EXAMINATION OF AIR FORCE CRASH DAMAGE OR DISABLED AIRCRAFT RECOVERY PROGRAM RESOURCING

GRADUATE RESEARCH PROJECT

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Abstract

The Air Force's resources are becoming more constrained every year. In turn, these opportunities provide a roadmap for solution planning and programming in direct support of weapon systems and the warfighter. This research effort is an attempt to provide a regionalization methodology and cost benefit analysis for the Aircraft Crash Damaged or Disabled Aircraft Recovery (CDDAR) Program in order to provide better management and maximum utilization of scarce resources. If we contrast the capabilities in both permissive and opposed environments, we discover that capabilities of the Air Force CDDAR program are unparalleled, bar none, when it comes to flexibility and adaptability to overcome unforeseen circumstances. The Air Force must be good stewards of tax payer dollars and that is what drives this research.

"Providing the world's most advanced logistical support to our warfighters, particularly in remote areas, is a daunting challenge in itself; but, we now also face the challenge of preparing for an uncertain future. It is especially difficult to do both in today's extremely constrained fiscal environment of mounting national deficits and flattening defense budgets. We therefore must achieve greater efficiencies by eliminating as much administration and overhead costs as possible; to maximize our operational advantage while contending with decreased purchasing power." (Schwartz, 2011)

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EXAMINATION OF AIR FORCE CRASH DAMAGE OR DISABLED AIRCRAFT RECOVERY PROGRAM RESOURCING

I. Introduction

Background

At a small airport in Papeete, Tahiti, a lone maintenance representative is responsible for turning aircraft and coordinating maintenance on DC-10 aircraft when they land. On this particular night, a DC-10 landed and over ran the runway. The aircraft came to a complete stop after the nose landing gear jumped over the sea wall and wound up nose-down in a lagoon. With the passengers and crew safely off the aircraft, how is the aircraft going to be recovered? Like many civilian airports, there are no recovery assets at the airport and minimal personnel to expedite the recovery; however, airport operations need to continue. (Smith, 2011)

Figure 1. Hawaiian Airline Nose in Water

This airline had the lone maintenance representative coordinate all the recovery operations. This included contracting a 100-ton crane and construction of a small isthmus comprised of rock and fill dirt out into the lagoon in order to support the weight of the crane. He also coordinated with the major overhaul facility and the original equipment manufacturer on how to remove the aircraft from the lagoon. During night time operations, a crane lifted the nose as the maintenance coordinator supervised two large tugs connected to each of the main landing gear. As the nose landing gear cleared the seawall, the tugs pulled the aircraft until the nose landing gear was back on solid ground. The nose was gradually lowered to the overrun area and the tugs were disconnected.

Figure 2. Barge with Crane for Recovery

Figure 3. Crane Positioning for Lift

After inspection of the nose landing gear trunions and braces, the maintenance representative ascertained that a standard tow bar and tug could pull the aircraft to a general aviation ramp, where subsequent repairs could be made. After several months and two wing-mounted engine changes, the aircraft was flown on a special ferry permit to an overhaul facility. The cost of this recovery was small compared to losing an entire aircraft. Due to the diligence of the maintenance representative and consulting with the original equipment manufacturer, significant further damage was prevented.

There are numerous other mishaps that have very different endings. Mishaps can occur because of pilot error, weather, equipment failure, maintenance malpractice, and even sabotage. The processes that are used to recover an aircraft vary by each scenario and aircraft type. This scenario illustrates that all airfields do not have everything they need to recover an aircraft in every situation. The ability to forecast an incident is a fleeting task, so you don't know when, or where, a mishap is going to occur.

The two distinct phases of an aircraft mishap are initial response and recovery. The Crash Damage or Disabled Aircraft Recovery program deals with both phases after an aircraft mishap. The initial response phase exposes people and equipment to immediate dangers from aircraft fire, gases, harmful vapors, and solid particles that are released into the environment from the mishap. The recovery phase of an aircraft mishap exposes personnel to "fibers and respirable/inhalable dusts as aircraft parts are moved, modified by cutting, breaking, twisting, or hammering." (AFI 21-101, 2010:253) Response and recovery actions take special training, equipment, and risk awareness so that injury and illness are mitigated to the greatest extent possible. In the Air Force, the aircraft recovery phase rests mainly on the Maintenance Group. Once the safety investigation board president has released the aircraft, the Maintenance Group coordinates efforts to move the disabled aircraft to a parking area or storage area.

The Air Force has a requirement for all host and tenant units with flying missions or active airfields/runways to maintain a Crash Damaged or Disabled Aircraft Recovery (CDDAR) capability. Primary responsibility is on the Maintenance Group Commander to establish the CDDAR capability (AFI 21-101, 2010). Each mission design series (MDS) does have some common equipment that can be used across different types of MDS's but specific equipment may also be required for recovery operations based on the specific incident. The requirement for CDDAR capability at each base was developed because it is impossible to accurately predict the timing and location of an aircraft mishap.

The term "mishap" or "incident" will be used interchangeable throughout this research paper. A mishap is defined by the Air Force in Air Force Instruction 91-204. "A mishap is an unplanned occurrence or series of occurrences, that result in damage or injury and meets Class A, B, C, D, and Class E event reporting criteria." (AFI 91-204, 2008:92) Air Force Class A through E reporting involves mishap events that are deemed important to investigate but not meeting mishap reporting criteria to mishaps involving a fatality or over $1 million dollars in cost.

In the civilian sector, the National Transportation Safety Board investigates aircraft mishaps. Individual carriers are held responsible to move their aircraft from airfields when they are impeding airport operations. When looking at the private sector, we must not only discern the differing techniques and practices between public and private sectors. We must also account for what the private sector does better or more efficiently; identify the rationale for any intentional differences; and, where possible, determine whether best practices and lessons learned can be exchanged and applied to the benefit of the military.

Stakeholders

The stakeholders in the CDDAR program include the citizens of the United States (U.S.). The citizens of the U.S. are the primary customer of the U.S. Air Force. They are expecting a military that is ready to accomplish the mission all the times. Not only do the citizens expect readiness, but they expect readiness to be balanced with the associated risk and cost. This drives the Air Force to be good stewards of tax payer dollars. This research effort seeks to provide the Air Force with a methodology to enable better use of tax payer dollars.

In addition to the customer, commanders at all levels from the Chief of Staff of the Air Force to the Squadron commander in the field, have a vested interest in readiness of our assets and their associated costs. CDDAR technicians at each base are trained and want to be ready when an incident calls requiring their expertise. They train on the equipment, keep inspections up to date, and search for new ways of doing business. However, does the Air Force need this robust, continuous capability at every location?

Problem Motivation

This research was motivated by a request from Headquarters Air Force (AF/A4/7PY) to examine if it is in the Air Force's best interest to regionalize Crash, Damaged, and Disabled Aircraft Recovery. The focus of this research is to investigate the risk, probability, cost, response time, and recommend courses of action to Air Staff on program resourcing.

Problem Statement and Research Objective

How should the Air Force resource the Crash, Damaged, or Disabled Aircraft Recovery Program? What theoretical lens might be applied to gain insight into this problem? What is the timeframe that equipment is usually required? How far can the equipment be from the required location on demand? The current method for accomplishing this objective requires analysis to determine a relevant methodology and means to improve its effectiveness and affordability. These challenges warrant a strategic effort to justify funding requirements.

Methodology

A strategic look is required to position assets with relationship to risk regarding probability of occurrence and impact based on duration of airfield closure. The methodology employed in this research is primarily quantitative in nature with qualitative background information collected through telephone interviews and electronic mail. Data was collected using various systems including Logistics Installations and Mission Support-Enterprise View (LIMS-EV), Air Force Equipment Management System, and aircraft technical data. To capture as many perspectives as possible, research efforts examined multiple Major Commands (MAJCOM) and civilian industry policies and procedures. In addition to MAJCOM policy review, the researcher contacted aircraft recovery experts within the Air Force and the civilian community for their expertise and ground level operational experience.

Assumptions

Two key assumptions were made regarding this research: 1) This research applies to Air Force Base home station CDDAR capabilities. Home station capabilities are what the host unit is able to provide at the current local operating area. 2) The data gathered during the timeframe of this research project is not time dependent. That is to say that this data is representative of data that would be collected in a future study of similar scope holding all else equal.

