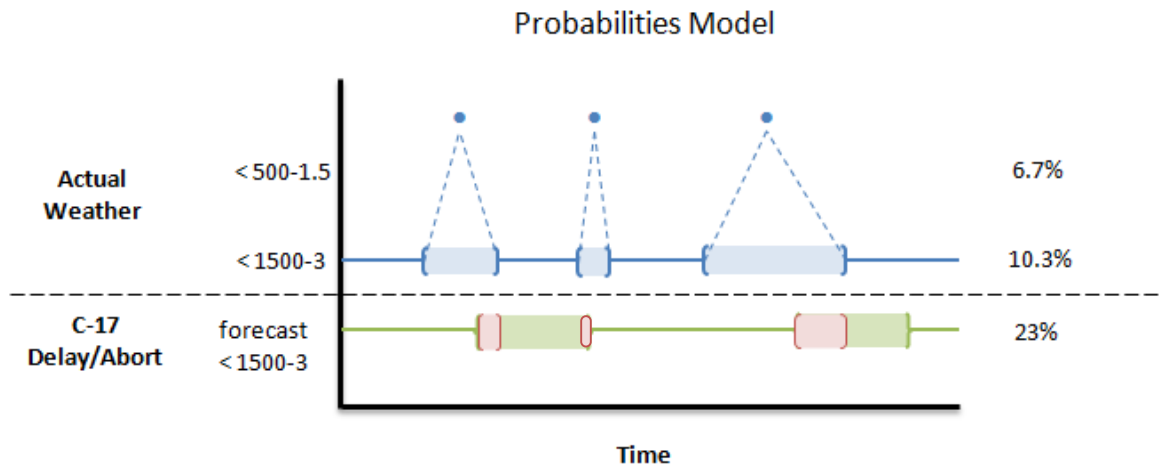
*\*Based on forecasted weather data*

Based on actual C-17 launch data from the past five seasons, we found that the C-17 delays or aborts a flight an average of 23% of the time per season (plus or minus 3% due to the variability in the data across the seasons).



**Average weather per season from the past five seasons (2007-2012).**

The figure above shows the breakdown of actual weather over the past five seasons. We measured 9 different ceiling and visibility criteria and found the percent of time (on average) the weather was below each of the 9 different criteria. The graph above shows that the actual weather ranged from being below 1500-3 an average of 10.3% of the time per season to being below 500-1.5 an average of 6.7% of the time.



### Modeling actual vs forecasted weather data

The model shows a graphical representation of the model used to bridge the gap between the analysis performed on actual weather data and the assumptions made regarding the unavailable forecasted data. The probabilities model shows the actual weather data model in blue with the arbitrary shaded blue blocks on the line representing the percentage of time the weather is below 1500-3. The probability of the weather actually being below 1500-3 is 10.3%. As the weather minimums decrease, the probability of being below these minimums will also decrease. This is denoted by the blue dotted lines which show that as we decrease the weather to 500-1.5, the probability of the weather being below 500-1.5 decreases to 6.7%. The forecasted weather data model is on the green line. The shaded green blocks on the line showing arbitrary sections of time that a C-17 flight is scheduled and each of these sections of time has a corresponding weather forecast. The red shaded blocks represent the times that the forecast is below 1500-3. As you can see, the red shaded blocks occur when the green shaded blocks overlap with the blue shaded blocks. The probability of a red shaded block

occurring is 23% because this is the average percentage of C-17 aborts/delays per season. As the weather minimums decrease and the blue shaded areas become smaller (denoted by the blue dotted lines) the red shaded areas will also become smaller. However, the size of the green shaded area will remain constant because it represents a set block of time for a scheduled flight. Therefore from this model we can conclude that as we lower the weather minimums, any decrease in the percent of time the actual weather is below these minimums leads to 1-to-1 decrease in the percentage of C-17 delays/aborts.

