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**FACTOR THEORY: BRIDGING TALENT MANAGEMENT
ENDS WITH DATA SCIENCE MEANS**

by

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Abstract

This research explains and predicts Airman turnover as a function of multiple influence factors and presents methods to predict separation with high accuracy. A concept called Factor Theory develops multidimensional Airman behavioral models to bridge the gap between the ends of talent management and the means of data science. The results demonstrate that Airmen act as predictable rational actors, weighing the costs and benefits of continued service as a value-maximizing proposition. Further, distinct retention behaviors manifest by Air Force Specialty Codes (AFSC) as a function of subculture dynamics and differing valuations of service experiences. By combining all theorized factors from the 2015 Air Force survey in a single dataset, machine learning and classical analytics indicate that Airman separation is predictable for Pilots, Combat Systems Operators, Physicians, and all other Air Force Officers with greater than 97% accuracy. The results refute the notion of Airmen as decisional “black boxes” and expendable assets. Rather, human capital is a perishable strategic resource that creates distinct advantages over the enemy, requiring contextualized management by Air Force Specialty Code (AFSC) in order to attain maximum returns. This research proposes two holistic solutions. First, a comprehensive Air Force Talent Management System; second, a new system of officer career progression called Career Multipath derived from the 16th Chief of Staff of the Air Force General Michael Ryan’s Force Development Initiative Program. This research provides rapid, evidence-based solutions to the Air Force Future Operating Concept, Strategic Master Plan, and “wicked” problem sets to remain competitive in future war.

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Introduction

In a series of memoranda in 2015 and 2016, Secretary of Defense Ash Carter stated that personnel formed the competitive edge of US military forces, and that to sustain that edge the military had to evolve its personnel system. Today, many internal and external factors challenge the Air Force. Internally, it faces personnel shortfalls in critical career fields and a belief that the fix is anything but managerial reform. Leaders point to a strong economy and a continuously high military ops tempo as some of the reasons, but the Air Force fails to take a deeper look at its practices and assumptions. Externally, the maturation of volatile, uncertain, complex, and ambiguous (VUCA) conflicts points to less certainty in the world and the necessity of placing the right Airmen, at the right place, at the right time in order to win. The concept of multi-domain battle provides efficacy to the view that Air Force human capital must become adaptive and superior to the enemy, thereby requiring new concepts in talent management and a challenging of the status quo.

This research investigates these vital issues, lays bare the facts using statistical methods, confronts assumptions underpinning that status quo, and suggests ways to ensure the continued dominance of the Air Force in the human domain. The research is sponsored by Air War College and supports a number of Air Force initiatives: Air Force Communities of Interest's resilient squadrons, predictive modeling; Air Force research topics return on investment associated with Airmen, mission-alignment, and retention; Strategic Master Plan and Human Capital Annex sections AG1.1, .2, .6, and IN2.3.

This research is organized into three parts. Part one models an Airman's decision to separate or remain in the Air Force as a complex, dynamic choice between the costs and benefits of a number of influential factors. Part two challenges the Industrial Age view of personnel as an asset with a strategic resource-based view. Part three constructs an Air Force Talent Management

System as a way to align personnel retention and performance to achieve common stakeholder outcomes. Additionally, part three includes the concept of Air Force Specialty Code (AFSC)-diverse, multipath careers that may inculcate a culture of variation and agility necessary in future war.



Part 1: Factor Theory

Purpose

The purpose of this research is to determine:

1. Do influential factors impact Airman turnover?
2. Are influential factors measurable, repeatedly and reliably?
3. Do influential factors vary across AFSCs? Are they universal?
4. Are influential factors expressible mathematically, can they predict turnover, and what do interventional strategies look like?
5. How do analytical-based strategies facilitate changes in talent management thought?
6. What should an Air Force talent management system look like?
7. How does the personnel system support building a multi-domain, VUCA Air Force of the future?

Background

Three core-AFSC study groups formed the basis of this research: pilots (AFSC 11X), Combat Systems Operators or CSOs (AFSC 12X), and physicians (AFSC 44X). Factor Theory underpins the results of the research as model of rational human behavior. As a theory, it defines as a set of general propositions that if proven correct, form principles for the explanation and prediction of turnover behavior.¹ Factor Theory proposes that the choice Airmen make in separating from the military is the difference of weighted costs and benefits. When this difference is positive, the member stays; when the difference is negative, the member leaves. Conceptually, Factor Theory attempts to explain, quantify, and predict the point at which an Airman feels that they have “had enough” by correlating influence factors to turnover. The theory believes an Airman’s decision to separate is one arrived at over time and is therefore

dynamic and contextual. A system view of Airmen facilitates understanding Airmen as the complex behavioral system they are.

Block 1: Hypotheses 1-3

Airmen as a Work-Life Balance System

Modeling Airmen as a complex behavioral system results in a non-linear model: a cause acting on a person's life does not necessarily result in an effect of the same magnitude elsewhere, nor is it likely predictable. For example, how each person handles stress and its impacts is non-linear and contextual. For this reason, Factor Theory does not attempt to model the complex, non-linearity of turnover decisions. Rather, it takes Airmen's decisions about turnover at face value and reduces complex choice in a simple explanation of Airmen as a system.

A system is a "bound complex of *elements...interrelated* in a purposeful manner by *processes which respond to events* to achieve an *objective*."² The two elements of Airmen as a system are their personal and military lives. Events form the "causes" in Airmen's lives, while processes are the contextual, non-linear approaches that manage their "effects." Typical military and personal events include deployments, PCS, TDY, vacations, birthdays, and civilian job offers originating within and outside Airmen's system boundaries. Processes absorb "cause" events and attempt to resolve their "effects," sometimes destabilizing the work-life balance system. Figure 1 illustrates Airmen as equalized and non-equalized work- life balance systems.

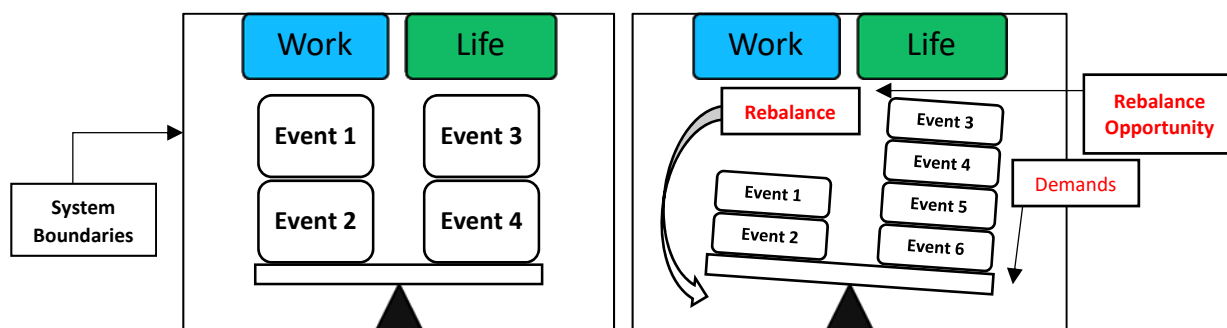


Figure 1. Airmen as Equalized and Non-Equalized Systems.

Role-balance theory explains the dynamic nature of work-life balance and its influence on turnover. In role-balance theory, individuals “actively engage in managing their complete system or role responsibilities” such that personnel with balanced systems “will be more effective in role-specific contexts” such as their military service or role as a parent.³ The left side of Figure 1 illustrates Case 1 of Airmen as an equalized work-life system, while the non-equalized case appears on the right. In the non-equalized case, life and work events internal to the system create imbalances that reduce Airman effectiveness. As a result, unbalanced Airmen behaviors should fall into one of four additional cases.

In Case 2, Airmen choose to live in an unbalanced work-life system for an extended period. In Case 3, Airmen re-balance the system by transferring work-life demands to the opposing side (spouse, job, etc.). In Case 4, Airmen ignore internal work-life demands as stress continues to build disproportionally to some critical point. Finally, in Case 5 Airmen re-balance the work-life system by using an external opportunity such as separating for a civilian job. All unbalanced cases result in reduced in-role performance and often devastating work-life outcomes, but Case 4 describes the exact point Airmen separate. In Factor Theory, this notional point is the Separation Threshold Value (STV) and *the decisive point of turnover*. In order to create balance in unbalanced work-life systems, Airmen must accept the imbalance (Case 2), transfer demands (Case 3), ignore demands (Case 4), or separate from the Air Force (Case 5).⁴ Table 1 summarizes the five work-life cases with Case 1 as the nominal condition. Figure 2 illustrates the dynamic nature of force imbalances with respect to the SVT. Note than in Case 5, both internal demands and rebalance opportunities must exist.

	Case 1: Optimal Performer	Case 2: Reduced Performer	Case 3: Cyclical Degradation	Case 4: Explosive Situation	Case 5: Separation
Internal Demand	Negligible	Y	Y	Y	Y
Airman Decisions	N/A	Accept imbalance	Transfer demands internally	Ignore demands	Separate
Result	Work-life balanced; resilient Airmen	Work-life imbalanced; degraded performance	Work-life imbalanced; passed to in-role contexts & abrupt balancing	Work-life imbalanced; expect abrupt balancing	Work-life imbalanced; STV tripped & external force relief exists

Table 1. Five Cases Summary.

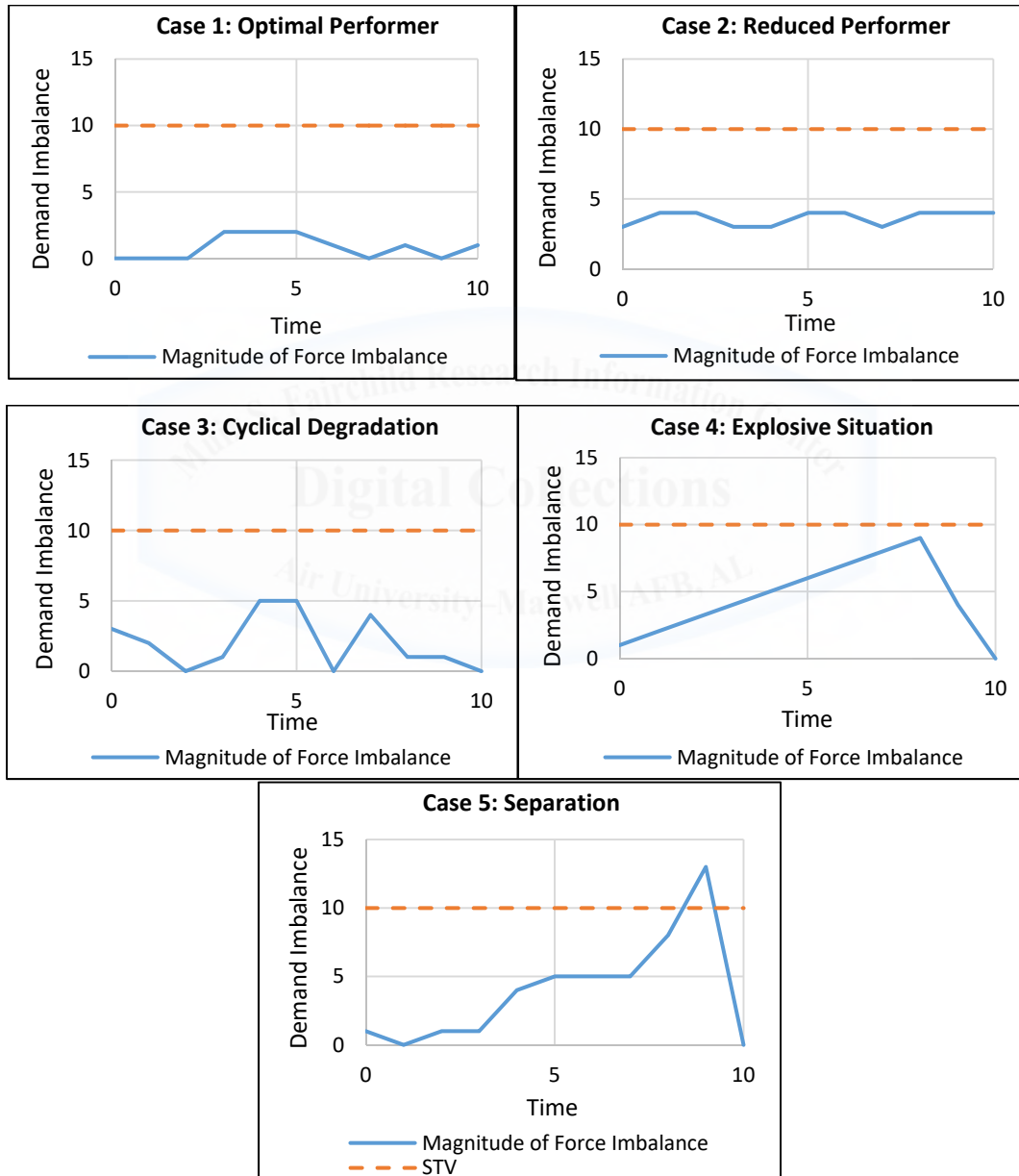


Figure 2. The Five Work-Balance Cases of Airmen as a System.⁵

The overall service objectives of Airmen as a system change throughout their career, leading to the time dependency of the five cases exhibited in Figure 2. Airmen track along the continuum of the five cases during their careers, presenting varying probabilities of separation. At any given time, multiple military and personal factors are at play based on Airmen's value standards. For example, an adventurous or rank-maximizing career may come into conflict with raising a family, causing the value standard to shift towards a life-friendly balance. This is because work-life balance is a two-way street with research indicating that a low conflict, highly rewarding job dynamic creates the best work-life balance.⁶ Beneficial family environments flow over as work enrichment, causing higher job satisfaction, higher organizational commitment, and reduced turnover.⁷ Airmen and their families can typically cope with infrequent, small duration imbalances or changes in priorities. However, the inability to adapt to prolonged states of work-life conflict leads to poorer work performance, tardiness, and absenteeism.⁸ Likewise, conflicted family environments negatively influence job dedication behaviors such as initiative and rule following along with interpersonal behaviors like cooperation and consideration⁹. In 1983, The US Army identified that one, single question most often determined reenlistment: Is my family happy?¹⁰ In order to restore the work-life balance of soldiers in the post-Vietnam era, the Army instituted a plethora of family-oriented benefits including high-quality childcare, dental and medical care, and recreation services that reversed its manning slide.¹¹ This evidence suggests that in the all-volunteer force, Airmen's work-life balance dynamics heavily influence separation decisions.

Because service is contextual, Factor Theory postulates that individual sentiments matter with respect to turnover intentions. Therefore, a contextual work-life balance model of turnover behaviors is a valid conceptual approach if contextual AFSC responses are significantly different

from the rest of the Air Force. If not, all Airmen respond the same towards separation or continued service and standardized Human Resources (HR) strategies suffice.

Hypothesis 1: *Research AFSCs exhibit significantly different responses in the 2015 Air Force survey stay and leave datasets when compared to the rest of Air Force officers.*

Factor Theory's work-life system view postulates that Airmen will focus on rebalancing their systems with internal options such as leave, different careers, or PCS's.¹² When rebalancing becomes the primary task, qualitative evidence would suggest that in-role task performance should decrease for conflicted and stressed individuals.¹³ Therefore, the need to balance likely drives Airmen service objectives to change.

Hypothesis 2: *Controlling for AFSC, the reported work-life balance factor scores of separated personnel correlate with the influence factor scores of separated personnel. The reported work-life balance factor scores of non-separated personnel correlate with stay-oriented influence factors scores.*

The work-life balance of Airmen should vary significantly among the stay and leave datasets, and correlate to a number of different influential questions because work-life is a multidimensional concept. For example, when a rebalancing opportunity arises such as a civilian job offer or a position in the Reserves, Airmen are more likely to separate if it eliminates the imbalance. Having many influences positively and negatively correlate provides evidence to the multidimensional view of Airmen.

Hypothesis 3: *Controlling for AFSC, the reported work-life balance of separated personnel correlate with leave-oriented external balancing forces such economic opportunities and job offers.*

Methods & Results: Block 1, Hypotheses 1-3

The Methods and Results sections present the analysis of the research hypotheses. Research influence factors came from the 2015 Air Force survey based on questions that asked Airmen to assess their turnover intentions. Pilots (AFSCs 11X), CSOs (AFSC 12X), and physicians (AFSC 44X) made up the survey “stay” and “leave” datasets.¹⁴ The leave datasets defined personnel with a declared Date of Separation (DOS), while the stay datasets defined personnel without a DOS. The data were randomly sampled across all Air Force officer AFSCs, then sorted for the research AFSCs of concern.¹⁵ Since the response of each participant was not influential on the response of other participants, survey participation was voluntary, and the answer to survey questions did not build from other questions, all responses are statistically independent.

During data processing, it was discovered that the 11X stay dataset was contaminated with fighter pilot (AFSC 11F) stay data. The uncontaminated 11X leave dataset is composed of 28% fighter pilots, 35% mobility pilots, 9% SOF pilots, 7% bomber pilots, and then all others. The contaminated, 11F stay dataset is composed of 96% fighter pilots (three times the amount in the uncontaminated 11X leave dataset). This contamination should not significantly influence the results for four reasons.

First, the four top pilot AFSCs (fighter, bomber, mobility, SOF) in the exit dataset are presently facing the same issues of high ops tempo, older aircraft, and a good economy. Likewise, institutional Air Force issues on leadership, promotion, and command perceptions exist throughout each aircraft community while the mobility, fighter, and SOF pilots composing 72% of the correct 11X leave dataset are easily the most taxed airframes in the Air Force. Second, the questions theorized as influence factors deal with institutional Air Force issues. Namely, 64% are associated with Air Force-level issues, while the remaining 36% are AFSC-

specific issues.¹⁶ Third, the satisfaction trends between the 11X leave and 11F stay datasets are very similar to the uncontaminated 12X and 44X leave and stay datasets, indicating that gross inaccuracies in retention sentiments are unlikely. For example, the uncontaminated 11X leave data shows all pilot types are 88% satisfied and 11% dissatisfied while the 11F stay data shows fighter pilots are 86% satisfied and 12% dissatisfied. Satisfaction is a top measure for predicting separation in the HR field, so any large inaccuracies in actual turnover are likely included in changed satisfaction levels. Lastly, correlation analysis of the contaminated 11F stay data with the uncontaminated 11X stay data for the theorized influence factor questions indicate two significantly different responses both trending towards less turnover. Table 2 below lists the theorized influence factor questions and its respective Chi-squared (X^2) tests for significance. An explanation of the Chi-squared statistical test appears later in this section.

Stay Dataset Question	11X stay vs 11F stay correlation (X^2)	Significantly different?
Immediate supervisor	0.979	N
Leadership at unit level	0.887	N
Overall Job Satisfaction	0.020	Y
Career Field Satisfaction	0.070	N
Contribute to Mission	0.906	N
Skills Utilization	0.711	N
Cohesion	0.446	N
Personnel Relationships	0.254	N
Personnel's Experience	9.26E-07	Y
Unit Climate	0.163	N
Bonuses/Special Pay	0.983	N
Retirement Program	0.953	N
Patriotism	0.382	N
Work/Life Balance	0.958	N

Table 2. AFSC 11X Stay and 11F Stay Dataset Equivalence.

Overall, the contamination of the 11X stay with 11F data should have negligible impact on the modeling results. Any 11X model inaccuracies will become evident during the validation and verification phase with hypotheses 1, 2, and 3 remaining unaffected. An interesting finding from this contamination is that the 11X and 11F stay datasets are nearly equivalent. The concepts

of organizational cultures and subcultures explains why this may be the case. Because AFSC subcultures experience both Air Force and contextual shaping forces, there should exist both similar and dissimilar AFSC behaviors. This trend appears to occur in the pilot data but likely exists across all AFSCs. The research dataset demographics were as follows:

AFSC 11X Leave Demographics

- 99% AFSC 11X Pilot, n≤389 survey participants. Participation varies by question
- 73% have or are working towards an Airline Transport Pilot (ATP) rating
- 28% fighter pilots, 35% mobility pilots, 9% SOF pilots, 7% bomber pilots, 7% C2/ISR, 4% CSAR, 3% RPA, 3% trainer, 2% test, 1% other
- 34% separating voluntarily, 53% retiring voluntarily, 14% involuntary. 88% satisfied with Air Force experience.
- Time considering separate/retire: 52% 0-6 months, 19% 7-12 months, 15% 13-24 months, 5% 25-36 months, 8% more than 36 months

AFSC 11F Stay Demographics

- 100% AFSC 11X Pilot, n≤693 survey participants. Participation varies by question.
- 48% have or are working towards an Airline Transport Pilot (ATP) rating 96% fighter pilot, 2% RPA, 2% trainer

AFSC 12X Leave Demographics

- 98% AFSC 12X CSO, n≤94 survey participants. Participation varies by question.
- 73% have or are working towards an Airline Transport Pilot (ATP) rating
- 25% bomber, 21% C2/ISR, 20% mobility, 16% SOF, 11% fighter, 7% others

- 20% separating voluntarily, 47% retiring voluntarily, 33% involuntary others. 86% satisfied with Air Force experience Time considering separate/retire: 53% 0-6 months, 22% 7-12 months, 14% 13-24 months, 4% 25-36 months, 7% more than 36 months

AFSC 12X Stay Demographics

- 99% AFSC 12X CSO, n≤863 survey participants. Participation varies by question.
- 51% have or are working towards an Airline Transport Pilot (ATP) rating
- 23% bomber, 28% C2/ISR, 10% mobility, 19% SOF, 13% fighter, 6% others

AFSC 44X Leave Demographics

- 98% AFSC 44X Physician (2% 48X Aerospace Medicine), n≤93 survey participants. Participation varies by question.
- 68% separating voluntarily, 32% retiring voluntarily, 0% involuntary. 70% satisfied with Air Force experience.
- Time considering separate/retire: 27% 0-6 months, 24% 7-12 months, 17% 13-24 months, 6% 25-36 months, 26% more than 36 months

AFSC 44X Stay Demographics

- 94% AFSC 44X Physician (4% 48X Aerospace Medicine), n≤326 survey participants. Participation varies by question.

Both the stay and leave surveys utilized the Likert Scale that shows the response of the concerned AFSC next to all other survey respondents including the parsed AFSC. Any conclusions made about the parsed AFSC (11X, 12X, or 44X) are grounded against all other Air Force officers because the “All” column includes a random sample of the parsed AFSC. Figure 3 provides an example of the summary response table. Question sample sizes for all research AFSCs varied from 12 to 2,139 with the majority of response sample sizes in the hundreds.

Survey Margin of Error (MOE) was reported at 1.29%, 2.6% and 4.36% for the 11X, 12X, and 44X surveys at collection, respectively.¹⁷

The 2015 Air Force Survey data contains 99 questions that ask Airmen to rate each dimension of service (pay, medical services, etc.) as a contributor to either stay or leave intentions. It was impractical to use all 99 questions for this research, so the data were reduced by using only those questions responding with greater than 50% of the population percentages in either the stay or leave categories. For example, questions with greater than 50% of responses answering with some extent of “leave” were counted as leave influences; answers with some extent of “stay” were counted as stay influences. Not all responses neatly fit into stay and leave categories. As Figure 3 indicates, 22% did not consider the specific question in a turnover decision, 24% said the question was neither a stay or leave influencer, 33% considered the question to influence leaving, and 20% said the question influenced them to stay. In this case, neither the stay nor leave categories capture a majority of the respondents, so the question was not used. By only using questions that elicited strong responses, fewer questions could capture more variability while explaining turnover through higher correlations.

Opportunities for career field/skills training and professional development	All (n=1757)	Core_11 (n=412)
	%	%
N/A	1.00000	1.00000
Did not consider this when making my decision	19.00000	22.00000
Very strong influence to leave	14.00000	12.00000
Strong influence to leave	10.00000	8.00000
Slight influence to leave	13.00000	13.00000
Neither an influence to stay nor leave	20.00000	24.00000
Slight influence to stay	12.00000	11.00000
Strong influence to stay	7.00000	6.00000
Very strong influence to stay	5.00000	3.00000
Total	100.00000	100.00000

Figure 3. Survey Question Response Data.

There were two methods available to process the data: parametric or non-parametric means. Parametric methods utilize assumptions about the underlying data, while non-parametric methods do not. The assumptions of a parametric test require the data to meet certain conditions,

while non-parametric tests are more flexible and require no such assumptions. The primary factors supporting non-parametric methods are:

- Data are better represented by the median. Outliers in ordinal categories can skew the center of the distribution. If the mean were used, a large shift would occur that is not representative of the population response data.¹⁸
- Ordinal or ranked data are being used with outliers. The survey responses are summarized categorically, yet the scale is ordinal. In this case, outliers can actually be representative of differences in population responses desired to measure. In the case of continuous data or using the survey means in a parametric test, the distribution can shift such that it negates valuable outliers.¹⁹
- Distribution of data are not normal. The survey responses indicate a mix of normal and non-normal distributions and exhibit both left and right-skewness (heteroscedasticity). While a parametric test can certainly handle this, using the mean for these tests may not be the best measurement as discussed above.
- Large sample sizes. Since the majority of survey responses are in the hundreds, the advantages and disadvantages of using either parametric or non-parametric tests converge. The sample sizes are simply so large the drawbacks of either method are limited. For example, if the sample size is large (greater than 100), and the data is Gaussian (normal) but a non-parametric test is chosen anyhow, very little is lost in power.^{20,21} Likewise for large sample sizes, if you choose a parametric test and the data is non-Gaussian (non-normal), the test is still robust.²²

In sum, *choosing a parametric or non-parametric test with large samples sizes comes down to the recognition of outliers and the convergence or divergence of the mean and median.* Since accounting for outliers is a concern, a conservative approach consistently adopts non-parametric

methods. The impact of this choice on power is negligible with the large sample sizes. Figure 4 below shows two plots of response data versus frequency indicating the diversity of responses in the surveys. The question on the right forms responses that are normal, while the question on the left exhibits heteroscedasticity. For these reasons, non-parametric Chi-squared testing offers the most flexibility when considering tests of independence. Main assumptions on the use of the Chi-squared distribution have been met since the surveys use the Likert (ordinal) scale and are comparing the research AFSCs against the rest of the survey population (independent groups).²³ The method used to determine the observed and expected values for the Chi-squared test are summarized in Attachment 1. For all tests of independence, a p-value of less than or equal to .05 defined a significant difference.