Limitations

The research conducted was quantitative and qualitative in nature and involved personal interaction in either a face to face, telephonic, or electronic mail interaction. Additionally, the limited timeframe of this research project prohibited a complete examination of all the program aspects. Further research could be accomplished to look at manning, training, equipment lists by MDS for specific packages, and Department of Defense regionalization opportunities. This research focused on equipment utilization and placement. Technical data for CDDAR operations is specific to each airframe, but lacks great detail for every situation. This is where experience comes into action on what equipment is required for common usage.

Implications

This research will provide AF/A4 a methodology to resource the Air Force CDDAR program. Research outcomes will provide methodology based recommendations for improving current processes identifying a path for better utilization of scarce resources and management actions that could take place to better the program. Feasible and actionable findings may allow AF/A4 to reallocate resources and readdress Air Force Instructions to promote a more effective and cost effective approach to the CDDAR program.

II. Literature Review

Chapter Overview

Crash Damaged and Disabled Aircraft Recovery (CDDAR) is a program that was developed by the Air Force to ensure there are trained technicians and equipment available to recover aircraft and get an airfield back into operations as quickly as possible. While CDDAR is a term that is specific to the Air Force, aircraft recovery is performed by other services in the Department of Defense and by the civilian aviation industry. In that light, research began with a review of relevant literature to fully understand concepts and processes as they relate to the Air Force CDDAR program. This chapter will discuss the relevant literature to help explain key concepts and structure of the current program along with an overview of the current funding structure for the CDDAR program. This chapter will also discuss how the civilian aviation industry executes aircraft recovery.

Problem and Context

The main sources of literature used to provide a basic understanding of the CDDAR program were derived from governmental sources that included Air Force instructions and Air Force Audit Agency audit reports. The Air Force instructions (AFI) were helpful by providing the basic guidelines that are followed throughout the Air Force. A review of each MAJCOM supplement to AFI 21-101 provided more detail than the parent AFI, but still left important details up to the operating bases to formulate plans and equipment requirements. In addition, Air Force Audit Agency's' audit reports on the

CDDAR program provided a great source of information and recommendations. Finally, the International Air Transportation Association provided information on how the civilian sector's airlines execute and resource their aircraft recovery program.

Risk Pooling

Risk pooling, a type of Operational Risk Management, is a strategy with the greatest potential to alleviate the uncertainty of demand. In operations management, according to Yigal Gerchaks' paper, "The Relation Between the Benefits of Risk Pooling and the Variability of Demand", risk pooling is "often achieved by consolidating a product with random demand into one location" (Gerchak, 2001: 2). The research on risk pooling demonstrates there are great benefits to achieving statistical economies of scale. This term has many other forms such as economies of scope and the term used sometimes in the military is "economies of force" (Hughes, 2011). Gerchak researched "how demand variability affects the consequences and benefits of risk pooling." His findings show that as intuition would suggest, the greater the demand variability the larger the benefits are for risk pooling. (Gerchak, 2001:3)

Sheffi states that forecasts are much better at the aggregate level and there are several strategies to deal with the uncertainty in a forecast. One of the strategies is product variability reduction. In product variability reduction, the options are reduced and packages are developed to be pushed forward. "The smaller number of options allows better risk pooling, lower variability and thus better forecasts and lower overall costs." (Sheffi 2002:11) Sheffi further states that "in order to pool the forecasting risk, companies should manage inventory centrally". (Sheffi, 2002:15)

Further research by Levi et al (Levi, 2003) shows that the three critical points on risk pooling include: 1) Centralizing inventory reduces both safety stock and average inventory in the system. In a centralized distribution system, whenever demand from one market is high and demand in another market is low, resources originally allocated for the low demand market can be reallocated to the other. 2) The higher the coefficient of variation, the greater the benefit obtained from centralized systems because the coefficient of variation is standard deviation/average demand. 3) The benefits of risk pooling depend on the behavior of demand from one market relative to demand from another.

The research on risk pooling shows that centrally managed inventory and reducing product options available helps to decrease forecasting risk and increases the benefits of risk pooling. This researcher suggests that a centrally managed inventory (CDDAR equipment package) be developed and located in only a few locations, and as Levi suggests, move the equipment from the lower demand locations to satisfy higher demand locations. This will mitigate every operating base having redundant equipment, lowering inventory and inspection costs saving the budget that the Air Force is provided.

Air Force Instructions

AFI 21-101 Para 14.10 provides Major Commands and bases with direction on the CDDAR program. The AFI states, "all host and tenant units with flying missions or active airfields/runways are required to maintain a CDDAR capability. The host unit is responsible for developing the CDDAR program, but execution of the program can be delegated to the tenant units as appropriate." (AFI 21-101, 2010:247-247) It also provides specific guidance that minimum response for an in-flight emergency (IFE) is a tow team which must remain in place until the IFE is terminated. The AFI also provides the option for MAJCOMS to regionalize CDDAR capability “where it makes sense”. (AFI 21-101, 2010:248) Currently, no MAJCOM has regionalized their CDDAR capability. Air Force Central Command has obtained equipment for several locations overseas, but not formally regionalized the program.

Even though AFI 21-101 Para 14.10.5.2.1 states to “Annually review and update required recovery equipment lists by MDS consistent with the provisions of this instruction.” (AFI 21-101, 2010:248) This information does not exist in published form. The closest example of a published list is the allowance standards that vary by MDS, location, and number of aircraft. Maintenance Group commanders are required to ensure sufficient equipment is available to include mobility/deployed operations, as authorized in the applicable allowance standards.

Based on a review of the applicable instructions, responsibility is pushed to the lowest level for equipment authorizations and purchases, base level program development, and local level aircraft expertise to “figure it out”. There is no mention of Air Force Material Command (AFMC) to provide lists of aircraft specific recovery equipment requirements. This is left up to the lead MAJCOMs to develop.

In the Air Mobility Command supplement, “En routes will coordinate all requests for CDDAR support through 618 AOC (TACC)/XOCL. MOBs will be prepared to rapidly deploy crash recovery equipment and personnel for their MDS as directed by 618 AOC (TACC)/XOCL in order to recover MAF assets.” (AMC Supplement to AF I21-

101, 2011:305) This requires each base to have a spare set of equipment to deploy at any time.

The AMC supplement also provides more detailed guidance on administrative details and provides clear guidance that lifting of grounded aircraft for training is forbidden. The ACC supplement provides no additional guidance to wings on CDDAR program requirements. The AETC supplement specifies that lift exercises on C-17, C-21 and F-22 aircraft will not be performed, but the ACC "lead MAJCOM" supplement does not put that limitation on ACC CDDAR training or exercises. Finally, the Air Education and Training Command (AETC) supplement provides guidance on contract maintenance support for CDDAR operations where most equipment is provided by the government.

The three supplements discussed are the lead MAJCOMs for the majority of aircraft in the inventory. The AFSOC supplement was not able to be reviewed, because it is not published on the Air Force Publications website.

Equipment

In order to recover an aircraft, special equipment is required. This equipment includes lifting bags, air distribution manifolds, slings, and cables. Some of the additional equipment required includes air compressors, shackles for connecting cables, and dunnage to support lifting bags and other equipment for debogging aircraft from uneven surfaces. The equipment consists of items common to all aircraft as well as aircraft-specific items. This is not an exhaustive list but it illustrates the numerous equipment requirements that exist for aircraft recovery.

Each piece of equipment has requirements for training and inspections that vary according to technical data and manufacture specifications. These requirements are critical to ensure readiness of the assets and technical ability of the technicians recovering the aircraft. More details are explained below on equipment specifics.

