Changing the Culture of Fuel Efficiency: A Change in Attitude

GRADUATE RESEARCH PROJECT

Russell D. Gohn, Maj, USAF

AFIT-ENS-GRP-14-J-6

DEPARTMENT OF THE AIR FORCE
AIR UNIVERSITY

AIR FORCE INSTITUTE OF TECHNOLOGY

Wright-Patterson Air Force Base, Ohio

AFIT-ENS-GRP-14-J-6

CHANGING THE CULTURE OF FUEL EFFICIENCY: A CHANGE IN ATTITUDE

GRADUATE RESEARCH PAPER

Presented to the Faculty

Department of Engineering and Management

Graduate School of Engineering and Management

Air Force Institute of Technology

Air University

Air Education and Training Command

In Partial Fulfillment of the Requirements for the

Degree of Master of Science in Logistics

Russell D. Gohn, MBA, BS

Major, USAF

May 2014

AFIT-ENS-GRP-14-J-6

CHANGING THE CULTURE OF FUEL EFFICIENCY: A CHANGE IN ATTITUDE

Russell D. Gohn, MBA, BS
Major, USAF

Approved:

Doral E. Sandlin, Col, USAF (Advisor)

9 May 14
Date

AFIT-ENS-GRP-14-J-6

Abstract

Due to the inconsistent financial position of the Air Force, every method for cost savings must be evaluated to ensure the Air Force can meet its National Security objectives with the most cost effective force available. As the Air Force is the largest user of energy within the DoD, fuel efficiency needs to be improved through new cost advantageous methods to avoid further cuts to readiness and recapitalization. Previous efforts to curb energy use within AMC have focused on programmatic and systematic issues. This paper will present a plan to modify military aviation culture reinforced during 10 years of rising DoD spending with positive motivation and commitment through benchmarking discrete mission performance using the KC-135 community at Royal Air Force Mildenhall (RAFM) as a test case. A fuel efficiency rating for tanker pilots will be modeled using mission metrics that are currently unavailable in a single database, but easily acquired. With this metric individual flyers should be intrinsically motivated to push fuel efficiency higher as a priority, and therefore accomplish missions and training within the tightest tolerances of fuel efficiency.

AFIT-ENS-GRP-14-J-6

I would like to dedicate this work to my family, which bears the sacrifices, both realized and unrealized, of my career. To my boys, it has been an absolutely wonderful year watching you grow. You bring life into our home and joy into my heart. To my wife and love, thank you for being with me every step of the way. You are the epitome of support to me and our family, and motivate me to be better every day…thanks for driving all those miles!

Acknowledgments

There are many people in my life that have taken the time and effort to help me succeed, and to stoke the flame of knowledge. Accomplishment of this research has been no different, and only proves that our greatest accomplishments are achieved with the help of others. Thank you to my academic advisor, Colonel Ned Sandlin, who's enthusiasm for research and its impact is responsible for manifesting the same in me. A big thank you to the 100th Air Refueling Wing, especially TSgt Jonathan Carlson and Josebell Bishop, who provided data support that was instrumental to this research. And, to my Square D leadership past and present who have ceaselessly supported me and this research. Once a member of the Bloody Hundredth…always a member of the Bloody Hundredth.

Russell D. Gohn

Table of Contents

List of Figures

List of Tables

List of Equations

CHANGING THE CULTURE OF FUEL EFFICIENCY: A CHANGE IN ATTITUDE

I. Introduction

Background

Fuel efficiency has long been a focus area for the Department of Defense (DoD) and Air Mobility Command (AMC), but as governmental spending comes under increased national scrutiny it will be even more imperative that we become as fiscally responsible as possible through focused energy conservation. In 2010, Michael Donley, then Secretary of the Air Force, issued *Air Force Energy Plan 2010*. The document serves as the framework for communicating energy goals to all military and civilian members within the service. Three major goals were laid out in the plan shown by Figure 1: reduce demand, increase supply, and culture change. It is the last of these three goals on which this paper will focus, which in turn will drive down the first. The plan states that, "energy management is an evolving process that will require the systematic incorporation of new information, rigorous insertion of technological advancements, and continuous improvement of processes and practices," which is exactly what changing culture within the context of Air Force aviation will require (Donley, 2010, p. 1). Even the *Air Force Energy Plan* states that culture change will be difficult, but it is also critical to maintaining any gains achieved through other measures. If the culture remains unchanged, aviators will revert back to performing missions in the same routine manner without placing a priority on efficiency. This would make regulatory change the sole driver of efficiency and confound sustained

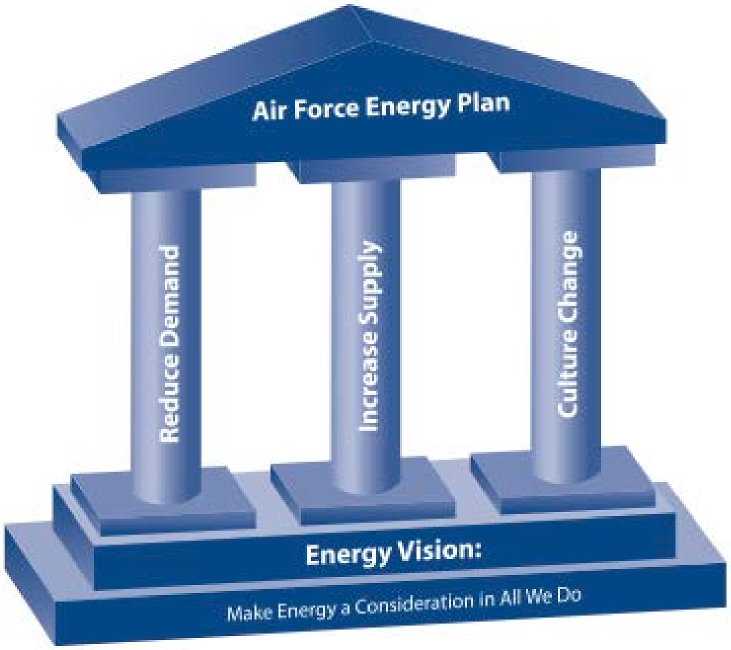


Figure 1: Air Force Energy Plan Pillars (Donley, 2010, p. 7)

improvements in any variable fuel efficiency metric. Since tomorrow's aviators are trained by today's, changing our current aviators is imperative through increasing not only the priority of fuel efficiency, but also the familiarity and comfort levels with available techniques.

The DoD is the largest energy user government-wide at 91% of all fuel consumed, and internal to that, aviation uses 84% of total Air Force consumption (Donley, 2010, p. 4). Previous efforts to curb energy use within AMC have focused on programmatic and systematic issues. Surprisingly, the pillar of culture change laid out in the *Air Force Energy Plan* has been largely left untouched by the academic community, except in the case of training and education as a blanket statement. Heseltine (2008) stated, "if $200 were saved on every sortie the command could save over $28M per year. While $ 28M is a significant amount of money, initial indications show the possibility of savings in excess of $160M per year through the application of major fuel efficiency initiatives across the command" (Heseltine, 2008, p. 29). A savings of

$200 per sortie would be realized through a decrease of roughly 40 gallons of fuel, which is easily attainable through utilization of a multitude of methods presented across the span of fuel efficiency research. One of the earliest change efforts during this conservation spring was *AMC Pamphlet 11-3*, now rescinded, that provided an informational approach towards fuel conservation, but little in the way of direction or true cultural change. Since 2001, when we experienced the largest increase in military spending since the late 1940's, military aviators have developed within a period where fuel usage has not been prioritized, through which pilots developed an engrained perspective of the fuel required for a comfort level. This all started to change in 2011 when the defense budget corrected and aircraft publication updates introduced new processes to determine the amount of fuel required per sortie. Several recent projects examine how to more efficiently operate the Air Force's aircraft fleet. Major Phil Morrison researched *Reballasting The KC-135 Fleet For Fuel Efficiency* (reduced the zero fuel weight of the aircraft); in 2009 Ray P. Matherne researched *Fuel Savings Through Aircraft Modification: A Cost Analysis* (the addition of winglets to KC-10 and KC-135 aircraft); and in 2008 Major Phil Heseltine researched *Analysis: KC-135 Lean Fuel Operations* (elimination of the standard ramp fuel). All of these papers, while providing an avenue for cost savings, focused on the aircraft and not the pilot who is ultimately responsible for determining the mission fuel load and employment of the aircraft to complete the mission. This paper will present a plan to modify military aviation culture reinforced during 10 years of rising DoD spending with positive motivation and commitment through benchmarking discrete mission performance using the KC-135 community at Royal Air Force Mildenhall (RAFM) as a test case. A fuel efficiency rating for tanker pilots will be modeled using mission metrics that are currently unavailable in a single database, but data is easily acquired at any organizational level. With this metric I believe that individual flyers will be intrinsically motivated to push fuel efficiency higher as a priority, and therefore accomplish missions and training within the tightest tolerances of fuel efficiency.

Problem Statement

Due to the inconsistent financial position of the Air Force, every method for cost savings must be evaluated to ensure the Air Force can meet its National Security objectives with the most cost effective force available. As the Air Force is the largest user of energy within the DoD, fuel efficiency needs to be improved through new cost advantageous methods to avoid further cuts to readiness and recapitalization.

Research Objectives, Questions, and Hypotheses

There are several goals for this research. The primary being to foster a culture within AMC that promotes efficient fuel usage through all phases of flight. This is particularly important in the application of training, which has only recently been viewed as an area for reduction. As a corollary, pilots will have to become adept at maximizing the value of each gallon of gas to accomplish the necessary objectives of each mission or risk failure to complete a particular objective or risk excessive fuel usage. To accomplish this goal several questions need to be answered:

1. How can we change military aviation culture in regards to fuel efficiency?
2. What variables need to be included in a pilot’s fuel efficiency rating?
3. Should a fuel efficiency metric be used as positive reinforcement?
4. Is there a need for a more robust AMC Fuel Tracker?

In many scenarios both military and civilian metrics have been used as a reactive scope of performance, often the measuring stick for awards or lack thereof. The contention being that military aviation culture can be affected through a morale and camaraderie building tool instead of a punitive metric approach. Additionally, pilots and leadership can use this metric as another descriptive analysis of performance. Once pilots have attained a fuel efficiency rating, they will be intrinsically motivated to increase that statistic for their own pride and for benchmarking purposes within a unit, as it will provide them with a realistic comparison to all like aviators within their major weapon system (MWS). This connection is the intersection of referent power and self-concept external motivation, and is seen extensively within the aviation subculture and flight crews (Barbuto, 2000, p. 387). Extending this idea, units could aggregate ratings for a unit rating, providing friendly strife between sister units, bases, or perhaps airframes in the future. This promotional rivalry could have a secondary benefit of finding best practices as well.

The hypothesis of this study is that a model can be created using historical data that will take into account all factors of flight to produce a true measure of a pilot's fuel efficiency. This model could prove useful in changing the culture of military fuel efficiency as part of an overall change strategy.

Research Focus

The purpose of this Graduate Research Project (GRP) will be to formulate a pilot efficiency rating equation that can be used to benchmark discrete missions. Specifically, the focus will be on the 100th Air Refueling Wing (100 ARW) at RAFM, which flies the KC-135 tanker, through development of a data set. This metric would be used as a positive motivator to boost fuel efficiency as a priority.

Methodology

The primary measurement tool employed will be regression model. Past methods to improve fuel efficiency and organizational culture change will be analyzed qualitatively. The study will then take a quantitative look at a data set comprised of missions flown by the 100 ARW with the goal of developing a metric that can be used to modify the culture within military aviation to improve fuel efficiency. The KC-135 airframe was chosen as an initial model because it has multiple missions at any given time including: air-land point-to-point, training, and air refueling operations. It is the Air Force's air refueling backbone and comprises the largest aircraft fleet in the operational inventory. Cargo aircraft would provide an easier regression, and special operations or airdrop platforms would prove more difficult. So, a middle of the road approach for this first model was selected. Overall fuel usage will be used as the response or dependent variable. Initially the predictor variables will be gross weight, flight time, flight distance, air refueling (AR) time on track, fuel dumping, receiver type (to determine track speed), number of radar approaches, and number of visual approaches. Other variables will be added as research is completed. AMC leadership, and in particular the AMC/A3 Fuel Efficiency Office (FEO) is the primary audience; Colonel Keith P. Boone, AMC/A3F is the research sponsor. He has agreed to provide data through the AMC Fuel Tracker. Contractors located within the AMC/A3F directorate have also offered to provide data and application of the AMC Fuel Tracker. Additionally, Mr. Steve Comeaux, A3RI MODSS Team Branch Chief/MODSS Project Manager, has made his resources available to furnish additional data and analysis that has not been packaged within the fuel efficiency program as well as a look at Military Flight Operations Quality Assurance (MFOQA) data. I believe this data will be more beneficial than that provided solely by the AMC Fuel Tracker, but it still does not encompass the full gamut of mission input required to perform the regression. To create the rating requires squadron aviation resource management (SARM) data in the form of training completion to account for heavier fuel consumption within the lower flight regime encountered during pattern training. Training accomplishment is a critical element to a comprehensive overview of any mission, which to this point has never been incorporated within AMC's Fuel Tracker or any other data set outside of unit analysis. SARM input will provide the data directly from the 100 ARW. The data will have to be manually merged for each mission from these three sources to come up with an inclusive data set that can adequately account for each phase of flight, regardless of which piece is accomplished on a particular mission.