<b>Model</b>
1% ↓ avg. weather ≈ 1% ↓ C-17 delays/aborts

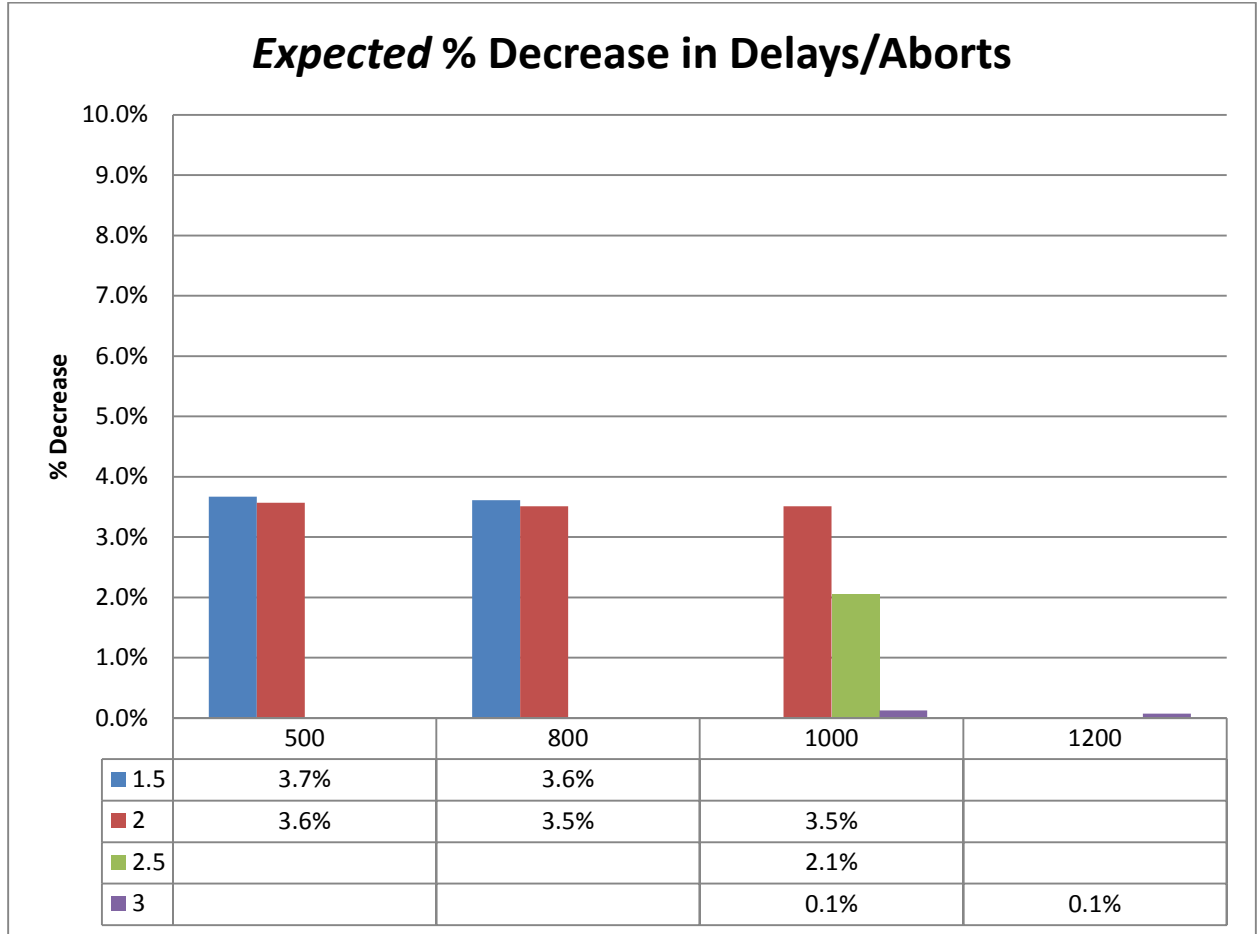
**Probabilities Model Summary**

	1500-3	1200-3	1000-3	1000-2.5	1000-2**	800-2	800-1.5	5500-2	500-1.5
<i>Expected % Delays/Aborts per season</i>	23.1%	23.1%	23.0%	21.1%	19.6%	19.6%	19.5%	19.6%	19.5%
<i>Expected % Decrease in Delays/Aborts</i>		0.1%	0.1%	2.1%	3.5%	3.5%	3.6%	3.6%	3.7%

**Expected percentage of C-17 Delays/Aborts per weather criteria**

\*\*Optimal weather minimum occurs at 1000-2.