Lifting Bags: Lifting bags are for lifting aircraft off the ground. They are placed under the wings or fuselage based on manufacturer recommendation and technical data. Lifting bags come in various sizes including 12, 15, 20, 26, 30, and 40 ton. Most lifting capacities are calculated at an airbag working pressure of seven pounds per square inch. The lifting bag example below is from AGE Logistics Corporation and their description of use is as follows:

> "Each Airbag element is constructed from a specially woven neoprene coated reinforced fabric. To lift an Aircraft at one point, would require a number of Single Element Airbags or 1 Multi-stack Airbag. Each element has a maximum lifting height of 8" therefore to lift an aircraft 10ft would require 15 single element airbags placed on top of each other. Each single element is inflated individually, giving the operator complete control of the lift and also retaining the maximum amount of rigidity. Stability and safety are achieved through the use of independent modules composed of three elements each. Low operating pressure prevents the risk of secondary damage. Modules can be stacked, up to five-high, as needed. Modules are lightweight and easily positioned by two people

under the aircraft lift positions. Modules are inflated by connecting a quick release air supply hose to the control console. Each element is fitted with a pressure relief valve to prevent over inflation. Velcro patches are provided on top and bottom of each module to provide lateral stability when stacking modules.” (Age, 2011)

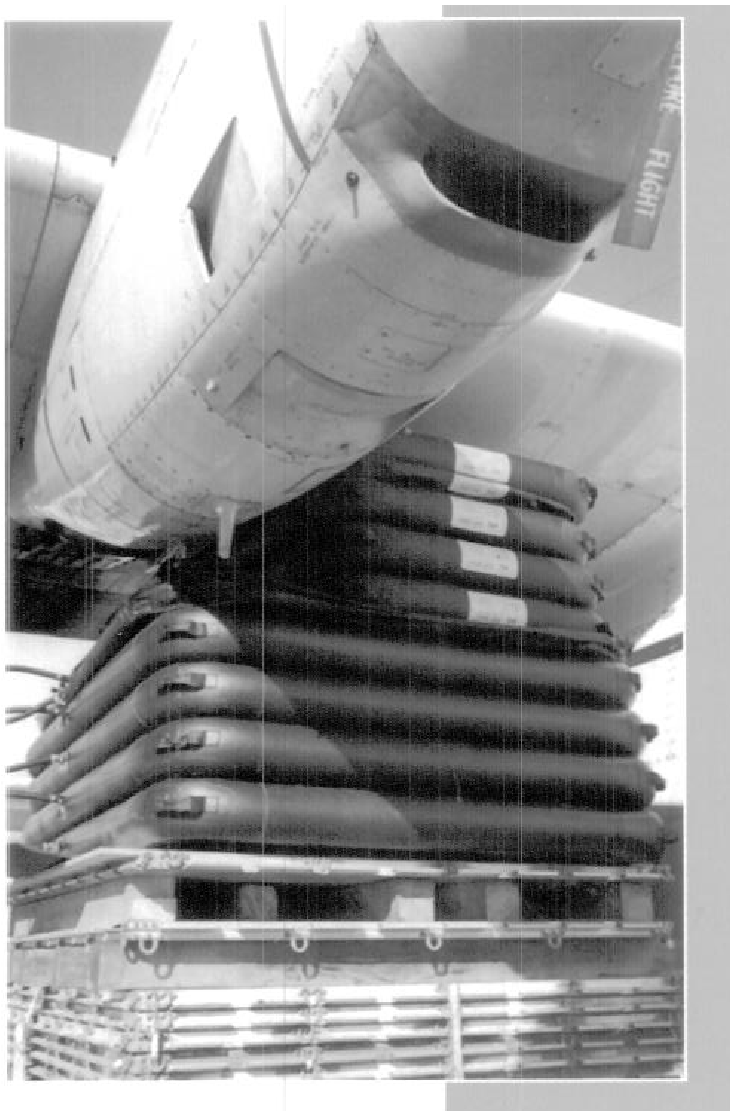

Figure 4. 26 and 15-Ton Airbags Under Wing

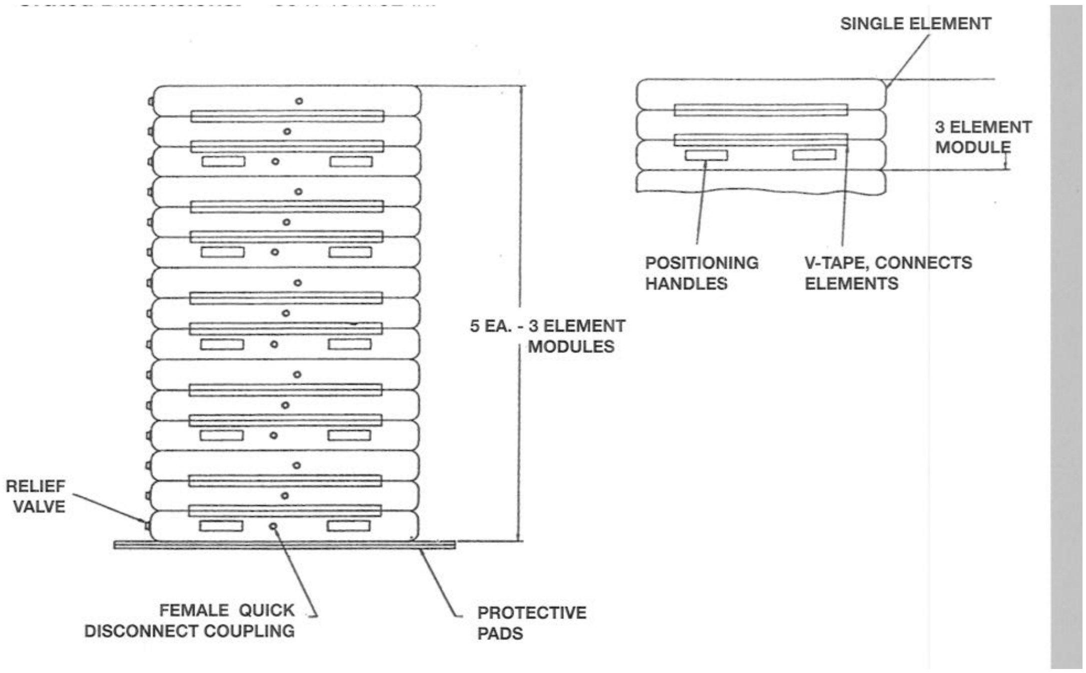

Figure 5. Manufacture Depiction of Airbag System

Manifolds: The single control console is used to distribute air to the airbags and pressurize them. It enables one person to control airflow to multiple bags depending on the configuration.

Figure 6. Manifold and Hoses

Fuselage Lifting Systems: Fuselage lifting systems, or slings, are typically placed under the front fuselage of an aircraft to lift the nose off the ground. After lifting the nose off the ground, a flatbed trailer or other device may be placed under the nose to support it for movement until the nose landing gear can be extended and used again.

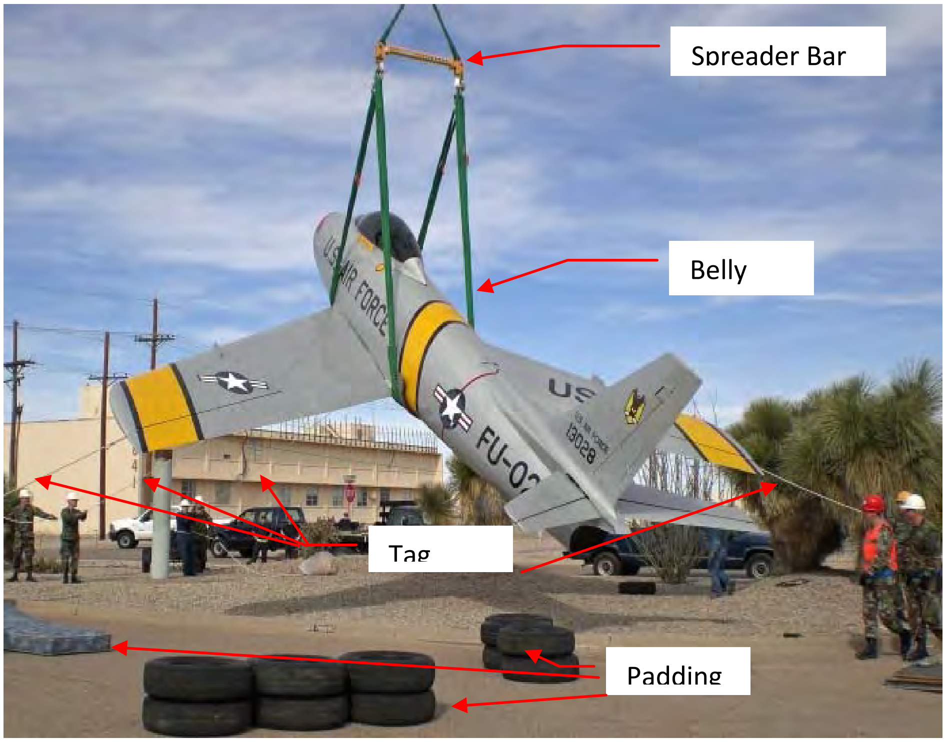

Figure 7. Aircraft Supported by Fuselage Lifting Device

Each recovery and debogging scenario may be different and require some specialized tooling. While Table 1 below is not an exhaustive list of every equipment item required, it does provide a perspective on how much equipment is required to be "ready" at all times, in-case an incident does occur (Conn, 2011).