Assumptions/Limitations

Care will have to be taken to ensure that all available variables are considered, and the most realistic model is created from the data. The biggest assumption is that human input errors are negligible. This is a substantial assumption given the number of manual inputs that will go into the final set due to the nonexistence of a usable database, for the purpose of this research, at this time. It will also be difficult to test the model without the addition of another data set or benchmark. In this case, another data set would prove or disprove that the same factors and assumptions represented by this data set hold true in a different scenario. A benchmark, on the other hand, would help show that a new model more accurately represents the varying factors of flight explained through this metric. This is not a major issue, as a final useable regression equation could only be produced through analysis of a much larger data set from across the fleet to remove unit bias and account for location differences (temperature and pressure altitude), one that would only be available after modification of current data collection systems such as the AMC Fuel Tracker. Due to the multitude of factors that affect flight, several variables will be difficult to model to include wind, variability of aircraft, and total distance flown. One of the data pieces, wind, is tracked through Advanced Computer Flight Planning (ACFP), while distance flown is an elusive target. Neither has yet to be pulled into the tracker, but could possibly with further research. To account for winds, only missions that depart and land at the same location will be analyzed. This allows us to assume that wind input will be negligible. Variability of aircraft will also be assumed to be negligible; its effects evening out over a pilot's many missions and somewhat accounted for with the inclusion of aircraft weight. Finally, the initial model will only incorporate KC-135 operations at a single location, but the process would be similar for other aircraft regardless of mission and location after this proof of concept is completed.

Implications

In today's shrinking DoD budget this research is more necessary than ever before. While past efforts have focused on aircraft fuel efficiencies, this research will develop a metric that can be used to change aviation culture, and where to focus energies towards that goal. As individual pilots attempt to improve upon their ratings, incremental returns will increase and multiply across all AMC missions, creating large savings over time. Additionally, this research could be expanded on by AMC/A3F after a more robust AMC Fuel Tracker is put in place that combines SARM and MFOQA data to provide metrics for any aircraft community across the range of the Air Force inventory. Once the multitude of data sets have been combined, a tremendous resource would be available for analysis and research at any governmental level, and the burden of input will be taken off Air Force wings that supplement AMC Fuel Tracker data to get the metrics they desire. Finally, aviators will have another metric that provides useful information of their actual performance in the aircraft.

II. Literature Review

Culture

A basic understanding of culture would show why it is the critical component of change. Schein (2004) describes that, “organizational culture is a set of basic assumptions that a group has invented, discovered or developed in learning to cope with its problems of external adaptation and internal integration, and that work well enough to be considered valid to new members as the correct way to perceive, think and feel with regard to those problems” (Schein E. H., 2004). Using Schein’s breakdown of culture, Pires and Cacedo (2006) further refine their definition:

> Culture exists in levels, The first is the level of artifacts, in which the rituals, symbols, visible organizational structures and processes represent the most important factors to be observed; the second level would be the shared values, where the strategies, goals and philosophies are most important; and, thirdly, the level of underlying basic assumptions, in which beliefs, perceptions, and unconscious and ingrained feelings represent the data to be analyzed (Pires & Macedo, 2006).

There are many explanations of culture ranging from specific element analysis to broad understanding. Some researchers even argue that culture is so poorly understood that it has become a melting pot for concepts, which are difficult to define. For our purposes Herguner & Reeves (2000) provide a solid framework from which to start, “organizational culture generally refers to people having shared beliefs, values and assumptions among themselves within the working environment” (Herguner & Reeves, 2000, p. 46). A further breakdown of culture as a structure shows that sub-cultures permeate, especially within large hierarchical organizations based on factors such as department, professional identity, ethnicity, and gender forming a group value system (Smollan & Sayers, 2009, p. 436). Air Force aviation, in this case those within AMC, easily fall in line with these definitions of culture and sub-culture. From the moment pilot candidates start training they are groomed with the ideas, beliefs, values, and assumptions of all of those who came before them. This is largely because other aviators from within the culture internally train them, so the cycle is repetitive. Jamieson (1990), states that this aspect of culture change, institutionalization within the education, is even more difficult than changing the culture itself (Jamieson, 1990). Finally, as they break off into specific airframes sub-cultures develop in much the same way as the main body was created.

Culture of Fuel Efficiency

The culture of change is a concept that the Department of Defense is striving to achieve as directed in the energy plan. More of the available research literature is spent on gains through large blocks of efficiency gains from aircraft modifications, reduction in flying, regulation modification, and route and mission optimization. A complimentary program with much potential is aggregate improvements through culture change, which at first appears to hold less potential because true gains are hidden by aggregation and variability. Partly because of this, most of the research skips organizational culture change to focus on the two other energy tiers, which are more definable. As large-scale gains become more paced, leadership's attention will shift to the individual, and in this case the culture of Air Force aviators. General Post states, "It's just a matter of changing culture, changing attitudes, and building trust in the system. As you educate people, they will see the benefits of it and become more confident in the tools we provide them" (McAndrews, 2010, p. 19). While it is easy to turn towards the individual, the payoffs become more incremental and spread over a wider timeframe, unpalatable for many in search of a quick fiscal panacea for today's budget. Amory Lovins, chairman of the Rocky Mountain Institute and co-author of *Winning the Oil Endgame*, said, "it could take years to change the culture within the Defense Department, but the payoff would be huge…the emphasis on energy has to flow from doctrine and strategy and end up in organizational structure, training, and reward systems" (Erwin, 2010, p. 32). Some researchers even indicate that cultural change is a fallacy. Instead, they point towards behavioral modifications through tighter personnel control methods in lieu of change in belief and value systems (Ogbonna & Wilkinson, 2003, p. 1152). But even within these counter arguments it is commented that a shorter time span and lower level of employee led to their opinions against conscious cultural change. Additionally, many change initiatives fail because they lack the full scope and understanding of what piece culture change has on any organizational change process (Lofquist, 2011, p. 225). This discussion is definitely not lost upon the AMC FEO, which opened its doors in October 2008 as a new front against the giant issue of fuel consumption within the Air Force (McAndrews, 2010, p. 16). From the beginning, culture change for sustained fuel efficiency gains was a core component of their gamelan (McAndrews, 2010, p. 16). Colonel Trayer of the fuel office understood that educating crews and getting them comfortable with new fuel loads and strategies was imperative to long-term change (McAndrews, 2010, p. 19). The office has produced many exceptional avenues towards reduction of fuel consumption. Additionally, headway has been made towards improving data collection of fuel consumption, a necessary ingredient towards any change measure. The Air Force Audit Agency reported that up until the AMC FEO stood up the AMC Fuel Tracker in July 2009 the Air Force did not have a sufficient method to track and monitor the field's use of aviation gas (McAndrews, 2010, p. 18). The Air Force Science Advisory Board (AFSAB) points out that improved tracking and reporting of Air Force fuel use can garner up to 3 percent in fuel savings (Heseltine, 2008, p. 33). While the structure of the *Air Force Energy Plan* is sound, energy management culture has not been steered to its fullest potential because attitudinal and behavioral norms have not been modified through education and training, and awareness and communication alone as laid out in the energy plan. These two factors, while key, are only a part of what organizational change literature has provided as a road map to accomplish change within a period of time. A necessary component to capture energy goals, and more importantly make them longstanding, is true culture change. This aligns with the objectives of measurement, management, awards, and incentives in the energy plan (Donley, 2010, pp. 13-15).

There appear many recurring themes within the realm of organizational change literature, which combine to form a strategy towards organizational change. An organizational change process requires three main concepts: process, leadership, and management (Conceicao & Altman, 2011, p. 33). Reiman, Johnson, and Cunningham (2011) discuss a model that revolves around strategic decision making, supply chain fuel efficiency, and an organizational culture of fuel efficiency to achieve overall fuel efficiency (Reiman, Johnson, & Cunningham, 2011, p. 75). The end goal of this and any change program is to align personnel resource capabilities, systems, and organizational structure to meet leadership's long-term objectives (Waterhouse & Lewis, 2004, p. 354).

Strategy

To aid AMC/A3F on its path towards cultural change requires a multi-faceted approach. This would be additive to AMC's current programs, and part of a larger program designed with cultural change at its core. Schein (1985) states that multiple levers, both primary and secondary, are required to achieve cultural transformation and overcome barriers to the same. These primary and secondary levers include, "more direct strategies, such as modifying organizational structure and work design, and the latter including more tangential approaches, such as changing appraisal system dimensions, reward strategies, and training and development

(Schein E. , 1985). Park (2002), who consolidated change literature to formulate success factors for Korean business, found that the most critical or often cited factors are the CEO's commitment, culture change in alignment with business strategy, employee participation, managing the anxieties of change, and training and education in conceptual studies, and communication, leadership, culture change in alignment with business strategy, and employee participation in empirical studies (Park, 2002, p. 91). Armenakis, Brown, & Mehta (2011) further broke this into two categories: developing and maintaining the organizational culture and selling an organizational culture change. In the first category they found the most influential factors are leadership, attraction-selection-attrition, socialization, reward systems, decision-making, and organizational learning (Armenakis, Brown, & Mehta, 2011, p. 311). For the second category they found that the change message from leadership needs to touch on five beliefs of the change population: why change, appropriateness of the change, knowledge and skills required for the change, perception of leadership internalizing the change, and the change's impact and benefits to the individual (Armenakis, Brown, & Mehta, 2011, p. 308). As in business process engineering approaches, senior leaders' roles are critical to decide upon strategy through planning, resource allocation, and providing continual motivation to the organization. Additionally, mid-level supervisors have a heavy role to play through establishment of norms and behavior modeling for personnel on a daily basis during the change process (Lyons, Swindler, & Offner, 2009, p. 469).

The missing elements of an overarching change strategy within the Air Force aviation culture to this point come from a review this applicable organizational change literature. While one particular model might not perform well within the context of this particular problem or within the organizational structure of the complex military hierarchy, a compilation of recurring themes applied to programs and strategies, such as what Park employed in 2002, should ensure the necessary ends are met. This same sentiment is echoed in Latham and Locke's (1979) Goal Theory, as they state that the particular methods to employ are driven by the circumstance and employee (Latham & Locke, 1979, p. 73). Through the study of over 20 cases, the themes of continuity of effort, use of resources (time and money), positive attitude, commitment (participation), and promotional methods are routinely found in the models presented above. Compounded with the current AMC/A3F strategy set of education, training, and empowerment, a combined approach will increase overall commitment to fuel efficiency by improving involvement, value relevance (prioritization), and problem identification (Vrontis, Thrassou, & Zin, 2010, p. 25). Any change process would take a lengthy period of time, as Harrison and Carol (1991) indicates that culture evolves through socialization and turnover (Harrison & Carrol, 1991). AMC's internal training model would also further increase the timeline. Routines, sub-cultures, and the status quo, additionally, would increase the timeline as they are all enemies of change. These extending factors offer a rationale for why counter resistance strategies are required alongside positive enforcers. In the absence of a counter strategy, even with better alternatives resistors to change and experience would keep personnel to their tried and true methods (Beck, Bruderl, & Woywode, 2008, p. 414).

Resistance

Resistance to change is a front on the war of cultural change that must be approached with premeditated planning. There are many reasons why people are resistant to change, some of which are, "individual investment in the status quo, lack of motivation for altering behaviors, and simply that the benefits to the organization are not necessarily consonant with the interest of the individuals (Vrontis, Thrassou, & Zin, 2010, p. 24). Eskerod and Skriver (2007) found that at the heart of organizational culture are factors which of itself resist the process of knowledge transfer leading to knowledge silos (Eskerod & Skriver, 2007). Within our context, all rationale is applicable, and reason to scope a counter approach. Vrontis, Thrassou, and Zin (2010) break down resistance as a psychological reaction to estimated personal perceptions of change's outcome on things and processes which are valued, or a person's inability to make an estimation of that value (Vrontis, Thrassou, & Zin, 2010, p. 38). Within the military there are multiple areas in which this concept plays out. It is exceptionally apparent within sub-groups (sub-cultures) of the military. Each sub-group will prioritize activities and resources differently, and how best to utilize them based upon engrained perceptions (Lofquist, 2011, p. 228). Aviators in particular value standardization, procedures, experience, and methodical orientation towards their work. Inertia theory argues that all of these factors, while positive aspects for reproducibility, produce heavy pressures against change functions as they detract from interest protection and the status quo (Kelly & Amburgey, 1991, p. 593). Similarly, the overall size of the military and the aviation sub-culture are resistors to change in and of themselves. "As organizations increase in size, they emphasize predictability, formalized roles, and control systems. Organizational behavior becomes predictable, rigid, and inflexible. Consequently, the probability of change in core features declines with size" (Kelly & Amburgey, 1991, p. 594). Finally, Kotter (2005) asserts that a change reversal can occur, regardless of the length of time that has transpired and the success of the change process if the change objectives are not engrained within the change population's values and beliefs (Kotter, 2005). Combating this resistance cannot be accomplished solely through education and training, which is why a much more robust strategy is required. Deal and Kennedy (1982) would agree with the premise that simply selecting a model and applying it to this problem would be a losing proposition (Deal &

Kennedy, 1982). Instead they advocate for application of processes to combat resistance factors and attain trust within the organization. Latham & Locke (1979) echo that trust is the key, and in its absence personnel will reject proposals (Latham & Locke, 1979, p. 78). Training and skill building are required for the population whereas flexibility and patience are required for leadership to bring the change into their personnel's own reality (Barbara & Las Casas, 2013, p. 9).

Continuous Effort and Resourcing

While resistance to change is a key detractor from change processes, continuous effort is the key enabler. Change cannot occur overnight and must develop over time, the same way current standardized practices, approaches, methods, and techniques have developed in the aviation community. This evolutionary change within the culture and applications of aviation pose a dilemma as they go unnoticed and unannounced, and affect the change process in the same way that positive deliberate change methods are employed (Lofquist, 2011, p. 226). Not only do the youngest of aviators need to learn and apply the desired changes, but also the stalwart instructors who have engrained thoughts about how best to accomplish a particular task. The continuous approach is supremely effective in this type of sustained change generation (Lyons, Jordan, Faas, & Swindler, 2011, p. 219). Even with a continuous approach an organization needs to devote extensive resources towards cultural change. Resources in this instance refer to personnel/leadership time and organization financial backing. In one example, a multinational engineering and manufacturing company afforded 4000 workers 37 days away from their primary roles to learn the necessary changes and skills required for an organizational change (Silvester, Anderson, & Patterson, 1999, p. 4). Just as in resistance to change, complexity of the organization and changes required both increase the resources required to make the change

(Kelly & Amburgey, 1991, p. 595). This is due to the many links between sub-units and ordered effects of changes within those groups. Kotter (2005) shows that early in the timeline both the behavioral and attitudinal changes start to appear as part of the process. Continually over time other signs start to appear such as in the routines of personnel who have integrated the change into their daily lives. Finally, at the end of the evolution the change is fixed within the culture (Kotter, 2005). This evolution or continual process is necessary, and comes directly from leadership. Fullan (1991) exerts that in the absence of continuous effort the change population would resist change efforts in three typical ways such as making only minimal appeasement changes, foregoing changes which they may have had the initial propensity to undertake, and outright opposition or ignorance of changes (Fullan, 1991).