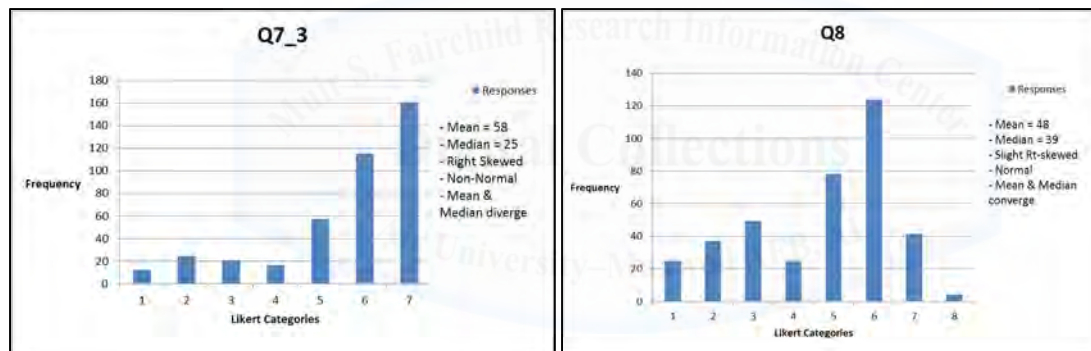


Figure 4. 2015 Air Force Survey Question Distributions.

Figure 3 indicates that questions contain an “N/A” field. This field is omitted from the Chi-squared test in all analyses since it is desired that population differences are measured only for eligible personnel. Including the “N/A” field would lead to spurious significance and skew analyses, reducing the validity of the statistical tests. When omitting the “N/A” field responses, it was technically appropriate to reduce the overall sample size by the amount omitted in the “N/A” field as if that line of data did not exist. There were no questions in the analyses that verged on significance where keeping the “N/A” field was decisive. Additionally, omitting the “N/A” fields

and correcting the sample sizes for all questions was outside of the timeline of the research and an assumed, minimal risk.

Lastly, some of the questions in the datasets had missing data or zero responses causing the Chi-squared test to return an error. Where each Likert category had a “0” or “.” in the percentage responded, it was replaced with a “.01” or “0,” respectively. Since the Chi-squared test statistic amplifies any differences in the data (mathematical squaring of response differences), the greatest skewing in the data occurs when the differences between responses are the largest. As a result, in the special event one response in a Likert category was a “.” and the other was a “0,” both were changed to “.01” to approximate zero so the differences were not amplified.²⁴ In no case did this procedure change the significance of the Chi-squared tests, but it did change the values of the X^2 test statistic slightly. Table 3 below presents the encoded question scores of the 2015 Air Force survey.

Question Response	Encoded Value
N/A	9
Did not consider this when making my decision	1
Very strong influence to leave	2
Strong influence to leave	3
Slight influence to leave	4
Neither an influence to stay nor leave	5
Slight influence to stay	6
Strong influence to stay	7
Very strong influence to stay	8

Table 3. 2015 Air Force Survey Question Scales.

Hypothesis 1: *Research AFSCs exhibit significantly different responses in the 2015 Air Force survey stay and leave datasets when compared to the rest of Air Force officers.*

Table 4 in the following pages summarizes the theorized influential questions using the aforementioned sorting procedure with common colors denoting shared AFSC influences. There are significant differences between the study AFSC’s survey responses and all Air Force officers.

This supports the view that the research's AFSCs differ in their behaviors compared to all Air Force officers, requiring different management and strategy considerations. These results are important because they show that turnover has a large, contextual component. For example, among those personnel that separated, CSO's and physicians do not have significantly different sentiments about work-life balance compared to all other Air Force officers whereas pilots differ significantly. This indicates a sentiment among pilots different from the rest of the Air Force, CSO's, and physicians.

Significantly different responses to the same question means something is occurring within AFSC populations. Ideally, *Airmen should leave for the same reasons; otherwise, it means different factors impact separation*. Figure 5 below provides an example of typical distributional shifts between the study AFSC's for the work-life balance question. The work-life balance chart on the left does not include CSO's because their responses were not significantly different from the rest of the Air Force (p-value=.24). The chart on the left also depicts the sharp rise in pilot separation responses that act at variance with the rest of the Air Force. The chart on the right captures the same sentiments for pilots in the stay and leave datasets. In both charts, some underlying phenomena are causing these shifts. In the chart on the left, what service factors drive such a significantly higher pilot sentiment versus all other officers? In the chart on the right, *how can pilots that leave have the same view of work-life balance as those who remain?* Statistical methods provide irrefutable evidence that these different relationships exist.

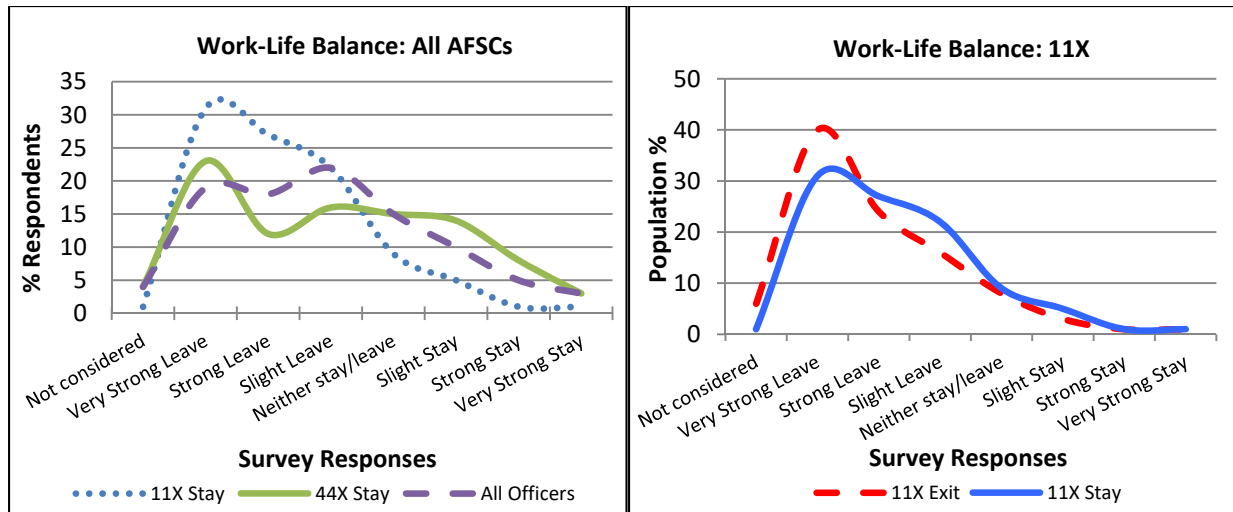


Figure 5. Distributional Shifts in the 2015 Air Force survey.

Along with indicating AFSC differences, Table 4 below indicates many similarities. CSO's and physicians show no difference in sentiments regarding their number of PCS moves compared to all other Air Force officers, but pilots show a heightened awareness towards their number of PCS's. Issues like these deserve more exploration because they act at variance with all Air Force officers. Table 5 reports the power of the Chi-squared test with the lowest statistical power achieved occurring for the 44X and 12X leave datasets due to the low number of samples. The post-hoc effect size for these two groups is .4 instead of .2 in order to achieve 80% power, decreasing the sensitivity in detecting small changes in the survey responses.

AFSC 11X Exit	Significantly different vs AF (X ² Test)	AFSC 12X Exit	Significantly different vs AF (X ² Test)	AFSC 44X Exit	Significantly different vs AF (X ² Test)
Promotion Opportunity	Y-.00	Promotion Opportunity	Y-.01	Job Stress	Y-.00
Senior AF Leaders	Y-.00	Career Development	Y-.04	Senior AF Leadership	N-.06
Number of PCS Moves	Y-.00	Number of PCS Moves	N-.15	Number of PCS Moves	N-.87
Deployment Locations	Y-.00	Deployment Locations	Y-.00	ADSCs	Y-.00
Length of Deployments	Y-.00	Unit Resources	N-.26	Unit Leadership	Y-.00
Number of Deployments	Y-.00	MAJCOM/HQ Leadership	Y-.03	Location Choice	N-.43
Leaving Family	Y-.00	Leaving Family	N-.21	Leaving Family	Y-.00
Children's Needs	Y-.00	TEMPO Away	Y-.02	Children's Needs	N-.82

Work-Life Balance	Y-.00	Work/Life Balance	N-.19	Work/Life Balance	N-.15
Civilian Jobs	Y-.00				
Additional Duties	Y-.00				
AF Evaluation System	Y-.00				
Choice of Job Assignment	Y-.01				
Work Outside Military	N-.43				
AFSC 11X Stay	Significantly different vs AF (X² Test)	AFSC 12X Stay	Significantly different vs AF (X² Test)	AFSC 44X Stay	Significantly different vs AF (X² Test)
Immediate Supervisor	Y-.00	Academic Education	Y-.03	Job Choice	Y-.03
Unit Leadership	Y-.00	Command Opportunity	N-.54	Job Security	Y-.00
Overall Satisfaction	Y-.00	Job Assignment	N-.17	Overall Satisfaction	Y-.00
Career Satisfaction	Y-.00	Career Satisfaction	Y-.00	Career Satisfaction	Y-.00
Mission Contribution	Y-.00	Deployed Experiences	Y-.00	Mission Contribution	Y-.00
Skills Utilization	Y-.00	Skills Utilization	Y-.00	Skills Utilization	Y-.00
Cohesion	Y-.00	Homestead	N-.07	Cohesion	Y-.00
Personnel Relationships	Y-.00	Job Satisfaction	Y-.00	Personnel Relationships	Y-.00
Unit Climate	Y-.00	Unit Climate	Y-.00		
Personnel's Experience	Y-.00	Basic Pay	Y-.00	Basic Pay	Y-.00
Retirement Program	Y-.00	Retirement Program	Y-.02	Retirement Program	Y-.00
Bonuses/Special Pay	Y-.00			Bonus/Special Pay	Y-.00
Patriotism	Y-.00	Patriotism	Y-.02	Patriotism	Y-.00
Work/Life Balance	Y-.00	Tricare Retirement	N-.37	Tricare Retirement	N-.49
		Flight Pay	Y-.00	Medical Specialty Care	Y-.00
		Work/Life Balance	N-.24	Work/Life Balance	Y-.00
		Overall Compensation	Y-.04	Overall Compensation	Y-.00

Table 4. Summarized Influential Questions vs. Air Force Officers.

AFSC	Power	Df	N min	N max	w	α
11X Leave	.86	7	410	412	.2	.05
11X Stay	.99	7	691	737	.2	.05
12X Leave	.84	7	97	97	.4	.05
12X Stay	.99	7	860	922	.2	.05
44X Leave	.85	7	100	100	.4	.05
44X Stay	.79	7	350	353	.2	.05

Table 5. Post-Hoc Power, X² Test.

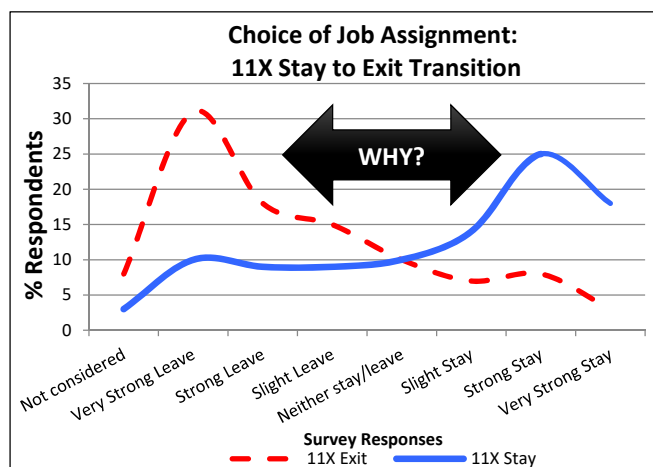


Figure 6. Example of Distributional Shifts in AFSC Sentiments.

All of the theorized influential questions exhibit the approximate response patterns depicted in Figure 6. In this chart, the choice of job assignment for pilots shifts significantly between the leave and stay datasets. Since Hypothesis 1 has detected significant shifts in the data, there is no dispute that AFSC's have different behavioral sentiments. Rather, the question now becomes why the shift.

Hypothesis 2: *Controlling for AFSC, the reported work-life balance factor scores of separated personnel correlate with the influence factor scores of separated personnel. The reported work-life balance factor scores of non-separated personnel correlate with stay-oriented influence factors scores.*

The 2015 Air Force survey data contains the question, "Maintaining work/life balance and meeting family commitments," and asks Airmen to rate if this factor influences them to leave or stay. Work-life balance is highly correlated to some influential questions, while very weakly correlated to others. The work-life balance shifts between the stay and leave groups do not capture the change in turnover sentiments comprehensively as theorized. The Spearman rank-order correlation was used because the survey data are on an ordinal, Likert Scale with categorical variables and because the data categories appear to have a monotonic (move together,

move away) relationship. Correlations for those leaving came from the leave survey, while the correlations for those who stayed came from the stay surveys.

Table 6 below summarizes the highest positive and negative correlation values for the datasets. Positive correlations indicated both work-life balance and theorized influence factors moved in the same direction, while negative correlations indicated work-life balance and the theorized factors moved opposite of each other. Note the small numbers of highly correlated values given that over 20 theorized influence factors comprised each AFSC. Also, note that pilots have a larger number of highly correlated influence factors to work-life balance compared to the other AFSCs. As a single measure, work-life balance results are inconsistent across functional communities. In Figure 7 below, all three AFSC's are significantly different among those who leave and stay with p-values of zero. Pilot and physician AFSCs exhibit a high percentage of leave responses regardless if an Airman leaves or stays. For pilots and physicians, it seems that there are limited work-leave balance gains by separating. For CSOs, the work-life balance shifts indicate that balance is more of an issue for those who leave.

11X Influences	Spearman Correlation to Work-Life	12X Influences	Spearman Correlation to Work-Life	44X Influences	Spearman Correlation to Work-Life
Civilian Jobs	.99	Leaving Family	.98	Location Choice	.87
Leaving Family	.98	Promotion Opportunity	.82	Children's Needs	.76
Non-Mil Work	.98	Overall Compensation	-.78	Job Stress	.88
Number of PCS	.97	Retirement Program	-.71	Job Assignment	.90
Deployment Length	.96	Patriotism	-.73	Medical Specialty Care	-.71
Children's Needs	.94			Overall Satisfaction	.74
Number of Deployments	.94			Retirement Program	-.76
Job Choice	.93			Retirement Tricare	-.76

Retirement Program	-.99				
Cohesion	-.93				
Skills Utilization	-.87				
Patriotism	-.87				

Table 6. Work-Life Balance vs. Influence Factor Correlations.

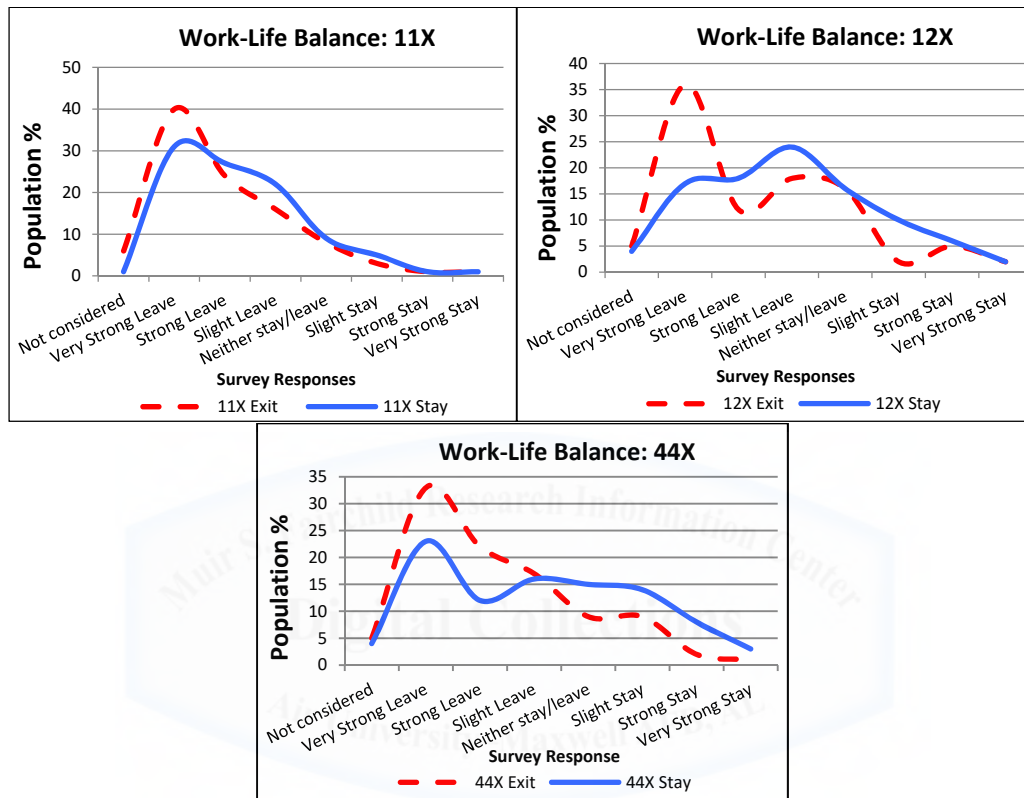


Figure 7. 11X, 12X, 44X Work-Life Balance Shifts.

The results in Table 6 for CSO's and physicians indicate that work-life balance does not capture turnover holistically since the number of correlated factors are few. Therefore, the work-life balance question does not capture the change in turnover sentiments holistically for all research AFSCs. Instead, an aggregation of influential questions like the 11X choice of job in Figure 6 likely captures more of turnover intentions. An overarching, work-life construct does not appear to exist over Airman as a system.

Hypothesis 3: *Controlling for AFSC, the reported work-life balance of separated personnel correlate with leave-oriented external balancing forces such economic opportunities and job offers.*

The work-life balance of the study AFSCs correlate to the reported availability of civilian jobs for pilots only. Like Hypothesis 2, correlations are inconsistent among AFSCs. Table 7 below summarizes the correlation values.

Outcome	11X Spearman Correlation	12X Spearman Correlation	44X Spearman Correlation
Leave	.99	.58	.56
Stay	.98	.87	.73

Table 7. Work-Life to Availability of Civilian Jobs.

For pilots, civilian jobs correlate to work-life balance regardless of turnover intentions (.98, .99). For CSOs and physicians, work-life balance and civilian jobs have a medium-high correlation (.58 to .73). These results again indicate that other factors in a multidimensional context may better explain turnover than work-life balance.

Block 2, Hypotheses 4-6

Factor Theory: Supporting Theories of Turnover

Factor Theory builds on the established behavioral models of Prospect Theory, Spirals, and Sense Making. The assumptions of rational acting and maximum expected utility apply to Airmen making separation decisions: Airmen assess their options, weigh consequences, and arrive at a value-maximizing choice. As summarized in the five cases of Figure 2, cases 2-5 present various negative outcomes for the Air Force and challenge the “black box” HR view of Airmen. Factor Theory may provide a solution by creating explanatory and predictive models of Airmen beyond the “black box” to both retain them and manage work-life imbalances.

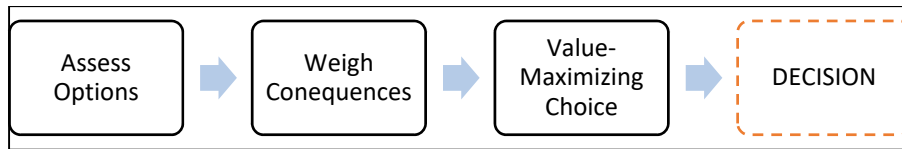


Figure 8. Airmen Decision Making Process.

Research into Factor Theory focuses on two distinct constructs. First, the impact of influential factors on individuals and their decisions; second, how influence factors between AFSC's can differ from one another yet produce the same separation outcomes. This is informative because HR strategies may require further sub-structuring.

Prospect Theory explains decision making under uncertainty as a function of frames of reference, subjective value functions, and gains and losses. A frame of reference is the position from which individuals assess current and present options, while subjective value functions assess the same gains and losses around a reference point.²⁵ Prospect Theory shows that individuals fear losses more than gains and will seek to protect beneficial, status quo states.²⁶ Factor Theory modifies Prospect Theory in two ways. First, Prospect Theory frames gains and losses with respect to monetary positions while Factory Theory allows decisions under both qualitative and quantitative judgments. Second, Prospect Theory looks at a single frame of reference and subjective value function, whereas Factory Theory presumes that many frames of reference and subjective value functions exist around a number of contextual influence factors. Theoretically, Airmen separation should occur when personnel compare the impact of gains and losses around subjective functions and frames of references and determine the benefits are not worth the costs.

Spirals are changes in job experiences that contribute to systematic positive or negative trajectories over time.²⁷ The experiences of Airmen create a *dynamic, real-time ledger* of costs and benefits towards continued service. At some point, this ledger becomes negative and continued service will appear more costly than beneficial. The significance of personal spirals is

that the impact of individual experiences act dynamically over time to create powerful sentiments and perceptions. Spirals indicate that sensitive screening tools can monitor and manage these trajectories and correct negative trends. Deciding to leave the Air Force is not an instantaneous decision; rather, it is a *cumulative process with respect to time*.

Sense Making involves the process by which Airmen interpret “discrepant events” relative to personal standards, understand why these events happened, and form estimates of their likelihood in the future.²⁸ Airmen subconsciously journey along an incremental path of event interpretation and prediction, *creating a chain of events* trending towards separation or continued service. Sense Making is theoretically contextual and can lead to service trends and sentiments that vary in direction and magnitude.

Factor Theory: Influence Factors

While the aforementioned theories underscore the structure of Factor Theory, the established field of descriptive decision theory explains the specific behavior and decisions of Airmen. The more managers and leaders understand what motivates their personnel and influences their behavior, the more effective the organization will be at maximizing productivity and increasing performance.²⁹ In a 1995 study, managers found that the top factors motivating employees changed little from 1946 but more importantly, managers perceptions of *what they perceived mattered* to employees were terribly off.³⁰ This leads to the idea of vital few and enduring influence factors that challenge the black box view of Airmen. Rather than *speculating* about what motivates Airmen, leaders should *know* what motivates them.

Expectancy Theory and the concept of the STV previously developed begin to answer the key question of what drives Airmen separation. Expectancy Theory states that the magnitude of human motivation depends on how much an Airman wants something relative to other things and the probability-effort tradeoff needed to acquire it. The critical takeaways from Expectancy

Theory are that Airmen motivations are dynamic, contextual, and relative to *their* perceptions. The optimal point is the state in which the totality of “want” and probability-effort “get” needs are in balance, in which case military service is a continued benefit. In the five cases of Figure 2, this is the “gets” and “wants” balance of case 1. The extent to which “wants” and “needs” misalign causes service imbalances, leading to the STV of cases 2-5 in Figure 2.

The decision matrix in Table 8 below describes how Airmen weigh influence factors to service outcomes on a contextual scale. In the table, influence factors are the rows while the service outcomes are the columns. The row factors depend on the analytical lens used to measure personnel sentiment, of which there are many in the academic field. In this research, selected questions from the 2015 Air Force survey form the factors. During the decision process, Airmen voluntarily restrict their contextual factors in the rows as they weigh separation. Factors may be both mutually inclusive and exclusive. For example, the opportunity to do something different outside the military also facilitates better options for childhood education and work-life balance, whereas for others this may not be the case. Factor Theory cannot distinguish these mutual inclusions. Rather, it seeks to understand influence factors acting in aggregate.

Influence Factor	Leave	Stay
Factor A (positive) <i>Ops Tempo Good</i>	Good Tempo Discontinued Service	Good Tempo Continued Service
Factor A (negative) <i>Ops Tempo Bad</i>	Bad Tempo Discontinued Service	Bad Tempo Continued Service
Factor B (positive) <i>Opportunities to Command Good</i>	Good Cmd Opportunity Discontinued Service	Good Cmd Opportunity Continued Service
Factor B (negative) <i>Opportunities to Command Bad</i>	Bad Cmd Opportunity Discontinued Service	Bad Cmd Opportunity Continued Service
...		
Decision Summary	[count of factors marked as “Leave” influencers]	[count of factors marked as “Stay” influencers]

Table 8. Decision Matrix.

The bolded conditions under the “leave” and “stay” columns of Table 8 demonstrate the decision rationale of achieving maximum expected utility. Expected utility says that some gain

“...is assessed by comparing utilities of two states of wealth,” and that the utility of gains differ only in the positivity or negativity in relation to two states.³¹ Typically, values of monetary wealth link to expected utility outcomes, but Factor Theory assumes a more generic definition of wealth to include any qualitative or quantitative gain. In the case of Factor A, there is little utility in either the “Good Tempo, Discontinued Service” or “Bad Tempo, Continued Service.” In other words, personnel are unlikely to make a discontinue service judgement if the tempo is good, just as they are unlikely to make a continue service judgement if the tempo is bad. This is because “Good Tempo, Discontinued Service” or “Bad Tempo, Continued Service” are not value-maximizing positions, but sub-optimal realities Airmen have to accept. Consequently, Factor Theory places Airmen choices into good-continue or bad-stop containers (bolded conditions); good-stop and bad-continue logic is assumed irrational. As personnel assess each factor, a running ledger accumulates and the outcome is the difference between stay and leave factor scores. The research postulates that the descriptive decision model in Table 8 is valid if the majority of Airmen separation behaviors act in this manner.