Table 1. CDDAR Equipment (Conn, 2011)

Item	Approx Price Per
Cat 1 Lifting Kit (sling, spreader bar, lifts up to KC-135s)	$ 25,000.00
Cat 2 Lifting Kit (sling, spreader bar, lifts all heavies)	$ 70,000.00
C-5 Mobi Mat Recovery Matting Kit	$ 285,000.00
Mobi Mat Recovery Matting 6 pc kit	$ 100,000.00
4' X 8' Recovery Mat	$ 225.00
Jack Hammer	$ 250.00
20K Synthetic Sling TPXCEE 2000 X 20' (debogging)	$ 300.00
20K Synthetic Sling TPXCEE 2000 X 60' (debogging)	$ 1,000.00
60K Synthetic Sling TPXCEE 6000 X 60' (debogging)	$ 1,300.00
Rescue Saw	$ 1,000.00
1 Air Shelter w/Blower	$ 10,000.00
Wireless Communication Head Set	$ 285.00
Portable Generator	$ 2,500.00
Shackles 55T (load meter)	$ 900.00
Shackles 35T (load meter)	$ 600.00
Sling Saver Shackles 35T	$ 600.00
Shackles 25T	$ 350.00
Sling Saver Shackles 25T	$ 350.00
Shackles 10T	$ 125.00
Shackles 5 T	$ 80.00
17K Tie Down Straps	$ 75.00
4" X 4" X 8' Plastic Timbers	$ 21.00
Tifor Tether Kits (3 plates, 1 tirfor, 9 stakes, 1 cable, 1 handle)	$ 1,400.00
20K Belly Band Strap	$ 300.00
3" Card Board 4' X 8'	$ 80.00
Air Bags 15T	59,788.00
Air Bags 26T (less required at KC-135 (4) and smaller units)	$ 69,735.00
4' X 8' Plywood	$ 25.00
Consoles	$ 6798.00
40T Sled (with turntable)	$ 100,000.00
Remote Reading Load Meter 50T	$ 6,000.00
Remote Reading Load Meter 25T	$ 3,000.00
Load Meter 5 T (tifor lines)	$ 800.00
PAPR Suits (respirator suits, no fit test required)	unknown

Air Force Audit Agency Reports

The Air Force Audit Agency conducted 12 local area audits on the Crashed, Damaged, or Disabled Aircraft Recovery Program from 5 Dec 05-24 Aug 06. The researcher was able to view and analyze all of these audits. The major themes in the local audits are (Audit, 2006):

1- Wing instructions were not consistent with AFI 21-101
2- Program managers did not properly identify, complete, and record training
3- Managers did not accurately validate equipment authorizations
4- Equipment authorizations exceeded actual requirements
5- Host/Tenant unit coordination lacked regarding joint training and equipment on hand

An Air Force level audit dated 27 November 2006 covered 16 base locations including bases from Air Mobility Command, Air Combat Command, Air Force Material Command, Air Force Special Operations Command, Pacific Air Forces, United States Air Forces in Europe, Air National Guard, and Air Force Reserve Command. The Audit was performed from August 2005 through June 2006 to determine whether Air Force personnel properly accounted for CDDAR equipment, properly established equipment authorizations, and effectively implemented CDDAR program requirements. This audit took into account some of the local audits for data gathering and information pooling.

The Air Force level audit calculated that “the Air Force maintains over $18.6 million of on-hand CDDAR equipment with an additional $5.4 million on order”. (AUDIT, 2006) The researcher was able to obtain the source data and replicate the same data analysis with current year inventory and unit cost data as derived from Air Force Equipment Management System (AFEMS). The results show that the Air Force authorizations have increased along with the in-use or on-hand equipment. According to Air Force Equipment Management System data, current inventory calculations for consoles, 15-ton, and 26-ton air bags are now at $70.4 million, for in-use equipment. This is an increase of $51.8 million from 2006 to 2011.