The table above shows the expected decrease in the percentage of C-17 delays/aborts per season for each of the 9 different weather criteria. The second row of the table shows that as the weather minimums decrease, the percentage of delays/aborts does not significantly decrease until the minimum of 1000-2.5. Another significant decrease in delays/aborts occur when the minimums are decreased to 1000-2 but then the percentages plateau and there is no benefit to further lowering the minimums past 1000-2.



#### Expected decrease in C-17 delays/aborts per weather criteria

The graph above shows this graphically where the green column (associated with 1000-2.5) shows the first significant jump and the first red column (associated with 1000-2) shows the second significant jump. From there, the columns remain constant in height. Therefore, we can conclude that the optimal weather minimum occurs at 1000-2.

## Appendix E. White Out Landing Emergency Procedure

AFI 11-2C130V3 CH 24 ANNEX A, 1 Jan 2014

### **WHITE OUT LANDING**

The following emergency procedure offers an effective means of landing the aircraft before aircraft fuel is completely exhausted. White Out conditions are situational, use CRM accordingly.

#### **WARNING**

4,000 lbs is the Emergency Fuel threshold. Land prior to going below 4,000 lbs total fuel to ensure adequate fuel is available to safely complete the landing.

#### **CAUTION**

When operating with less than 6,000 lbs of total fuel in the main fuel tanks, place the **CROSSFEED** valve switch to **OPEN** and the **BOOST PUMP** switch to **ON** for all tanks containing fuel; place the **CROSSFEED SEPARATION** valve switch to **OPEN**. When fuel quantity of any main tank is less than 1,000 pounds, the engine being fed by that tank will be on crossfeed.

#### **NOTE**

In case of a Go-Around consider initiating White Out Landing procedures with enough fuel for more than one White Out Landing attempt.

#### **Pre-landing Procedures**

1. Normal configuration: Gear and Skis down, Flaps 100% (4 good engines)
2. Position aircraft into the wind, with zero drift within the target landing area
3. Establish a 100-200 FPM descent while flying wings level at threshold speed
  - Make standard airspeed and VVI callouts
4. Remain on instruments and descend until the aircraft touches down
  - Anticipate ballooning as the aircraft enters ground effect

#### **After landing Considerations**

1. Upon touchdown, bring the throttles into reverse using open snow techniques
  - Slow power reductions and careful transition into the Ground Range
2. Keep the aircraft tracking straight with wings level.
3. Pilot monitors nose ski position, transfer Yoke to Copilot
4. The necessity to taxi the aircraft is situational and extreme caution should be exercised due to ground hazards and propeller/wingtip contact with the snow
  - Use all available resources to navigate ( DR, SCNS, aircraft radar etc.)
5. Contact ATC (HF, Iridium etc.) when safe on snow (workload permitting)

**WHITE OUT LANDING AIRCREW TASKS**

1. Pilot
  - Set Radar Altimeter to 25 feet
  - Set heading bug to zero drift heading
  - Set airspeed bug to threshold speed (L2)
  - Set CDI off TACAN (as required)
  - Trim for threshold speed and 100-200 FPM descent
2. Copilot
  - Back up airspeed, VVI, zero drift heading, wings level
  - Maximize use of area boundaries and maintain positional awareness
  - Look for ground
3. Navigator
  - Program White Out area boundaries into SCNS
  - Use flight plan overlay on radar display/Falcon view
  - Wind and drift updates
  - Radar Altimeter callout (100, 50, 40, 30...etc.) pacing
  - Maximize use of area boundaries and maintain positional awareness
4. Flight Engineer
  - Monitor engine and system instruments
  - Check stall speed for weight/configuration/30° of bank (time permitting)
  - Look for ground and back up Navigator on Radar Altimeter callouts
5. Loadmaster
  - Check cargo restraint (secure loose gear in cockpit and cargo compartment)
  - Brief passengers