Hypothesis 4a: *Controlling for AFSC, the majority (>50%) of personnel within AFSCs indicating to separate will have a higher score of leave factors than stay. The majority (>50%) of personnel within AFSCs indicating to stay will have a higher score of stay factors than leave.*

Airmen assessments of influential factors should align along contextualized values, norms, and beliefs to form subcultures. Subcultures usually arise in large, decentralized organizations faced with common problems, experiences, or situations.³² Subcultures exist because unique and influential trends within AFSCs force them to “cope with problems of external adaption and internal interaction.”³³ Therefore, differences in influence factor responses are representative of the different service experiences among AFSCs.

Hypothesis 4b: *Different AFSC turnover groups in hypothesis 4a demonstrate different distributions of stay and leave responses to theorized influential factors.*

As the score of leave or stay factors increase, personnel will exhibit more leave or stay behaviors. It is not clear if this is a linear or non-linear relationship. For example, the method used to determine the influence factors (binary logistic regression) allows for nonlinearity between variables, namely survey scores versus turnover outcome.

Hypothesis 5: *Controlling for AFSC, as the difference in leave or stay factor scores increase, the percentage of personnel leaving or staying will increase. As the difference in leave or stay factor scores decrease, the percentage of personnel leaving or staying will decrease.*

Factor Theory expects an approximately symmetrical, s-curve relationship of turnover intention as a function of the difference of the sum of factor scores. Figure 9 indicates the theorized s-curve with the origin as the reference point for Airmen's central value judgement(s). As the difference, or delta, between the sums of factor scores increase, the percentage of personnel reporting an outcome (stay or leave) rise steeply at first, then taper off and achieve little change.

As the number of leave or stay factors become equal, Airmen should have increased sensitivity to differences in factor scores (higher slope of the s-curve). As the number of leave or stay factors grow, Airmen should have decreased sensitivity to differences in factor scores. The sensitivity or slope will decrease because a large number of factors have less discriminatory power in value judgement(s), whereas the sensitivity will increase because fewer factors offer more discriminatory power.

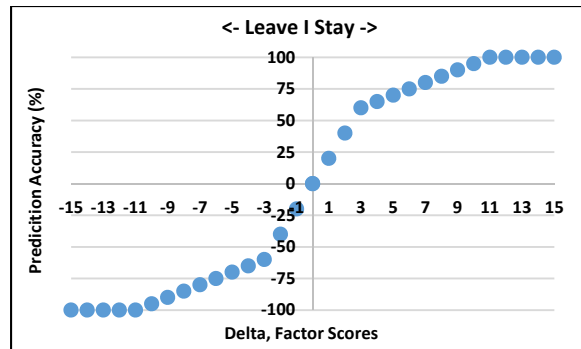


Figure 9. Percentage of Personnel Leaving vs. Difference in Factor Scores.

Hypothesis 6: *Controlling for AFSC, as the difference in leave or stay factor scores increase from the origin, outcome sensitivity will indicate a decreasing curve slope. As the difference in leave or stay factor scores decrease towards the origin, outcome sensitivity will indicate an increasing curve slope.*

Methods & Results: Block 2, Hypotheses 4-6

For the hypotheses in Block 2 and later, the research did not control for Years of Service (YOS) because that data was inaccessible. If the results of the analysis below differ significantly than expected, YOS may play a role among survey respondents.

Hypothesis 4a: *Controlling for AFSC, the majority (>50%) of personnel within AFSCs indicating to separate will have a higher score of leave factors than stay. The majority (>50%) of personnel within AFSCs indicating to stay will have a higher score of stay factors than leave.*

A majority of AFSC personnel separating had a much larger count of leave factors than their stay counterparts, while those AFSC groups who stayed had a much larger count of stay factors. The survey-encoded responses were used to tally the scores marked as “stay” or “leave” for each AFSC group. Scores of two through four counted as leave, while scores six through eight were counted as stay. Each response was given an equal weight even though a score of two equated to “strongly leave” and a score of four was “slight leave.” Scores of one, five, and nine

(“did not consider,” “neither influence,” and “N/A”) were omitted because they had no influence on turnover decisions. Table 9 below summarizes the factor scores.

AFSC	Leave Count	Stay Count	Number of questions	Count percentages
11X Leave	1728	194	9 Leave / 13 Stay	90% Leave / 10% Stay
11X Stay	1861	3169	9 Leave / 13 Stay	36% Leave / 63% Stay
12X Leave	1377	314	9 Leave / 15 Stay	81% Leave / 19% Stay
12X Stay	1142	3271	9 Leave / 15 Stay	26% Leave / 74% Stay
44X Leave	1432	323	9 Leave / 15 Stay	82% Leave / 18% Stay
44X Stay	1551	4246	9 Leave / 15 Stay	27% Leave / 73% Stay

Table 9. Stay & Leave Factor Scores.

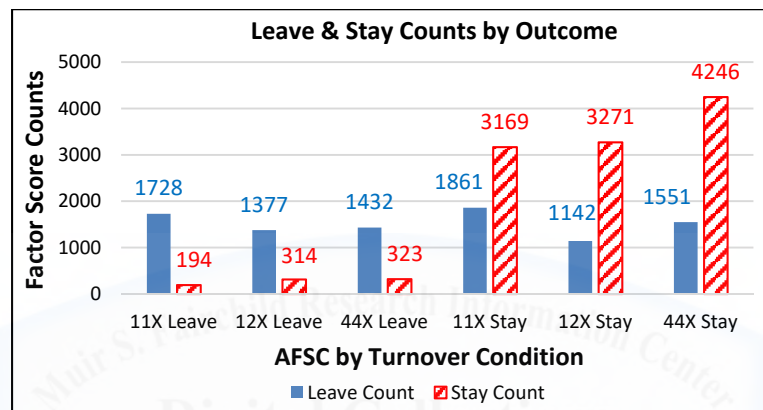


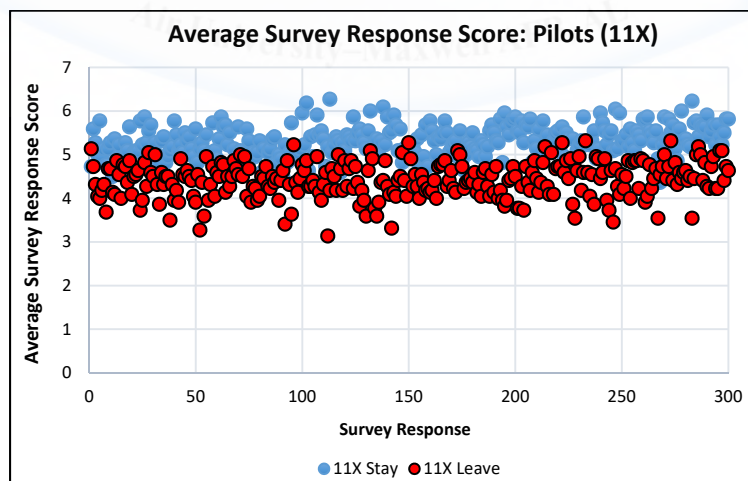
Figure 10. Leave and Stay Counts by AFSC & Outcome.

As noted in Table 9 above, those who either stayed or left had a higher outcome count than the opposing category. Across all AFSCs, the count of leave factors was much higher than the stay factors, even though the numbers of stay factors (13 or 15) were greater in all cases. In all stay surveys, the counts of stay factors were quite high when Airmen stayed, while very low when leaving. On the other hand, the counts of leave factors across AFSCs remain relatively constant regardless of turnover state. *What likely forces turnover then is the reduction in reasons to stay over reasons to leave.* It is as if Airmen experience certain factors as enduring leave influences, while a number of critical stay factors keep them serving. This is informative for four reasons. First, *a retention strategy should focus on stay factors*, as they appear to drive turnover more than leave factors. Second, there should exist a shift in scores between the stay and leave groups across all AFSCs. Third, even though the number of stay factor questions was greater

than leave factor questions, it does not appear to dominate the leave turnover results. Fourth, the presence of small percentages of opposite sentiments indicates a minority of Airmen staying when reporting leaving, and vice versa. If the split among stay and leave responses were closer to 50%, later hypotheses could expect significant error in turnover predictions because leave and stay sentiments would indicate no difference in actual turnover.³⁴ The percentages of Table 9 and Figure 10 above indicate this should not be the case.

Hypothesis 4b: *Different AFSC turnover groups in hypothesis 4a demonstrate different distributions of “stay” and “leave” responses to theorized influential factors.*

The average response distributions of separated and remaining personnel are significantly different, indicating definite shifts in population behaviors. The average survey responses indicate the trends of Figure 11 below. Note the distinct grouping of stay versus leave responses with the region of small overlap along with the slow rise of average scores responses likely due to imperfect resampling methods.



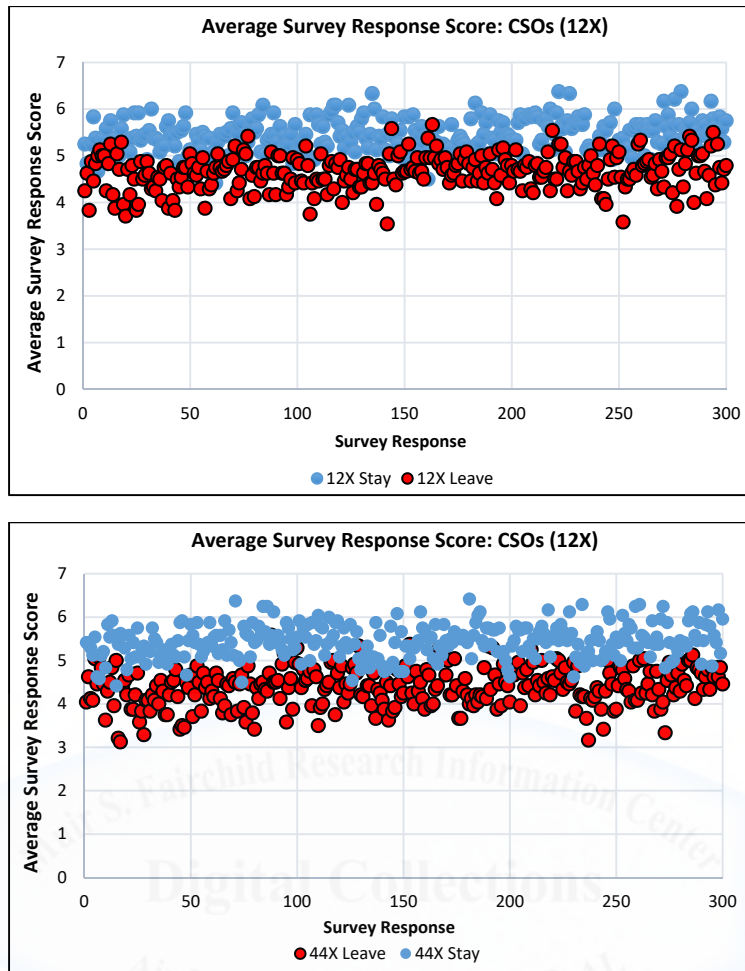
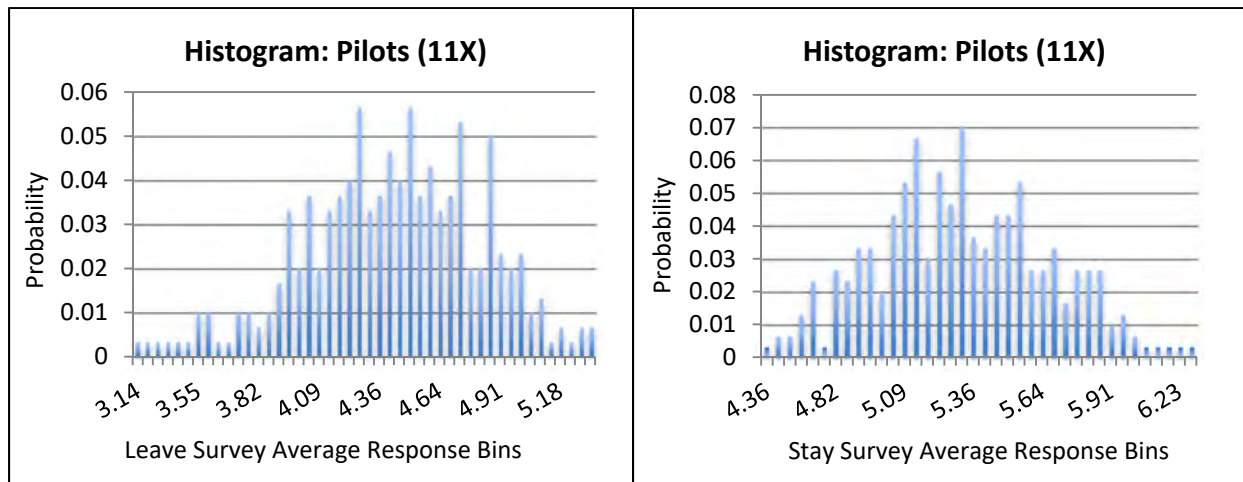


Figure 11. Average Survey Scores by AFSC, Stay vs. Leave.

Histograms of the responses in Figure 12 were created for the stay and leave groups of each AFSC and tested for significant difference using a two-sample t-test. Note the histograms below are each normally distributed and differ in responses at the .05 level of significance.



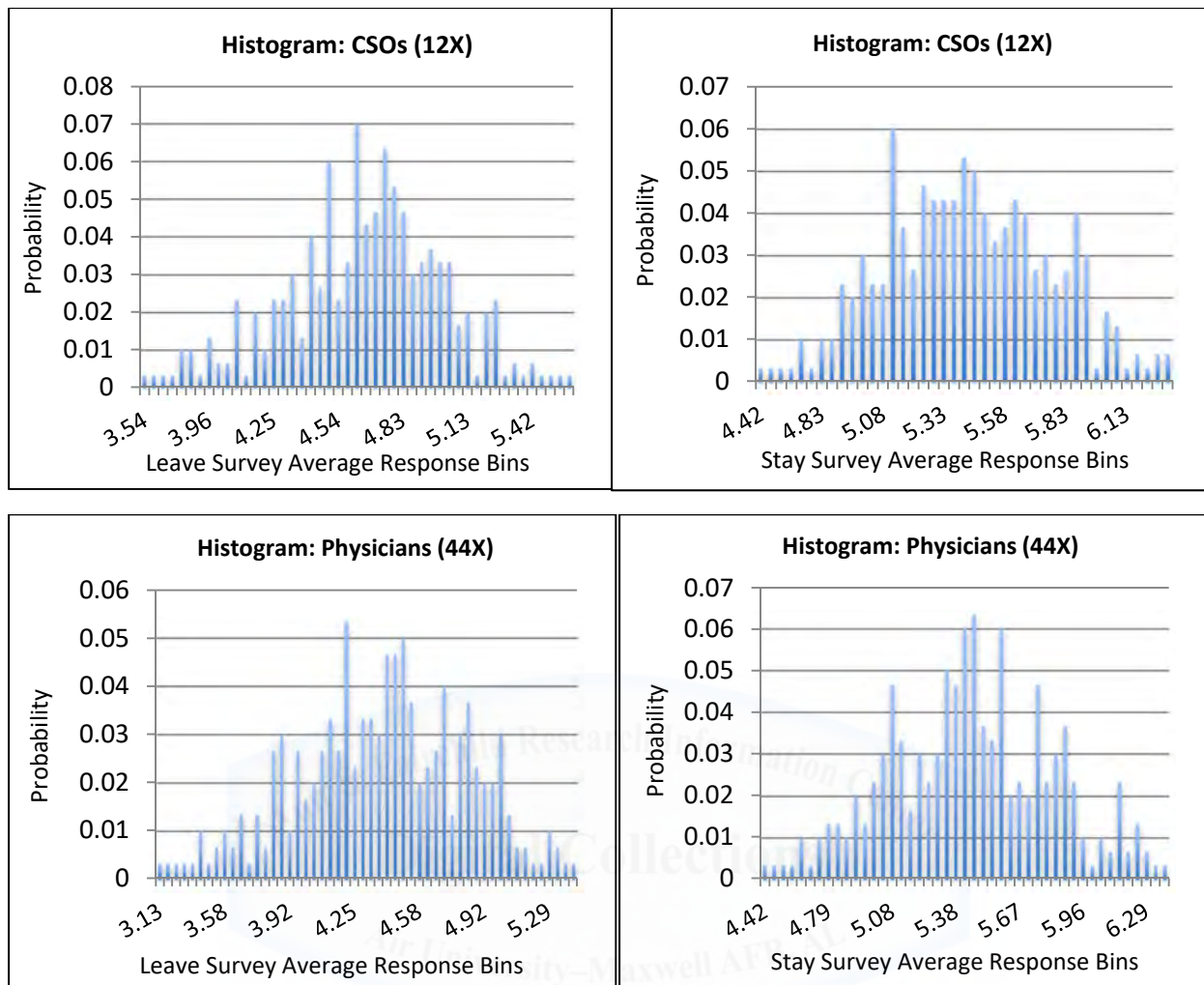


Figure 12. Histograms, Stay vs. Leave & Normality.

Because of the normality of average responses exhibited in Figure 12, the probability of occurrence for a response is expressible as the likelihood of one outcome over another in Table 10. For any Airman's response to the influential questions, the likelihood of them leaving versus staying and vice-versa is determinable at the .05 level of significance. Note the high model fit (R^2) and that x_1 or x_2 for each AFSC is the average leave or stay survey score. Table 13 indicates which questions are considered stay versus leave factors while Attachment 2 contains the survey questions to compute x_1 and x_2 .

$$(1) \text{ Leave vs. Stay Likelihood} = 1 \times 10^{12} \times e^{-5.69x_1}$$

$$\text{Model Fit } R^2 = .87$$

$x_1 = \text{Average Leave Factor Score}$

$$(2) \text{ Stay vs. Leave Likelihood} = 5 \times 10^{-13} \times e^{5.84x_2}$$

Model Fit $R^2 = .86$

$x_2 = \text{Average Stay Factor Score}$

Pilot Turnover Likelihood = Greater of (1) or (2)

Pilots (11X)

$$(3) \text{ Leave vs. Stay Likelihood} = 9 \times 10^{11} \times e^{-5.46x_1}$$

Model Fit $R^2 = .88$

$x_1 = \text{Average Leave Factor Score}$

$$(4) \text{ Stay vs. Leave Likelihood} = 1 \times 10^{-12} \times e^{5.46x_2}$$

Model Fit $R^2 = .88$

$x_2 = \text{Average Stay Factor Score}$

CSO Turnover Likelihood = Greater of (3) or (4)

CSOs (12X)

$$(5) \text{ Leave vs. Stay Likelihood} = 2 \times 10^{11} \times e^{-5.31x_1}$$

Model Fit $R^2 = .90$

$x_1 = \text{Average Leave Factor Score}$

$$(6) \text{ Stay vs. Leave Likelihood} = 2 \times 10^{-12} \times e^{5.46x_2}$$

Model Fit $R^2 = .88$

$x_2 = \text{Average Stay Factor Score}$

Physician Turnover Likelihood = Greater of (5) or (6)

Physicians (44X)

Table 10. Leave & Stay Likelihood by AFSC.

Hypothesis 5: Controlling for AFSC, as the difference in leave or stay factor scores increase, the percentage of personnel leaving or staying will increase. As the difference in leave or stay factor scores decrease, the percentage of personnel leaving or staying will decrease.

Two different analytical lenses were used to test this hypothesis. In the first approach, both influence factor scores and responses were equally weighted towards turnover, while in the second approach, factor scores and responses were weighted unequally. The second approach was developed because the survey questions had three levels of stay and leave influences in factor questions (slight, strong, very strong), requiring a weighted analysis method. The difference in the results forms the trade space in turnover prediction accuracies of the two assumptions.

Case 1, Equal Factor Weights

In Case 1, turnover prediction is dependent upon the difference in factor scores using equal weighting. Here, “strongly leave” has the same impact on turnover as “slightly leave,” the more unrealistic of the two weighting methods. No average score probability analysis was provided in Case 1. The resulting turnover formulas are indicated in Figure 13 below.

$$\begin{aligned}
 \text{Turnover Prediction} &= \sum \# \text{ of Leave Response Scores} - \sum \# \text{ of Stay Response Scores} \\
 \text{Turnover Prediction} + \text{ } &= \text{Leave} \\
 \text{Turnover Prediction} - \text{ } &= \text{Stay} \\
 \text{Accuracy for given Delta Count} &= \left| \frac{\text{Predicted Turnover}}{\text{Actual Turnover}} \right|
 \end{aligned}$$

Figure 13. Prediction Formulas & S-Curves, by AFSC.

As the difference in leave or stay factors scores increase, the percentage of personnel leaving or staying increase. As the difference in leave or stay factor scores decrease, the percentage of personnel leaving or staying decrease. Table 11 below summarizes the prediction accuracy as a function of the factor counts, while Figure 14 indicates a single AFSC’s turnover s-curve.³⁵

Delta, Factor Counts + : Leave - : Stay	AFSC 11X Outcome Prediction Accuracy	AFSC 12X Outcome Prediction Accuracy	AFSC 44X Outcome Prediction Accuracy
≤ 4	100%	100%	100%
3	94%	100%	98%
2	95%	100%	93%
1	38%	100%	82%
0	0%	0%	0%
-1	100%	38%	81%
-2	100%	73%	95%
≥ -3	100%	100%	100%

Table 11. Turnover S-Curve Predicted Accuracy vs. Delta Factor Counts.

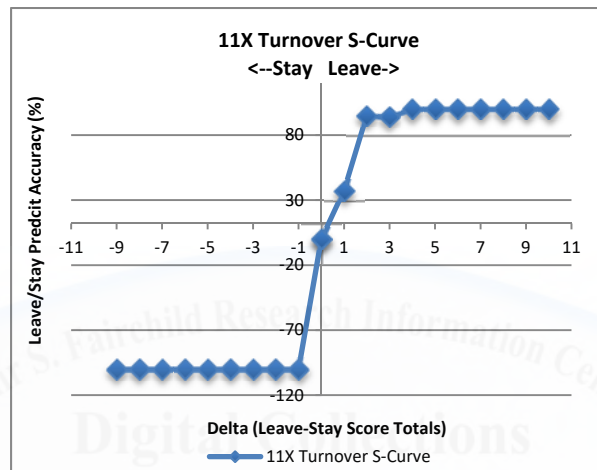


Figure 14. Turnover S-Curve, Pilots (11X), Case 1 Method.

The outcome prediction accuracy decreases for each AFSC dissimilarly. For pilots, the breakdown is exclusively on the positive side of the factor count (0-3), indicating that some factors within the stay influence questions are perceived as leave-oriented for some Airmen. As question response distributions flatten from their bell-curve shape, the accuracy of the s-curve predictions decrease. For CSOs the trend is opposite, indicating that some leave questions are perceived as stay-oriented. For physicians, the breakdown is approximately symmetrical about zero indicating both the leave and stay questions exhibit flattening of their bell-curve responses. Therefore, by assuming equal response and influence factor weights, predictions become less accurate about the origin. The separation threshold values for each AFSC lie in the region defined by the prediction accuracy fall-offs.

Case 2, Unequal Factor Weights

In Case 2, turnover prediction is the difference in factor scores using unequal factor weighting from Hypothesis 7. As survey responses are multiplied by their factor weights, Airmen indicate distinct stay or leave intentions. For example, “strongly leave” (encoded value of 2) multiplied by the influence factor weight (2 x 1.21, etc.) summed across all survey responses (2 x 1.21 + 3 x 1.45 + ...). The resulting turnover formulas, prediction s-curves, and accuracies are indicated in Figure 15, 16 and Table 12 below.

$$Outcome\ Score_{Leave\ or\ Stay} = \sum_{1}^n (Response\ Score_n) \times (Factor\ Weight_n)$$

$$Turnover\ Prediction = |Outcome\ Score_{Stay}| - |Outcome\ Score_{Leave}|$$

$$Turnover\ Prediction\ "+" = Stay$$

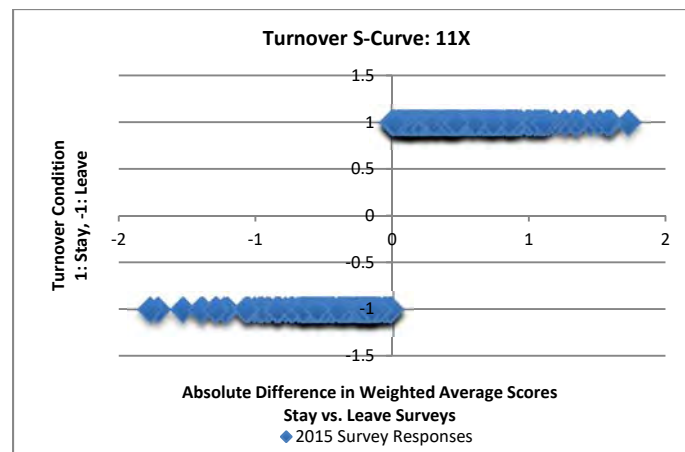
$$Turnover\ Prediction\ "-" = Leave$$

$$Accuracy\ for\ given\ Delta\ Count = \left| \frac{Predicted\ Turnover}{Actual\ Turnover} \right|$$

Figure 15. Turnover Prediction Formulas & S-Curves.

Delta, Factor Counts + : Leave - : Stay	AFSC 11X Outcome Prediction Accuracy	AFSC 12X Outcome Prediction Accuracy	AFSC 44X Outcome Prediction Accuracy
> 0	100%	100%	100%
0	100%	100%	100%

Table 12. Turnover S-Curve Predicted Accuracy vs. Delta Factor Counts.