Commitment & Attitude

It should be obvious that to complete an organizational change that ownership of the process, commitment to it, and a proper attitude are required functions. Internalized commitment makes the case for change in a few ways, either through change adoption rewards, adoption due to the need to identify with the organization, or internalization of the change values (Armenakis, Brown, & Mehta, 2011, p. 311). From the top down of an organization it must be apparent that the change is of high value to leadership, or else alternatives would be used to arrive at the same end state due to the strength of sub-cultures (Lofquist, 2011, p. 229). Smollan & Sayers (2009) even go so far as to state that production of commitment and appropriate attitudes among the change population is the most critical task of management. This will make personnel appreciate the goals of the transformation and feel that they are a part of the team (Smollan & Sayers, 2009, p. 438). Personnel need to be a part of the process from both an operational standpoint, and also to understand why the change is necessary from within context. Much like a virus more of the organization will develop affective commitment the longer they are a part of the change and become intrinsically motivated through recognition of the value of the change goal (Smollan & Sayers, 2009, p. 441). Some possible tactics towards ensuring participation from the organization are through leadership modeling of the behavior, education and training, and becoming active in the change process through proposing possible solutions (Armenakis, Brown, & Mehta, 2011, p. 309). Low commitment enforces a hierarchical rule based institution, whereas a high commitment model promotes empowerment and shared values (Ogbonna & Wilkinson, 2003, p. 1153). This shows why simply changing regulation (low commitment) has no chance of changing the culture on its own and solely creates a new baseline. Through goal setting and use of metrics, commitment can be achieved from within the organization. Informal competition as seen in Latham and Locke's (1979) study actually increases commitment and performance while simultaneously decreasing costs (Latham & Locke, 1979, p. 73). Finally, proper attitude is a must, especially from mid-level management and instructors. These are the personnel instruments that will be spreading the change throughout the organization and reducing resistance. Their continual push towards implementation throughout the organization will increase psychological commitment (Vrontis, Thrassou, & Zin, 2010, p. 25). Without showcasing their belief, understanding, and outcomes of the change others will not adopt the changes. The same is true of the inverse attitude, which would counter gains in the same fashion as a positive attitude achieves. Thus, achieving positive attitudes and buy-in early in the process is a requirement of any change strategy (Lofquist, 2011, p. 227).

Promotion Systems and Metrics

Most models reviewed indicate that a promotion or reward system must be put in place to ensure the longevity of a culture change, and for any organizational change for that matter. This is primarily important during the beginning stages of a change process. Bandura (1986) highlights the importance of an early rewards system to ensure compliance with change measures are started out on the right path and are aimed at the organization's goals (Bandura, 1986). Based on Schein's (1984) work fuel efficiency culture change is no different and requires mechanisms to promote, reward, and recognize the individual contributions made towards process goals (Reiman, Johnson, & Cunningham, 2011, p. 77). This not only gives an intrinsic reward for application, but also models appropriate behaviors for others to witness. As the change process continues, so to do the promotional activities. At this point it may be clear to leadership that some personnel are not attitudinally committed to the transformation just as many will be highly motivated to see its completion. The rewards program must take this into account in the form of promotions or dismissals (Odagiu & Piturlea, 2012, p. 2). While at first this may appear to be excessive for the Air Force structure and hierarchy, but understanding that it is a step process mimicking the values already important to the service lend credence to its inclusion. Performance appraisals and feedback sessions would be an obvious place to integrate review of an individual's contribution to the proposed changes as needed. Additionally, to properly motivate personnel through rewards, metrics must be produced that appropriately track the behaviors wishing to be modified. The design of these metrics needs to promote the behavior change. Negative behaviors, which could influence the metric, must also be a known measure to ensure that tracking is appropriate (Reiman, Johnson, & Cunningham, 2011, p. 77). Highlighting these metrics through the rewards and promotion system can take many different forms, limited only by the organization's business rules and structure. Training and development programs should incorporate the metrics as a standard of practice to ensure that all areas of professional development encapsulate the change message (Armenakis, Brown, & Mehta, 2011, p. 311).

As stated by the Air Force Audit Agency, AMC got off to a slow start with data tracking. With the inclusion of the fuel tracker a tool is available to produce metrics valuable to a culture change. AMC/A3F aims to increase confidence in fuel planning through use of the fuel tracker and a metrics-based approach. The end goal would be a reduction in unwarranted fuel additions to sorties (McAndrews, 2010, p. 19). Inclusion into a change strategy would take that goal even further and change how crews fly their selected profiles, keeping fuel savings as a priority not only on the ground, but also in the air. This idea is exactly what Heseltine (2008) proposed as the perfection step in his lean fuel process. By analyzing mission completion data obtained through the fuel tracker one can determine how efficiently the mission was flown (Heseltine, 2008, p. 30). Currently the data is available to accomplish just that, but it has not been put into use through a specific fleet-wide program, or a singular database.

Commercial Applications

Just as the military can decipher understanding from civilian literature, so to can they derive ideas employed through their civilian counterparts. The military has historically borrowed many ideas from the civilian sector such as mission index flying (MIF). “MIF uses airborne solution software in the cockpit, allowing aircrews to fly at optimal altitudes and airspeeds for their current flight conditions, thereby minimizing flight time and fuel burn” (Joyner, 2011, p. 16). The FEO office believes, once MIF becomes mainstream within the community, that it could reduce fuel consumption throughout AMC by one to two percent (Joyner, 2011, p. 16). But what motivates members to utilize MIF in the cockpit on a daily basis? While the commercial air sector has always been able to reduce fuel consumption by constantly upgrading its planes and engines, they, like the military, have sought new ways to press fuel savings (Joyner, 2011, p. 16). Through measures targeting aircraft and route optimization, among other wholesale approaches, the U.S. airline industry reduced its fuel consumption by roughly 5 percent from 2000 through 2006 (Joyner, 2011, p. 14). Unfortunately, not even these large improvements can offset the rising cost of fuel. For every one cent per gallon of oil increase it costs the industry $160M (Heseltine, 2008, p. 32). To combat these rising trends commercial carriers have turned to other savings measures through their aviators and dispatchers, the two groups responsible for the fuel allocation of each aircraft. Through multiple site visits the prevailing theme of commercial air carriers is that successful fuel savings is a cultural issue (Heseltine, 2008, p. 37). Furthermore, two central strategies are forming that many companies are instituting to reap the benefits and maintain profitability within the civilian air market. Mr. John Dietrich, Atlas Air Executive Vice President and Chief Operating Officer, commented that Atlas uses a profit sharing strategy to directly tie the success of the company to the employee (Dietrich, 2014). Within this first strategy an aviator would financially benefit from the consolidating savings of all pilots utilizing best practices to reduce fuel burn. Unfortunately for the military, direct financial compensation is probably an insurmountable hurdle. Luckily, a second strategy has emerged from Federal Express (FedEx). FedEx employs both information technology systems and feedback to its pilots and dispatchers within its *Fuel Sense* program to reduce the fuel burned on missions. The employee portion of *Fuel Sense* involves providing pilots and dispatchers with historical averages and percentages of contingency fuel the data reflects is statistically needed for missions. Those practitioners can then use that information to tighten tolerances of their fuel planning given real time mission constraints and field variables. Finally, the end goal is to provide those same personnel feedback on their next shift showing how they performed statistically compared to the mean of the sample group (Lusk, 2014). This strategy bears striking resemblance to Latham and Locke's (1979) technique of Goal Theory previously discussed (Latham & Locke, 1979). Through methods similar to these, American Airlines is reducing 30 minutes flying time on average, saving 30 million gallons and $50M in annual costs (Heseltine, 2008, p. 34). Mr. Dave Lusk, Senior Manager of Global Operations Control at FedEx, stated that central to this plan is not to overreact to increased diverts and missed targets (Lusk, 2014). Punitive measures in relation to these outliers would cause a pullback from commitment to change measures. Again, harkening back to Goal Theory and commitment discussions previously offered.

Throughout any fuel improvement initiative both the government and aviators alike require that safety be maintained to ensure that the search for dollar savings does not drive jets into the ground. This is not as imperative in route optimization, but aircraft improvements and aviator modeling require oversight to ensure that safety is held in high regard. The FAA requires that improvements to existing aircraft are approved, which ensures a safeguard, but personnel oversight is not as simple. Fortunately, "the International Air Transportation Association (IATA) asserts that accurate and efficient fuel management will actually improve safety because it requires additional attention, accuracy, increased situational awareness, and can reduce overall fuel budget by 5 percent" (Heseltine, 2008, p. 32). With this in mind assurances on the appropriateness of fuel measures is found, but careful analysis of their implications should always be at the forefront of any change measure.

III. Methodology

Data Sources & Format

The data for this research came from three key areas: the AMC Fuel Tracker, 351st Air Refueling Squadron (ARS) post-mission data reports, and 351 ARS SARM outputs. All missions were collected from the AMC Fuel Tracker for the 100 ARW during the period October-December 2013. Post mission reports were also collected for these same missions directly from the subject unit at RAF Mildenhall, United Kingdom. Collection of both sources allowed a check of the accuracy of all missions in the electronic database, and to correct for missing or inaccurate data. This produced a much cleaner set of data without gaps. Also, the data sheets provided additional variables that are not present within the AMC Fuel Tracker including: on-station time, off-station time, end of air refueling time (EAR), aircraft gross weight, and number of contacts. Missions that did not land at the same point as departure were removed from the data set as wind was not accounted for in the variables. Additionally, any mission that presented a large gap in data for an unexplained reason was removed as an outlier. Then, the 351 ARS SARM provided the number of landings each aircraft performed through a review of historical record form 781s. The number of visual, precision, and non-precision approaches would have been better variables to determine the exact number of patterns flown in the higher fuel consumption regime of lower altitude, but unfortunately SARM data is compiled and zeroized at the end of every six months. This made collection of this data impossible. Although, the number of landings is a suitable replacement, as the assumption is that few or no aircraft made a go-around in this time period. This is a good assumption as most aircraft training of this type is reserved for the simulator. In the KC-135, and especially in a difficult crosswind landing field such as RAF Mildenhall, the landing phase is more valuable for teaching landings than go-arounds. Sequestration was also a factor adding to the solvency of the assumption as it has pushed even more training into the simulator. The data was then prepared so that every phase of the flight could be analyzed for inclusion in the regression.

The number of landings was multiplied by a time and speed element to give an estimation of landing distance and time flown. The time per approach was estimated at 15 minutes as it could not be determined if the pattern was a visual or radar approach (times between 10-20 minutes were analyzed with 15 being the best fit). The speed used to arrive at landing distance flown was 180 knots, a typical speed flown on visual and radar patterns. The type of receiver was used to determine the speed flown during AR (pulled from flight regulations). This rate was multiplied by the time the tanker was with the receiver as given by post-mission reports to arrive at receiver distance. Speed flown while loitering, or waiting, for the receiver was estimated by endurance speed at the aircraft's weight midway through the mission (beginning weight minus half the sum of fuel burned and fuel offloaded). That rate (speed) was also multiplied by the time the receiver was on-station without a receiver (off-station time minus on-station time minus the sum of AR contact time minus EAR time) to achieve loiter distance. Both refueling distance and loiter distance were combined to form AR distance. Landing distance was added to AR distance to become total distance. These factors were deemed initially important as they are where a pilot exercises judgment in the employment of thrust and speed to complete a mission. To capture the combination of the higher burn rate periods refueling time and landing time were added to form high burn rate time. The next major sector affecting a pilot's fuel burn is weight. The actual aircraft weight was determined through analysis of each aircraft's form F, maintained by the 100th Maintenance Group. It was found that aircraft weight in this data set varies plus or minus

2,474 pounds from 122,665 pounds, so it was determined to be important. Note: One aircraft's weight was unavailable due to being retired, so an average weight of the remaining 15 aircraft was used in its place. This was calculated to be 121,937 pounds with a standard deviation of 1,219 pounds. Takeoff weight was calculated by adding aircraft gross weight with fuel and cargo weight. In most cases, KC-135 missions carry zero pounds of cargo which became a factor later. Fuel offloaded was utilized in two variables. The first was directly as fuel offloaded. The second was a mid-mission fuel offload weight designed to mimic the same variable AMC produced for their models. To arrive at this variable half of the fuel offloaded is added to the cargo weight. Since no receiver air refueling is conducted at RAF Mildenhall by organic pilots, fuel on-loaded was removed from the equation. A small application of fuel usage, although part of a description of fuel burned, auxiliary power unit fuel burn time was calculated by adding the pre- and post-mission use time. From there a rate was calculated by multiplying by 250 pounds per hour, which constitutes normal operation. Note: 43 of the 165 missions did not have a pre- or post- flight APU burn, so an average of all missions was used. The resultant figure was .3 and .0 hours respectively with a standard deviation of .2 and .1 hours. Finally, specific aircraft factors were attempted to be controlled through use of a dummy variable for each of the 16 aircraft flown during missions. In all situations actual figures were used instead of planning figures as fuel consumed on a mission is the dependent variable. Using planning figures would derive a completely different outcome. Every attempt was made to isolate specific events in the aircraft that add to the description of fuel burned. At the completion of this preparation there were 16 independent variables available for analysis against the dependent variable, fuel burned.