**NOTE**

**If other aircraft are in or anticipate to be in the White Out area, communicate with other aircraft to divide up the area and use radar, TCAS, air-air TACAN, GPS position to maintain separation with other aircraft.**

**NOTE**

**If a large angle turn is needed to point the aircraft into the wind after an unsuccessful instrument approach, consider a slight climb to provide maneuvering altitude due to the close proximity of the ground.**

## Appendix F. Acronyms

ACL	Allowable Cabin Load
AE	Aeromedical Evacuation
AFI	Air Force Instruction
AFRC	Air Force Reserve Command
AMC	Air Mobility Command
ANG	Air National Guard
BOS	Base Operating Support
CDRUSPACOM	Commander, United States Pacific Command
CDRUSTRANSCOM	Commander, United States Transportation Command
CHC	Christchurch
CJCS	Chairman, Joint Chiefs of Staff
CJTF	Commander, Joint Task Force
CJTF-SFA	Commander, Joint Task Force Support Forces Antarctica
COMAFFOR	Commander, Air Force Forces
COMNAVFOR	Commander, Naval Forces
COMPACAF	Commander, Pacific Air Forces
COMPACFLT	Commander, Pacific Fleet
DCJTF-SFA	Deputy Commander, JTF-SFA
DOD	Department of Defense
EAS	Expeditionary Airlift Squadron
GDSSII	Global Decision Support System II
IAW	In accordance with
JAOC	Joint Air and Space Operations Center
JOA	Joint Operations Area
JTF	Joint Task Force
JTF-SFA	Joint Task Force Support Forces Antarctica
LNO	Liaison Officer
MCM	McMurdo Station
MOA	Memorandum of Agreement
MSC	Military Sealift Command
NAVFOR	Naval Forces
NSF	National Science Foundation
NVG	Night Vision Goggles
NZ	New Zealand
ODF	Operation DEEP FREEZE
OPCON	Operational Control
OPORD	Operations Order
OPP	Office of Polar Programs
OPR	Office of Primary Responsibility
ORM	Operational Risk Management
PACAF	Pacific Air Forces
PACFLT	Pacific Fleet
PACOM	Pacific Command

PSR	Point of Safe Return
RON	Remain Over Night
SAAM	Special Assignment Airlift Mission
SATCOM	Satellite Communications
SFA	Support Forces Antarctica
SG	Surgeon General
SPAWAR	Space & Naval Warfare Systems Command

## **Appendix G. Definitions (taken from MOA between DOD and NSF)**

1. Active Guard and Reserve (AGR). National Guard and Reserve members on voluntary active duty providing full-time support to National Guard, Reserve, and Active Component organizations for the purpose of organizing, administering, recruiting, instructing, or training the Reserve Component.
2. Administrative Control (ADCON). Direction or exercise of authority over subordinate or other organizations in respect to administration and support, including organization of Service forces, control of resources and equipment, personnel management, unit logistics, individual and unit training, readiness, mobilization, demobilization, discipline, and other matters not included in the operational missions of the subordinate or other organizations.
3. Air National Guard Liaison to NSF/OPP Rated field grade officer assigned for duty at NSF to provide continuous liaison to operational units, the Air National Guard, and other major commands/agencies as required for the planning and execution of NSF-requested support.
4. Air National Guard / Logistics (ANG/A7). The Logistics Directorate of the Air National Guard responsible for initiating and executing logistics policy in the areas of aircraft maintenance and engineering. Accomplishes Air Staff Major Command duties in planning, programming, and allocation of resources
5. Air Force Reserve Logistics (AFRCILG). The Logistics Division of the Air Force Reserve is responsible for initiating and executing logistics policy in the areas of aircraft maintenance and engineering. Accomplishes Air Staff Major Command duties in planning, programming, and allocation of resources
6. Area Director. The senior contractor official responsible for implementing NSF tasking, as assigned, and the supervision of contractor operations with appropriate liaison with the NSF Representative and SFA JTF/CD.
7. Commander. Joint Task Force Support Forces Antarctica (CJTF SFA). PACOM appointed commander of the operation in support of the USAP, in the Antarctic Joint Operating Area. Dualhatted as the commander, 13th Air Force, which is the execution organization for ODF in the PACOM area of responsibility.
8. Deputy Commander Joint Task Force Support Forces Antarctica (DCJTF SFA). The designated on-scene commander of DOD Support Forces in Antarctica. Can be dual-hatted as the 13th Air Expeditionary Group Commander (13 AEG/CC). He/she is responsible for all military logistical support functions provided to NSF in Antarctica under the provisions of this MOA and must be a rated officer.
9. DOD Liaison to NSF/OPP. The senior ANG rated officer assigned for duty at NSF to provide continuous liaison and DOD policy guidance between DOD and NSF.