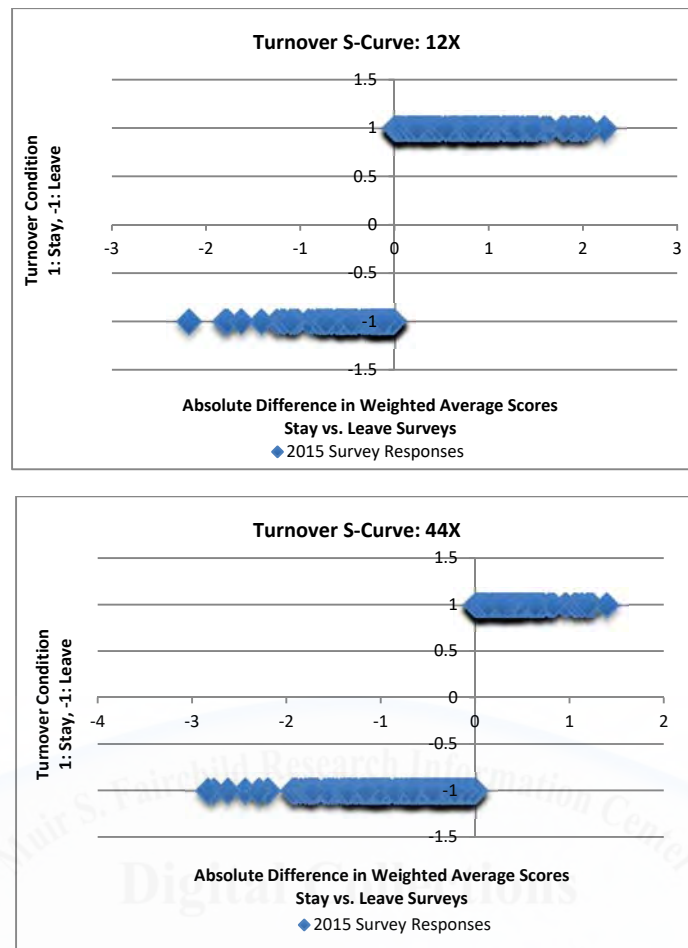


Figure 16. Turnover S-Curves by AFSC.

Hypothesis 6: *Controlling for AFSC, as the difference in leave or stay factor scores increase from the origin, outcome sensitivity will indicate a decreasing curve slope. As the difference in leave or stay factor scores decrease towards the origin, outcome sensitivity will indicate an increasing curve slope.*

In Case 1, as factor score differences approach and depart the origin, they exhibit increasing and decreasing curve slopes, respectively. As Prospect Theory predicts, the turnover s-curves exemplified by Figure 16 denote increased outcome sensitivity about the origin. As influence factor scores transition from leave to stay and vice-versa, the extent of “wants” and “gets” alignment become clear for Airmen. This is because a fewer number of influence factors have more discriminatory power in service decisions. In Figure 16, pilots appear more sensitive

to factor imbalances than CSOs tolerating only one-third of the CSO factor imbalance before separating. Likewise, CSOs tolerate pilot imbalances for three times longer. This aligns with CSO's low voluntarily separation rate (20%), high involuntary separation rate (47%), and lowest perception of civilian job opportunities (four times poorer perception than pilots and physicians combined).

It appears that military-civilian mobility plays a role in separation. The perceived immobility of CSO skills tends to retain them after pilots or physicians would have left. This supports the idea that increasing the “stickiness” of Airmen skills such that they are less portable to the civilian market may retain them longer.

In Case 2, the transition from stay to leave is nearly instantaneous because of survey score multiplication by their AFSC factor weights; the changing curve slope through the origin seen in Case 1 does not exist. When considering the more likely weighted case, very little sensitivity attributes to decreasing factors. In Case 2, it appears that weighting heavily influences turnover decisions.

Validation of the Case 2 model performed well using the 2018 ACSC student population considering its basis on 2015 sentiments from the entire Air Force population. The actual accuracy of the model is 82% and differs from the theorized accuracy of 90% for three reasons. First, ACSC pilots are more committed to the Air Force and willing to tolerate higher levels of factor imbalance. This is of concern from a performance perspective because the model of Airmen as a system indicates they are operating in a degraded state. Second, ACSC pilots will have different factor weights than the general population of pilots. Finally, pilots in 2018 value different influence factors than pilots from 2015. A new model based on 2018 data should increase accuracy for both the ACSC and overall Air Force pilot population. Figure 17 below indicates very good model accuracy of 82% with the ACSC student population of pilots

indicated in red. The model assumptions in blue are from the 2015 Air Force survey. Streamlined surveys using the influential turnover factors are located in Attachment 2 for each of the research AFSC's.

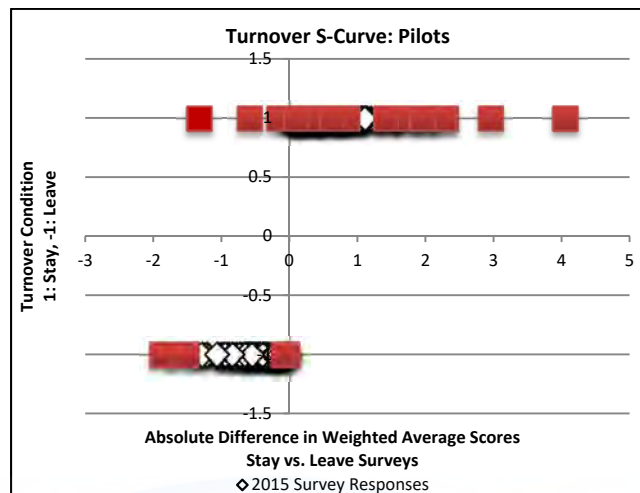


Figure 17. Actual Turnover Model Performance, ACSC Pilots (11X).

Block 3: Hypotheses 7

A model of aggregate AFSC behavior as a function of influential factor responses may yield powerful explanatory and accurate results than linear calculations. By combining all factor responses in relation to outcomes, various non-linear statistical methods can shed light on relationships and correlations not seen by simple, first-order techniques. Unified models of AFSC behavior may predict behaviors across various organizations by recognizing when factor scores align in turnover outcomes.

Methods & Results, Block 3: Hypothesis 7

Hypothesis 7: *As factor scores align with personnel known to have separated from the Air Force, an Airman is more likely to separate. As factor scores align with personnel known to have stayed in the Air Force, an Airman is more likely to stay.*

A unified model of influential factors by AFSC was created by combining the manually sorted questions into a single dataset. Binary logistic regression analyzed the leave and stay responses by ASFC and then reported the statistical significance of each theorized influence factor in the model.

Logistic regression can handle qualitative responses such as those found in the Likert Scale of the Air Force surveys. Since the leave survey was administered to personnel with a DOS, the responses in that survey were attributed to a leave or an encoded “0” behavior; this is the unsuccessful condition. Likewise, since the stay survey was administered to personnel not separating, the responses in that survey were attributed to a stay or an encoded “1” behavior; this is the successful condition. The following assumptions were met for the Logistic Regression:³⁶

- Cases are independent
- Does NOT assume a linear relationship between the dependent variable and the independent variables
- Independent variables can be the power terms or some other nonlinear transformations
- The dependent variable assumes a binomial distribution of the response
- Equal variance does NOT need to be satisfied
- Errors need to be independent but NOT normally distributed
- Goodness-of-fit measures rely on sufficiently large samples; not more than 20% of the cells' counts are less than 5

While personnel in service participated in the stay survey, it does not indicate that the population is completely representative of a stay decision. Some members of the 2015 survey may actually have separated after the survey was completed, so attributing a stay outcome to that dataset is only as accurate as saying personnel did not have a DOS. This fact should result in

actual predictive errors, the extent of which is unknowable. Additionally, some of the populations sampled in the leave surveys entered the Air National Guard and Reserves rather than terminate military service completely. Within the context of Active Duty service however, they left. In Figure 18, the first question of the stay survey asks the respondents about their future status.

What are your current intentions toward remaining in the Air Force beyond your present service commitment?	All (n=13640)	Core_11F (n=738)
	%	%
Definitely will remain in the Air Force beyond current service commitment	27	12
Probably will remain in the Air Force beyond current service commitment	23	18
Leaning toward remaining in the Air Force beyond current service commitment	13	14
Undecided	12	18
Leaning toward NOT remaining in the Air Force beyond current service commitment	9	14
Probably will NOT remain in the Air Force beyond current service commitment	9	17
Definitely will NOT remain in the Air Force beyond current service commitment	6	7
Total	100	100

Figure 18. Percentage of Survey Participants with Undetermined Future Status.

Note that 38% of those responding were leaning towards not staying in the Air Force past their current service commitment. Likewise, 44% were leaning towards remaining with 18% undecided. Splitting the undecided amongst the leave and stay groups results in 47% and 53% leaving and staying-a nearly equal split. This is indicative of the error potential in saying all stay survey participants actually stayed. There were a number of options:

- Assume that the stay survey data is representative of a stay decision (100% stay)
- Assume that the stay survey data is not representative of a stay decision (0% stay)
- Use the classification cutoff value of the statistical analysis package to account for stay decision ambiguity in the data (50% split) & accept some real-world error³⁷

Binary logistic regression produces a probability that the success condition (staying) is 100%. The Excel RealStats package uses a classification cutoff value that takes the value specified (for example, .5) and attributes anything larger to a success condition. In this way, the

classification cutoff accounts for imperfection in the case respondents will leave after reporting they would stay. As Figure 18 indicates, a very reasonable value for the classification cutoff should be .5 (50%) since a nearly equal split exists among the leave and stay groups. It would be unreasonable to set a classification cutoff to .2, indicating there is evidence to believe that 80% of the respondents in the stay survey will indeed stay while 20% will leave. Likewise, a cutoff value of .9 would overly restrict the logistic regression results around near perfect stay behavior. Using a classification cutoff value of .5 should provide realistic results.

The leave and stay survey data were provided in categorical, summary form. Based on Air Force data privacy concerns, there is no way to see the individual survey results for each Airman. In order to recreate the source data for the logistic regression, a large number of synthetic responses were generated from each question's sample population using Microsoft Excel's Solver tool (with replacement). Figure 19 below indicates the actual question distribution on the left and the synthetic distribution results on the right for a run of 70 samples. Note the good similarity of the distributions by Likert response category.

Likert Cat	Q7_3 Pop	Resampled Q7_3 Pop
1	4%	3%
2	6%	4%
3	5%	4%
4	4%	4%
5	14%	10%
6	28%	31%
7	39%	43%

Figure 19. Excel Solver Synthetic Data Validity.

In the first run of the logistic regression analysis, a number of questions appeared insignificant to each ASFC model. For example, six factors were removed as insignificant in the 11X first run. The final, unified models arrived at 22, 24, and 24 factors for the 11X, 12X, and 44X AFSCs, respectively. The models included prediction accuracy, pseudo-R² values, Hosmer-Lemeshow goodness of fit tests, and odds ratios (factor weights) related to turnover. Of note, the Hosmer-Lemeshow test determines if the model is a poor fit by testing if its data conflicts with

the assumptions of binary logistic regression. P-values less than .05 indicate a poor fit, while p-values greater than .05 indicate there is no evidence of poor fit. Values for an approximate R^2 value were included for those familiar with linear regression model fitting. Table 13 summarizes the unified model statistics for each AFSC while equations (1)-(5) in the following pages provide the turnover prediction equations. The General Air Force (GAF) Model was developed based on all Air Force officers in the 2015 survey data and provides a flexible alternative.

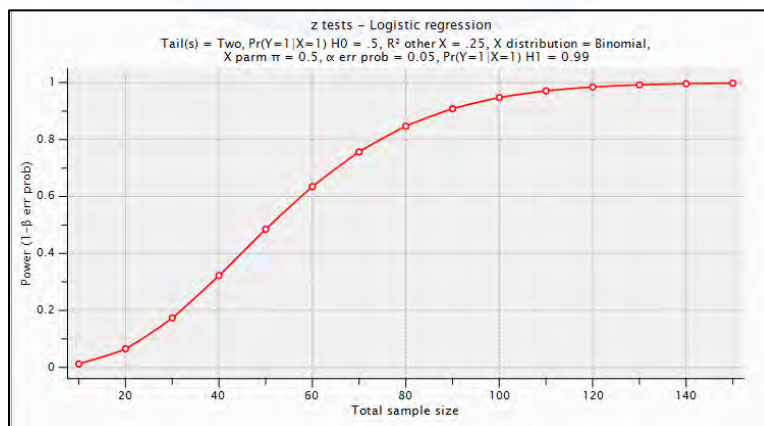
AFSC	Prediction Accuracy	Pseudo- R^2 (N/CS/L/L _{ADJ})	Hosmer-Lemeshow Fit Test	Approximate R^2 Value ³⁸
11X	90.7%	.69/.61/.82/.63	1 – No poor fit	> 90%
12X	88.5%	.62/.58/.77/.58	.69 – No poor fit	> 90%
44X	91.7%	.71/.63/.84/.65	.10 – No poor fit	> 90%
GAF	88.3%	.77/.58/.63/.58	.99 – No poor fit	> 90%

Table 13. AFSC Unified Model Statistics.

Figure 20 below depicts the power of the logistic regression models. H_1 was defined as someone staying given factors shown in the exit surveys indicative of leaving; this was set at 99% since all respondents in the exit survey separated. H_0 was defined as someone staying given factors that have not been shown in the retention surveys indicative of leaving; this was set at 50% since survey respondents stated they were split if they were going to separate. R^2 was set .25 ($R=.5$, therefore $R^2 = .25$) because the independent variables (factors) indicate a moderate to strong association with the dependent turnover variable. The “X parm $\pi = 50\%$ ” is the proportion of the sample believed to exhibit separation behavior. At a sample size above 127, power approximates to 1 with required power of .8 requiring at 75 survey samples. If the R^2 value is increased to a worst-case .81 at a required power of .8 while leaving all else constant, the sample size must at least equal 294. The actual sample sizes in each logistic regression model were 600, so even in the worst-case condition achieved power was greater than .8.

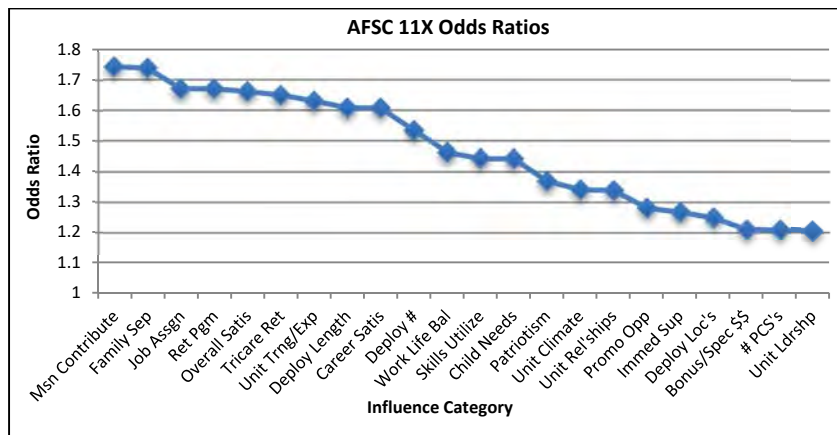
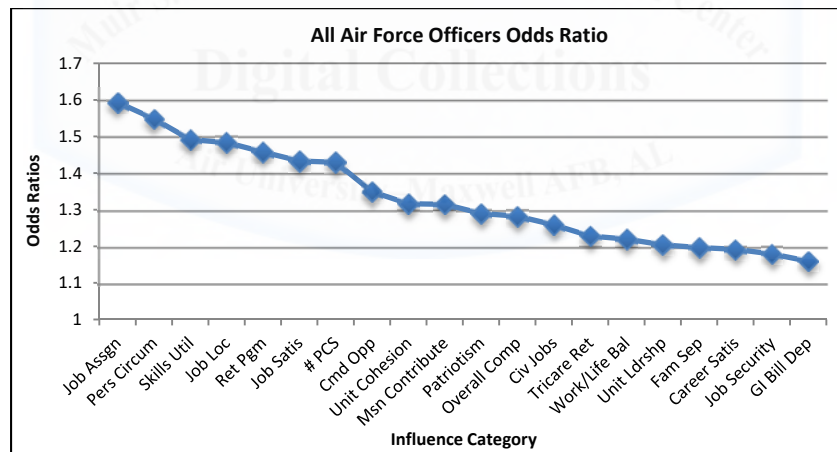
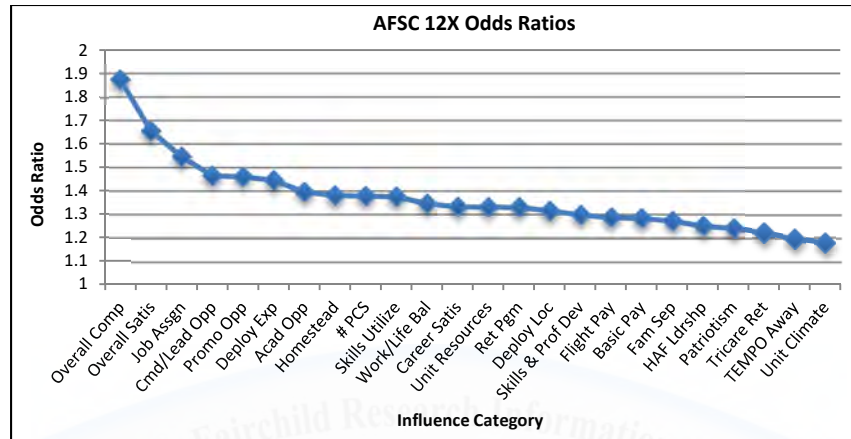
The prediction accuracies of Table 13 for each unified model are extremely high (approximately 90%). An accuracy value of .5 would indicate the models are no better than

chance at predicting turnover. The pseudo- R^2 values explain the total variability captured by the model and is similar to the R^2 value used in other regression methods. Low values indicate that a model does not capture the true relationships between the independent variables (x) and the dependent variable (y), while high values do. Whereas R^2 values are an ordinary least squares measure of the variance explained by the model and evaluated between zero and one, pseudo- R^2 values have a minimum value of zero and rarely approach one because they are based on a maximum likelihood calculation.³⁹ Three pseudo- R^2 values are presented for the unified models: Nagelkerke's (N), Cox and Snell's (CS), McFadden's (L), and an adjusted McFadden's. Each AFSC model was iterated by evaluating the significance of each influence factor, with the three pseudo- R^2 measures steadily improving to the final Table 13 values. Ranges above .4 for McFadden's measure are considered excellent and equivalent to an R^2 value of .9.⁴⁰ The adjusted McFadden corrects for additional factors that do not explain the relationship between the independent and dependent variables. Along with the pseudo- R^2 values, the Hosmer-Lemeshow fit tests indicate all models fit the data well.



Input Parameters		Output Parameters	
Tail(s)	Two	Critical z	1.9599640
Determine =>	Pr(Y=1 X=1) H1	Total sample size	127
	Pr(Y=1 X=1) H0	Actual power	0.9903430
	α err prob		
	Power (1- β err prob)		
	R ² other X		
	X distribution		
	X parm π		

Figure 20. Binary Logistic Regression Power.⁴¹



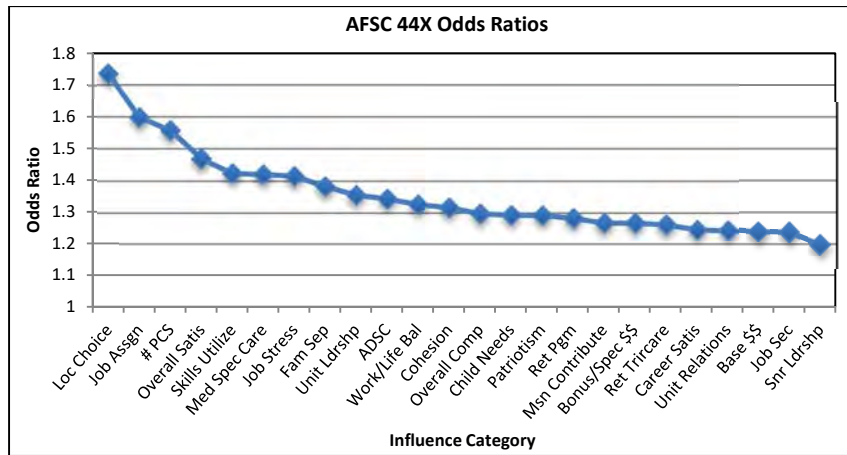


Figure 21. AFSC Odds Ratios (Factor Weights).

$$p_i = 1/1 + e^{-a-bx_1 \dots -bx_n}$$

(1) General Logistic Regression Equation

$$p_i = 1/1 + e^{40.92 - 2477x_1 - 1904x_2 - 2224x_3 - 4749x_4 - 4279x_5 - 5529x_6 - 3803x_7 - 3662x_8 - 5131x_9 - 2370x_{10} - 1865x_{11} - 5077x_{12} - 4746x_{13} - 5553x_{14} - 3670x_{15} - 2918x_{16} - 4886x_{17} - 2941x_{18} - 1908x_{19} - 5130x_{20} - 3144x_{21} - 5006x_{22}}$$

(2) Logistic Regression Equation: 11X

$$p_i = 1/1 + e^{37.97 - 3787x_1 - 2610x_2 - 3209x_3 - 2742x_4 - 2403x_5 - 2235x_6 - 2860x_7 - 1782x_8 - 2974x_9 - 3331x_{10} - 3816x_{11} - 4357x_{12} - 3227x_{13} - 3682x_{14} - 5041x_{15} - 2874x_{16} - 3187x_{17} - 1641x_{18} - 2501x_{19} - 2858x_{20} - 6276x_{21} - 2159x_{22} - 1992x_{23} - 2521x_{24}}$$

(3) Logistic Regression Equation: 12X

$$p_i = 1/1 + e^{35.0423 - 2825x_1 - 2573x_2 - 3479x_3 - 2959x_4 - 3048x_5 - 1800x_6 - 3244x_7 - 4430x_8 - 5511x_9 - 4689x_{10} - 3847x_{11} - 2116x_{12} - 2209x_{13} - 2380x_{14} - 3540x_{15} - 2755x_{16} - 2186x_{17} - 2377x_{18} - 2137x_{19} - 2498x_{20} - 2606x_{21} - 2562x_{22} - 3512x_{23} - 2336x_{24}}$$

(4) Logistic Regression Equation: 44X

$$p_i = 1/1 + e^{28.48 - 4658x_1 - 3944x_2 - 1794x_3 - 1857x_4 - 3598x_5 - 1648x_6 - 1753x_7 - 2736x_8 - 4000x_9 - 2749x_{10} - 1480x_{11} - 3769x_{12} - 2486x_{13} - 2545x_{14} - 1985x_{15} - 2053x_{16} - 2993x_{17} - 3573x_{18} - 4370x_{19} - 2301x_{20}}$$

(5) Logistic Regression Equation: All Air Force Officers (GAF)

The odds ratios of Figure 21 above represent the weight of each influence factor on turnover decisions. A one-unit change in survey sentiments in either direction (very strongly leave to strongly leave, vice-versa) results in the decrease or increase of turnover probability by the amount of the odds ratio. For example, an odds ratio of 1.72 indicates that for every one-unit change in reported survey question sentiment, the odds an Airman stays or leaves changes by 72%. An Airman's probability of stay or leave is determined by the direction of the sentiment change.

The practical result of the logistic regression models is fitting a mathematical equation to turnover at a stated accuracy and pseudo-R² value. Both the high accuracy and pseudo-R² values of Table 13 indicate excellent model fit to the dataset. While many possible influence factors can cause turnover, the factors identified were restricted to those available in the 2015 Air Force Survey. For example, another reputable academic survey like the Meyers Three-Component Model will frame turnover around measures of organizational commitment. Likewise, the 2015 survey did not address issues such as commissary, welfare and recreation, and base education services in regards to turnover. Table 14 below lists the separation factors for each research AFSC.

11X Factors	12X Factors	44X Factors
<i>Promotion Opportunity</i>	<i>Promotion Opportunity</i>	<i>Work/Life Balance</i>
<i># PCS's</i>	<i>Skills & Professional Development</i>	<i>Children's Needs</i>
<i>Deployment Locations</i>	<i># PCS's</i>	<i>Job Stress</i>
<i>Deployment Length</i>	<i>Deployment Locations</i>	<i>ADSC</i>
<i>Deployment Number</i>	<i>Family Separation</i>	<i>Unit Leadership</i>
<i>Family Separation</i>	<i>HAF Leadership</i>	<i>Senior Leadership</i>
<i>Work Life Balance</i>	<i>Unit Resources</i>	<i>Family Separation</i>
<i>Children Needs</i>	<i>TEMPO Away</i>	<i># PCS</i>
<i>Job Assignment</i>	<i>Work/Life Balance</i>	<i>Location Choice</i>
<i>Immediate Supervisor</i>	<i>Academic Opportunities</i>	<i>Job Assignment</i>
<i>Unit Leadership</i>	<i>Command/Leadership Opportunities</i>	<i>Overall Satisfaction</i>
<i>Overall Satisfaction</i>	<i>Job Assignment</i>	<i>Job Security</i>
<i>Career Satisfaction</i>	<i>Homestead</i>	<i>Career Satisfaction</i>
<i>Mission Contribution</i>	<i>Deployment Experiences</i>	<i>Mission Contribution</i>
<i>Skills Utilization</i>	<i>Overall Satisfaction</i>	<i>Skills Utilization</i>
<i>Unit Relationships</i>	<i>Career Satisfaction</i>	<i>Cohesion</i>
<i>Unit Training & Experience</i>	<i>Skills Utilization</i>	<i>Unit Relationships</i>
<i>Unit Climate</i>	<i>Unit Climate</i>	<i>Bonus/Special \$\$</i>
<i>Bonus/Special \$\$</i>	<i>Basic Pay</i>	<i>Base \$\$</i>
<i>Retirement Program</i>	<i>Retirement Program</i>	<i>Retirement Program</i>
<i>Patriotism</i>	<i>Overall Compensation</i>	<i>Overall Compensation</i>
<i>Tricare in Retirement</i>	<i>Patriotism</i>	<i>Patriotism</i>
	<i>Tricare in Retirement</i>	<i>Medical Specialty Care</i>
	<i>Flight Pay</i>	<i>Tricare in Retirement</i>
Note: Italicized factors are leave-oriented factors		

Table 14. AFSC Leave and Stay Factors.