Table 1: Listing of variables

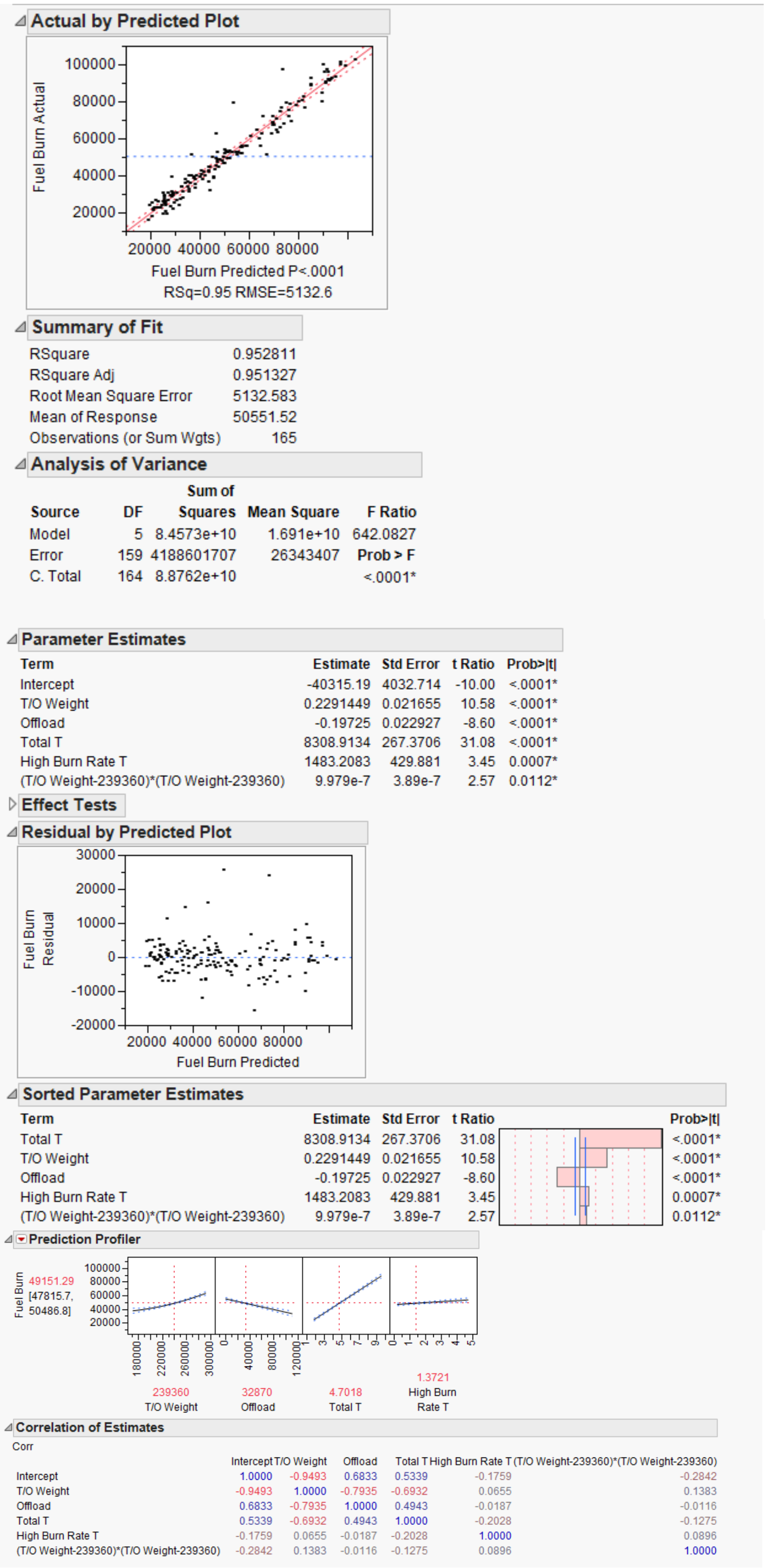
#	Variable	Full Name	Units	Description
1	T/O Weight	Takeoff Weight	Lbs	Aircraft gross weight plus takeoff fuel plus cargo
2	Offload	Fuel Offloaded	Lbs	Total fuel offloaded
3	Mid M Offload	Mid Mission Offload	Lbs	Half fuel offload plus cargo weight
4	Receiver T	Receiver Time	Hrs	End of air refueling time minus air refueling contact time
5	Loiter T	Loiter Time	Hrs	Off-station time minus on-station time minus Receiver Time
6	Landing T	Landing Time	Hrs	Number of approaches times 15 minutes
7	High Burn Rate T	High Burn Rate Time	Hrs	Receiver Time plus Landing Tme
8	Total T	Total Time	Hrs	Receiver Time plus Loiter Time plus Landing Time
9	Rec D	Receiver Distance	Miles	Receiver Time times air refueling speed (receiver dependent)
10	Loiter D	Loiter Distance	Miles	Loiter Time times endurance speed (assumed at Mid Mission Weight)
11	Apch D	Approach Distance	Miles	Landing Time times 180 (assumed speed)
12	AR D	Air Refueling Distance	Miles	Receiver Distance plus Loiter Distance
13	Total D	Total Distance	Miles	Air Refueling Distance plus Approach Distance
14	Dummy Var Tail	Tail Number Identification	#	Number representing a tail number
15	APU T	Auxillary Power Unit Time	Hrs	Pre-flight APU time plus Post-flight APU time
16	APU Burn	Auxillary Power Unit Fuel Burn	Lbs	APU Time times 250 lbs/hr (normal burn rate)
Dependent Variable	Fuel Burn	Fuel Burned	Lbs	Takeoff Fuel minus Landing Fuel minus Offload

Data Analysis and Model Build

The data was analyzed using Microsoft Excel and JMP10. With sixteen independent variables a large database is required by statistical process to achieve appropriate results. Standard measure for the field is somewhere between a factor of 10-20 times the number of independent variables for the data set (StatSoft, 2000). While the data set used is on the left side of this spread, it is still large enough to produce an appropriate regression. Excel produced adequate results analyzing the independent variables individually and within a stepwise regression (forwards and backwards). Initial results easily achieved an R squared of over 90%, which displays very good explanatory power. But, multiple variables could be added or subtracted with minimal change to the R squared, so optimization was difficult. Furthermore, interaction of terms was near impossible with 16 independent variables.

To delve deeper into interaction terms JMP10 was employed for its ease of analysis. First, it validated all the results seen in Excel. Next, least squares models and stepwise regressions were produced using factorials to the second degree (multiplicative interaction between variables) and response surface (independent variables squared). The results produced were only slightly superior to that achieved without interaction terms. A 1-2% increase in R squared was realized with multiple equations of roughly the same magnitude. Additionally, with the inclusion of interaction terms associated base terms were retained in the model to maintain model hierarchy. Fortunately, all regression terms produced p-values that were well within confidence intervals (below .00007).

A few final methods were utilized to attempt a removal of additional noise in the regression. The residuals of the regression of takeoff weight and total time were further regressed to see if their removal would allow additional variables to surface with more explanatory power. Additionally, all variables were regressed after being normalized into a z-score to ensure that the power of their units was not affecting the outcome. In both cases a better regression was not realized. While the independent variable dummy variable tail proved to be significant, it was removed from the resultant equation. The variable is a nominal number used as a substitute for tail number. The goal of its inclusion was to determine if a specific aircraft varied the fuel burn, but the resultant perturbations in the equation would have significantly increased the complexity of the equation without a substantial gain in explanatory power. Also, multicollinearity was checked with all variables to ensure that highly correlated factors (greater than .8) were removed from the equation. Many of the variables within the variable set were correlated (intentionally) to determine which would work best. This is especially true between like variables of distance and time, which are only varied by a rate term. Variables also showing correlation were: total distance, air refueling distance, receiver distance, receiver time, and high burn rate time. The resultant analysis is displayed in Figure 2.



Actual by Predicted Plot

Summary of Fit

RSquare	0.952811
RSquare Adj	0.951327
Root Mean Square Error	5132.583
Mean of Response	50551.52
Observations (or Sum Wgts)	165

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	5	8.4573e+10	1.691e+10	642.0827
Error	159	4188601707	26343407	Prob > F
C. Total	164	8.8762e+10		<.0001*

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	-40315.19	4032.714	-10.00	<.0001*
T/O Weight	0.2291449	0.021655	10.58	<.0001*
Offload	-0.19725	0.022927	-8.60	<.0001*
Total T	8308.9134	267.3706	31.08	<.0001*
High Burn Rate T	1483.2083	429.881	3.45	0.0007*
(T/O Weight-239360)*(T/O Weight-239360)	9.979e-7	3.89e-7	2.57	0.0112*

Effect Tests

Residual by Predicted Plot

Sorted Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Total T	8308.9134	267.3706	31.08	<.0001*
T/O Weight	0.2291449	0.021655	10.58	<.0001*
Offload	-0.19725	0.022927	-8.60	<.0001*
High Burn Rate T	1483.2083	429.881	3.45	0.0007*
(T/O Weight-239360)*(T/O Weight-239360)	9.979e-7	3.89e-7	2.57	0.0112*

Prediction Profiler

Correlation of Estimates

Corr

	Intercept	T/O Weight	Offload	Total T	High Burn Rate T	(T/O Weight-239360)*(T/O Weight-239360)
Intercept	1.0000	-0.9493	0.6833	0.5339	-0.1759	-0.2842
T/O Weight	-0.9493	1.0000	-0.7935	-0.6932	0.0655	0.1383
Offload	0.6833	-0.7935	1.0000	0.4943	-0.0187	-0.0116
Total T	0.5339	-0.6932	0.4943	1.0000	-0.2028	-0.1275
High Burn Rate T	-0.1759	0.0655	-0.0187	-0.2028	1.0000	0.0896
(T/O Weight-239360)*(T/O Weight-239360)	-0.2842	0.1383	-0.0116	-0.1275	0.0896	1.0000

Figure 2: Minimum AIC Model Using JMP10

After the model was built it was checked for factors to ensure that it conforms to statistical standards and appropriately represents the data set. Linearity, randomness of sampling, normality of error, and equal spread of error variance must all be satisfied to ensure that the model is appropriate. First, the data can be assumed to be random as the data was taken from a three month period of time in which mission type (training or operational mission) would be normally distributed. Three months represents half of the overall training period, so the time of year was not overly important. As well, all missions have been accounted for, both those input into the AMC Fuel Tracker and those flown by the unit and not input into GDSS2. This improves upon randomness extremely well as these missions are part of what the unit performs on a day-to-day basis, but are not accounted for in overall mission tracking due to the type of operation. The fact that data is pulled from one unit is of little consequence as it is the disparity in mission types that is of essence. Finally, the KC-135 by nature blurs the line between training and operational mission, as both are performed on every mission, satisfying the requirement of randomness. Figure 3 displays the factor of linearity. Actual fuel burn is graphed against the regression's predicted fuel burn. The resultant data line should conform to a very straight line without gross outliers, providing a sound linear model. Figure 4 displays the normality of error. In this graph the residuals (actual fuel burn minus regressed predicted fuel burn) share a normal distribution with minimal skewedness. From the data set provided we can see a strong normal distribution with no trailing tendency left or right, and centered on zero. Finally, 5 displays the equal spread of error variance. This is a graph of the residual fuel burn versus the predicted values of fuel burn. To show equal variance the chart should be centered on zero with no visible pattern displayed by the data. In this case the data shows a very normal variance