10. Joint Task Force-Alaska (JTF-AK). Coordinates Defense Support of Civil Authorities (DSCA) for the Alaska region.

11. McMurdo Station. The complex of facilities at McMurdo Station which constitutes the hub for air and ship operations, the storage point for ship-delivered bulk fuel, the staging base for annual resupply of South Pole Station, and for the support of other inland sites. It is also the support hub for the major portion of U.S. research conducted in Antarctica.

12. National Science Foundation/Office of Polar Programs (NSF/OPP). Office within the NSF that manages or coordinates scientific activities in the Arctic and Antarctic Polar Regions, and that has been designated via Presidential Memorandum to serve as the single point manager for all U.S. activities in Antarctica.

13. NSF Representative in Antarctica. The NSF senior staff member designated by the Director of the Office of Polar Programs of the NSF (OPP) to provide for on-site management of the U.S. Antarctic Program (USAP).

14. Operational Control (OPCON). Pertaining to DOD organizations, the command authority to perform those functions of command over subordinate forces involving organizing and employing commands and forces, assigning tasks, designating objectives, and giving authoritative direction necessary to accomplish the mission. OPCON includes authoritative direction over all aspects of military operations and joint training necessary to accomplish missions assigned to the command.

15. Operation Deep Freeze (ODF). The DOD operation within USAP that provides logistic support.

16. Pacific Air Force (PACAF). The air component of PACOM.

17. Pacific Command (PACOM). The supported unified command for Operation DEEP FREEZE, assigned the Pacific Area of Responsibility, as defined by SECDEF/JCS Unified Command Plan.

18. Secretary of the Air Force for Manpower and Reserve Affairs (SAF/MR). The focal point for Air Force policy oversight of human resources and Reserve component programs. SAF/MR directs the development of policy and advises the Secretary of the Air Force on programs for Manpower and Reserve Affairs that respond to Air Force Secretariat, Office of the Secretary of Defense, Congressional, and Administration guidance.

19. Senior United States Representative in Antarctica. The designated ranking U.S. government official in Antarctica, as authorized by the Director, National Science Foundation.

20. System Program Office (SPO). A general term of reference to those DOD organizations directed by individual managers exercising authority over the planning, direction, and control of tasks and associated functions essential for support of designated weapons or equipment systems. The authority vested in this organization may include such functions as research, development, procurement, production, material distribution, and logistic support, when so assigned.

21. Tactical Control (TACON). Command authority over assigned or attached forces or commands, or military capability or forces made available for tasking, that is limited to the detailed direction and control of movements or maneuvers within the operational area necessary to accomplish missions or tasks assigned. Tactical control is inherent in operational control. Tactical control may be delegated to, and exercised at any level at or below the level of combatant command. When forces are transferred between combatant commands, the command relationship the gaining commander will exercise (and the losing commander will relinquish) over these forces must be specified by the Secretary of Defense. Tactical control provides sufficient authority for controlling and directing the application of force or tactical use of combat support assets within the assigned mission or task.

22. United States Antarctic Program (USAP). United States scientific activities in Antarctica as managed and budgeted by NSF/OPP, including the logistic support of those activities in Christchurch, New Zealand; Punta Arenas, Chile; and Antarctica.

23. US Northern Command (USNORTHCOM). The supported command for operations in part of the Arctic Region, assigned the Alaskan and North American continent Area of Responsibility (AOR) as defined by SECDEF/JCS Unified Command Plan.