Table 2. Comparison of 2006 and 2011 Authorized

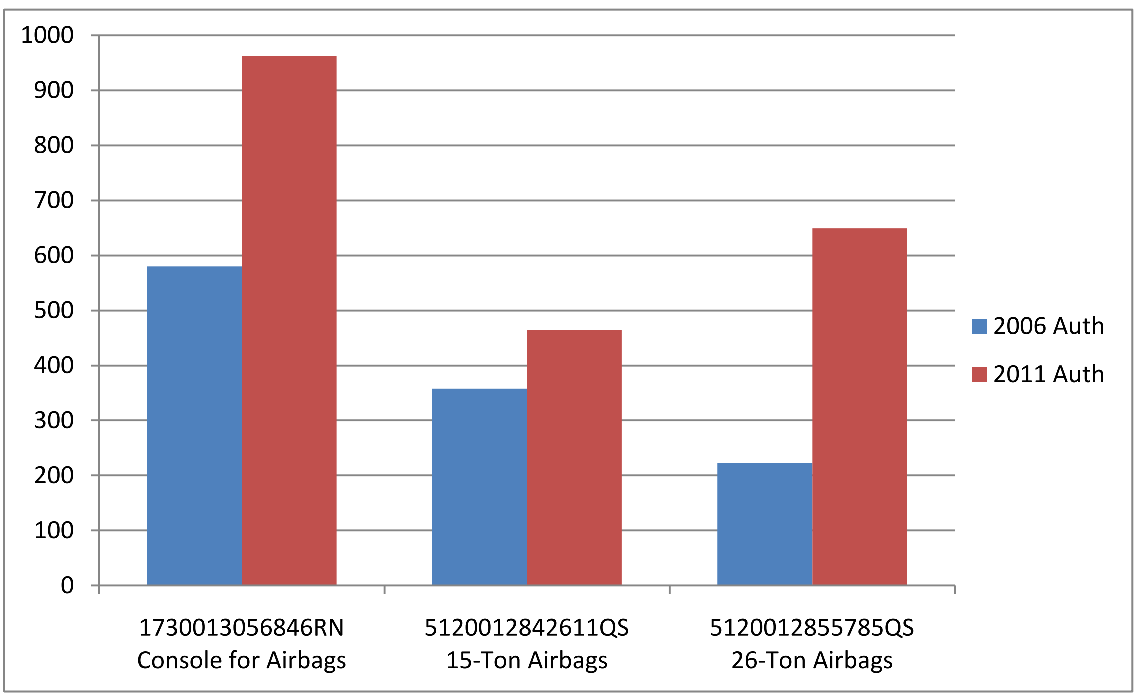

Table 3. Comparison of 2006 and 2011 In-Use

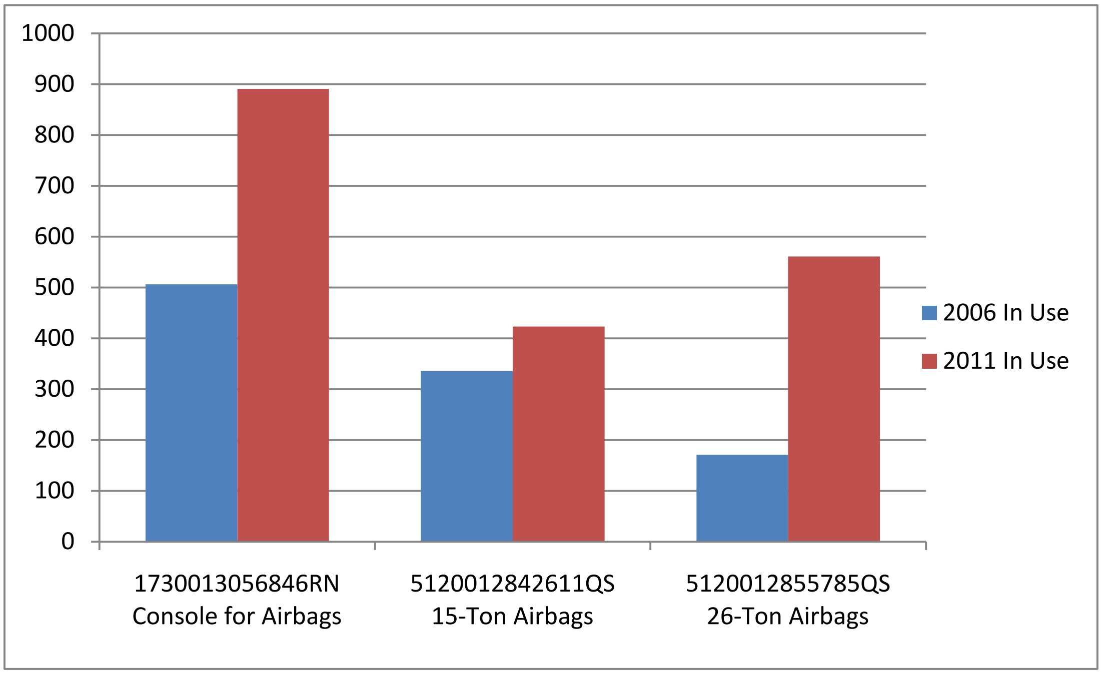

Table 4. Original Audit Numbers from 2006 Audit

NSN Nomenclature	Authorized	In Use	Unit Price	Total Inventory Cost
1730013056846RN Console for Airbags	580	506	$6,798.00	$3,446,586.00
5120012842611QS 15-Ton Airbags	358	336	$28,284.83	$9,320,431.89
5120012855785QS 26-Ton Airbags	223	171	$34,164.07	$5,842,055.97
				$18,609,073.86

Table 5. Original Audit Numbers with 2011 Unit Price

NSN Nomenclature	Authorized	In Use	Unit Price	Total Inventory Cost
1730013056846RN Console for Airbags	580	506	$6,798.00	$3,439,788.00
5120012842611QS 15-Ton Airbags	358	336	$59,788.00	$20,088,768.00
5120012855785QS 26-Ton Airbags	223	171	$69,735.00	$11,924,685.00
				$35,453,241.00

Table 6. 2011 Quantity with Unit Prices from 2006 Audit

NSN Nomenclature	Authorized	In Use	Unit Price	Total Inventory Cost
1730013056846RN Console for Airbags	962	891	$6,798.00	$6,057,018.00
5120012842611QS 15-Ton Airbags	464	423	$28,284.83	$11,964,483.09
5120012855785QS 26-Ton Airbags	649	561	$34,164.07	$19,166,043.27
				$37,187,544.36

Table 7. 2011 Quantity with Unit Prices from 2011

NSN Nomenclature	Authorized	In Use	Unit Price	Total Inventory Cost
1730013056846RN Console for Airbags	962	891	$6,798.00	$6,057,018.00
5120012842611QS 15-Ton Airbags	464	423	$59,788.00	$25,290,324.00
5120012855785QS 26-Ton Airbags	649	561	$69,735.00	$39,121,335.00
				$70,468,677.00

By calculating the delta and percent change between the 2006 and 2011 authorizations and in-use quantities, one can see the dramatic increase of authorized and in-use CDDAR equipment inventory during the five year period.

Table 8. Comparison of Authorized and In-Use Inventories

NSN Nomenclature	2006 Auth	2011 Auth	Delta	% Change	2006 In-Use	2011 In-use	Delta	% Change
1730013056846RN Console for Airbags	580	962	382	166%	506	891	385	176%
5120012842611QS 15-Ton Airbags	358	464	106	130%	336	423	87	126%
5120012855785QS 26-Ton Airbags	223	649	426	291%	171	561	390	328%

This inventory increase does not take into account any equipment items that are not loaded properly into AFEMS by the owning units. Assuming 100% of units do not accomplish100% proper inventories this calculation still under values the total equipment inventory for these three equipment items Air Force wide.

Further research reveals that this inventory will continue to grow into the unforeseen future. The item manager at Warner Robins Air Logistics Center (404 SCMS/GUOBB) currently shows 102 consoles, 79 15-ton airbags, and 130 26-ton airbags on backorder (Table 9). In addition, there are 68 consoles, 25 15-ton airbags, and 27 26-ton airbags currently on contract for purchase Air Force wide (Table 10). This illustrates the Air Force has contracted another $3.8 million dollars’ worth of inventory for 2011 and another $14.4 million waiting to be contracted in the future.

Table 9. 2011 Backorders Not on Contract

NSN Nomenclature	Backorders not on contract	Unit Price	Total Inventory Cost
1730013056846RN Console for Airbags	102	$6,798.00	$693,396.00
5120012842611Q 15-Ton Airbags	79	$59,788.00	$4,723,252.00
5120012855785QS 26-Ton Airbags	130	$69,735.00	$9,065,550.00
			$14,482,198.00

Table 10. 2011 Backorders on Contract

NSN Nomenclature	Backorders on Contract	Unit Price	Total Inventory Cost
1730013056846RN Console for Airbags	68	$6,798.00	$462,264.00
5120012842611Q 15-Ton Airbags	25	$59,788.00	$1,494,700.00
5120012855785QS 26-Ton Airbags	27	$69,735.00	$1,882,845.00
			$3,839,809.00

The Air Force level audit drew several conclusions and made two recommendations to AF/A4. The first conclusion was that personnel maintained accountability and serviceability of CDDAR equipment, yet personnel did not effectively manage CDDAR equipment requirements. One of the findings includes that managers maintained excess equipment yet did not have equipment to support transient aircraft.

The second recommendation was that CDDAR program requirements were not effectively implemented. Hands-on recovery training was not being conducted and the Air Logistics Centers were excluded from CDDAR guidance. Furthermore the Air Force level audit report reported that 12 of 16 bases reviewed did not have CDDAR equipment to support transient aircraft. The bases expected the aircrafts home station to deploy and clear the runway with their own maintenance personnel. (Audit, 2006) This finding is in compliance with the Air Mobility Command supplement to AFI to 21-101 but is not standardized across the Air Force.   At other locations, Air Force personnel did not have the right configurations of equipment necessary to successfully recover aircraft. For instance, Moody AFB had 13 airbag modules but would not have been able to successfully lift their assigned aircraft because of not having complete airbag systems. This broad look at the CDDAR programs has great implications and required a strategic look by Air Force leadership to develop solutions to the problems exposed through the audit.

The Air Force level audit also found that some host units would properly provide enough CDDAR equipment for both host and tenant units but the tenant unit would still have its own on-hand equipment to provide for its self. This creates a duplication of resources not only for equipment items but also for inspection requirements and storage facilities. This is a very costly way of doing business. An additional source of excess equipment is when units would purchase extra bags as spares for just in case.

The final reason for units having excess equipment is “personnel based recovery equipment requirements on the assigned aircraft numbers rather than the equipment needed to recover a single crashed or disabled aircraft, used inconsistent application for the same aircraft at different locations, and obtained insufficient equipment to recover assigned aircraft required by Air Force Technical Orders and manufacturer’s guidance.” (Audit, 2006:4)

The audit cites the cause for these conditions for four reasons (Audit, 2006:5):

1) Each base is required to have its own CDDAR program rather than implementing a regional CDDAR operational concept.
2) Maintenance Managers did not provide functional oversight to provide equipment discipline and consistency of allowance standards.
3) CDDAR managers established equipment allowances based on locally-determined requirements.
4) Major Commands did not establish or identify an inability to implement a training program.

This broad look at the CDDAR programs by the Air Force Audit Agency has great implications and requires a strategic look by Air Force leadership to develop solutions to the problems exposed through the audit. Since the time of the Air Force level Audit, Air Education Training Command has developed an Air Force level course curriculum for CDDAR training and the first class was scheduled to start in May 2011. The training to be performed Sheppard Air Force Base includes class and hands on training including actual aircraft lifting with bags and harnesses. This training has been modeled off the training performed at Davis-Monthan AFB Arizona where the Air National Guard performs CDDAR training. The Davis-Monthan training includes performing aircraft lifts and hands on instruction.

The Air Force Audit Agency has continued to look at the CDDAR program since the 2006 Air Force level audit. There have been three local audits since 2006 at Luke AFB, Randolph AFB, and Columbus AFB. These local audits still have findings of excess equipment and are more focused on the training documentation in IMDS and the AF IMT 2426.