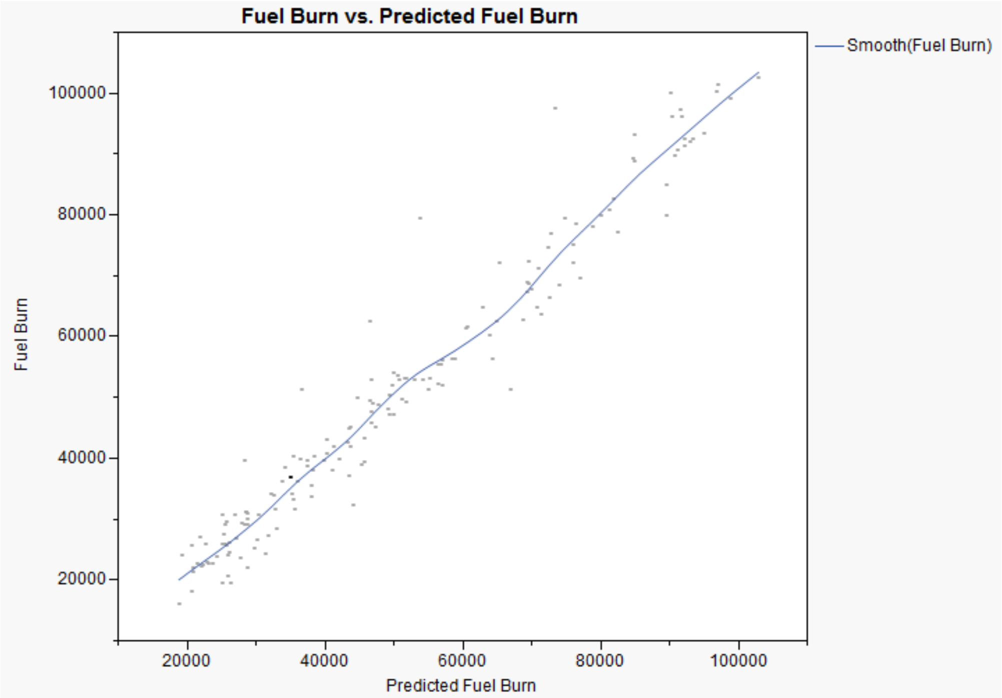


Figure 3: Linearity of the Data Using JMP10

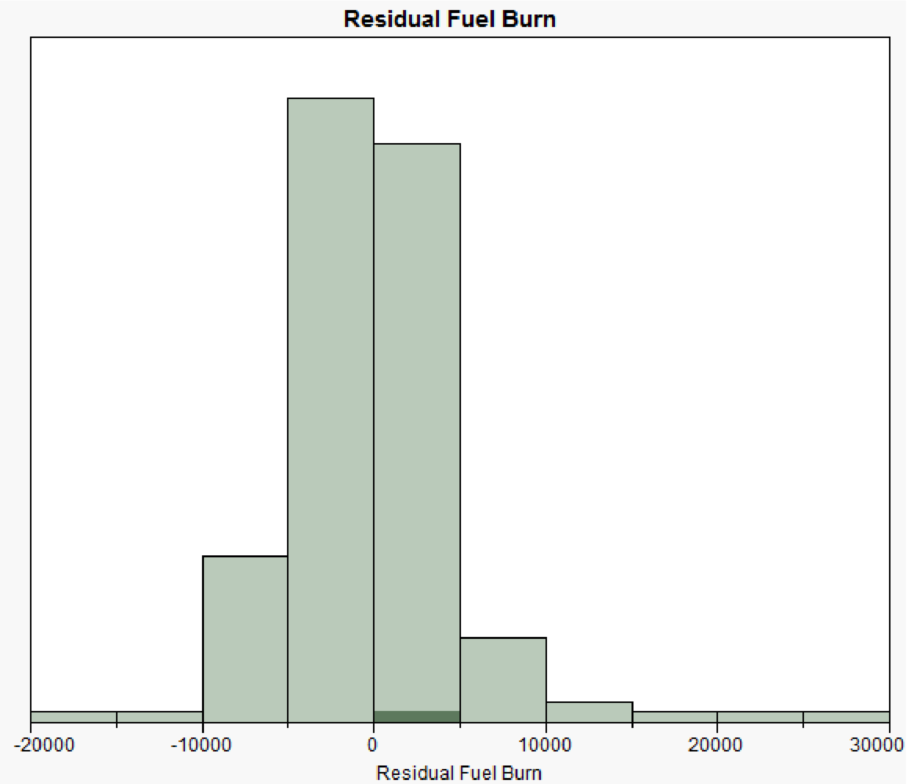


Figure 4: Normality of Error Graph Using JMP10

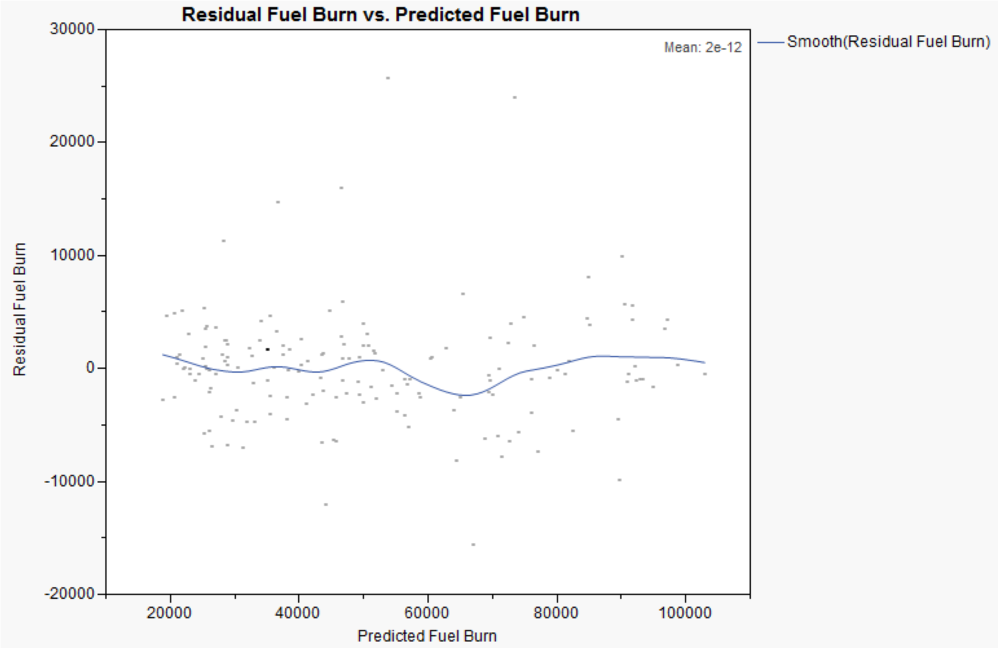
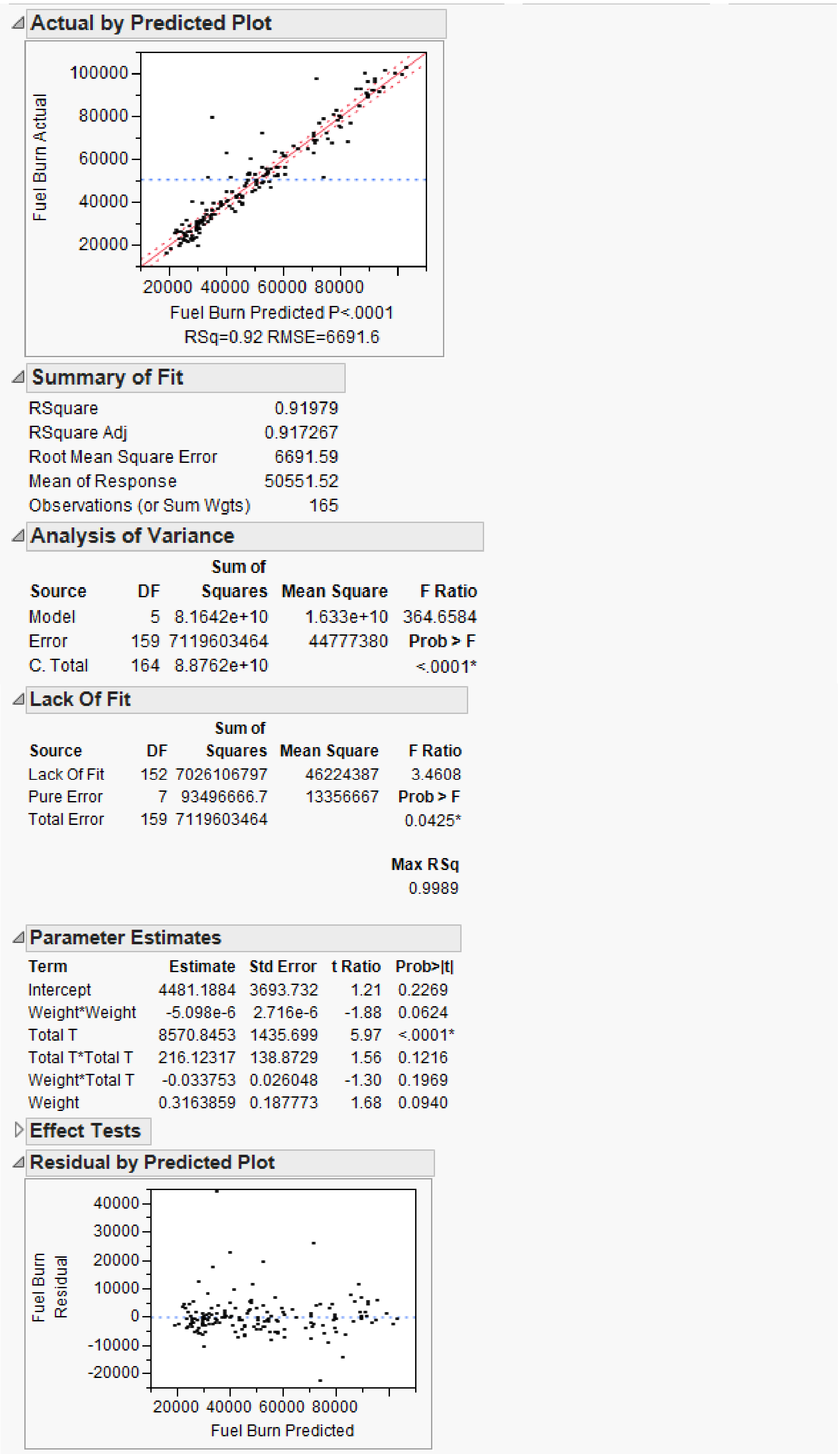


Figure 5: Equal Spread of Error Variance Plot Using JMP10

around zero. With all four of these factors satisfied we can be confident that the resultant equation produced appropriately displays the data set.

With production of the regression complete, a method to benchmark the results was researched. AMC produces a periodic regression on their data to analyze discrete mission fuel usage, but with different regression intent. That model is the best comparison available and was utilized. The model was analyzed within JMP10 using the same methods as above. The results in Figure 6 show similar conclusions that were witnessed prior, and shared an R squared value above 90%. AMC's model uses five factors (two discrete variables and three interaction terms) to produce its explanatory power: mid-mission weight, total time, mid-mission weight squared, total time squared, and mid-mission weight times total time. AMC's weight factor is produced by taking half of both fuel on-loaded and off-loaded and adding the sum to cargo weight.



Actual by Predicted Plot

Summary of Fit

RSquare	0.91979
RSquare Adj	0.917267
Root Mean Square Error	6691.59
Mean of Response	50551.52
Observations (or Sum Wgts)	165

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	5	8.1642e+10	1.633e+10	364.6584
Error	159	7119603464	44777380	Prob > F
C. Total	164	8.8762e+10		<.0001*

Lack Of Fit

Source	DF	Sum of Squares	Mean Square	F Ratio
Lack Of Fit	152	7026106797	46224387	3.4608
Pure Error	7	93496666.7	13356667	Prob > F
Total Error	159	7119603464		0.0425*
				Max RSq
				0.9989

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	4481.1884	3693.732	1.21	0.2269
Weight*Weight	-5.098e-6	2.716e-6	-1.88	0.0624
Total T	8570.8453	1435.699	5.97	<.0001*
Total T*Total T	216.12317	138.8729	1.56	0.1216
Weight*Total T	-0.033753	0.026048	-1.30	0.1969
Weight	0.3163859	0.187773	1.68	0.0940

Effect Tests

Residual by Predicted Plot

Figure 6: Standard Least Squares AMC Model Using JMP10

This may seem confusing in our context, but the AMC model was built to display data across an array of aircraft.

Finally, both regressions were normalized to produce a pilot's rating score that was centered around 100. The genesis for this conversion came from review of the NFL's passer rating. By normalizing the residuals, a number was produced that can be understood as a quantitative scale familiar to all without statistical training. First, the residuals were sorted numerically. In this case, positive residuals were poor performers and negative residuals were above average. Once the residuals were sorted a multiplication factor, X (Equation 1), was utilized to normalize the positive or negative terms to a 0-50 scale. The largest of either the positive or negative residuals was used to create the factor. The scale chosen was solely to get the rating scale to a familiar comparison to the NFL's. Any residual of zero would garner an average pilot efficiency score. The final step in completing the equation was then to subtract the product of the multiplication factor and the residual in question from 100 (Equation 2).

Equation 1: Determining the Multiplication Factor X

$$Largest\ Residual\ Term\ in\ the\ Data\ Set\ (Absolute\ Value) * X = 50 \tag{1}$$

Equation 2: Pilot's Mission Fuel Efficiency Rating

$$100 - (Residual * Multiplication\ Factor) = Pilot's\ Mission\ Efficiency\ Rating \tag{2}$$

Revisit Problem, Questions, and Scope

The main thrust of the research problem is to change the culture of fuel efficiency. The data used to produce the regression above shows large explanatory power with an R squared of 95%. It does not use every variable encountered on a discrete mission, but it does remove enough noise to provide a solid prediction of how fuel is burned on a discrete mission. This is critical to the research as the units of fuel variation encountered may be extremely small comparatively. Additionally, strong explanatory power will most likely be required to ensure aviators that their mission and flight performance is being appropriately analyzed. In this light, the use of the metric can produce the needed impetus for aviators to advance fuel efficiency in their pre-flight planning and during mission execution. A review of the research questions breaks down the results to this point:

- How can we change military aviation culture in regards to fuel efficiency?

Through analysis of the change literature, the themes of continuity of effort, use of resources, positive attitude, individual commitment, and promotional methods are required in a complimentary program along with AMC's current methods of education, training, and empowerment. Use of the suggested regression and follow-on rating equation through goal setting and internal promotion can achieve the required results. The outcome seen should increase involvement and prioritization through identification of the problem, the situation required from our initial hypothesis.

- What variables need to be included in a pilot's fuel efficiency rating?

From the analysis presented five specific independent variables rise to the surface: takeoff weight, fuel offloaded, total flight time, high burn rate time, and takeoff weight squared. These five terms have been determined to provide the best explanatory power without over complication of the regression equation.

- Should a fuel efficiency metric be used as positive reinforcement?

Since the suggested fuel efficiency metric provided does not contain complete explanatory power, it would be irresponsible to utilize the metric in any manner other than for positive enforcement or general reference. This is not a detractor of the research as the end goal is improvement of fuel efficiency through culture change, and not a standalone performance indicator. This seems tempting for leaders, but using the metric as such would destroy its ability to be used for culture change. Further research could add to the tolerances of the regression, and allow additional avenues for the product. But, current DoD policies do not allow analysis of MFOQA data for action against individual aviators due to safety implications, and this data is very similar in nature (Chu & Krieg, 2005). Even with further refinement of the regression, the second order effects of chasing indicators to improve a pilot's score could jeopardize safety. The same care should be employed in any analysis of this data to ensure that the field will not modify behavior to the detriment of safety. Use of the metric for the designed purpose of morale and knowledge, though, can enhance safety by promoting thorough and dedicated mission and performance study. Additionally, the National Football League (NFL) uses a similar statistic to rate its passers. This was partially an impetus for this research. On NFL.com the website quotes, "it is important to remember that the system is used to rate pass-ers, not quarterbacks. Statistics do not reflect leadership, play-calling, and other intangible factors that go into making a successful professional quarterback" (NFL Quaterback Rating Formula, 2014). The same is true for aviators analyzed with this metric. It does not account for all factors experienced in flight including judgment, aircraft problems, receiver issues and changes, air traffic control, delays, etc. These measures are more than enough to make the case that this metric, while an excellent source of information, should only be used for positive enforcement within the unit.

- Is there a need for a more robust AMC Fuel Tracker?

The addition of the AMC Fuel Tracker has been a boost to the command as a bed of data for analysis and trend tracking. Inclusion of a few additional data points would allow for the suggested regression to be performed automatically and at little cost. The additional data utilized in this research comprised only six additional variables. Of those, only four would be required for the regression. While a balance must be taken on reduction of unnecessary time requirements for the field, the benefits should far outweigh the minimal costs. Additionally, some wings require crews to complete additional paperwork above and beyond the fuel tracker so that internal metrics can be produced. It is possible some of this is stovepipe actions due to lack of knowledge of the AMC Fuel Tracker and its applications. Regardless, to input the data into the AMC Fuel Tracker most crews maintain a paper copy during flight to ensure they have all data necessary to enter into the database when the mission is complete. Inclusion of a few additional data points could reduce command wide reproduction of data and metrics, which would be a welcome improvement. Cross-talk of programs used within aviation such as ARMS and MFOQA would be beneficial to reduce the manual workload required as well. This method has already been employed within the AMC Fuel Tracker to pull data from GDSS2 and ACFP.