24. 13th Expeditionary Group Commander (13 AEG/CC). When established by DOD, serves as the designated agent for all airlift issues in the area of responsibility (AOR) or joint operations area (JOA) and for other duties as directed. He/she coordinates authority between the CJTF SFA, 613 AOC/AMD, airlift coordination cell, the air mobility element, the Tanker Airlift Control Center (TACC), the joint movement center, and the air operations center in order to expedite the resolution of airlift problems.

25. 109 Airlift Wing (109 AW). New York Air National Guard airlift wing operating and maintaining a fleet of LC-130s and C-130's out of Stratton Air National Guard Base, Scotia, New York. (Wynne, 2007) (Stone, 2012)

## **Appendix H. White-Out Landing, Skier 53**

On Friday January 9, 2009 the crew for Skier 53 conducted normal preflight and mission planning to include a good forecast and weather brief for the day. The takeoff was delayed due to a few maintenance issues with the Ignition Control Relay. We took off from Williams Field and completed the mission to the South Pole approximately 3+30 hours late. The leg to the South Pole was uneventful and proceeded as planned. Normal Ground operations were performed and return weather was received while on the ground at the South Pole. The following forecast for our arrival window was received: 260/10 8000m SCT0150 BKN030 BKN100 29.00 (no fog noted). We opted to keep an extra 1,000 lbs. of fuel for a full length taxi back then took off, climbed out and flew back to McMurdo.

We received a weather observation at Pole 3 with visibility of 800m and SCT030. We queried the weather forecaster and he gave us the same arrival weather we received while at the Pole. He stated "the fog will burn off long before your arrival time". At Pole 2 we made our position report in the blind because we did not have contact with Mac Center. All radios were quiet and we were unable to make contact with the iridium phone. The next weather we received was 20 miles prior to Pole 1. The current observation was winds calm 400m SCT SFC OVC003 with similar weather at Pegasus. We were informed that Pegasus was closed because the observer and Fire Department were called back to McMurdo.

We had 11,000 pounds of fuel when we received the weather, so we pulled power back to 700 TIT and slowly drifted down to Flight Level (FL) 240 feet from FL280 in order to reduce our fuel flow and devise a plan. Siple Dome weather was below

minimums as well. We also discussed Terra Nova Bay and the Nannsen Ice Runway as an option, but decided against it since there was no support or weather reporting capability. Our crew made a plan to shoot one MLS to Pegasus and the remainder of our approaches would be to Williams Field. I set a bingo fuel of 6000 lbs. in order have enough fuel to fly the Emergency White Out Procedure and taxi back into parking.

We had to deconflict with a Twin Otter that was also trying to get into Williams Field. The Twin Otter flew an approach to Williams Field and went missed approach. He proceeded to Pegasus while we flew and MLS to Skiway 25 at Willy. We went missed approach, followed with a TACAN approach to Skiway 25 which was also a missed approach. On our third attempt, we briefed the Whiteout Procedure and decided we had enough fuel to fly one more approach before going to the whiteout landing area. The weather was not improving, but the Loadmaster and Copilot did see a few lead-in flags to Skiway 7 when they looked straight down from around 300 feet AGL on our missed approaches. We flew one more TACAN approach to Skiway 25, went missed approach and accomplished the Emergency White Out Landing Procedure.

The entire crew did a great job performing their assigned duties very calm and collectively. We had very little wind, no drift and no visibility. We landed in "Zero-zero" conditions while still on instruments. I landed softly at landing speed and 100 feet/minute descent rate, and then performed a "min-run ski landing". The aircraft had about 5200 pounds of fuel upon landing and we taxied back for 20 minutes. The visibility was less than 400 feet the entire way, so we utilized the TACAN, SCNS and radar to safely taxi to Skiway 7 and proceed to the ramp. We did not have radio contact while in the White Out Area. We made radio contact with Willy Tower and Skier

Maintenance when we reached Skiway 7. We taxied back to our parking spot and shut-down with approx. 3600 pounds of fuel remaining (Herdrick, 2016).