International Air Transportation Association (IATA)

The International Air Transportation Association is an international trade body, created over 60 years ago. IATA represents 230 airlines comprising 93% of scheduled international air traffic. The association leads, represents, and serves the industry through industry best practices, expertise and working groups. The IATA understands that general tools and vehicles are usually locally available but found it necessary to take measures to ensure specialized lifting equipment is available on short notice world-wide. Knowing that this equipment is costly, attention was paid to solving the problem of its provision at the least cost to the industry, consistent with adequate availability.

The IATA has a working group called the Aircraft Recovery Task Force (ARTF) that coordinated with the International Airlines Technical Pool (IATP) on fulfilling the requirement of pooling aircraft recovery equipment. This working group analyzed the requirements and concluded that 11 lifting kits, strategically placed around the world would meet the requirements for the industry. The 11 proposed kits were developed and the cost-sharing by the airlines was based on rate of exposures and operational areas. This methodology was determined to be reasonable equitable by the airlines participating in the pool. (Civil Aviation, 2011)

This risk pooling resulted in a “lifting kit consisting of six 23-tonne pneumatic lifting bags, two 73-tonne large-extension hydraulic jacks and one set of tethering equipment, stored on pallets and ready for immediate shipment to any accident location together with skilled operating personnel”. These kits are now available at “Australia (Sydney), Brazil (Rio de Janeiro), France (Paris), India (Bombay), Japan (Tokyo), South Africa (Johannesburg), United Kingdom (London), and United States (Chicago, Honolulu, Los Angeles and New York).” (Civil Aviation, 2011) These kits may be supplemented with kits for the lifting of other wide body aircraft consisting two 40-ton lifting bags.

This pooling arrangement has served the industry well; it takes into account the high cost of equipment and pools the risk across the industry. If an airline is not a member of IATP, there is a substantial charge for the user of the kit and the requestor is required to pay for transporting the kit from the pool location to the sight of the incident.

The IATA sites that experience shows that the time for an incident investigation and obtaining permission to move the aircraft may easily amount to 20 hours or more especially with the larger aircraft. In most cases, the recovery kits should be at the recovery site before commencement of the lifting operation is allowed. "A kit from one of the pool locations can be transported to any airport in the world where it may be required, within a maximum of approximately ten hours, and more often within five or six hours." (Civil Aviation, 2011) The IATA experience also indicates that the equipment for lifting of aircraft will be only needed in only approximately five cases during a single operating year. With the IATA representing 93% of international passenger traffic and 230 airlines this demonstrates a great opportunity for the Air Force and the Department of Defence to seek advice from our civilian counterpart.

Canadian Transportation Accident Investigation and Safety Board

The Canadian Transportation Accident Investigation Safety Board makes recommendations to Canadian airports and air carriers. In addition to general aviation practices, they provide guidance on disabled aircraft removal. The board recommends that the Disabled Aircraft Removal Plan should take into consideration frequency of air traffic, size and weight of aircraft, and physical characteristics of the aerodrome when determining requirements for removal operations. Section 9.3.1.3 recommends that the following should be taken into account when developing the plan for aircraft removal (Canada, 2011):

1) A list of equipment and personnel on, or in the vicinity of, the aerodrome which would be available for such purpose;
2) Arrangements for the rapid receipt of aircraft recovery equipment kits available from other aerodromes;
3) A list of nominated agents acting on behalf of each aircraft operator at the aerodrome;
4) A statement of the aircraft operator arrangements for the use of pooled specialist equipment; and

5) A list of local contractors (with contacts and telephone numbers) with suitable removal equipment for hire.

This demonstrates that the Canadian government is concerned about aircraft recovery and provides guidance on what to include in a plan. The list also references the use of pooled specialist equipment. This is a form of regionalization and pooling risk with limited budgets in Canadian aerospace.

Funding

The CDDAR program is subject to Department of Defense budget constraints. Each unit is responsible for funding their own CDDAR equipment through Operations and Maintenance (O&M) funds. The researcher was unable to locate a source code for all CDDAR assets. Without a funding source code for CDDAR alone, an enterprise view of all assets and costs associated cannot be established for the CDDAR program.

Literature Review Summary

The purpose of this chapter was to review relevant literature and highlight the principles that apply to the researches study. The first principle is providing guidance to the organizations that must execute recovery operations. While big picture generic guidance is good for broad spectrum operations, CDDAR guidance needs to be broad regarding program management but must be focused regarding specific aircraft requirements. The Air Force approach to CDDAR has been hands off with each base figuring it out on their own. The Air Force needs to bridge the gap between AFI, MAJCOM supplement and Technical orders on each aircraft.

The second principle is inventory management. With AFMC involvement from the System Program Office engineers, CDDAR technicians and MAJCOM leadership could be better informed regarding assets required. This asset requirement visibility would lead to an AF level view and the pooling opportunity for risk and resources within the Air Force. With the CDDAR equipment in-use inventory growing yearly, the Air Force has a great opportunity to mitigate inventory cost, inspection requirements, and reallocate resources to where they are needed most.

The third principle is asset positioning. Using the IATA model of kit development and distribution, the Air Force has a great source of expertise to use for CDDAR asset positioning. The civilian aviation industry is a profit driven industry, examining their operations and risk pooling demonstrates that not all locations need to have every asset available at all times for aircraft recovery. With large aircraft incidents, the IATA has determined there is time to deploy assets to where they are needed and this gives the investigators time to investigate. Industry needs are being met by pooling their assets and they have demonstrated that regionalization produces cost savings.

III. Methodology

Chapter Overview

For purposes of this research, regionalization will be focused on the continental United States (CONUS) geographical area. CONUS active duty AMC, ACC, AFMC, SPC and Global Strike Command (GSC) bases are eligible to send CDDAR equipment to be consolidated at the regionalization sites. The regionalization methodology does not include Air Force Reserve units as regionalization candidates due to response times or the Air National Guard because the ownership of CDDAR equipment may have been state funded therefore not eligible to be consolidated.

Limitations

The methodology used is limited to the data that is available in AFEMS. The data pulled from AFEMS does not include every Air Force base in the CONUS. If a unit has not input their inventory data into AFEMS, the data is not available for analysis. Some of the bases not included are Nellis AFB, Langley AFB, Hill AFB, Randolph AFB, Scott AFB, Columbus AFB, Keesler AFB, Laughlin AFB, Goodfellow AFB, Malmstrom AFB, and F.E. Warren AFB.

Regionalization Location Methodology

To select locations for regionalization, a factor rating methodology is used. The key factors identified for rating include: aircraft type permanently assigned to the base, active duty personnel availability, number of runways at the base, Air Mobility Command must be able to task the aircraft through Tactical Airlift Control Center, and distance from other regionalization locations. Locations selected for regionalization of CDDAR equipment are selected first, on access to active duty transport aircraft and then active duty location. C-130 and C-17 aircraft are the tactical airlift choices for transport. The C-130s bases must be able to be directly tasked through TACC. Table 11 describes the aircraft type and base location options.

Table 11. Regionalization Candidate Aircraft and Bases

C-130	C-17
Dyess AFB, TX	Charleston AFB, SC
Little Rock AFB, AR	Travis AFB, CA
	McChord AFB, WA
	Joint Base McGuire-Dix-Lakehurst, NJ
	Dover AFB, DE

Kit Contents Methodology

The standard quantity of airbags and consoles per airframe is based on AFEMS authorization data and has been confirmed by CDDAR subject matter experts for fighter, bomber and cargo aircraft. For purposes of this research, the authorized quantity in AFEMS per aircraft type will be the quantity demanded per event. An event is when a single aircraft requiring airbags needs to be recovered from a crash or deviation from a hardened surface. Table 12 shows the authorized equipment quantities by aircraft type as derived from AFEMS. Using the highest number required per equipment item, a standard regionalized location inventory level is established. This enables any regionalization location to have equipment to respond to any airframe incident with the maximum quantity of CDDAR equipment required.

Table 12. Authorized Equipment by Aircraft

	Quantity Required		
Aircraft	**26-Ton**	**15-Ton**	**Consoles**
C-5	11	4	15
C-17	8	6	14
C-130	1	4	5
KC-135	8	8	16
B-1	2	2	4
B-52	14	0	14
U-2	0	5	5
A-10	0	4	4
F-15	0	3	3
F-16	0	4	4
MAX # in column	14	8	16

This maximum inventory level is then multiplied by the number of regionalization locations in the CONUS. Total numbers required for regionalization at 5, 6, or 7 different sites have been calculated and are listed in Table 13.