A scalable turnover prediction tool for HR practitioners is depicted in Figure 22 below using the equations (2) through (4) above. The Excel-based spreadsheet allows the user to input scores from the correlated survey questions of Attachment 2 and calculate the probability an individual will stay in the Air Force. Because the final surveys use 22-24 questions (factors) of the original 99, small-scale delivery methods such as through mobile devices or direct mail are realistic. The tool quickly allows the Air Force to understand what motivates *each* Airman's turnover intentions as a function of their service factors. Utilizing these turnover-measuring tools operationalizes analytics, mathematics, and facilitates the active management of personnel to minimize turnover. The implications of these models and tools are discussed in Part 3 as a future talent management system. When applying this tool on the 2018 ACSC student population of pilots, it was 86% accurate in predicting turnover versus the previous model's 82% accuracy. Attachment 3 contains the Excel-based prediction calculators for leaders and managers.

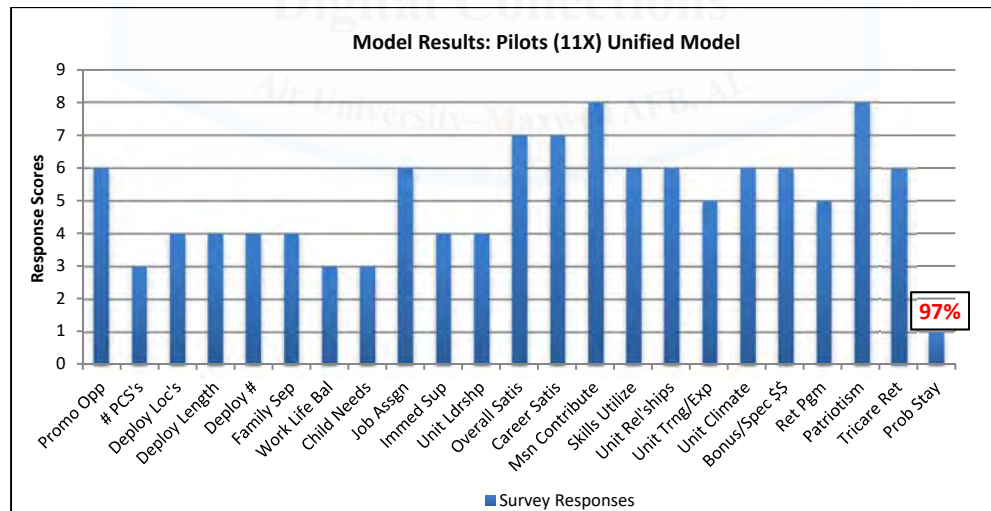


Figure 22. Excel Turnover Prediction Tool.

The 2015 leave surveys ask Airmen to rank a series of questions and has often been cited by senior leaders as the reasons for Airmen turnover.⁴² These questions do not frame the responses about separation or retention; rather they are a non-contextual list. Neither do the questions appear in the 2015 stay survey, resulting in a leave-focused list. The aforementioned

unified models present a holistic view that is counterfactual to the rhetoric on separation. Figure 10 in prior pages demonstrates that separation is driven by a loss in service benefits rather than an increase in costs. Additionally, some stay-focused issues may be easier to deal with than systematic, leave-focused issues. Unfortunately, the data indicates that focusing on leave factors alone eliminates the other half of the solution space. For example, the top factor in the unified pilot model (mission contribution) does not even register in the leave model because it is the top reason to stay. Therefore, mission contribution is overlooked because leadership only considers those issues forcing departures rather than asking what makes Airmen stay.

The unified model results are valid so long as the population measured conforms to the underlying distribution of the 2015 Air Force Survey data for each AFSC. For example, Figure 23 below indicates the work-life balance responses for separated and retained 11X personnel. Note the distinct shift in the survey responses between the stay and leave outcomes as a function of turnover.

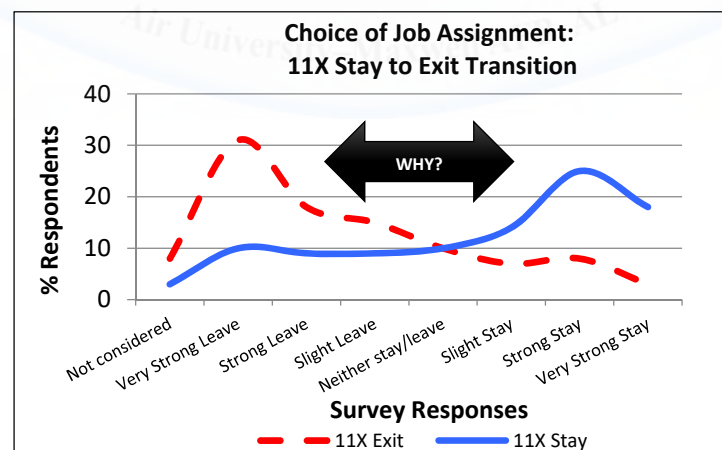


Figure 23. AFSC 11X Work-Life Balance.

The Excel-based prediction tool of Attachment 3 assumes that a surveyed population is statistically identical to the underlying distributions of each AFSC model in this research. Additionally, any future population predictions must consider the changes in Airman sentiments from the 2015 survey. Applying the 2015 unified models to a population of 11X's surveyed in

2021 may be inaccurate because the underlying factor questions may no longer correlate to turnover sentiments. Also, it matters little if the population surveyed is from a different part of an AFSC community so long as their responses match the distribution of the 2015 data. If it is shown that an AFSC subgroup does not significantly differ in their responses from the 2015 survey, then the prediction tools and models developed are valid for assessing turnover in those populations. This is a legitimate concern because the AFSC models derive from a random sampling of all Air Force officers, rather than those personnel in a top 20% IDE program used for the 11X validation. Rather than proving or estimating validity for many populations, it is far easier to prove when certain cases do not meet the 2015 distributional assumptions.

The operational method for this procedure is to survey a statistically significant number of personnel in the population of concern using the surveys in Attachment 2, and comparing those responses to the 2015 data distributions. The extent to which AFSC distributions are significantly different determines model validity and answers the question of “who can these models apply to?” Note that the 12X and 44X models were not validated due to insufficient number of personnel available and time constraints. Operational use of these two models requires validation before considered accurate.

Selected Influence Factor Analysis, 11X

In Figure 21 *pilot turnover is most impacted by the ability to contribute to the mission*, as indicated by its high odds ratio (influence weight) of 1.74. Recall that for every one-unit change in reported mission contribution sentiment, the odds a pilot stays or leaves changes by 74%. The *factor with the least impact on turnover is unit leadership* at 1.20. Therefore, the weight range between 1.74 and 1.20 dictates the trade space in which the Air Force can enact reforms for a predicted return. For example, it may be easier for the Air Force to reform pilot job assignments at a weight of 1.67 (3rd highest influence factor) that has a synergistic impact on perceived

mission contribution. If the Air Force allows a pilot to do a job they feel is most impactful while meeting the institution's needs, then perceived mission contribution should also increase.

Likewise, the number of deployments and locations were moderately weighted at 1.53 and 1.25, respectively. Positive changes in deployment management should have synergistic and beneficial impacts across the spectrum of deployment-related influence factors.

The nature of unit relationships and climate with weights of 1.34 highlights the importance of healthy units and revitalizing squadrons. The data indicates that *a one-unit change in unit relationships or unit climate has more impact on turnover than perceptions of the promotion system, immediate supervisors, deployment locations, bonus money, number of PCS's, and unit leadership by themselves*. For pilots, high comradery and sense of purpose outweigh a number of systemic, hard to fix issues like deployment ops tempo and the promotion system. Putting the best leaders in flying units with beneficial leadership traits like people-focused emotional intelligence (MBTI type indicator) can offset ops tempos that are difficult to reform.

Of particular note for pilots is the low weight (1.21) attributed to bonus/special pay such as offered through the Aircrew Retention Program (ARP). This is *a very significant finding* and confirms what many aviators have said about taking bonus money. Namely, that it works for some but not all as a turnover inhibitor. There are two primary reasons for this. First, the economics of the bonus cannot compete with superior airline hiring rates and pay. Figure 24 below indicates why this is the case.

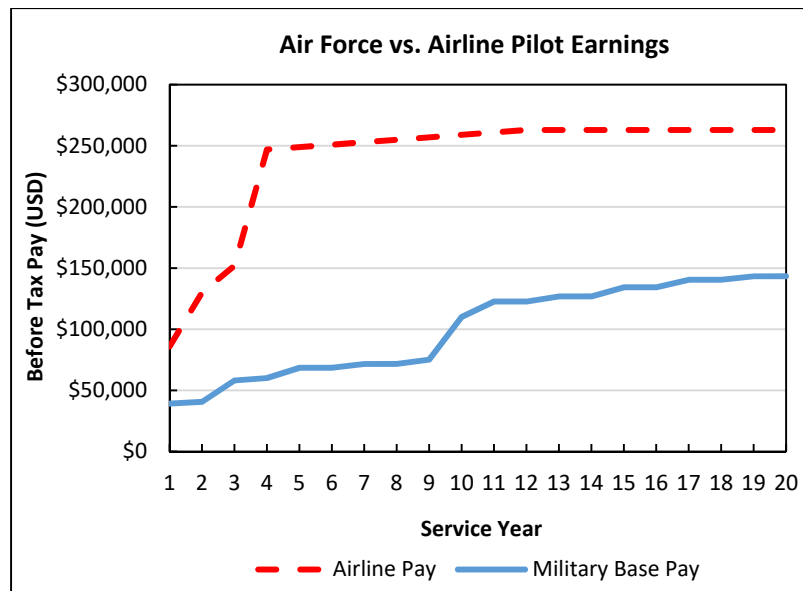


Figure 24. Air Force Pay vs. Airline Pay.

Figure 24 demonstrates that an Air Force pilot's salary never exceeds that of an airline pilot over a twenty-year period and that the Air Force simply has no position of monetary superiority.⁴³ From the start of year 1, a major airline first-officer (co-pilot) outclasses Air Force second lieutenants. The rise at year four for the airlines is the conservative move to captain in the present economy, while the rise at year 10 for the military is the rank of Major and the highest ARP bonus of a fighter pilot in FY18 (AFSC 11F) taken concurrent with pilot training ADSC expiration.

The second reason the ARP weights so low is that monetary benefit is just one reason why Airmen serve. As the AFSC modeling in Figure 22 indicates, service is a multidimensional concept with many influences. The lesson for pilot management is that *what the Air Force thinks matters in pilot turnover is not true for many Airmen*. The indisputable, scientific fact is that the ARP bonus is the 20th influencer of 22 influence factors for pilots in the Air Force.

Selected Influence Factor Analysis, 12X

CSOs exhibit completely different turnover behaviors. Whereas pilots were relatively insensitive to the ARP bonus designed to retain them, CSOs rate overall compensation as a high

influence factor at 1.87. Compensation refers to the full package of monetary benefits and social incentives (pay, leave, medical, retirement, etc.). Overall satisfaction and job assignment follow at weights of 1.66 and 1.55 respectively, indicating *an AFSC community with limited paths and lowered perceptions of command, promotion, and academic opportunities*. Career satisfaction appears at a moderate 1.33, with skills and professional development following at 1.30. The aforementioned influences are all higher than issues of flight and basic pay. This creates a picture of *a crew force that is underappreciated and underutilized*. It would appear from these results that *the most synergistic strategy to retain CSOs would be AFSC expansion or cross training*. As more aircraft and systems reduce reliance on human navigation skills, this rated AFSC appears as good candidates for a Career Multipath program outlined in Part 3 of the research.

Selected Influence Factor Analysis, 44X

Physicians demonstrate completely different influence factors versus pilots and CSOs. The *top factor for this career field is choice of job location* at 1.74, followed by job assignment at 1.60, and number of PCS's at 1.58. Overall satisfaction is fourth at 1.47 and ahead of skill utilization at 1.42 in fifth. Job stress appears for the first time in any model and unit leadership is the highest at 1.42 and 1.36, respectively. The remaining factors assume values between 1.38 and 1.2. Again, *bonus money and special pay ranked low* as 18th of 24 factors. Physicians appear *focused on beneficial jobs and locations* while minimizing PCS moves. A proportion appears *underutilized and stressed*, indicating issues within their medical career fields or personal lives. These views are reinforced by overall satisfaction influences at a weight of 1.47, much like CSOs. Because physicians are *very career and individual-oriented*, it is likely that personnel management strategies require a human touch compared to pilots or CSOs. Whereas CSOs may just want more opportunities for utilization, *physicians want utilization in the right place in minimal PCSs*. Since a "homestead" factor was not included in the model like CSOs (8th of 24

CSO factors), it is unlikely that *the number of PCSs* are excessive but instead *do not create the right synergy with skills and job utilization*. This is explained by the transitory nature of physician's careers, with many leaving early for lucrative opportunities. For example, physician leave data indicates that 68%, or nearly double that of the next closest career field, separate voluntarily.

A Pareto Analysis is provided in Figure 25 below to indicate the top 20% of factors supporting a maximum impact HR strategy without considering implementation costs. A more flexible, opportunity-based strategy can target factor reforms in a notional tradeoff between costs and synergy achieved. By targeting factor reforms with the highest synergy between issues at the lowest acceptable costs, the Air Force can frame institutional reforms in a realistic trade space.

AFSC	Top 20% Factors	Weights	Increase in Prob _{Stay} for 1-unit shift in each category ⁴⁴
11X: Pilots	Msn Contribute	1.742	348%
	Family Sep	1.738	
	Job Assignment	1.670	
	Ret Program	1.670	
	Overall Satisfaction	1.661	
12X: CSOs	Overall Comp	1.873	300%
	Overall Satisfaction	1.655	
	Job Assignment	1.546	
	Cmd/Lead Opportunity	1.464	
	Promo Opportunity	1.460	
44X: Physicians	Location Choice	1.735	278%
	Job Assignment	1.598	
	# PCS	1.557	
	Overall Satisfaction	1.469	
	Skills Utilize	1.424	

Maximum Impact Strategy

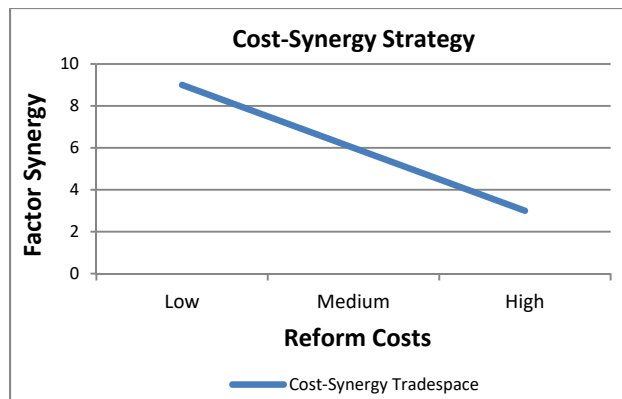


Figure 25. Maximum Impact Strategy vs. Cost-Synergy Strategy.

Machine Learning Methods

Machine Learning methods offer a different view into Airmen separation behaviors. The machine learning results are similar to the previous logistic regression analysis with additional insights. The 711th Human Performance Wing (HPW) at Wright-Paterson AFB conducted the analysis using a technique called Topological Data Analysis (TDA).⁴⁵ TDA is optimized to handle extremely large datasets, capture non-linear relationships, and uncover the “unknown unknowns” (non-hypothesized correlations).⁴⁶ The power of machine learning is threefold. First, it moves beyond the idea of hypothesis testing into data correlation to leverage the tremendous amount of information in today’s environment. Second, TDA breaks down complexity into meaningful information that is inherently unknowable. Third, machine learning and artificial intelligence eliminates the need for numerous statisticians and specialists into one or a handful of data scientists.

In Figure 26 below, TDA software generated a 29-dimensional point cloud for CSOs illustrating key distributions within the 2015 survey data. Each node represents common data distributions while the lines connecting them represent their relational paths. The nodal networks the data form and their proximity to each other represents similar quantitative properties. Different colors represent similar qualitative properties (red indicates leave, blue indicates stay)

and the colors in between transitional turnover states. Table 15 below compares the results of the logistic regression and TDA for CSOs. Of note, the third and fourth logistic regression factors substitute in TDA with logistic regression's seventh and eighth factors, demonstrating TDA's ability to measure distributions within distributions.

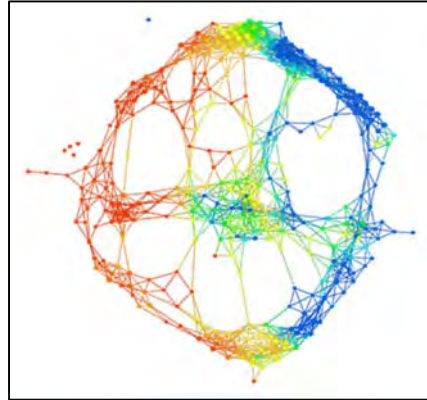


Figure 26. 29-Dimensional TDA Point Cloud, CSOs.

Rank	Logistic Regression Modeling Factor	Turnover Prediction Accuracy	TDA Modeling Factor (Logistic Rank)	Nearest Neighbor Prediction Accuracy
1	Overall Compensation	88.5%	Job Assignment	97.3%
2	Overall Satisfaction		Cmd/Lead Opportunity	
3	Job Assignment		Homestead (8)	
4	Cmd/Lead Opportunity		Academic Opportunity (7)	
5	Promotion Opportunity		Overall Compensation	

Table 15. CSO Logistic Regression vs. TDA Results.

Of note, logistic regression produced an accuracy for predicting turnover, while TDA predicted where the next node would appear in the point cloud. In Figure 26, all CSOs transition from stay to leave (blue to red) via paths over the top, middle, and bottom of the point cloud. These paths coincide with leaving for one or all of the top four TDA reasons in Table 15 above; note the similarity in factor rankings between the two modeling methods using similar coloring. Additionally, about 50% of all CSOs left because of medical specialty care issues. Conversely, 100% of those who stayed did so because of the influence from the first four TDA factors.

TDA for pilots and physicians is possible by providing the 711th HPW or an equally capable organization with the latest Air Force survey data. The raw data was requested from HAF/A1 but not released to either this research or Dr. Ryan Kramer at the 711th HPW due to privacy and sensitivity concerns. Of note, TDA of the pilot data indicated that the ARP ranked 15th of 28 factors while the logistic regression analysis threw it out. Again, money is a minor influence for most pilots.

Block 4, Hypotheses 8

While many factors theoretically influence separation decisions, research has shown that satisfaction is a good indicator of turnover intentions.⁴⁷ While satisfaction changes have shown to predict turnover, it does not provide a multi-faceted view of Airmen behaviors as explained in previous hypotheses.⁴⁸ Reported satisfaction may provide an alternative to Factor Theory as an efficient, single measure of turnover sentiments. However, organizational tenure, work expectations, and psychological stress all play key roles in mediating turnover decisions and may limit the effectiveness of satisfaction as a single measure.

Hypothesis 8: *When controlling for AFSC, job satisfaction is a less accurate measure of turnover than Factor Theory.*

Methods & Results, Block 4: Hypotheses 8

Hypothesis 8: *When controlling for AFSC, job satisfaction is a less accurate measure of turnover than Factor Theory.*

“Overall job satisfaction” was regressed with turnover using binary logistics modeling. Table 16 below presents the summary statistics of the models. As expected, job satisfaction as a sole predictor does not perform as well as Factor Theory’s use of multiple factors.

AFSC	Prediction Accuracy	Pseudo-R ² (N/CS/L/L _{ADJ})	Hosmer-Lemeshow Fit Test	Approximate R ² Value ⁴⁹
11X	60.7%	.12/.09/.07/.06	.22 – No poor fit	< 70%

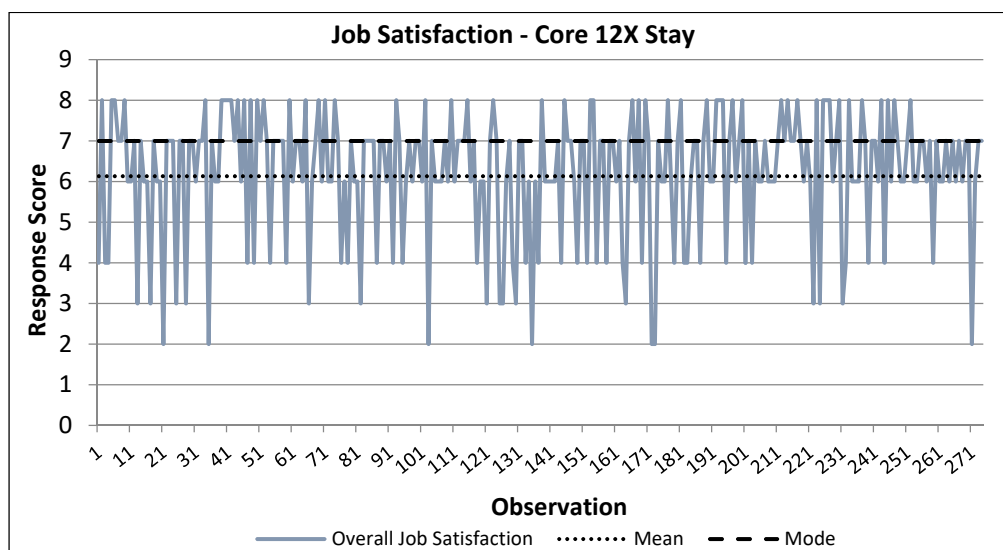
12X	61.8%	.08/.06/.05/.04	0 – Poor fit	< 70%
44X	64.2%	.17/.13/.10/.09	.02 – Poor fit	< 70%

Table 16. Job Satisfaction vs. Turnover.

Overall job satisfaction in the leave and stay surveys exhibit a large spread of responses. Table 17 below provides the summary statistics for each AFSC and the satisfaction question; note the tendency of leave groups to have a lower average survey score. The large spread of responses is indicative of why overall job satisfaction and single predictive variables are not as effective as using multiple responses. Because the 95% confidence intervals on the mean responses in Table 17 are so large, it is impossible to attribute turnover to a single factor like satisfaction because the response can belong to both stay and leave outcomes. Figure 27 illustrates the variability in CSO satisfaction responses with factor scores of one, five, and nine below omitted for clarity. The pilots and physicians show similar shifts per Table 17.

AFSC	Mean	Standard Deviation	95% Confidence Interval on Mean Response
11X Stay	6.33	1.62	3.09 - 9.57
11X Leave	5.31	1.98	1.35 - 9.27
12X Stay	6.13	1.64	2.85 - 9.41
12X Leave	5.12	2.30	.52 - 9.72
44X Stay	3.87	2.12	0 - 8.11
44X Leave	5.54	2.19	1.16 - 9.92

Table 17. Job Satisfaction vs. Turnover Summary Statistics.



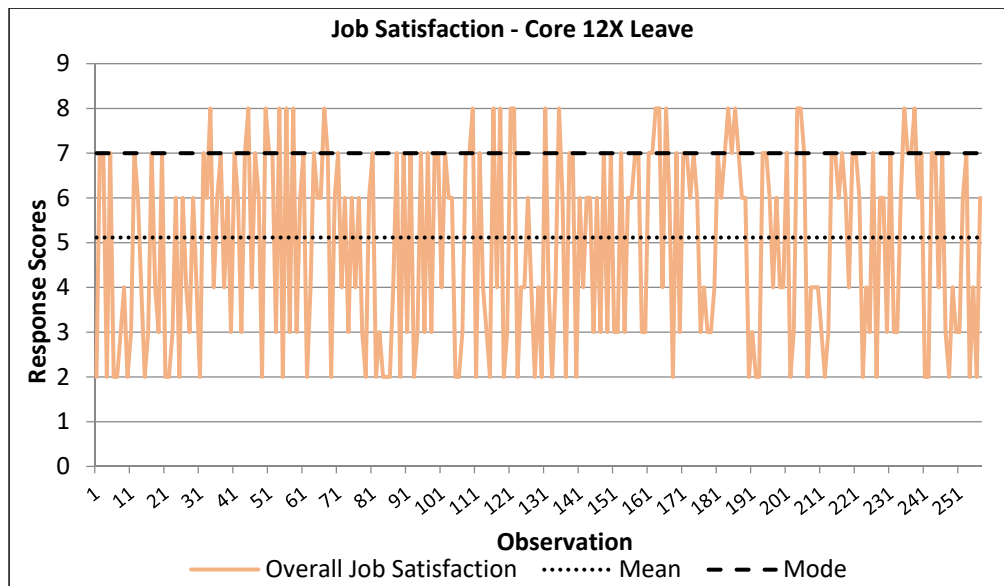


Figure 27. CSO Job Satisfaction, Stay vs. Leave.

Another interesting trend is the proportion of respondents indicating nearly identical overall satisfaction in the stay and leave datasets. Logically, those who leave should report lower satisfaction than those that stay, but this is not the case across the study AFSCs with Figure 28 below depicting this trend. Satisfaction scores were summed for those responses indicating some level of “satisfaction,” while dissatisfaction was summed with those reporting some level of “dissatisfaction.” Of concern is the fact that those who leave are just as satisfied as those who stay, while those who stay are just as dissatisfied as those who leave. Yet again, this demonstrates that satisfaction as a single measure is inadequate to characterize the multidimensional nature of Airmen turnover.