Specific techniques and dollar savings are not discussed within the research. Both factors are adequately evaluated within other research and the field in question. There is much gain in specific techniques, such as early flap and gear extension, which can cost up to 100 pounds per minute, and fuel flow increases approximately 50 percent when configured. (Heseltine, 2008, p. 33). While both are critically important, they are an input to the research and not the output. How a specific pilot modifies his flying to achieve fuel gains is not as important in this research as the numerical summation of gains (or losses). In the past much research has been presented that identifies savings from aircraft modification and mission modification (route structure). Additionally, regulations have changed restricting pilots on fuel usage and giving them supplementary programs and processes to save fuel (MIF). But, there is little to no research found that provides aviators with a motivation to use these new methods, or furthermore to perfect their art within the realm of fuel efficiency. Armed with a consolidated plan including the metric provided in this research, AMC has a new avenue to achieve extensive savings.

IV. Analysis and Results

Run Model

From JMP10 and the selected data we return the following regression expressions and equations:

Equation 3: Predicted Fuel Burn Regression

$$(0.2291449 * Takeoff\ Weight) - (0.19725 * Offload) + (8308.9134 * \ Total\ Time) + (1483.2083 * High\ Burn\ Rate\ Time) + (9.97e^{-7})(Takeoff\ Weight - 239360)^2 = Predicted\ Fuel\ Burn \tag{3}$$

Equation 4: Fuel Burned Residual

$$Actual\ Fuel\ Burned - Predicted\ Fuel\ Burn = Fuel\ Burned\ Residual \tag{4}$$

Equation 5: Pilot's Mission Fuel Efficiency Rating

$$100 - (Fuel\ Burned\ Residual * .00195) = Pilot's\ Mission\ Fuel\ Efficiency\ Rating \tag{5}$$

Equation 6: Pilot's Average Fuel Efficiency Rating

$$\frac{\sum Pilot's\ Mission\ Fuel\ Efficiency\ Ratings}{Number\ of\ Missions} = Pilot's\ Avg\ Fuel\ Efficiency\ Rating \tag{6}$$

Equation 7: Unit's Average Fuel Efficiency Rating

$$\frac{\sum Pilot's\ Avg\ Fuel\ Efficiency\ Rating}{Number\ of\ Pilot's\ Rated} = Unit's\ Avg\ Fuel\ Efficiency\ Rating \tag{7}$$

Initial Results Assessment and Validation

Through the use of sensitivity analysis we can see that all of the factors within the equation make sense in terms of effecting fuel burn. By themselves, takeoff weight, total time, and high burn rate time increase the predicted fuel burn. This follows a normal thought process as the first two are basic measures of fuel burn. The third term is also a traditional fuel increase as it combines approach (landing) and air refueling time. From our earlier analysis, approach time is simply the number of approaches multiplied by a time factor, in this case 15 minutes. Both of these functions use (on average) more fuel than standard cruise. The final single factor, fuel offload, displays odd at first that it would decrease the overall fuel burn predicted with an associated factor increase. But, a simple review of the terms leads to understanding. Since this term is increasing independently of a flight time change (total time remains constant) the aircraft would become lighter quicker with a larger offload. Lighter aircraft burn less fuel, leading back to the original proposition of an increase in takeoff weight. But, this factor is small compared to an increase of time. A one unit increase in total time is equal to an increase of over 42,000 pounds of offload (absolute value). The unit providing the data performs many training missions with a variety of receivers both foreign and domestic. To reduce the overall mission cost, fuel is not always passed from the tanker to the receiver. But, the mission still maintains all the appropriate variables. Because of this there is little to no difference between a training mission and an operational mission (which is why the goal is a mission type normalizing equation).

In the equation there is only one interaction term, takeoff time squared. This factor does not affect the equation in the same order as the other four variables. The rationale is that the term is an equalizing factor. Since it is a squared term that is first structured through subtraction, the resultant interaction term varies exponentially from zero at the term that was subtracted. This puts an additional fuel price on heavy aircraft and slightly rounds out the curve for lighter aircraft. AFI 11-2KC-135V3 states that every pound of excess fuel carried results in an increased fuel burn rate of 3 percent per hour in the KC-135 (Heseltine, 2008, p. 34). So in regards to the equation, once an aircraft exceeds 239,360 pounds, the interaction term adds an additional exponential fuel amount to the predicted fuel burn to the increase experienced by takeoff weight independently. On the minus side of 239,360 pounds the equation has determined that the reduction in weight is not linear, and has reduced the static effect of takeoff weight decreases with the same interaction term. Since the term is squared, it is always a positive addition to the regression equation. So, reducing the weight of an aircraft (takeoff weight) would cause an overall reduction through the weight factor, but a slight resultant increase through the interaction term.

To properly benchmark the fuel metric, an additional regression was created using AMC's terms. Within AMC's model, six separate regressions are used (with the same five variables) based on the type of mission producing R squared values ranging from .94 to .98 with their data set. The regression equation produced from the data set in this research produces an R squared of .92, which makes sense given the compilation of all mission types. The regression was then normalized using the same procedure to create a pilot efficiency score. The resultant twin sets of data were then analyzed using Excel. Table 2 shows the descriptive statistics prior to score normalization. Three different sets were broken out to see if there were any trends within either set. Overall scores (complete data set), instructor pilot (IP) scores, and aircraft commander (AC) scores are displayed. IPs tend to perform more training in the higher fuel consumption regime of the lower altitudes, because they are qualified to do the training. So, we would expect to see a wider range in their residuals without a normalizing factor such as high burn rate time. The data can support this assumption as there is a shift in the minimum and maximum scores experienced by ACs under the AMC model, and not as much in the research model. The AMC model produces a higher standard deviation, but given that the units discussed are pounds of fuel this is

Table 2: Regression Equation Statistics

Descriptive Statistics	*Research Model*		*AMC Model*	
Overall n=165	Standard Deviation	5054	Standard Deviation	6589
	Sample Variance	25540254	Sample Variance	43412216
	Range	41333	Range	66920
	Minimum	-15674	Minimum	-22641
	Maximum	25658	Maximum	44279
	Kurtosis	7	Kurtosis	15
	Skewness	1	Skewness	2
IP Only n=113	Standard Deviation	4960	Standard Deviation	6934
	Sample Variance	24606329	Sample Variance	48084097
	Kurtosis	8	Kurtosis	16
	Skewness	2	Skewness	3
	Range	41333	Range	66920
	Minimum	-15674	Minimum	-22641
	Maximum	25658	Maximum	44279
AC Only n=53	Standard Deviation	5251	Standard Deviation	5819
	Sample Variance	27573714	Sample Variance	33860998
	Kurtosis	7	Kurtosis	8
	Skewness	1	Skewness	2
	Range	36027	Range	32367
	Minimum	-12110	Minimum	-6342
	Maximum	23917	Maximum	26025

not extreme and caused mainly by lower R squared. The model produced through this research also carries skewedness and kurtosis that are slightly more normal (0 and 3 respectfully) than the AMC model. Overall, no major differences can be taken from the data.

After the data sets were normalized into pilot efficiency scores, the ten pilots with the most missions flown were consolidated in Table 3. In this case the two data sets are even tighter, with score differences (model average – AMC model average) approaching zero as mission number increases. Now the research model standard deviation is slightly higher than that of the AMC model. In this case, no inference can be made about crew position as there are not enough data points. Finally, multiple tables were created in Excel to match pilot scores against varying

Table 3: Individual Pilot Breakout

Name	Crew Position	Missions	Model Average	AMC Model Averages	Difference	Model Standard Deviation	AMC Standard Deviation
Pilot A	IP	6	99	99	-1	9	7
Pilot B	AC	5	96	100	-4	4	3
Pilot C	IP	8	98	95	2	14	11
Pilot D	IP	11	100	100	0	4	2
Pilot E	IP	6	101	101	0	8	5
Pilot F	IP	6	101	100	1	2	3
Pilot G	AC	6	100	102	-2	10	4
Pilot H	IP	7	99	102	-3	6	5
Pilot I	IP	9	99	99	0	8	2
Pilot J	AC	5	94	93	1	5	9

variables encountered in the data. None of these variables have been modified like high burn rate time so that the interaction of the regression with the raw data could be witnessed. Figure 7 through 11 each show a scatter plot of pilot efficiency scores against the factors of takeoff weight, total flight time, air refueling time, fuel burned, and number of landings. In each of these situations we would expect to see a zero sloped trend with a y-intercept of 100. This would indicate that the data set has a normal distribution, and the equation appropriately states the data with a mean of 100 (an average efficiency score). In most of the cases we find exactly that, zero (or close to zero) slope. In two of the cases the AMC model produces a negative slope, indicating that it is weighted or does not fully explain the factor within the efficiency scores (which are derived from the residuals). These factors are takeoff weight and air refueling time. Since there is no factor within the AMC model that compartmentalizes air refueling, this is not complicated. The change is also very small with a one point reduction in efficiency with every extra hour of air refueling. As for takeoff weight, this is probably attributable to the interaction of the variables employed within the model and the data set used in the research. Since many