# Appendix I. Quad Chart



## Point of Safe Return Minimums... How Low Can You Go?



### Introduction

The Department of Defense (DOD) has supported the National Science Foundation (NSF) for over 60 years in Antarctica. Missions from in support of Operation Deep Freeze (ODF) require specially qualified aircraft and aircraft operating under guidance specific to this operation. The LC-130 is modified with seats which allow it to deliver cargo and personnel to the remote skways throughout the continent. The aircraft also performs inter-theater airlift between Christchurch, New Zealand and McMurdo Station, Antarctica when the C-17 is not available. Neither aircraft can fly this mission without regulations and procedures specific to ODF. The aircrews flying this mission are required to calculate a Point of Safe Return (PSR) prior to each flight. This calculation determines how far the aircraft can fly enroute to McMurdo then return to Christchurch while maintaining required fuel reserve. Aircrews receive an updated weather forecast as they approach the PSR which determines whether or not they can continue to McMurdo or "boomerang" back to Christchurch.

### Research Focus

Determine how often McMurdo experienced specific weather levels and analyze if there are operational benefits associated with changing the weather minimums required to continue past the current PSR of 500 feet and 3 miles. Also determine if there is a time of day that offered better weather conditions for ODF planners to exploit.

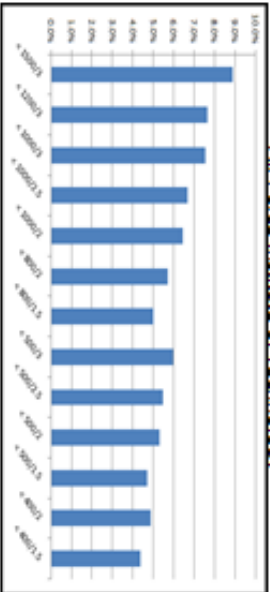
### Collaboration

HQAMCASL, JTF-SFA, 108 AVW, SPAWAR



Maj Bret Echard

Advisor: Lt Col Joseph R. Huscroft, PhD  
Advanced Studies of Air Mobility (ENS)  
Air Force Institute of Technology



Season	McMurdo mass	Delays	Cancells	Aborts	% Delays/Cancells/Aborts
2008-2009	427	25	26	7	13.6%
2009-2010	489	27	70	15	22.9%
2010-2011	552	13	71	8	16.7%
2011-2012	481	13	52	7	15.0%
2012-2013	433	10	34	9	12.2%
2013-2014	424	15	77	8	23.6%
2014-2015	266	4	24	7	13.2%
2008-2015	3072	107	364	61	17.0%

McMurdo Area	<1500/3	<1200/3	<1000/3	<1000/2.5	<1000/2	<800/2
Predicted Cancel, Abort, Delay %	20.6%	19.3%	19.2%	18.4%	18.2%	17.4%

McMurdo Area	<800/1.5	<500/3	<500/2.5	<500/2	<500/1.5	<400/2
Predicted Cancel, Abort, Delay %	16.7%	17.7%	17.2%	17.0%	16.4%	16.6%

### Methodology

The data, provided by SPAWAR, consists of weather observations for the McMurdo area from November 2009 up to December 2015. The total percentages of weather observations at specific levels in the McMurdo area was then found by totaling the observations for each location and calculating a percentage. This represents the percentage of time that location experienced weather at those specific levels. This data was also grouped into time categories at each location to determine if there was a time of day that historically offered better weather for operations. Operational flight data from Polar Mission Summary was then compiled for all LC-130 flights from November 2008 - March 2015 in the McMurdo area. The data was then filtered to display only missions that experienced a weather delay, cancellation or abort caused by McMurdo weather. The percentage of missions affected by weather was determined for each year as well as an overall percentage.

### Results

The analysis showed that overall 17% of LC-130 McMurdo missions were affected by weather with a point of safe return minimum of 500 feet and 2 miles. The analysis relied on the C-17 model that assumed for every 1% change in average weather there would also be a 1% change in weather delays. Based on the analysis, the 2015-2016 PSR minimum of 500 feet and 3 miles appears to be ideal for the LC-130 mission. The time period of 1201 - 1800 Zulu represented the worst time of day for aircraft operations at McMurdo. This period was 3-4% higher in weather observations than the others which were all within 5% of each other. The results also verified the C-17 study previously performed by PACAF/AS.

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