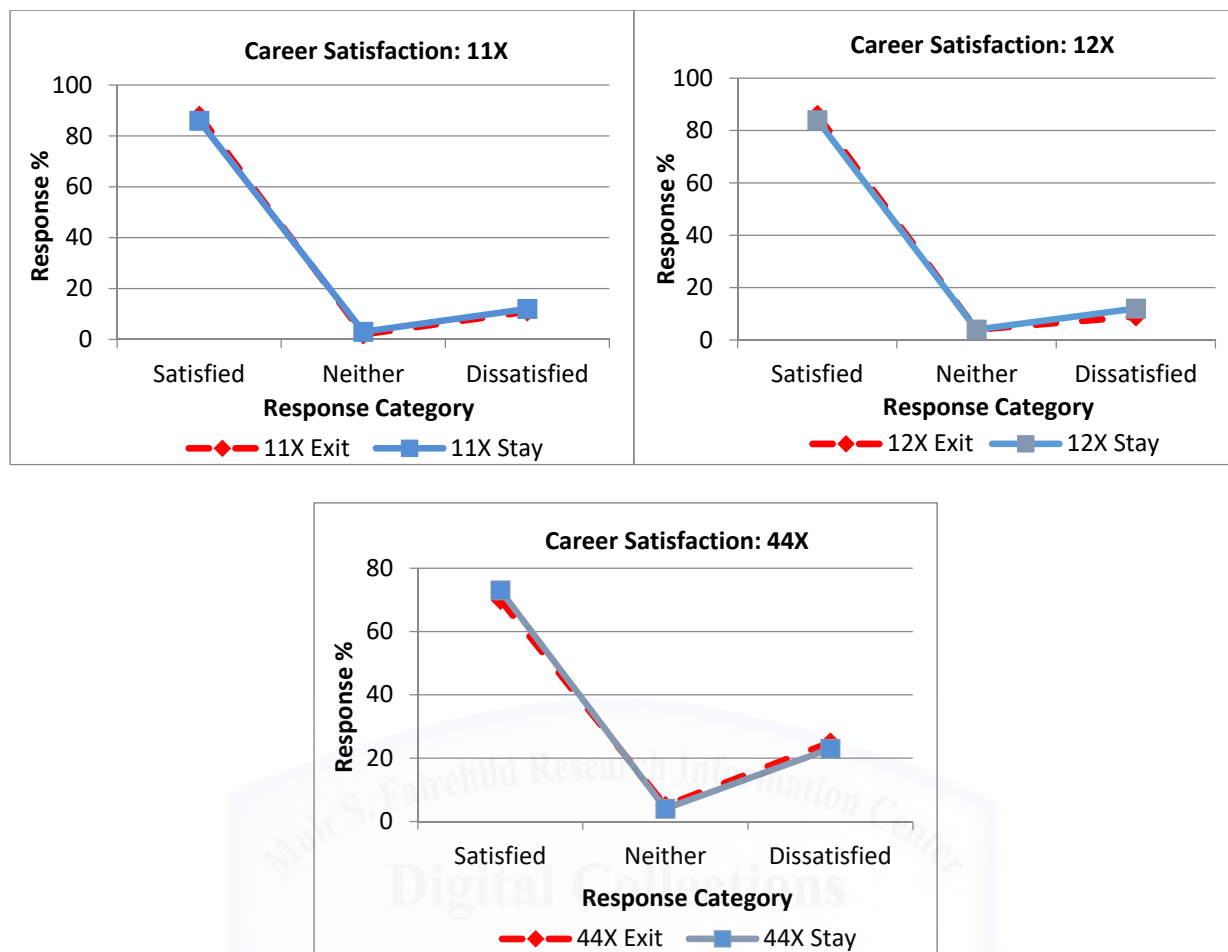


Figure 28. Equal Satisfaction & Dissatisfaction Across AFSCs.

Block 5: Hypotheses 9

Factor Theory: Exploring AFSC Subcultures

Subcultures share the values of the larger organization but also contain values, norms, and beliefs reflecting their functional tasks, jobs, and experiences. The boundaries of subcultures manifest along organizational stovepipes or silos because of the functional nature of subgroups. In the Air Force, common backgrounds, tasks, and experiences define AFSC subgroups and serve to create functional silos.⁵⁰ Personnel in AFSCs claim membership to the operator subculture since the majority of these personnel comprise “the line” rather than “the staff” of the Air Force.⁵¹ Their daily activities are defined by human interaction, communication, trust, and teamwork that gets the job done, manages internal and external pressures of achieving

objectives, and forms and modifies culture over time. Institutional Air Force behaviors at odds with AFSC cultures act to alienate and reduce the morale of operators because it tends to identify leadership as misinformed outsiders.⁵²

Qualitative assessments of turnover intentions indicate that AFSCs provide the first organizational stovepipe in which different sentiments emerge. For example, the differences between the 11M (mobility) and 11F (fighter) cultures are self-evident so there should exist similar differences between 11X's, 12X's, and 44X's because of *observable functional differences in subcultures*. At the same time, a unifying Air Force culture should exist around the core values that are superior to that of subcultures. Therefore, certain functional aspects of service span cultural divides, while others do not.

Hypothesis 9: *Different Core AFSCs both share and vary in influence factors and their weights.*

Methods & Results, Block 6: Hypotheses 9

Hypothesis 9: *Different Core AFSCs both share and vary in influence factors and their weights.*

Each of the four AFSCs is both alike and different in their influence factors, with approximately one-third of the factors shared by the four AFSCs. Tables 18 through 20 below summarize the 4-, 3-, and 2-way common factors and their respective influence weights. The focus of analysis will be on the 4-way common factors.

Influence Factor	11X	12X	44X	GAF
Job assignment	1.67	1.55	1.60	1.59
PCS number	1.21	1.38	1.56	1.43
Skills utilize	1.44	1.38	1.42	1.49
Family separation	1.74	1.27	1.28	1.20
Work-life balance	1.46	1.35	1.33	1.22
Patriotism	1.37	1.24	1.29	1.29
Retirement program	1.67	1.33	1.28	1.46
Tricare retirement	1.65	1.22	1.26	1.23

Career satisfaction	1.61	1.33	1.25	1.19

Table 18. 4-Way Common Influence Factors.

Influence Factor	11X	12X	44X	GAF
Mission contribution	1.74		1.27	1.31
Overall compensation		1.87	1.30	1.28
Unit leadership	1.21		1.36	1.20

Table 19. 3-Way Common Influence Factors.

Influence Factor	11X	12X	44X	GAF
Mission contribution	1.74		1.27	
Unit climate	1.34	1.18		
Unit relationships	1.34		1.24	
Promotion opportunity	1.28	1.46		
Command/lead opportunities		1.46		1.35
Deployment locations	1.25	1.32		
Bonus/special pay	1.21		1.27	
Cohesion			1.32	1.32
Unit leadership	1.21		1.36	
Job location			1.74	1.48

Table 20. 2-Way Common Influence Factors.

Equal influence factor weights across AFSCs indicate statistically identical factor responses. When two or more influence factor weights are identical, the perceived importance of the issues are equally treatable across AFSC lines. Airmen perceive approximately two-thirds of the influence factors differently. For example, in the 4-way factor interactions of Table 18, work-life balance increased the likelihood of pilot separation 24% more than the general Air Force officer population for every one-unit change in turnover sentiment. Given pilots' high ops tempo and general fatigue, this makes sense. Therefore, the variation in common influence factor weights and distributions demonstrates that various communities see the same issues in different lights. Figure 29 below depicts four box plots of the distribution of 4-way influence factor weights.

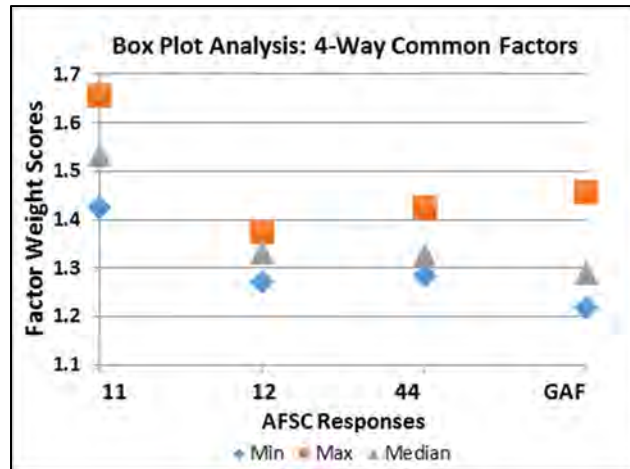


Figure 29. Factor Weight Box Plots & Summary.

The 4-way box plot indicates that amongst those common factors, contextual and statistical differences exist between the 11X community and all others (lack of overlap between 11X box plot and all others). For the work-life balance question alone, the 12X and 44X reported values of 1.35 and 1.33 are different from the 11X value of 1.46. Additionally, the 4-way AFSC box plots in Figure 29 are approximately normal around the mean with good symmetry for the 11X and 12X factor weights, and moderate symmetry for the 44X and GAF factor weights. A one-sample t-test on a mean weighting value of 1.33 indicates that the 11X factor weights are indeed significantly different. Therefore, unequal influence factor weights result in significantly different AFSC valuations of the same issue. This evidence is both visually observable and statistically demonstrable.

The link between the valuation of influence factors and turnover is due to unique AFSC cultures and contextual Airmen experiences, as evidenced by previous results. Culture and subculture measurement matters when considering turnover strategies because it determines the effectiveness of intervention strategies. The 11X contamination with 11F data resulted in a surprising find: 11F's and 11X's shared statistically identical factor commonality of 86%. On the other hand, factor commonality between the 11X, 12X, 44X, and GAF models were 13.4%.

While a general retention strategy for 11X's would also fit 11F's with 86% factor commonality, the same retention strategy applied to the other study AFSCs will have reduced effectiveness because it fails to address the balance of AFSC issues. This micro-AFSC view is underdeveloped and not operationalized in any Air Force retention strategies.

A relative measure of a retention strategy's effectiveness then is the percentage of total factor commonalty between AFSCs times the equivalence of the factor weight distributions. As an approximate method, the factor response distribution is equivalent to a large visual shift in the factor weights, but a statistical test is the only way to know for sure.

$\text{Retention Strategy Synergy} = \frac{\text{Percentage of Shared Factors} \times \text{Percentage of Equiavalent Response Distributions}}{\text{Percentage of Equiavalent Response Distributions} \approx \text{Equivalent Factor Weights}}$

Figure 30. Retention Strategy Synergy.

As an example of the above relation, the total factor commonality between the four AFSCs is nine of 67 factors, or 13.4% (the 11X AFSC is the only factor distribution that is significantly different). Resultantly, the synergy of applying an 11X strategy to 12X's, 44X's, or GAF is 0% because the factor weight distributions are not equal for any one factor. In other words, the more factor weights differ, the less likely a "one size fits all strategy" is effective. Service contexts and cultures require micro-level understanding of Airmen and AFSC-specific interventions. In another example, applying an 11X strategy on 11F influence factors is 73% effective (86% shared factors times 85% equivalent factor weights), or 12 of 14 equivalent response distributions. The retention strategy synergy described in Figure 30 above is not an absolute or predictive measure. Instead, it provides a conceptual framework and yardstick

to consider how effective a retention strategy from one AFSC onto another can be as a function of shared culture.

The key trait of an effective retention strategy is that it successfully addresses each AFSC's influence factors. This means that retention strategies can be more effective if they consider micro-level AFSC characteristics. AFSCs high in shared culture and context should be treated similarly, while those low in shared culture and context need customized strategies. The consequence of not identifying these micro-influences within AFSCs is increased turnover.

Factor Theory: Conclusion

Factor Theory proposes that the choice Airmen make in separating from the military is the difference in a series of weighted factors that interplay with each other in complex but predictable ways. The modeling of Airmen as dynamic systems demonstrates four behavioral cases of reduced performance and elevated turnover that should concern the Air Force. The established field of descriptive decision theory takes an Airman's dynamic service and reduces it into simplified, static conditions. In understanding, measuring, and creating decision matrices of personnel, the Air Force can formulate scientific hypotheses and develop robust models that correlate separation and retention behaviors. Machine learning algorithms simplify this formulation and close the gap between experimentation and solutions by correlating data to separations through human-machine teaming. From the relationships predicted in all turnover models, specific intervention strategies can significantly reduce turnover. The hypotheses presented fundamentally challenge the Industrial Age view of Airmen as "black box" assets and builds a case for a new, Information Age HR system.

Part 2: The Human Capital of Airmen

Part 1 proposed several hypotheses that construct dynamic models of Airmen behaviors. The statistical evidence developed prove that Airmen make turnover choices as rational actors and that these choices are constructible as a system of weighted influence factors. Part 2 explores why Industrial Age thinking has limited the understanding of Airman and prevented a multidimensional view of their behaviors.

Human Capital: Social Contracts

The military social contact tradition is an unwritten agreement between service members and the State. The military social contract assumes that in return for service, military personnel will enjoy a reasonable standard of living, fair compensation, desired occupation, access to good schools and education, and a reasonable retirement among others. The terms ‘reasonable’, ‘fair’, ‘desired’, and ‘good’ tied to the aforementioned service dimensions are contextual and relative to each Airman.

The Air Force and other military organizations see themselves as social actors that pursue their owns goals and interests.⁵³ A careful balancing act occurs between fulfilling the expectations of Airmen and the needs of the Air Force to accomplish the mission. Resultantly, managing Airman ‘gets’ and Air Force ‘needs’ are largely viewed as mutually exclusive. This is because the Industrial Age view of personnel omits the multidimensional nature of service, as seen in Factor Theory’s influence factors. As priorities and resources change, the balance will inevitably shift between the mission ‘needs’ and personnel ‘gets’, but the Air Force must consider how its actions influence Airmen.⁵⁴ As such, the Air Force has a special responsibility to acknowledge personnel’s needs or face the consequences of violating the unwritten social contract and higher rates of turnover.

Human Capital: The Industrial Asset View

In a 1961, economist Harry G. Schaffer stated, "...it is generally inadvisable to treat man as human capital" and that "...economics has little to gain and much to lose by the universal application of the capital concept to man." This economic, non-monetary incentive view of human capital is vitally important because it sheds light on the Industrial Age view of personnel. Most today would disagree with Mr. Schaffer's assessment.

The key to understanding the present Industrial Age view of personnel is that there is no distinction between human resources once assigned by the personnel system: Pilot A has the same capabilities and motivations under the system as Pilot B. No matter which pilot fills a job, the act of assignment within the institutional Air Force equates to mission accomplishment, job performance, and a sufficient contractual return on the investment of that service member. Does the assignment of Pilot A into Job X yield a higher return on investment (ROI) than Pilot B in the same job? The present system cannot answer this question. To do so would assume that the system could relate the action of personnel assignments to outcomes, such as retention or unit performance. The inability to determine the factors that influence human capital ROI from the performance and retention perspectives is the reason why the industrial assignment system remains intact and Schaffer's 1961 argument endures.

The basis for Schaffer's arguments are invalid once organizations quantify each person's uniquely weighted service factors, such as with Factor Theory, and operationalize it in a talent management system. This way, outcomes such as performance and retention align as measures of human capital ROI. Commanders at all levels cannot simply hope that personnel system is doing right for the Air Force. The personnel system must evolve such that the maximization of human capital ROI occurs from personnel's accession through retirement. The views and research on human capital as a strategic resource make this abundantly clear.

Human Capital: A Resource, Not an Asset

The Industrial Age assumed that specialization in career fields maximized human capital returns. Yet, today's environment has moved well beyond the Industrial Age and into the Information Age. A basic, economic argument underpins the asset view of Airmen. The division of labor articulated by Adam Smith in the *Wealth of Nations* enabled 20th century specialization and enormous productivity through comparative advantages.⁵⁵ Returns on human capital utilization assumed that the "endowed differences" in personnel were negligible, and that investment in human skills was a fixed cost independent of human capital development.⁵⁶ Since costs were fixed, it made sense to maximize the abilities of personnel because there were no penalties in doing otherwise.⁵⁷ However, the penalty for this view in the Information Age will be unsustainable turnover because personnel no longer accept the view that their human capital lacks "endowed differences." Mobility in the global job market further complicates the matter. Personnel are not just Industrial Age assets, but price-maximizing resources that can walk-away when their Active Duty Service Commitments (ADSC) expire or they feel continued service no longer benefits them. This is because personnel view themselves as resources with inherent wealth and value, not assets. What the Air Force must realize is that unlike other strained resources, human capital will walk away.

Human Capital: A Concept in Competitive Advantage

The Air Force finds itself operating in a complex environment defined by voluminous, high-speed data flows. Data becomes information by processing and logic, and human capital is key in creating the structures, access, and information that will give commanders both decision and competitive advantages.⁵⁸ The value of the Air Force to the state arises from its ability to select, retain, and employ personnel in accomplishment of its mission by viewing human capital as a vital strategic resource.

The resource-based view of organizations states that performance differences occur because of variances in resources and capabilities.⁵⁹ The attainment of valuable resources such as human capital create positive returns and competitive advantages, and in the case of the Information Age, decision advantage. As other nations achieve parity with the United States in terms of capabilities and tangible resources such as aircraft and cyber systems, a winning edge will rest with the side that can leverage rare and non-imitable resources of human capital.⁶⁰

A 2001 study of professional services determined that human capital resource utilization was significant in increasing organizational performance in three ways. First, tacit knowledge developed under unique, long-term circumstances produced higher returns than articulable, professional knowledge employees studied.^{61,62} The result that “learning by doing” tacit knowledge is more powerful than “learning by being told” professional knowledge implies human capital development within AFSCs is a long-term process. The rapidity of the Information Age and the nature of Airmen turnover should worry the Air Force because replacing human capital is a time-consuming and costly process that challenges Industrial Age skill development.

Second, the act of bundling human capital resources of intellect, quality of degrees, and social capital in “leveraged” packages compared to generic human capital produced no performance gains.⁶³ This indicates that the management of human capital requires precision when considering performance outcomes, as simply employing those high in human capital resources does not result in significantly better organizational performance. The right person needs to be on the right bus at the right time for maximum performance. Human capital strategies must carefully consider skills and abilities against expected tasks for the best person-outcome fit.

Third, the interaction of human capital between firms' service and geographic diversification increased performance. Service diversification was performing new services while geographic diversification performed them in physically new areas. The significant finding for the Air Force is one of increasing the probability of success under information asymmetry. When operating in both new professional services and geographic areas, firms performed better with higher human capital resources. By corollary, when operating in new and rapidly changing combat environments, the best chances of success come by maximizing human capital, all other factors being equal.

By creating economies of scope where managerial skills are relatable across paradigms and geography, the Air Force can stand to benefit most from adaptability and agility across the spectrum of operations. Rather than gathering superior human capital in a few elite AFSCs, all personnel will need their unique abilities leveraged in the right job to create competitive advantages.⁶⁴

Human Capital: Managing Increased Unit Performance

Human capital is a vital, non-substitutable, and inimitable resource that a modern management system must value. *Inimitable* resources are those that are not re-created easily, have a history, interconnectedness, social complexity, and casual ambiguities that fuse nodal relationships.⁶⁵ *Non-substitutable* resources are those for which strategic substitutes do not exist, such as creativity and innovation.⁶⁶ A system that is sensitive to turnover factors can create decision and competitive advantages while increasing organizational performance by employing inimitable and non-substitutable resources better than the enemy.

A 2011 study determined that changes in generic human capital caused changes in job service behaviors such as efficiency and quality, increasing job-specific human capital and organizational performance.⁶⁷ This study is significant because it demonstrates the ability of a

resource-based, human capital management strategy to create higher levels of organizational performance around non-substitutable and inimitable human capabilities. By creating a system that puts the right Airman in the right job, performance gains are possible. Therefore, the Air Force has a stake in shaping performance around human capital and talent management.

The resource-based view of generic and job-specific human capital considers personality, cognitive ability, and tacit knowledge key to creating performance gains. Personality is a strong indicator of desirable service behaviors such as empathy, adaptability, teamwork, and effective communication while cognitive ability supports fast learning and development of additional knowledge.⁶⁸ As generic human capital increases, so too does job-specific human capital and tacit job knowledge, leading to competitive advantages and increased organizational performance. While it makes sense to put the smartest people in the most important jobs, the nature of personnel-job fits are more nuanced. Research demonstrates that measurable personality traits other than IQ are just as important. Putting the right Airman in the right job then is about knowing both the person and the roles required by the organization.

Research in service industries has shown that as personnel gained job training and experience over time, they forged better performing teams.⁶⁹ These higher performing teams developed innate senses of their environment beyond the rules and guidelines of their job's explicit, formalized knowledge. As work conditions changed in one study, employee's innate tacit knowledge told them when it was time to cook more food based on the line of customers rather than by a food shortage.⁷⁰ In the long-term, changes in job performance behaviors such as speed, accuracy, and product quality increased productivity and profitability over time.⁷¹ In another study, a 1% increase in generic human capital produced a 2% increase in sales per labor hour, demonstrating that front-end investments in human capital result in increased organizational performance by developing tacit knowledge deliberately.⁷²

In regards to separation, research demonstrates that turnover decreases tacit knowledge while altering the social structure of organizations.⁷³ The alteration of social structures occurs when personnel no longer serve as links in the network, reducing the effectiveness and efficiency of network operations in knowledge-based organizations like the Air Force.⁷⁴ A firebreak to high turnover is the concept of social network density, or the ratio of the number of relationships to all possible relationships in a network.⁷⁵ Dense networks lead to greater cooperation, accountability, and information sharing because the knowledge of others roles increases flexibility and adaptability under high turnover conditions.⁷⁶ The idea of dense intra-organizational networks fundamentally challenges the ability of the hierarchical, vertical structure of the military to endure periods of high turnover with the same level of performance. Therefore, as Information Age requirements and processes increase in the Air Force, it should assume and plan against less adaptability and flexibility for a given turnover rate.

Air Force Cognitive Trends

What then is the state of Air Force turnover and tacit knowledge? Access to AFOQT cognitive data was denied by the Air Force, so an alternative method was developed relating IQ to attained educational degrees. Using measured intelligence and IQ data, the average intelligence of people with BA/BS, MA/MS, and PhDs are 115, 120, and 125 respectively.^{77,78} This data is applicable to the Air Force as a reasonable measure of IQ trends but it limited for two reasons. First, the IQ approximations are accurate for *trends* but not the *actual* IQ of Air Force officers. Second, the state of advanced degrees in the officer corps is not a comprehensive measure, but rather represents a composite measure of experience, knowledge, and capabilities gained through both service and education. Evidence suggests that physiological factors are just as important to IQ development as psychological or cultural ones. Regardless of IQ data used, the two limitations discussed remain unaccounted for in all known standard measures and are

thus universal concerns when conducting IQ data analysis. Air Force officer composition by fiscal year and degree type is presented in Figure 31 while personnel trends' influence on Air Force IQ is presented in Figure 32 below.

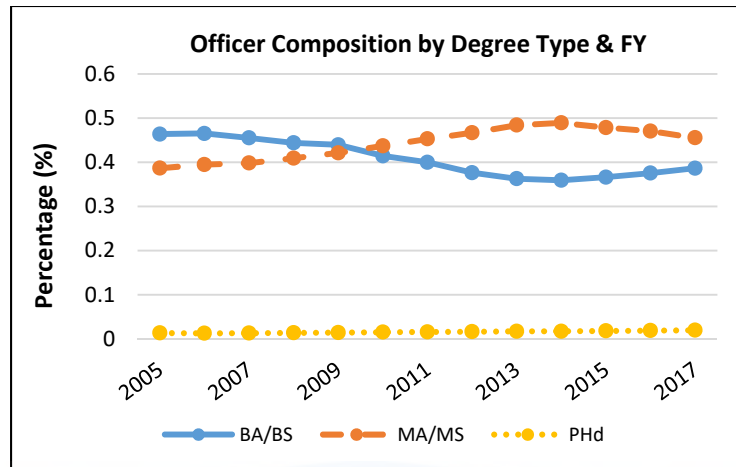


Figure 31. Officer Composition by Degree Type & FY.⁷⁹

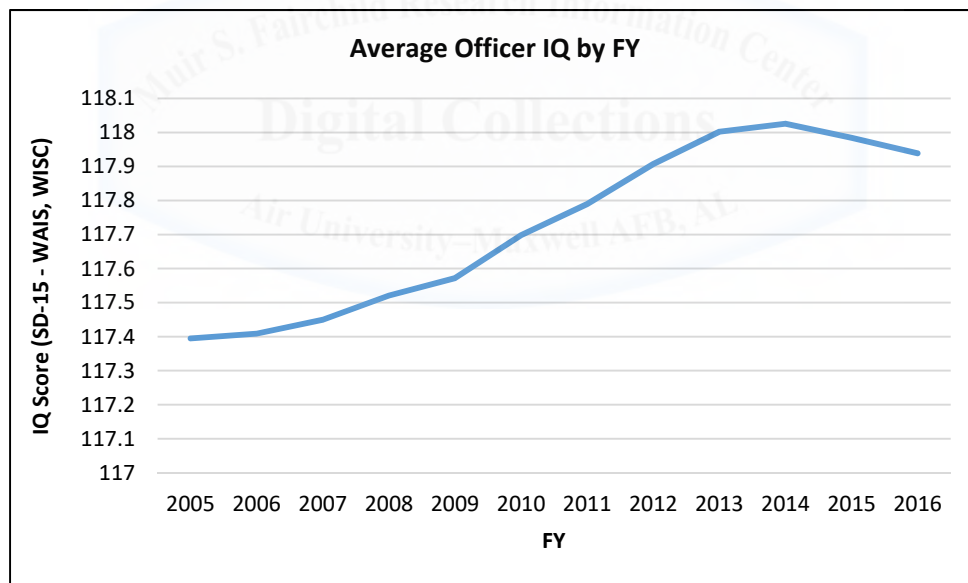


Figure 32. Average Air Force Officer IQ.⁸⁰

From mid-2009 to 2014, those officers in Figure 31 with advanced degrees made-up the majority of the officer population. After 2014 though, the MA/MS officer population decreased, indicating a loss of tacit knowledge (note the uptick of BA/BS degrees). As younger personnel remain in the Air Force, the data should see a reversal in the MA/MS downward trend as new

degrees are earned. In FY16, the turnover was -3.9% (accessing personnel) for BA/BS degrees and 2.2% (losing personnel) for MA/MS degrees; since 2005, the average turnover for BA/BS degrees is 3% and for MA/MS degrees .1%.