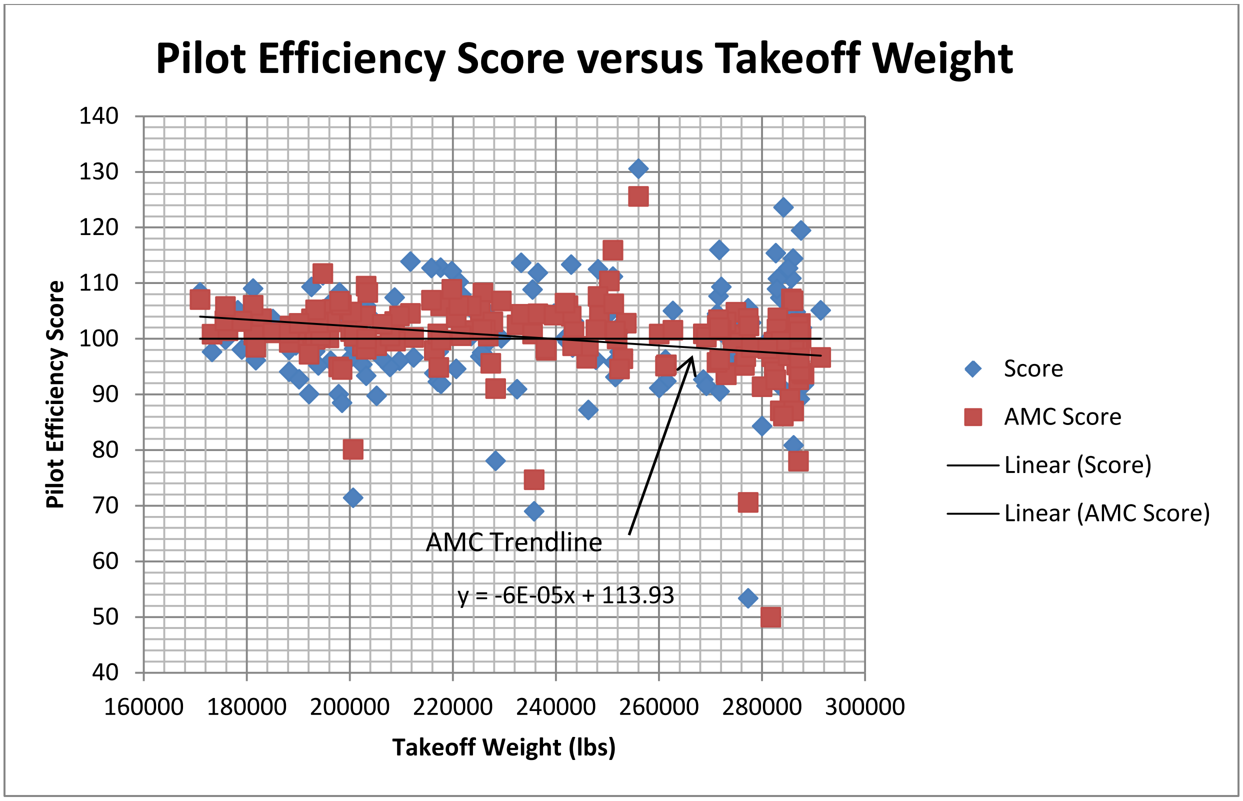


Figure 7: Pilot Efficiency Score versus Takeoff Weight Graph

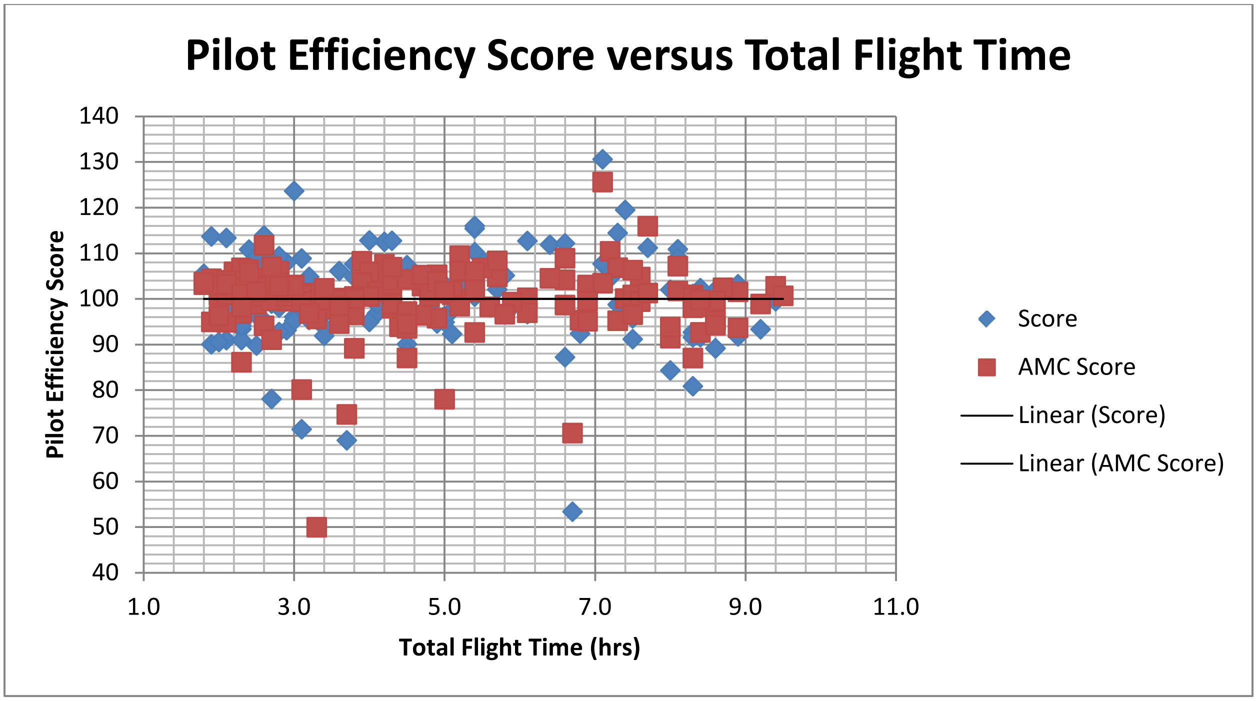


Figure 8: Pilot Efficiency Score versus Total Flight Time Graph

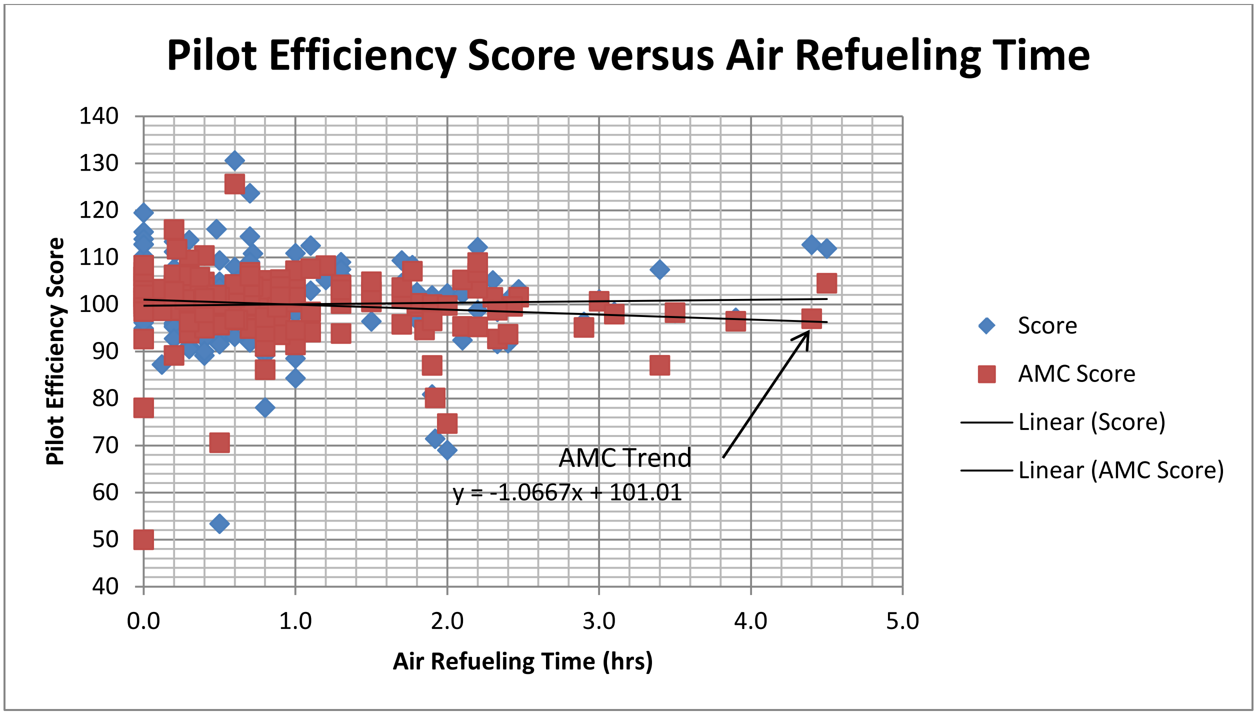


Figure 9: Pilot Efficiency Score versus Air Refueling Time Graph

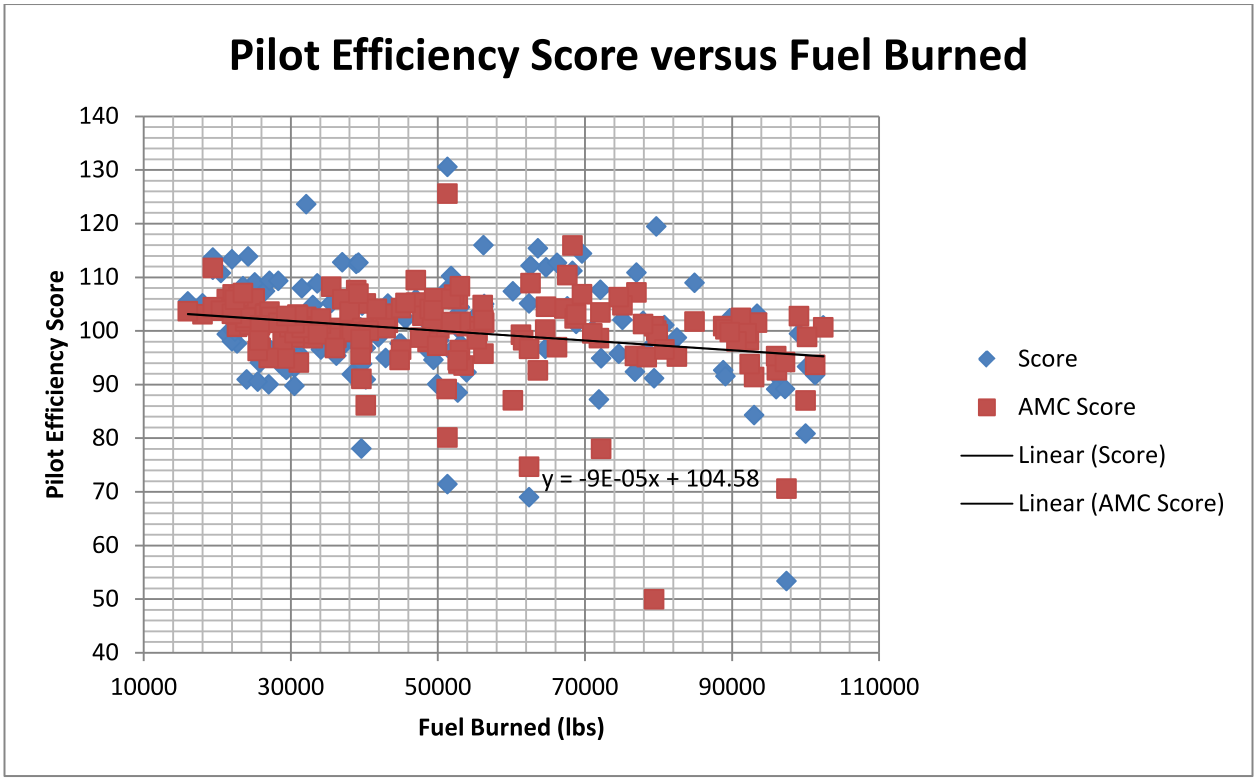


Figure 10: Pilot Efficiency Score versus Fuel Burned Graph

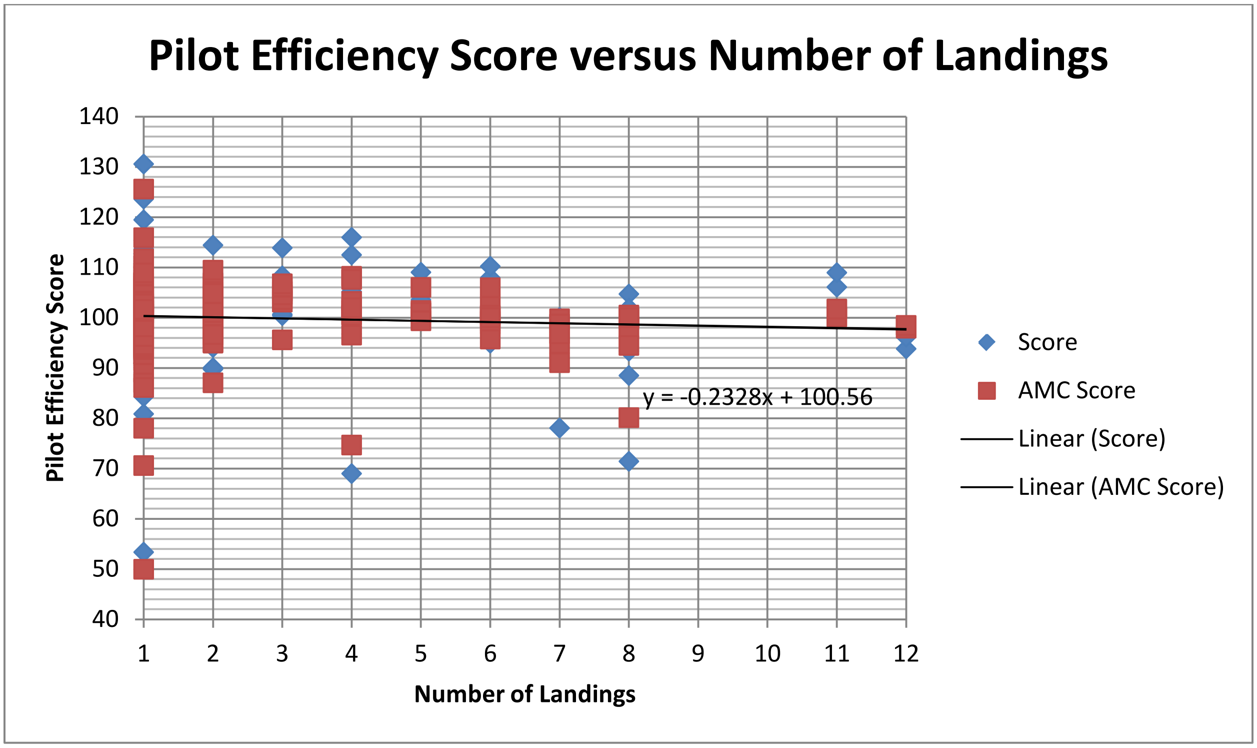


Figure 11: Pilot Efficiency Score versus Number of Landings Graph

different mission types are accounted for in the data, many missions appear in which there is zero offload. Because of this, three variables within the AMC equation become zero. This assumes zero cargo, which is almost entirely the case. That puts the entire emphasis on the total time variable without any interaction from other predicting variables. The remaining three plots show close to zero or equal movement in the trend line (both model's trend lines overlap) and a good match by both models. Also, the slightly larger standard deviation can be seen in the research model data as it projects above and below the other model in the graphs. One final note is emphasized in Figure 11. Here it can be seen that either the AMC model does a good job of deciphering the effects of multiple landings, or the effects on those mission fuel flows are not truly significant. This could be the case as the high burn rate time variable within the research model accounts for differences in number of approaches, but no like variable exists within the

AMC model. Unfortunately there are not many data points on the right of the graph to make the case. Regardless, both data sets display the same trend in number of approaches, which is a very slight decrease over time.

Summary

The regression equation and resultant pilot efficiency scores produced above are not necessarily representative of the entire field of aviators, nor was it intended to be. The design was a proof of concept. Compilation of a sample of missions (with appropriate randomness) or the entire population of missions for a period of time would be used to produce the baseline metric. A good timeframe for this look would be six months or one year, to capture the entirety of a training period or year and varying mission type components. The resultant regression equation and efficiency score equation could then be utilized for the next period (six months or a year) until a re-baseline is required. This re-baseline is needed to ensure that updated techniques, equipment, and effort are being represented by the equations. Passwords and restrictions already in place for the AMC Fuel Tracker could be used to ensure that metrics are not utilized outside of their intended location. On a final note, the research theory presented is much more important than the derived equations. While they work for the unit in which the data was produced, the exact same conditions may not be present in others. In this research historical data was reviewed over three months from one unit. Individual units could reproduce the same data set with a little work, but a much better proposal would be to track the missing variables within the AMC Fuel Tracker. The metrics could be produced automatically or with little effort and made available to units with research needs. This would help to produce a baseline regression model and efficiency equation for the entirety of an aircraft fleet.

V. Recommended Action

Management Action

The secretary of the Air Force issued a mandate in 2008 for the Air Force to cut its fuel consumption 10 percent by 2015, using 2006 as a baseline (Joyner, 2011, p. 14). The proposed culture change method and resultant efficiency scores are one way to achieve those ends through modification of mission burns and not as a reduction of flight hours. As it stands now, neither the overall fuel efficiency plan or the integral metric could be utilized within the force without modification of current systems. The main change required would be within the current AMC Fuel Tracker. Fortunately, this change would be minor and also require minimal resources to implement. The main detractor of this change would be additional man-hours from aviators returning from missions. In some units this data is already collected for organic metrics and data sets, which would nullify some of the additional workload. The benefits, though, would also far outweigh the costs. A more integrated data set would allow for further research in other areas, as well as give AMC options for use long into the future. Once completed, AMC could focus on an overall fuel efficiency plan for the mobility forces. Only through top-down leadership and perceived importance from the field could this plan fully achieve its desired aim-change of the fuel efficiency culture. Another benefit of this plan is its minimal cost to the system in terms of finance. All assets should be in place to make the program a reality. All that remains is a continuous leadership promotion of the desired outcome.

Within the context of the metric itself, lower level commanders and informal unit leaders share the most power for motivation of use. Discussion and healthy rivalry are all that is required to boost the metric from awareness, to interest, to trial, and finally to acceptance. A further benefit of application is that once aviators determine that they need to change to improve upon their own perceived weakness in fuel efficiency prioritization, they will seek out methods to improve their skills and flight habits. This again will happen on the ground within a planning and training atmosphere as well as in the air through trial. As well the same leaders who led the charge to promote the method in the beginning will be found to be the ones in possession of the skills needed to improve upon flight habits, but additional informal leaders can be generated as professional leaders within the realm of fuel efficiency. This only improves upon the corporate knowledge and professionalism of an already dynamic career field.