Table 13. Total CONUS Equipment Inventory

	Max Quantity Required For Single Incident Response		
Number of Regionalization sites	**26-ton 14**	**15-ton 8**	**Console 16**
5	70	40	80
6	84	48	96
7	98	56	112

Kit Consolidation Methodology

To determine where to pull inventory from to stock a regionalization location was determined based on shortest distance to travel from inventory pull locations. Ragsdale states this type of heuristic as "always ship as much as possible along the next available path with the shortest distance (or least cost)." (Ragsdale, 2007:76) To determine shortest distance between bases a Google map was utilized to calculate driving distances. Once driving distances were calculated then the following steps were taken:

1) Pull equipment items from nearest base until zero balance on that item
2) Once zero balance, go to next nearest base until demand at regionalization site is satisfied
3) If only one item is pulled from a base look at next base for a single consolidated shipment

Another method that could have been used is linear modeling. The Ragsdale text provides guidance on how using heuristics could solve this type of transportation and location problem versus a linear model using Solver in Microsoft Excel. (Ragsdale, 2007) To develop a linear model for this would have taken 465 lines of code to formulate the basic optimal solution set. Using a heuristic may not be perfectly optimal but it does provide a method with rigor that is repeatable. The heuristic also provides a timely development process to solve problem. This method is similar to other classic transportation and facility location problems not only in civilian but military applications alike. Similar models have been used in military application research including consolidation of security forces equipment for deployment purposes (Skipper et al, 2010).

IV. Results and Analysis

Regionalization Location Solution

The researcher selected five locations for regionalization, McChord AFB, Travis AFB, Dover AFB, Charleston AFB, and Dyess AFB. Joint Base McGuire-Dix-Lakehurst and Little Rock AFB were not selected based on proximity to other regionalization location alternatives. In addition, Dyess AFB was selected over Little Rock AFB because of the multiple aircraft type availability at the location enabling the regionalized location to service two different MDS's at one location versus Little Rock AFB with only one.

Kit Contents Solution

The kits required at each regionalization site will contain 8 15-ton airbags, 14 26-ton airbags and 16 consoles. This kit contents is able to handle any single aircraft mishap. In addition, this inventory also provides additional capability if multiple incidents occur requiring other equipment.

Kit Consolidation Solution

Total inventory required to be transferred to regionalization sites included, 26 26-ton airbags, 7 15-ton airbags and 10 consoles. This inventory was sourced based on the heuristic developed in the methodology section. The inventory was sourced from 11 different Air Force bases as listed in Table 14. This sourcing method minimized distance traveled to the regionalization locations in order to minimize cost of transportation.

Table 14. Where Equipment Was Pulled From

Equipment	# Moved	CHARLESTON	DOVER	DYESS	MCCHORD	TRAVIS
26-Ton	26	4-Robins 1-Moody 1-Patrick	2-Andrews	3-Altus 1-Cannon 3-Tinker 1-Barksdale	6-Fairchild	4-Edwards
15-Ton	7	2-Robins		2-Cannon	2-Mountain Home	1-Edwards
Console	10	4-Robins		4-Cannon	2-Fairchild	

Table 15 shows the inventory levels at regionalization locations prior to consolidation. Including maximum inventory data from Table 12, total quantity required to be transferred for regionalization was calculated.

Table 15. Inventory Before Consolidation

Equipment	Required Inventory at Each Location	CHARLESTON	DOVER	DYESS	MCCHORD	TRAVIS
26-Ton	14	8	12	6	8	10
15-Ton	8	6	10	6	6	7
Console	16	12	24	12	14	22

Table 16 shows the additional inventory required by location to meet at least 100% of the inventory requirements at each of the regionalization locations. The total equipment requirement needing transport is 26 26-ton, 7 15-ton, and 10 consoles.

Table 16. Additional Inventory Required at Consolidation Locations

Equipment	Total # to Move	CHARLESTON	DOVER	DYESS	MCCHORD	TRAVIS
26-Ton	**26**	6	2	8	6	4
15-Ton	**7**	2	-2	2	2	1
Console	**10**	4	-8	4	2	-6

Knowing the total quantity to be transferred to each regionalization location, the researcher then needed the distances to the nearest base with CDDAR equipment inventory. Using the distances in Table 17, inventory at each "pull" location was allocated to a regionalization location until minimum inventory was established. Table 14 shows the complete results of this analysis.

Table 17. Distances from Consolidation Locations

	ROBINS	SEYMOUR JOHNSON	MOODY	PATRICK	HURLBURT FIELD	ALTUS	CANNON	TINKER	BARKSDALE	MCCONNELL	KIRTLAND	LITTLE ROCK	WHITEMAN	OFFUTT	ELLSWORTH
CHARLESTON	267	276	281	411	568										
DYESS						194	269	303	390	456	489	531	681	744	968

	ANDREWS	MCGUIRE	WRIGHT-PATTERSON	FAIRCHILD	MOUNTAIN HOME	MINOT	BEALE	EDWARDS	DAVIS-MONTHAN	SHEPPARD
DOVER	96	117	565							
MCCHORD				297	581	1294				
TRAVIS							85	370	883	

After inventory was transported to regionalization locations, the final inventories shown in Table 18 meet the minimum requirement for consolidation with some locations having more inventory than required.

Table 18. Inventory Post Consolidation

Equipment	Min Requirement	CHARLESTON	DOVER	DYESS	MCCHORD	TRAVIS
26-Ton	14	14	14	14	14	14
15-Ton	8	8	10	8	8	8
Console	16	16	24	16	16	22

This post consolidation inventory list shows additional inventory at Dover and Travis due to the fact that both bases already had more inventory than was required for regionalization of some equipment items. This excess equipment is able to be turned-in in accordance with Air Force instructions.

After regionalization of CDDAR equipment items, the excess inventory may be and is assumed to be eliminated through proper Air Force approved turn-in methods. This eliminates the inventory costs and inspection requirements associated with excess inventory. After regionalization at five locations, total CONUS inventory on CDDAR equipment includes 70 26-ton airbags, 40 15-ton airbags, and 80 consoles. Table 19 authorized quantities have been changed to match the required inventory quantity of each equipment item. Table 19 also shows the total inventory cost at the regionalization locations.

Table 19. CONUS Regionalization Inventory Cost

Nomenclature	Authorized	In Use	Unit Price	Total Inventory Cost
Console	80	80	$ 6,798.00	$ 543,840.00
15-ton	40	40	$ 59,788.00	$ 2,391,520.00
26-ton	70	70	$ 69,735.00	$ 4,881,450.00
				$ 7,816,810.00

Table 20 shows the inventory cost calculations of all three equipment items across all active duty CONUS locations totaling $32.9 million. After subtracting the regionalization inventory cost (Table 19) from the current total inventory cost (Table 20), one can see this result eliminates over $25 million dollars of excess inventory when only considering active duty resources. Resale value is not taken into account for any of these equipment items. Adding in resale value, will only bolster the inventory turn in savings already estimated.

Table 20. Pre-Regionalization CONUS Inventory Cost Excluding AFR and ANG

Nomenclature	Authorized	In Use	Unit Price	Total Inventory Cost
Console	343	191	$ 6,798.00	$ 1,298,418.00
15-ton	159	149	$ 59,788.00	$ 8,908,412.00
26-ton	240	326	$ 69,735.00	$ 22,733,610.00
				$ 32,940,440.00

Table 21 shows the inventory cost calculations of all three equipment items across all CONUS locations including AFR and ANG totaling $60.2 million. After subtracting the regionalization inventory cost (Table 19) from the CONUS inventory cost including AFR and ANG (Table 21), one can see the savings increases to over $52.4 million dollars.

Table 21. Pre-Regionalization CONUS Inventory Cost Including AFR and ANG

Nomenclature	Authorized	In Use	Unit Price	Total Inventory Cost
Console	812	744	$ 6,798.00	$ 5,057,712.00
15-ton	378	367	$ 59,788.00	$ 21,942,196.00
26-ton	552	477	$ 69,735.00	$ 33,263,595.00
				$ 60,263,503.00

Summary

The strength of these solutions is great due to the consolidation number savings being very under estimated. The underestimation is because there is more inventory in the Air Force than is currently in the AFEMS system. This underestimation makes this solution set not brittle to changes in inventory numbers across the CONUS area. In addition to underestimating the total Air Force inventory, this study focuses on the CONUS geographical area. If expanded to include Air Force wide inventory and regionalization across the world the benefits could be even greater. This heuristic could be used to expand this concept of operations to worldwide operations including contingency operation locations.