While the FY16 percentages seem reassuring (accessing more than separating), the historical averages indicate that the Air Force will lose a large portion of BA/BS personnel before they can earn a MA/MS (3% vs .1% average turnover, respectively). This point is very critical and illustrated by Figure 33 below. Since 2014, the Air Force has lost on average 1,823 MA/MS personnel while only gaining 490 BA/BS personnel annually. This loss difference requires that in FY18, the Air Force must acquire at least 1,333 new officers plus a margin for 3% average annual turnover (40 officers) plus the offset to average MA/MS losses since 2014 of 824 to reverse the trend of IQ loss. This results in an FY18 requirement of approximately 2,197 new officers, or 240% more than FY17 accessions. The longer the Air Force does not make up for the quantitative losses of MA/MS personnel, the more Air Force IQ will decrease because of the growing gap between older MA/MS and younger BA/BS holders. In summary, officers with higher approximate IQs are leaving faster than their replacements can be trained and developed.

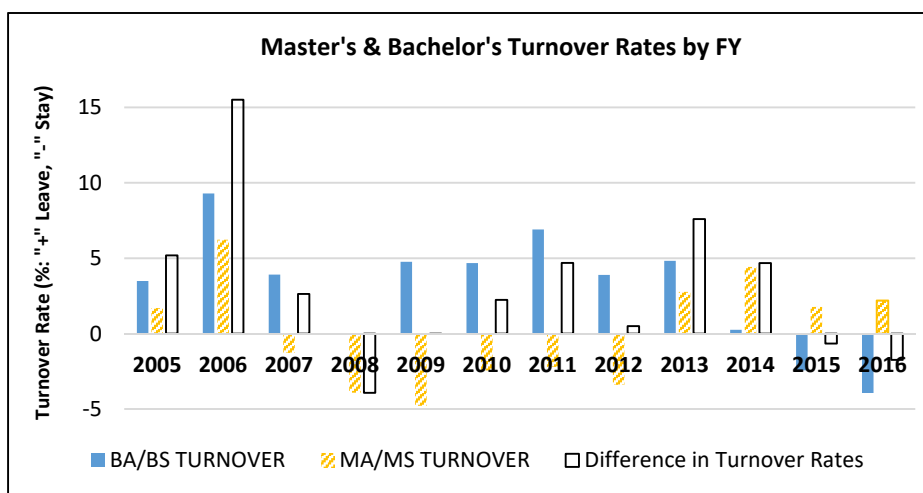


Figure 33. Difference in Turnover Rates by FY.

A secondary aspect of tacit knowledge is the dimension of stable personality.

Emotionally stable personnel are more agreeable, conscientious, adaptable, empathetic, engage in teamwork, and communicate more effectively⁸¹. Assuming older personnel have more stable personality, tacit knowledge in the officer ranks decrease when the Air Force loses older personnel. Officer strength data indicates that in FY17, 9% of the force was composed of the 17-24 age group of young Lieutenants, 49% the 25-34 age group of Lieutenants to young Majors, 31% the 35-44 age group of Majors to Lieutenant Colonels, and 11% over 45 age group of senior Lieutenant Colonels and above.⁸² Correlating total officer strength to age groups allows for a quick assessment of force composition trends. Utilizing a Pearson correlation measure, since 2005 the 17-24 age group moves very strongly with total officer strength, the 25-34 group moves moderately, the 35-44 group moves very strongly, and the over 45 group moves very strongly. The interpretation is that as total officer strength increases or decreases, all age groups move in the same direction except that the 25-34 age group increases or decreases slower than the rest. The significance is that the FY17 data indicates a future force trend of Lieutenants outnumbering Majors, creating a younger and thinner FGO force structure in outlay years.

Qualitatively, this is known to be the case. Air Force operational bomber squadrons report that younger, less experienced Lieutenants and Captains exceed the number of more senior personnel required to lead them.⁸³ Likewise, issues in meeting Air Staff requirements has led to the voluntarily recall of personnel to fill those jobs.⁸⁴ This has left a noticeable gap in guidance and on-the-job training of personnel, logically leading to less capable officers and reducing tacit knowledge in those units.

While not all organizations are sensitive to the same separation trends, the outlook for the Air Force is not good considering the outflow sensitives of Master's degree personnel. One strong, single indicator of this trend is the US Total Nonfarm Employment Payroll correlated to

officer end strength by age group. Since 2007, the 17-24 age group moves moderately negative, the 25-34 age group moves weakly positive, the 35-44 age group moves strongly negative, and the over 45 age group moves strongly negative to the Total Nonfarm Payroll. With the exception of the 25-34 age group, as the US Total Nonfarm Employment Payroll increases, turnover occurs and officer end strength decreases. The significance of this single indicator is that as the US nonfarm economy hires, the 25-34 age group will experience less turnover than all others, creating an operational-level, rank-heavy force without sufficient development from older FGO's and surrounded by younger subordinates.

Considering the losses of cognitive ability, stable personality, and strong economic performance, the Air Force finds itself in a worsening situation. Unless new officer accessions change drastically, the higher relative outflow of experienced personnel with advanced degrees is leading to a downward trend in average officer generic human capital and tacit knowledge based on research in the academic field. While most in the 25-34 age group should have stable personalities, there are reduced numbers of older personnel to impart wisdom and emotional development on those that remain. To regain its 2014 position of tacit knowledge and cognitive ability, the Air Force will need to retain its present force and gain significantly more personnel.

Human Capital: Conclusion

Managing and developing hard to imitate human capital resources create distinct competitive and decision advantages. If explicit, job-related knowledge defined the Industrial Age, then tacit knowledge will define the Information Age. Complex environments will require personnel to leverage their experience and training in new and dynamic conditions. Building a human capital management system shaped around preserving both personnel's explicit and tacit knowledge is key. If the Air Force continues to accept the turnover of personnel in the Information Age, regardless of "good" retention states, it will also accept the resource-based

view that negative changes in organizational performance will occur because its tacit knowledge is decreasing. High or “good” retention is not an indicator of ability and its use is a dangerous fallacy. Research and analysis indicates that Air Force officer IQ has decreased since 2014 and the outflow of experienced, older personnel has reduced tacit knowledge.

Developing skills, abilities, and experience in personnel require the irreplaceable factor of time in a continually accelerating Information Age. The IQ data in Figure 32 indicates that this will be a difficult battle to fight and a hard trend to reverse when combined with the forces of the US economy. The correlations among type of degree indicates that in order to restore officer IQ to 2014 levels, the Air Force will have to increase the total number of Ph.D. and MA/MS holders faster than it is gaining new BA/BS holders in the right areas. Unless direct accessions address this issue in career fields with cognitive and experiential outflows, it will take years until BA/BS holding officers earn advanced degrees while serving operationally.

Part 3: Talent Management

Talent, Management, and a System: The Talent

Human capital is a strategic resource requiring careful consideration and management because of the Air Force's dependence on personnel to operate advanced equipment in complex operating environments. Person-organization fit results in the "right people, on the right bus, at the right time" to accomplish the mission.⁸⁵

Each Airman provides unique knowledge, skills, abilities, and behaviors (KSAB) to the Air Force in exchange for services under the social contract. This informal, trusting relationship must optimize the use of Airmen's vital human capital while at the same time preventing its exhaustion as a perishable resource. The cognitive, physical, and behavioral human dimensions form the perishable "wells" from which Airmen become overloaded, exhausted, and display separation intentions.⁸⁶

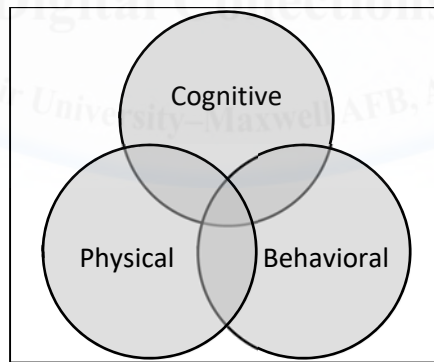


Figure 34. The Dimensions of Talent.

The cognitive dimension is comprised of the elements of perception, judgment, memory, and reasoning assessed through intelligence and aptitude tests. Cognition underwrites learning, critical thinking, and effective decision making while increasing the Air Force's stock of generic human capital that through experience, creates irreplaceable tacit knowledge.⁸⁷ The question remains, who and what skills are needed to meet future warfighting demands? By defining

KSABs required for the future, the Air Force can position itself for victory or at a minimum hedge its bets. While it is not be clear what the Institutional Air Force thinks it needs, it is very clear that it does not need the KSABs of the Industrial Age such as wrote skills, stovepipe problem solving, and stifled critical thinking. Critical KSABs for the future include the ability to human-machine team, flexibility with changing technology platforms, lifelong learning, and curiosity.⁸⁸ The KSABs of future Airmen need to evolve with their learning needs and as they advance in their careers. Continuous learning structures and programs such as adaptive PME, learning squadrons, merit-based advancement, and diverse job assignments are needed now.

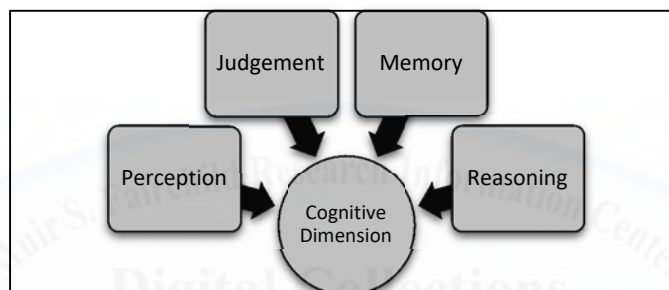


Figure 35. The Cognitive Dimension.

The physical dimension includes the elements of physical and mental health, resilience, and adaptability. A holistic approach to health and fitness through readiness, nutrition, weight management, and sleep mitigates the impacts of stress while improving cognition.⁸⁹ If the fight of the future is defined in volatile, uncertain, complex, and ambiguous (VUCA) terms then science predicts that the healthier team has the advantage, all other factors being equal.⁹⁰ Why should the Air Force make this a fair fight? It must inoculate a comprehensive lifestyle of health and fitness into daily operations if it desires unmatched advantages. Resiliency in the Air Force has come to mean briefings about sexual assault and wingman integrity. Rather, personal resiliency is about creating a physically and mentally strong force capable of quick recovery and reintegration after demanding operations.⁹¹

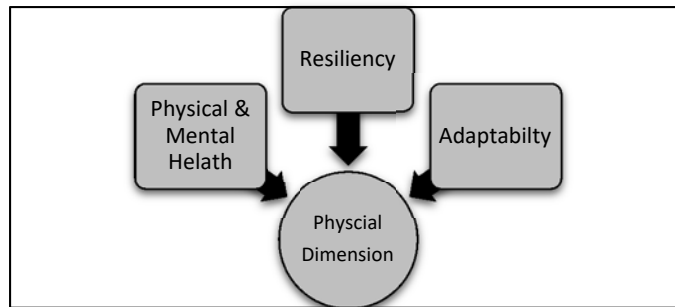


Figure 36. The Physical Dimension.

The behavioral dimension includes those factors that lead to higher rates of turnover such as poor work-life balance, mission contribution, and evolving values and beliefs about continued service. Factor Theory proves that Airmen are multidimensional and not behavioral black boxes, requiring a completely new way of thinking about comprehensive Airmen management. The inability to measure and express the impact of the behavioral dimension with respect to turnover and performance limits the realm of the possible. Institutional excuses such as competitive free market pay do not stand up to Factor Theory's results that show separation behaviors as contextual and varied. For pilots, the top retention factor of mission contribution (1.74 weight) has nearly four times more influence than pilot bonuses (1.21 weight). On the other hand, CSOs rate overall compensation first (1.87 weight) while doctors highly value choice of job location (1.74). Given these results, the Air Force must concede that service is a multi-dimensional concept.

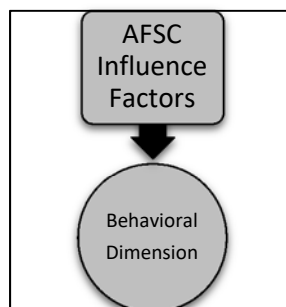


Figure 37. The Behavioral Dimension.

Talent, Management, and a System: The Management

Management of personnel should occur by linking the required KSABs of desired outcomes to available Airmen. In doing so managers, leaders, and policy makers remove institutional and personal biases in exchange for the best human-outcome fit while reducing wasteful management practices. Machine learning algorithms and artificial intelligence have compressed the scientific method so much that it is relatively obsolete as a means of fitting data to outcomes. Whereas science and mathematics have produced unified theories and holistic models of phenomena without time as a constraint, operations in the Information Age demand rapid explanatory and predictive power. In order to learn quickly, the technology-focused Air Force will increasingly have to rely on data correlated to performance outcomes without the benefit of extended debate and deliberation inside a scientific method that will fail the OODA loops of the future. This is observable today as data and information overwhelms organizations' ability to act on them while easy, linear complications have given way to non-linear complexities. Accepting the decision advantage afforded by human-machine teaming and correlated data will enable rather than inhibit management practices of the future. To believe that the human mind can effectively manage non-linearity unaided is a failure to appreciate the limits of human cognition and biases.

Talent, Management, and a System: The System

The Air Force needs a data-centric and scientific talent management system because the investment in human capital as a resource is fundamental in innovating to accomplish the mission. The world's transition from the Industrial Age to the Information Age means it is necessary to derive meaning from vast amounts of data. Of all the branches of the military, the Air Force has proven most reliant on technology and its ability to adapt and remain flexible as threats evolve. A talent management system creates decision advantage with data science technologies

because it places the right person, on the right bus, at the right time by converting data to information thereby enabling control. Machine learning algorithms and advanced analytics allow organizations to derive meaning from large amounts of data into correlations rather than causality, eliminating the scientific method in favor of rapidity.⁹² In turn, decision advantage allows the Air Force to operate within and beyond the OODA loops of the enemy. The paradigms of the Industrial Age are gone and the Air Force needs to accept it.

In this light, the objective of the Air Force Talent Management System (AFTMS) is to maximize the inherent KSABs of each Airman to create competitive and decision advantages. AFTMS acts as the single integrator forming the interface between Airmen's human dimensions and personnel managers by integrating accessions, retention, and development in a secure architecture.⁹³ Three principles form the basis of AFTMS:

1. Personnel are strategic, perishable resources
2. Talent management requires a systems approach⁹⁴
3. Talent management seeks maximum person-outcome fit

In the Information Age, personnel are a *strategic resource* because the speed and voracity in which data and information exist requires finely tuned tacit knowledge and mature organizational communication paths that only time can create. Personnel are *perishable* because they exist as a finely tuned system of work and life elements that act as costs and benefits towards continued service.

A proposed AFTMS construct is illustrated in Figure 38 below and should use methods, tools, and procedures that act coherently to acquire and convert data into information, analyze it, and predict desired outcomes. This process essentially shifts the Air Force's Industrial Age system into a human-machine management team. AFTMS can accomplish this through data, logic, and access layers in a systems approach. In order to operationalize talent requirements,

organizations and processes must convert their personnel needs into KSABs and scientific predictors of performance in the *data layer*.⁹⁵ These KSABs must be baselined at accession and measured throughout Airmen's careers to gauge development potential. Algorithms in the *logic layer* analyze the data and perform the desired operations such as optimal job matching, skill screening, and turnover minimization.⁹⁶ Machine learning algorithms continually run and analyze incoming data to find patterns and matches as specified by the personnel system and users. As a single integrator, AFTMS maintains a capability to relate the inputs and outputs of all logic processes to create synergy. Lastly, a transparent *access layer* engages users and interfaces with Air Force requirements.⁹⁷ All layers should maintain an open systems design in which interfaces, tools, and datasets can come and go as technology and user needs evolve.

AFTMS completely redefines the notions of person-organization fit. In the Industrial Age, the organization was the driving imperative behind maximizing personnel outcomes as a function of maximum economic utility. In the Information Age, competitive and decision advantages occur when organizations achieve person-outcome fits around the deliberate development of an individuals' KSABs.

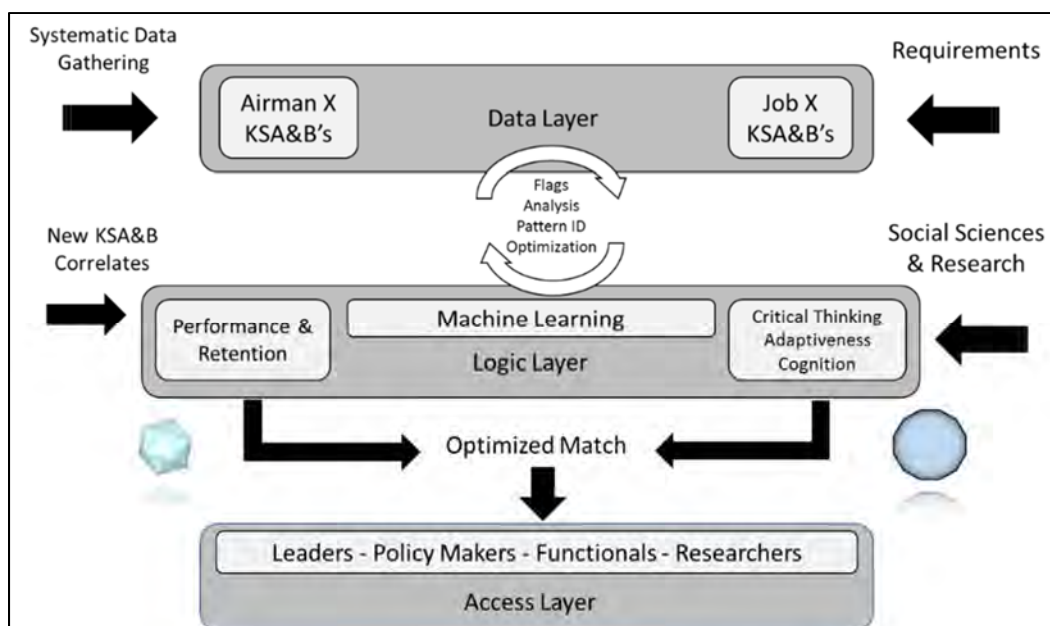


Figure 38. Industrial Age vs. Information Age Human-Machine Teaming.

Comprehensive behavioral lenses provide policy makers with a construct to minimize waste and maximize outcomes. By baselining the behavioral dimension at accession and re-measuring Airmen throughout their career, the Air Force achieves maximum retention, performance, and utilization through data-driven, outcome-based personnel strategies. Positive outcomes can increase by combing the cognitive and physical domains into future constructs of comprehensive Airman measures in AFTMS' adaptable framework.

Career Multipath: Background

Career Multipath utilizes AFSC crossflow for related job variation to increase adaptability and effectiveness in the Information Age and to facilitate multi-domain careers. Career Multipath increases retention by providing job flexibility, enlarging the pool of officers qualified in another AFSC, and empowers officers to make decisions in a second specialty. For example, training operational squadron personnel in cyber warfare and IT systems empowers them as front-line users to understand and manage cyber-attacks before they impact operations. Likewise, broadening financial analysts into contracting and acquisitions will allow each to gain

insight in how their processes complicate cost overruns. Personnel management in the Air Force has forced specialization with limited broadening, or variation. An “ideal” officer career places individuals in a number of different jobs within their AFSC in order to create relative breadth. The Information Age Air Force will require critical thinking, learning agility, and wisdom in order to achieve multi-domain dominance in a complex world. Personnel cannot succeed in multi-domain operations without being multi-domain.

Career Multipath: Defining Critical Competencies

Unfortunately, the Air Force does not value multi-domain competence and scientific measures of officer capability. Analysis of the Army officer promotion system indicates that of 13 years of US Military Academy promotees, those with one standard deviation higher cognitive ability had as much 32% lower odds of promotion.⁹⁸ All other factors being equal, the Army’s promotion board selected officers with significantly less cognitive ability.⁹⁹ Because standard measures of cognition are not included in either Army or Air Force promotion selection, there is no reason to believe that bright Air Force officers have significantly better chances. The truth is that organizations select and promote personnel as a reflection of their values. There are a number of possible explanations for the Army promotion data. First, those officers with higher cognitive ability opt for non-standard career paths impacting their professional “box checks”.¹⁰⁰ Second, intellectually superior personnel are discouraged from competing in a system that perpetuates mediocrity. Third, intelligent personnel may not be challenged enough or become bored with relatively mindless assignments. Regardless, cognitive high performers are very likely disadvantaged from achieving the same success as intellectually inferior Airmen. The Army has taken steps to change this and defines their critical human competency needs as cognitive ability, learning agility, and crystalized intelligence. These human competencies support a culture of critical and creative thinking to “understand, visualize, and describe

problems and approaches to solving them.”¹⁰¹ Adapting these competencies to the Air Force is depicted in Figure 39 below.

Cognitive ability is the capacity “to understand abstract concepts and ideas, to reason accurately, and to solve problems.”¹⁰² As the strongest indicator of job performance, cognitive ability has shown to correlate with increased objective and subjective performance.¹⁰³ The assured way to add cognitive ability in organizations is to recruit highly intelligent personnel in the first place. *Learning agility* is the “ability to understand and apply many conceptual things simultaneously.”¹⁰⁴ Learning agility is synonymous with “learning to learn,” or learning rate. Psychometric surveys measure specific learning agility while those personnel identified as “NT’s” on the Meyers-Briggs Type Indicator (MBTI) display high levels of “learning to learn.”¹⁰⁵ Organizations that embody learning make deliberate attempts to provide experiences and opportunities that develop a distinct advantage in assimilating or processing information into new problem sets, such as with Career Multipath.¹⁰⁶ Additionally, optimized learning at the individual level spurs innovation, intuition, and insight throughout organizations.¹⁰⁷ Lastly, *crystalized intelligence* brings cognition, learning agility, and personnel’s experience to bear on problems. Also known as wisdom, it is the “summation of retained and usable frameworks, mental models, knowledge, and ability to communicate that knowledge to others.”

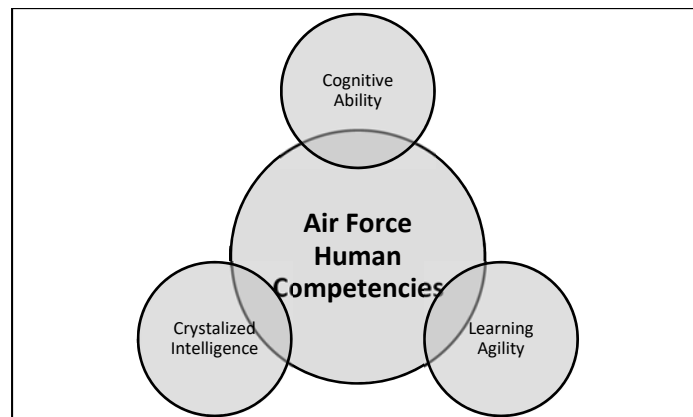


Figure 39. Air Force Human Competencies in Career Multipath.

The characteristic of Career Multipath is horizontal movement commensurate with vertical development, as illustrated in Figure 40 below. The difference in Multipath and the status quo is the valuation of lateral movements in creating increased individual and organizational learning through nodal networks. As Airmen gain experience and learn in new environments and systems, new nodal networks form in the brain and by extension, the organization.¹⁰⁸ The shortest distance between two points is a straight line, and when individuals fail to develop robust nodal connections, they have to take longer paths towards solutions or have no path at all.

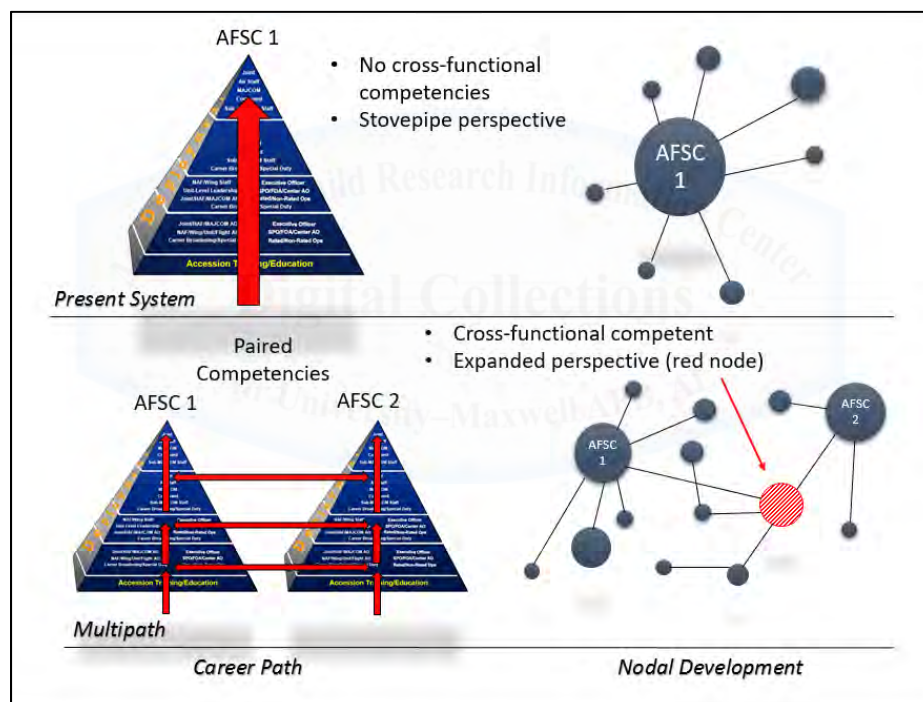


Figure 40. Multipath vs. Traditional Nodal Development.