Both regression methods analyzed in the research add benefit to the field and are excellent measures of fuel burn. The current AMC regression shows exceptional performance given its design, which allows it to be utilized across the fleet of AMC aircraft. The research regression also shares those same attributes, but additionally has further benefit for use. With the inclusion of mission variables specific to the pilot and aircraft flown, the field will be able to identify better with the metric, and a mission type normalizing metric will make it easier to utilize. While the pilot efficiency rating is all that will be displayed or given to the aviators, a logical next step would be understanding how that metric is produced. Knowledge that the metric accepts inputs from the aircraft (gross weight), number of approaches, and length of air refueling should help to ensure pilot's that they are being evaluated appropriately, which is of great importance in this field as in any.

The change of culture is a lofty goal, but one that is required to get at hefty fuel savings on an individual mission basis. Programs designed to achieve these ends need to be consolidated into a master plan and not simply released in step to the crew force. In that way the overall importance of these initiatives will be amplified. Reducing our dependency on oil should make these resources available for investment in future force and infrastructure needs, which is exactly what the Air Force needs in this tough fiscal environment (Buchanan, 2006, p. 51). Institution of the presented framework can be an avenue for the military to achieve further savings, and ensure that our lean force is capable of change.

Future Research

While the primary motivator of this research is found in the overall application of organizational change, additional work would be complementary to the resultant metric proposal. An available avenue for growth within the metric would be to further analyze additional independent variables to further explain the noise associated with the regression and achieve a tighter tolerance for R squared. This additional explanatory power would go a long way towards the metric gaining acceptance within the ranks of military aviation. As part of this improvement, research into different mission subsets (air-land and air drop) and the resultant change in fuel burn associated would be relevant. This research attempted to consolidate all mission sets within the same model by analysis of a variety of independent variables. This is mostly out of necessity as a standard KC-135 mission, especially within the unit analyzed for this research, consistently blurs the line between mission and training. Another excellent opportunity for research would be an experiment in the application of this culture change plan and metric within the context of goal theory to provide definitive results on its application within the field.

Bibliography

Armenakis, A., Brown, S., & Mehta, A. (2011 September). Organizational Culture: Assessment and Transformation. *Journal of Change Management, 11*(3), 305-328.

Bandura, A. (1986). *Social Foundations of Thought and Action.* Englewood Cliffs: Prentice-Hall.

Barbara, B. Z., & Las Casas, A. L. (2013). Process of Change in the Organizational Culture in Building a Co-Creative Company: A Case Study at GE Healthcare. *Journal of the Academy of Business & Economics*, 5-16.

Barbuto, J. J. (2000). Influence Triggers: A Framework for Understanding Follower Compliance. *Leadership Quarterly , 11*(3), 365-387.

Beck, N., Bruderl, J., & Woywode, M. (2008). Momentum or Deceleration? Theoretical and Methodological Reflections on the Analysis of Organizational Change. *Academy of Management Journal, 51*(3), pp. 413-435.

Buchanan, S. C. (2006 3rd Quarter). Energy and Force Transformation. *Joint Forces Quarterly*(42), pp. 51-54.

Chu, D. S., & Krieg, K. J. (2005). *Military Flight Operations Quality Assurance Implementation.* Office of the Secretary of Defense.

Conceicao, S. C., & Altman, B. A. (2011 Spring). Training and Development Process and Organizational Culture Change. *Organization Development Journal, 29*(1), 33-43.

Deal, T. E., & Kennedy, A. A. (1982). *Corporate Cultures: The Rites and Rituals of Corporate Life.* New York: Perseus Books Publishing, L.L.C.

Dietrich, J. (2014, February 10). Atlas Air Executive Vice President and Chief Operating Officer. (R. Gohn, Interviewer)

Donley, M. B. (2010). *Air Force Energy Plan 2010.* Retrieved 2013 10-September from www.safie.hq.af.mil

Erwin, S. I. (2010 April). Trick Question: How Much Does the Pentagon Pay for a Gallon of Gas? *National Defense*, 30-32.

Eskerod, P., & Skriver, P. (2007). Organizational Culture Restraining In-House Knowledge Transfer Between Project Managers-A Case Study. *Project Management Journal, 38(1),* 110-122.

Feng, P. P., Kinsel, W. C., Thal, A. E., & Bleckmann, C. A. (2011 Summer). Jet Propellant 8 Versus Alternative Jet Fuels: A Life Cycle Perspective. *Air & Space Power Journal*, 47-55.

French, S. L., & Holden, T. Q. (2012). Positive Organizational Behavior: A Buffer for Bad News. *Business Communication Quarterly, 75*(2), pp. 208-220.

Fullan, M. (1991). *The New Meaning of Educational Change.* London: Cassell.

Harmon, F. G., Branam, R. D., & Sandlin, D. E. (2011 Summer). Achieving the Air Force's Energy Vision. *Air & Space Power Journal*.

Harrison, J. R., & Carrol, G. R. (1991). Keeping the Faith: A Model of Cultural Transmission in Formal Organizations. *Administrative Science Quarterly, 36*, 552-582.

Hartman, J., & Khademian, A. M. (2010 Nov/Dec). Culture Change Refined and Revitalized: The Road Show and Guides for Pragmatic Action. *Public Administration Review*, 845-856.

Herguner, G., & Reeves, N. (2000). Going Against the National Cultural Grain: A Longitudinal Case Study of Organizational Culture Change in Turkish Higher Education. *Total Quality Management, 11*(1), 45-56.

Heseltine, B. P. (2008). Contemporary Issues. *Air Force Journal of Logistics, XXXI*(4), 29-37.

Jamieson, I. (1990). Pre-Vocational and Voactional Education: The New Vocationalism, Economic Understanding and the World of Work. In B. D. (Ed), *The New Social Curriculum.* Cambridge: Cambridge University Press.

Joyner, B. (2011 April). Fuel Efficient. *Citizen Airman*, pp. 14-17.

Kelly, D., & Amburgey, T. L. (1991). Organizational Inertia and Momentum: A Dynamic Model of Strategic Change. *Academy of Management Journal, 34*(9), 591-612.

King, D. (2009). Energy Security: A Global Challenge. *2009 Topical Symposium.* Institute for National Strategic Studies.

Kotter, J. P. (2005). *Liderando Mudanca.* Rio de Janeiro: Campus.

Latham, G. P., & Locke, E. A. (1979 Autumn). Goal Setting - A Motivational Technique That Works. *Organizational Dynamics, 8*(2), 68-80.

Lofquist, E. A. (2011 June). Doomed to Fail: A Case Study of Change Implementation Collapse in the Norwegian Civil Aviation Industry. *Journal of Change Management, 11*(2), pp. 223-243.

Lusk, D. (2014, April 7). Senior Manager of Global Operations Control FedEx. (R. Gohn, Interviewer)

Lyons, J. B., Jordan, J., Faas, P., & Swindler, S. (2011 June). Organizational Development Goes Digital: Applying Simulation to Organizational Change. *Journal of Change Management , 11*(2), pp. 207-221.

Lyons, J. B., Swindler, S. D., & Offner, A. (2009 December). The Impact of Leadership on Change Readiness in the US Military. *Journal of Change Management, 9*(4), pp. 459-475.

Marshall, S. (1993). Managing the Culture: The Key to Effective Change. *School Organisation, 13*(3), 255-268.

McAlearney, A. S., Fisher, D., Heiser, K., Robbins, D., & Kelleher, K. (2005 Spring). Developing Effective Physician Leaders: Changing Cultures and Transforming Organizations. *Hospital Topics: Research and Perspectives on Healthcare, 83*(2), 11-18.

McAndrews, L. (2010 Mar-Apr). Fuel Efficiency Among Top Priorities in AMC's Energy Conservation. *The Mobility Forum*, pp. 16-19.

McGourty, C. (2009-2010). USS Green: How the American Military is Lighting a New Energy Frontier to Combat Costs. *Harvard Kenedy School Review, 10*, pp. 56-59.

Morton, J. F., & Truver, S. C. (2011 35-39-November-December). The Great Green Fleet: Naval Warfighting Imperatives for Energy Security. *Defense AT&L*.

NFL Quaterback Rating Formula. (2014). Retrieved April 3, 2014, from NFL.com: http://www.nfl.com/help/quarterbackratingformula

Odagiu, C., & Piturlea, M. (2012). *Organizational Change Management. A Cultural Approach.* Doctoral School, Valahia Unitversity of Targoviste, Romania. International Conference of Scientific Paper.

Ogbonna, E., & Harris, L. C. (1998). Managing Organizational Culture: Compliance or Genuine Change? *British Journal of Management, 9*, 273-288.

Ogbonna, E., & Wilkinson, B. (2003 July). The False Promise of Organizational Culture Change: A Case Study of Middle Managers in Grocery Retailing. *Journal of Management Studies, 40*(5), 1151-1178.

Park, W.-W. (2002). The Coporate Culture Change Campaigns in Korea: Lessons from Their Failures. *Managing Korean Business*, 89-110.

Pires, J. C., & Macedo, K. B. (2006, January-February Volume 40, Number 1). Cultura Organizacional em Organizacoes Publicas no Brasil. *RAP*, pp. 81-105.

Ray, K. W., & Goppelt, J. (2011). Understanding the Effects of Leadership Development on the Creation of Organizational Culture Change: A Research Approach. *International Journal of Training and Development, 15*(1), 58-75.

Reiman, A. D., Johnson, A. W., & Cunningham, W. A. (2011 Fall/Winter). Competitive Advantage and Fuel Efficiency in Aviation. *Journal of Transportation Management*, 75-91.

Schein, E. (1985). *Organisational Culture and Leadership.* San Francisco: Jossey-Bass.

Schein, E. H. (2004). *Organizational Culture and Leadership.* San Francisco: Jossey-Bass.

Silvester, J., Anderson, N. R., & Patterson, F. (1999). Organizational Culture Change: An Inter-Group Attributional Analysis. *Journal of Occupational and Organizational Psychology*(72), 1-23.

Smollan, R. K., & Sayers, J. G. (2009 December). Organizational Culture, Change and Emotions: A Qualitative Study. *Journal of Change Management, 9*(4), 435-457.

Solis, W. M. (Mar 2008). Overarching Organizational Framework Could Improve DOD's Management of Energy Reduction Efforts for Military Operations. *Testimony Before the Subcommittee on Readiness, Committee on Armed Services, House of Representatives.* United States Government Accountability Office.

StatSoft, I. (2000). *Multiple Regression*. Retrieved April 17, 2014, from Electronic Textbook StatSoft: www.uta.edu/faculty/sawasthi/Statistics/stmulreg.html

Vrontis, D., Thrassou, A., & Zin, R. M. (2010 Autumn). Internal Marketing as an Agent of Change - Implementing a New Human Resource Information System for Malaysian Airlines. *Journal of General Management, 36*(I), pp. 21-41.

Waterhouse, J., & Lewis, D. (2004). Communicating Culture Change. *Public Management Review, 6*(3), 353-376.

Yazici, H. J. (2009 September). The Role of Project Management Maturity and Organizational Culture in Perceived Performance. *Project Management Journal, 10*(1002), 14-33.

REPORT DOCUMENTATION PAGE	*Form Approved* *OMB No. 0704–0188*

1. REPORT DATE (DD–MM–YYYY) 13-06-2014	2. REPORT TYPE Graduate Research Paper	3. DATES COVERED *(From — To)* May 2013 – June 2014

4. TITLE AND SUBTITLE Changing the Culture of Fuel Efficiency: A Change in Attitude	5a. CONTRACT NUMBER 5b. GRANT NUMBER 5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S) Gohn, Russell D., Major, USAF	5d. PROJECT NUMBER 5e. TASK NUMBER 5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Air Force Institute of Technology Graduate School of Engineering and Management (AFIT/EN) 2950 Hobson Way Wright-Patterson AFB OH 45433-7765	8. PERFORMING ORGANIZATION REPORT NUMBER AFIT-ENS-GRP-14-J-6
9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES) Headquarters Air Mobility Command Colonel Keith Boone, Chief, Fuel Efficiency Division 402 Scott Drive Scott Air Force Base, IL 62225 COMM (618)-229-1339, DSN 779-1339, keith.boone@us.af.mil	10. SPONSOR/MONITOR'S ACRONYM(S) AMC/A3F 11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION / AVAILABILITY STATEMENT
Distribution Statement A. Approved for Public Release; Distribution Unlimited

13. SUPPLEMENTARY NOTES
This work is declared a work of the U.S. Government and is not subject to copyright protection in the United States

14. ABSTRACT

Due to the inconsistent financial position of the Air Force, every method for cost savings must be evaluated to ensure the Air Force can meet its National Security objectives with the most cost effective force available. As the Air Force is the largest user of energy within the DoD, fuel efficiency needs to be improved through new cost advantageous methods to avoid further cuts to readiness and recapitalization. Previous efforts to curb energy use within AMC have focused on programmatic and systematic issues. This paper will present a plan to modify military aviation culture reinforced during 10 years of rising DoD spending with positive motivation and commitment through benchmarking discrete mission performance using the KC-135 community at Royal Air Force Mildenhall (RAFM) as a test case. A fuel efficiency rating for tanker pilots will be modeled using mission metrics that are currently unavailable in a single database, but easily acquired. With this metric individual flyers should be intrinsically motivated to push fuel efficiency higher as a priority, and therefore accomplish missions and training within the tightest tolerances of fuel efficiency.

15. SUBJECT TERMS
Fuel Efficiency, Pilot Rating, Regression Model, Mobility

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
					Col Ned Sandlin, AFIT/ENS
a. REPORT	b. ABSTRACT	c. THIS PAGE	UU	64	19b. TELEPHONE NUMBER (Include Area Code) (937) 255-3636 x4740, doral.sandlin@afit.edu
U	U	U			

Standard Form 298 (Rev. 8–98)
Prescribed by ANSI Std. Z39.18