V. Conclusions and Recommendations

Conclusions

According to the calculations used in this research, the Air Force could save up to $50 million in inventory alone when a regionalization approach to CDDAR program management is implemented. This research focused on only three equipment items what are the most costly of all CDDAR assets in the field. The savings will only be greater when applying this methodology to other items required for CDDAR operations and across areas other than CONUS.

This researcher is not suggesting regionalizing all assets required for CDDAR operations. There is an immediate need for equipment items that would be financially more efficient to keep located at each base across the CONUS. Some of these items would include snatch cables, shackles, tie straps, lumber and plywood among numerous items. The three items included in this research are common across all MDS's and are trained on by all CDDAR technicians.

The savings in inventory reduction could come at a price of readiness. The IATA has calculated their risk using occurrence rates based on location, MDS, and traffic. This researcher recommends the Air Force calculate risk using the same methodology. The price of Air Force readiness cannot be calculated with data currently available. A significant finding of this research unveiled there is no current tracking method to capture when CDDAR equipment is used during an aircraft incident. To calculate readiness (risk), incident occurrence rates need to be determined by MDS and base location. The

Air Force Safety Center does not collect this data currently. Each MAJCOM may have some data from personal knowledge but there is no standard data collection method.

Summary of Recommendations

The following list provides recommendations for improvements in CDDAR program resourcing and management.

1- Air Force leadership needs to take a strategic approach to regionalization across all MAJCOMs versus the current approach of leaving the decision up to the individual MAJCOMs.

2- Implement a regionalization approach to CDDAR program resourcing.

3- Expand this implementation to outside CONUS areas and potentially across the Department of Defense.

4- AMC requires each base to have a spare set of equipment to deploy at any time. The researcher proposes that regionalization could be used to alleviate this equipment requirement.

5- The Air Force could use the AMC Air Operation center as the tasking agency for all CDDAR equipment across all MAJCOMs if regionalized.

Finding

Air Force does not currently collect CDDAR equipment usage data by MDS and base. If this data is collected, researchers could analyze the data and determine risk probability based on aircraft type and base. This in-turn could be used to determine better locations for CDDAR equipment regionalization and quantity of equipment to stock.

Recommendations for Future Research

The researcher recommends the Lead MAJCOMs coordinate with the aircraft system program offices in AFMC to develop a proposed CDDAR equipment list that goes beyond the three equipment items explored in this research project.

This research could be greatly enhanced by having actual CDDAR equipment usage rates by airframe and by base. This information could be used to measure risk and probability of occurrence at each location by airframe.

Calculating response time and cost of response transportation would better quantify the benefits and risk associated with regionalization of CDDAR equipment. Further research could be accomplished to quantify manning, training, and equipment cost savings of regionalization. This regionalization concept lends its self to DoD implementation. Further research could explore the regionalization of all DoD recovery assets around the world similar to how the IATA manages their recovery assets.

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Vita

Major Dain O. Kleiv is married with five children and is enrolled as an Intermediate Development Education student earning a Masters of Logistics Degree at the Air Force Institute of Technology, Wright-Patterson Air Force Base, Ohio. Major Kleiv entered the Air Force in 1997 as a Reserve Officer Training Corps graduate of the University of South Florida. He then earned a Masters of Aeronautical Sciences degree in 2003 from Embry Riddle Aeronautical University. His previous experience includes numerous field level assignments including Command of the 7th Maintenance Operations Squadron and leading aircraft maintenance on B-1, KC-135R, MH-53J/M and MC-130E aircraft. Major Kleiv also has served at the MAJCOM level working Force Development Officer Assignments and Depot Maintenance Analysis at Headquarters Air Force Material Command. Additionally, he has deployed on numerous occasions in support of Operations ALLIED FORCE, SOUTHERN WATCH, and ENDURING FREEDOM. After completing his masters degree Major Kleiv will be taking command of the 22nd Maintenance Squadron at McConnell AFB, Kansas.

Appendix A.

Blue Dart

The Air Force's resources are becoming more constrained every year. In turn, these opportunities provide a roadmap for solution planning and programming in direct support of weapon systems and the warfighter. This research effort is an attempt to provide a regionalization methodology and cost benefit analysis for the Aircraft Crash Damaged or Disabled Aircraft Recovery (CDDAR) Program in order to provide better management and maximum utilization of scarce resources. If we contrast the capabilities in both permissive and opposed environments, we discover that capabilities of the Air Force CDDAR program are unparalleled, bar none, when it comes to flexibility and adaptability to overcome unforeseen circumstances. The Air Force must be good stewards of tax payer dollars and that is what drives this research.

"Providing the world's most advanced logistical support to our warfighters, particularly in remote areas, is a daunting challenge in itself; but, we now also face the challenge of preparing for an uncertain future. It is especially difficult to do both in today's extremely constrained fiscal environment of mounting national deficits and flattening defense budgets. We therefore must achieve greater efficiencies by eliminating as much administration and overhead costs as possible; to maximize our operational advantage while contending with decreased purchasing power." (Schwartz, 2011)

Appendix B.

Quad Chart

Crash Damaged, Disabled Aircraft Recovery Resourcing

Elevator Statement:

Regionalization of CDDAR assets presents the Air Force with an opportunity to save tax payer dollars and better utilize scarce resources. This research demonstrates how to put words into action.

Major Dain O. Kleiv
Department of Operational Sciences (ENS)

ADVISORS
Lt Col Joseph Skipper
&
Dr. William Cunningham

Research Goals:

- Determine methodology to select CONUS regionalization locations and select locations
- Determine methodology to determine required inventory at regionalization locations
- Develop methodology for where to acquire regionalization inventory from

Regionalization Cite Location Options

C-130	C-17
Dyess, TX	Charleston, SC
Little Rock, AR	Travis, CA
	McChord, WA
	McGuire, NJ
	Dover, DE

Total Conus Inventory

NSN Nomenclature	Authorized	In Use	Unit Price	Total Inventory Cost
Console for Airbags	812	744	$6,798.00	$5,057,712.00
15-Ton Airbags	378	367	$59,788.00	$21,942,196.00
26-Ton Airbags	552	477	$69,735.00	$33,263,595.00
				$60,263,503.00

Conus Regionalization Inventory

NSN Nomenclature	Authorized	In Use	Unit Price	Total Inventory Cost
Console for Airbags	80	80	$6,798.00	$543,840.00
15-Ton Airbags	40	40	$59,788.00	$2,391,520.00
26-Ton Airbags	70	70	$69,735.00	$4,881,450.00
				$7,816,810.00

Regionalization Inventory Savings with ANG and AFR: **$52,446,693.00**

CDDAR Asset Requirements

Aircraft	15-Ton	26-Ton	Consoles
C-5	4	11	15
C-17	6	8	14
C-130	4	1	5
KC-135	8	8	16
B-1	2	2	4
B-52	0	14	14
U-2	5	0	5
A-10	4	0	4
F-15	3	0	3
F-16	4	0	4
MAX # in column	8	14	16

Further Research Opportunities:

1-Risk probability by MDS and location
2-DoD wide application
3-Response time calculations
4-Additional kit items

Limitations:

1-Data limited to AFEMS
2-No data on equipment usage rates
3-Inventory cost only, no carrying cost or inspection manpower savings

Sponsor:
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14. ABSTRACT
The Air Force's resources are becoming more constrained every year. In turn, these opportunities provide a roadmap for solution planning and programming in direct support of weapon systems and the warfighter. This research effort is an attempt to provide a regionalization methodology and cost benefit analysis for the Aircraft Crash Damaged or Disabled Aircraft Recovery (CDDAR) Program in order to provide better management and maximum utilization of scarce resources. If we contrast the capabilities in both permissive and opposed environments, we discover that capabilities of the Air Force CDDAR program are unparalleled, bar none, when it comes to flexibility and adaptability to overcome unforeseen circumstances. The Air Force must be good stewards of tax payer dollars and that is what drives this research.

15. SUBJECT TERMS
CDDAR, Crash, Damaged, Disabled, Aircraft, Recovery, Consolidation, Regionalization, Cost Benefit Analysis

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