The opportunity costs for traditional officer paths are exposure to different career fields and decreases in invention and innovation potential. The lateral and vertical movement in Career Multipath is synonymous with the established Human Resources (HR) field of job enlargement and job enrichment. Horizontal and vertical development has shown to increase satisfaction, production, reduce turnover, and increase the knowledge gained from a related field¹⁰⁹ Yet, not

everyone qualifies for Multipath. Individuals with unfulfilled lower-order needs and disturbed work-life balances will likely find new operating conditions stressful while those with less cognitive ability and leaning agility may find it overwhelming.¹¹⁰ Turnover plays a key role in selecting capable, committed, and innovative leaders since individuals are unlikely to make contributions in particular domains until after a decade of study and immersion.¹¹¹ While cognitive ability is relatively stable once gained, creating learning agility is more dynamic and malleable.

The related job variation in Multipath (working on different but similar kinds of problems over time) can create faster learning rates when compared to deep specialization or unrelated variation.¹¹² However, the extent to which related variation creates faster learning rates depends on an optimal zone of variation and relatedness as two continuous constructs. At zero variation and maximum relatedness, specialization dominates and produces lowered diverse learning outcomes than some variation; at maximum variation and zero relatedness, diversification dominates.¹¹³ In addition to learning agility, related variation increases crystalized intelligence and new nodal links form. The trade space between specialization and diversification in Figure 41 below is the unrealized area that Career Multipath attempts to exploit.

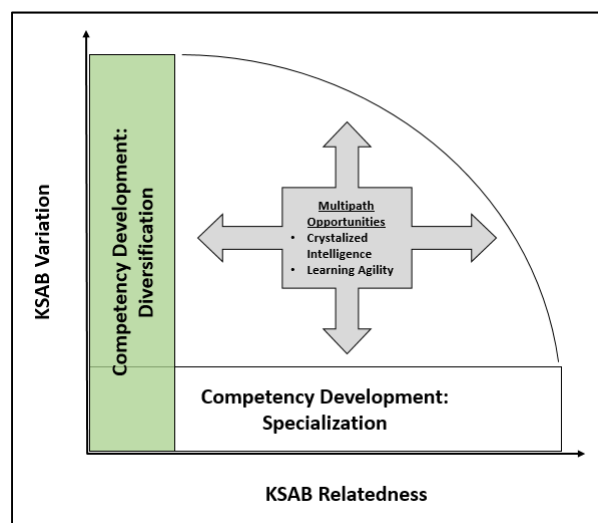


Figure 41. Specialization vs. Diversification Tradeoffs.

While the variation-relatedness tradeoff seems daunting from an HR perspective, it's because the Air Force believes relatedness is anchored in functional abilities. This view is not correct and remains as an artifact of Industrial Age thinking. In order to refute this perspective, institutions must consider Airman KSABs rather than the functional division of Airmen. For a given amount of job variation, organizations must first define the required KSABs of each AFSC through force surveys or scientific studies. For two or more AFSCs, the extent to which KSABs differ determines variation, while KSAB similarities determine relatedness. For example, bomber and mobility pilots are similar in that they are both pilots of complicated, multi-engine aircraft with a number of crewmembers; they are more similar than they are different in both the functional and KSAB perspectives. On the opposite side of the functional-KSAB spectrum, fighter and mobility pilots have less in common than the latter pair because fighter pilots fly simple, single-seat aircraft in rather complex missions. From the functional and KSAB standpoint, there is little similarity between the two.

The differences in the functional and KSAB arguments are subtle. In a middle-ground example, fighter pilots and acquisition managers (63AX) are highly unrelated by functional job tasks, but related in KSABs because they have to problem-solve frequently and time manage tasks carefully. Seeing personnel in this way leads to an important observation: relatedness is contextual rather than functional. By conflating functionality with KSABs, the personnel system is limited in considering other paradigms that attempt to separate the two. By mapping job KSABs along dimensions of relatedness and variation, the Air Force can develop a conceptual framework for considering how different jobs really are. In the case of the fighter pilot and acquisitions manager, it is reasonable to expect that the pilot can do just as well in the manager role because the core officer skills are transferable and fitting to the tasks, albeit specialized knowledge is required. The same is not likely true for the manager because the job knowledge of

a fighter pilot is highly specialized. In a Talent Management system, KSABs define functional groupings, not the other way around. In this way, it is possible to see that a fighter pilot can fill a management role and adapt to the necessary skillset, while unlikely the other way around.

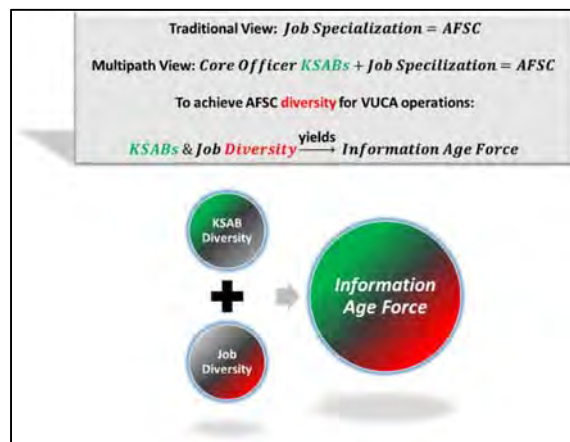


Figure 42. Traditional & Multipath Views of AFSCs.

The KSAB view of Airmen in Figure 42 above breaks down AFSCs into components. The jump between AFSCs then is a matter of KSAB and job matching, such as through AFTMS. All AFSC's are composed of core officer elements and specialized training; therefore, if the differences in specialization are resolved through measures like job KSABs, many officer positions are readily interchangeable. In doing so, functional arguments and stovepipes disappear because the acknowledgement of KSABs opens the solution space. As the differences between variation and relatedness KSABs increase, performance should decrease beyond some optimal point because Airmen exceed their capabilities. Job enlargement studies have proven that, as more skills are required to do something new, frustration increases causing lowered satisfaction and motivation.¹¹⁴

To determine retention and performance optimality, multipath requires correlated measures of performance in certain roles or objective assessments of how well personnel have contributed to organizations. Feedback into AFTMS or another system is critical for assessing relationships in variables and framing future assignments. The more data that is available to

describe the outcome of a multipath assignment, the more AFTMS can explain why personnel succeeded or failed. In turn, KSAB requirements emerge as fast as the analysis of the data are completed. Machine learning algorithms train themselves to find patterns and explanations in the data once given an initial direction. In creating a comprehensive and automated system like AFTMS, the Air Force can leverage automation and human-machine teaming to maximize person-outcome fit.

Career Multipath: Operational Framework & Execution

The Air Force's Future Operating Concept (FOC) calls on the Air Force to develop an FDI-like, Career Multipath system,

"A balanced pool of Airmen, some with deep expertise and *some with diverse experience*, supported by a greater and purposeful differentiation of selection, development, and placement to improve proficiency in multi-domain approaches, mission-critical areas, operational design, full-spectrum operations, and cutting-edge technologies."¹¹⁵

Creating Air Force officers with diverse AFSC backgrounds is not a new concept. In 1998, CSAF General Michael E. Ryan noticed a KSAB disparity between the requirements of General officer jobs and those who filled them, creating an environment where senior leaders were "too specialized to be useful."¹¹⁶ His Force Development Initiative (FDI) desired to cultivate certain professions' KSABs through the intentional management of officer careers.¹¹⁷ While geared towards filling the command positions of senior officers, General Ryan's vision was to create maximum person-organization fit in what is essentially Career Multipath. In General Ryan's words, "Transforming officer development is more important to the Air Force's future than acquiring the F-22 or JSF...and there's a greater risk of failure."¹¹⁸ Figure 43 below illustrates the operational goal of Career Multipath and its ability to support VUCA operations and Information Age warfare.

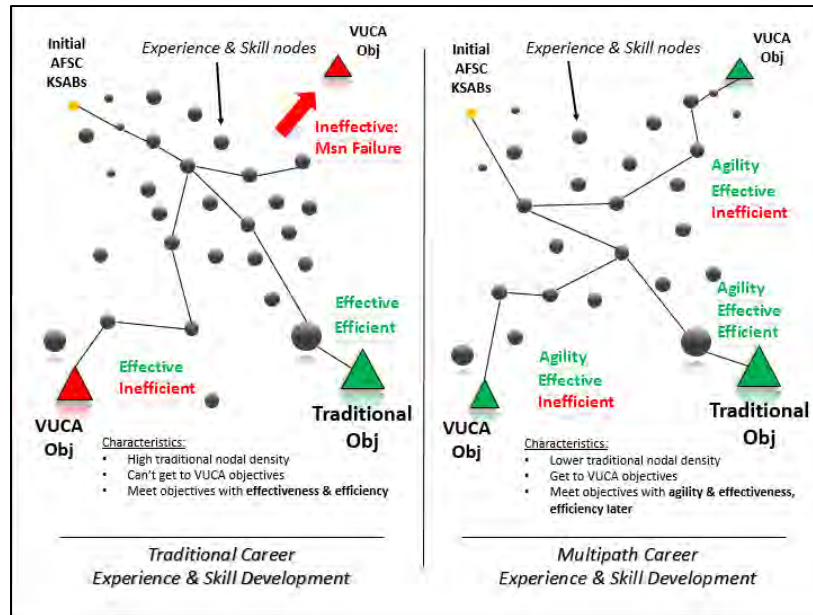


Figure 43. Traditional vs. Career Multipath Experience & Skill Development.

In Figure 43 above, a “traditional” career results in experience and skill node densities to meet military objectives with efficiency. The tradeoff is that traditional skills and experiences prevent success in VUCA environments. In the traditional paradigm, some VUCA objectives are met effectively, while others are met ineffectively resulting in mission failure. Multipath trades traditional experiences and skill node densities for the ability to reach unknowable VUCA objectives. Multipath provides agility and effectiveness first, and then efficiency later as conditions permit.

The first step in operationalizing Career Multipath is to determine the baseline human competencies desired in the future. As proposed here, those competencies are cognitive ability, learning agility, and crystallized intelligence. Since cognitive ability is largely a given and requires innovation in the development and delivery of knowledge, learning agility and crystallized intelligence become the key dimensions in Multipath. Learning agility and crystallized intelligence are fostered by exploiting the trade space between KSAB diversification and specialization, breaking down functional stovepipes along the way. Therefore, the Air Force

must create nodal roadmaps of the experiences and skills desired to succeed in VUCA environments. Much of this information should come from existing psychology and social sciences, with Air Force-sponsored research into new areas.

The second step in operationalizing Multipath is the identification of paired AFSCs that support the nodal roadmap of experience and skill development. In the early 2000's, the FDI team developed tables of primary AFSCs and their paired secondary AFSCs by determining the kind of multi-domain skills officers were expected to need, as illustrated in Figure 44. Using these secondary AFSCs, the RAND team roughly doubled the utilization (related variation) of previous officer experiences. Using the latest advancements in social science, secondary AFSCs would require revision along with integrating a holistic retention predictor, such as Factor Theory.

Primary Occupation	Paired Secondary Occupations
Fighter	Air power employment Political-military Logistics Plans and programs Acquisition Information operations Space Education and training
Bomber	Air power employment Acquisition Space Political-military Logistics Plans and programs Information operations Education and training
C2ISR-rated ^a	Air power employment Information operations Space Logistics Plans and programs Acquisition Political-military Education and training
Mobility (tanker and/or airlift)	Air power employment Mobility operations Acquisition Space Logistics Plans and programs Political-military Information operations Education and training
Special operations	Air power employment Space Plans and programs Logistics Acquisition Political-military Information operations Education and training
Space	Acquisition Communications Aerospace power employment Intelligence Plans and programs Information operations Political-military Education and training

Figure 44. FDI Primary and Secondary AFSC Pairings.

Career Multipath vs. the Status Quo

Career Multipath results in integrating the influential work-life factors of Airmen with human capital and AFSC competencies to realize maximum return to officer performance, retention, and agility. Career Multipath builds on AFTMS as the system that centralizes KSAB analysis, without which Multipath is ineffective. Table 21 below lists the traits of Career Multipath and its impact on the present system.

Multipath Impact on Present System “One Size Fits All”	Multipath System Traits “Many Shapes, Many Fits”
Disturbs Status Quo • Requires leader & organizational <i>support</i>	Flexible Manning Options • <i>Reduced impact of personnel shortfalls</i> • Reduce Force Shaping actions
Lowers Manning Decision Authority • Requires leader & organizational <i>trust</i>	KSAB-Based Assignment Matching • Maximize performance where needed • Maximize retention
KSAB Transition • Empowers those with KSAB/TM skills • Dis-empowers Industrial Age HR • Requires new training & personnel	Human-Machine Teaming • Reduce human biases in decision making • Empower lower-level organizations
AFTMS System / MILPDS Expansion • Build new TM system • Expand MILPDS well-beyond original intent	Leverage Social Sciences & Resources • Team with human performance organizations across DoD • Share constrained & rare resources
Digitization of Personnel • KSABs of <i>every</i> Airman	Lowered decision-making • Empower front-line commanders & functionals

Table 21. Multipath Traits vs. Present System Impacts.

In addition to the RAND FDI study, research into multi-domain operations and experience in VUCA environments has refined human requirements. In the Air Force’s Future Operating Concept, AG1.1-.2 of the Strategic Master Plan identifies supplemental human dimensions necessary in future war:¹¹⁹

- Readiness, responsiveness, critical thinking, adaptive behaviors, innovation, creativity, collaboration, social networking skills, emotional and cognitive intelligence
- Recruit & assess individuals with demonstrated potential and contemporary mission-critical skills
- Open-mindedness and resilience¹²⁰

The third and final step in operationalizing Career Multipath is to determine when an officer enters the program. In the FDI study, RAND and AFPC identified six “trigger” points such that the secondary skill was acquired by promotion to Colonel: selection to Major, Intermediate Developmental Education (IDE), selection to Lieutenant Colonel, Senior Developmental Education (SDE) at Lieutenant Colonel, command, and commander-designated review.¹²¹ However, in order to create a secondary-AFSC diverse force in the operational officer ranks, selection at mid-level Captain is necessary. This portion of the research is unrefined because it requires contextual, stakeholder inputs. Once operationalized, the execution of Career Multipath occurs in three steps:

1. Measure and upload job and Airmen KSABs into AFTMS.
2. Match Airmen to job KSABs to maximize person-outcome fit.
3. Measure personnel and organizational outcomes within AFTMS and to the objective of a retained, max-performed, and agile force.

Career Multipath: Personnel Policy Changes

In a series of memoranda in 2015 and 2016, Secretary of Defense Ash Carter outlined how people formed the competitive edge of US military forces and how that edge could be maintained by adapting the personnel system to changes in the operating environment. Those changes have become necessary due to strong internal and external forces such as the influential forces demonstrated in Factor Theory and a robust, hiring economy. The effectiveness of Multipath in integrating individual KSABs into a holistic, beneficial solution comes by delegating assignment-matching roles to commanders and empowering functional managers to make additional personnel decisions. AFI 36-2640 provides guidance, directs the Air Force personnel development process, and defines the purpose of force development (FD),

“...develop *institutional and occupational competencies* in all Airmen through education, training, and *experience opportunities to satisfy* current and *future Air Force mission requirements*... It depends on underlying processes which integrate and *synchronize senior leader perspectives, institutional requirements, and modeling tools* used to forecast those requirements (both qualitative and quantitative)...”¹²²

In a series of subsections, AFI 36-2640 highlights additional objectives of FD including the maximization of Airmen’s capabilities, transparency, enhanced institutional competencies, and “building cross functional leaders” along with “building depth.”¹²³ These areas highlight concerns and the need for clarifications and changes within the roles of USAF/A1, Functional Authorities (FA), Functional Managers (FM), Career Field Managers (CFM), AFPC, and commanders.

USAF/A1, FA’s, FM’s, CFM’s, and AFPC

The immediate, overriding concern is the lack of a comprehensive human capital resource strategy or stated policy prioritizing critical KSABs, such as The U.S. Army Human Dimension Concept (TRADOC Pam 525-3-7). While an Air Force Human Capital Annex exists in the latest Strategic Master Plan, it is insufficient to deal with the Information Age human capital problems outlined here. Policy objectives aligned to future Air Force mission requirements is critical. The necessities of the Information Age and future war should drive officer selection, development, and career progression to succeed in VUCA environments. The entire personnel enterprise must align to create Airmen with superior cognitive ability, learning agility, and crystallized intelligence along with the requirements of section AG1.1-.2. of the Air Force’s FOC. Policy tools and systems, such as Factor Theory’s predictive modeling or AFTMS as a transparent talent integrator, require consistent deployment within HR management practices. Turnover will continue to challenge the military, so personnel policies and strategies

need to account for losses of experienced personnel. As an institution, the Air Force should inculcate a skill-diverse, learning culture by embracing Career Multipath and FDI for the entire force structure. Of key concern is the need to build cross-functional leaders and depth to dominate in VUCA environments, multiple domains, and the Information Age. Increasing the nodal densities of skill and experiences across Air Force is a hedge against uncertainty and empowers Airmen in a multi-domain construct.

AFPC Policies

AFPC has a role to play in decentralizing selection cycle functions to enable commanders and functional manager's flexibility. First, the assignments process heavily favors central control at AFPC with functional managers limited in their ability to flow personnel across organizations and AFSC boundaries, even if it is in the interest of the Air Force as mandated by AFI 36-2640.

The Air Force's Exception to Policy (ETP) guidelines are too restrictive and actually serve to increase Airman turnover. From the summer of 2015 to 2016, a new 21R (logistician) functional manager at AFPC experienced "7-day option" separations as high as 13%. During 2016, he and his team identified that their managerial and assignments processes were lagging behind personnel expectations of transparency. The functional and his team implemented specific human capital and talent management practices including updating their web-based assignments page with detailed information on the assignments process, developmental opportunities, and open billets. The 21R manager created monthly assignment briefs focused on career field concerns, an LRO career field newsletter, and AFSC crossflow opportunities that started from "yes" rather than "no." By FY 2017, the functional team had reduced separations per assignment cycle to as low as .4%,

*“...the investment in people (not just the top 20% of the career field, but to everyone else) clearly shows that it works in keeping individuals in the AF. They are bought-in, they trust AFPC, they know what is expected, they understand how we do business which enables them to make a more informed life decision.”*¹²⁴

In another case, the 21R functional team coordinated for an AFSC crossflow rather than lose an experienced officer. In this case, the loss of one officer in the 21R field was a gain for the overall Air Force through another 10-year commitment. The idea that a loss in one career field is a gain for the rest of the Air Force is not a commonly held view. In the case of crossflow, members must either pursue an ETP or have a medical, academic, or quality control reason for transfer.¹²⁵ Functional managers balance Headquarters Air Force (HAF) personnel sustainment matrices by career field and year group during crossflows, and any overages become susceptible to force shaping.¹²⁶ The ETP process, “valid” transfer requirements, and sustainment matrices clearly do not incentivize flexibility at the career field functional manager level.¹²⁷ In an environment of excessive organizational resistance, the 21R team converted a separating Airman into a 10-year commitment by remaining flexible and innovative.¹²⁸ Had this not occurred a high quality officer would have left the 21R career field, security forces would have had to fill the billet, and the Air Force would have been left with lowered retention all because the ETP process was inflexible. Less-prepared functional teams will not fare this well and will continue to lose personnel because policy lags practicality.

The ETP process seriously hinders retention. In order to crossflow an Airman, a laborious exception to policy request is required which disincentives the procedure. In order to accept someone into a career field, AFPC cites that a functional manager can only do so when the Airman in question has medical, academic, or quality issues.¹²⁹ As a matter of policy, crossflows are practically inhibited and a stigma of poor officership precedes personnel moving into new

communities. Rather than restrict those closest to personnel management, AFPC should state priorities and let functional managers and commanders best determine how to meet them. For example, if the Air Force's top priority is to ensure no more than 10% loss of one AFSC in the present assignment cycle, commanders can utilize Factor Theory or another tool to maximize person-outcome fit. AFSC crossflows need rebranding as a positive event. The idea that only trouble Airmen crossflow are at odds with future requirements. Unless a smarter force of experienced, fast learners quickly materializes, the Air Force must consider crossflows, Career Multipath, and FDI as creative paths to an Information Age force.

Talent Management Conclusion

Human capital in the Information Age is a vital strategic resource that creates distinct advantages over the enemy. As warfare becomes increasingly contested with respect to technology and capabilities, distinct advantages in human capital and how to employ technology will become decisive. Like multi-domain battle, the age of easy wins are over and the Air Force will require superior cognitive, behavioral, and physical skills to dominate the uncertain future.

At least three dimensions of human performance are critical. First, the cognitive dimension is comprised of the elements of perception, judgment, memory, and reasoning assessed through intelligence and aptitude tests.¹³⁰ Cognition underwrites learning, critical thinking, and effective decision-making while increasing the Air Force's stock of generic human capital that through experience, creates irreplaceable tacit knowledge Critical KSABs for the future include the ability to human-machine team, flexibility with changing technology platforms, lifelong learning, and curiosity. Second, health and fitness through readiness, nutrition, weight management, and sleep mitigates the impacts of stress while improving cognition.¹³¹ If the fight of the future is defined in VUCA terms, then science predicts that the healthier team has the advantage, all other factors being equal. Third, the behavioral dimension

includes those factors that lead to higher rates of turnover such as poor work-life balance, mission contribution, and evolving values and beliefs about continued service. Factor Theory proves that Airmen are multidimensional and not a behavioral black box, requiring a completely new way of thinking about comprehensive Airmen management.

Management of these human dimensions requires new paradigms and constructs of thought. In doing so managers, leaders, and policy makers remove institutional and personal biases in exchange for the best human-outcome fit while reducing wasteful management practices. Machine learning algorithms and artificial intelligence have compressed the scientific method such that extraneous exploration is relatively obsolete as a means of solving problems quickly. As proposed here, AFTMS is one such construct to address these challenges. Additionally, Career Multipath utilizes AFSC crossflow for related job variation to increase adaptability and effectiveness in the Information Age, facilitating multi-domain careers. The Information Age Air Force will require critical thinking, learning agility, and wisdom in order to achieve multi-domain dominance in a complex world. Personnel cannot succeed in multi-domain operations without being multi-domain.

Finally, personnel management practices, such as the Air Force's ETP guidelines, are too restrictive and actually serve to increase Airmen turnover. Decentralization and distribution of some aspects of personnel management are necessary to meet the future demands of the Air Force and the needs of its personnel. As General Ryan's said, "Transforming officer development is more important to the Air Force's future than acquiring the F-22 or JSF...and there's a greater risk of failure."¹³²

Research Conclusion

The results of this research indicate that the established views and management practices of the Air Force's Industrial Age personnel system act against, rather than for, Airmen retention. The evidence for this conclusion is the present system's view of personnel as assets rather than vital strategic resources. Factor Theory and the rational actor model explain that Airmen retention decisions are multidimensional, contextual, measurable, and therefore susceptible to influence and intervention strategies. The Air Force's perception of what matters to Airmen are at odds with what the data reveals. The top retention influencer for pilots is mission contribution, while the ARP program is 21st of 22 influences. In fact, for every one-unit positive change in separation sentiment, influencing mission contribution increases the odds of staying by 53% over the ARP. The question remains, what is the more economical and practical solution: changing the system or throwing money at the problem? The results indicate the same phenomena for CSOs, physicians, and all Air Force officers albeit in different influences and weights, proving service is contextual. Several explanatory and predictive tools have resulted from this research, to include operationalized examples of machine learning methods and classic analytics. Factor Theory provides a window into the decisions of Airmen in near real-time, yet it can only serve as the bridge between desired ends and executable means.

With respect to *ends*, this research has uncovered that the Air Force wants talent management but is unsure of what it needs for future war, VUCA environments, multi-domain operations, and the Information Age. The inability to express ends inhibits any future development in the talent realm. As a solution, AFTMS provides a scalable construct in which the Air Force can take small steps and experiment along with research and educational partners.

With respect to *means*, Career Multipath builds on Gen. Michael Ryan's FDI work and demonstrates how it can solve two "wicked" problems at once: retention and performance. The

FDI program demonstrated that new ways of personnel management are possible through leadership and personnel system support. Career Multipath provides a conceptual framework to deal with the wicked problems of the future by refining personnel assignment “success” as a comprehensive, data-driven measure of person-outcome fit. No longer can the Air Force afford to take an institution-centered view of Airmen service, but instead must ask how its practices contribute to success and failure. Across the panacea of operations, the world will become more integrated and non-linear. Intuitively, the Air Force must ask how its personnel system is adapting to these new realities. By framing future war around key human competencies, the Air Force can evolve its personnel practices into talent management around human performance science. Lastly, regulatory relief and policy options are available to increase retention and performance in the short term. By shifting personnel management down to lower levels, those with the most stake in personnel outcomes can better meet the needs of functional communities while reducing Airmen turnover through mutually beneficial assignments.

In the words of former Secretary of Defense Ash Carter, “The unpredictable landscape in which we operate requires us to continually revisit, improve, and evolve our personnel management process to ensure we optimize and retain our best talent.”¹³³ Every day the Air Force fails to deal with these problems is another day it has to play catch-up.

Attachment 1: Chi-squared Methodology



Categorical Data Analysis

Related topics/headings: Categorical data analysis; or, Nonparametric statistics; or, chi-square tests for the analysis of categorical data.

OVERVIEW

For our hypothesis testing so far, we have been using parametric statistical methods. Parametric methods (1) assume some knowledge about the characteristics of the parent population (e.g. normality) (2) require measurement equivalent to at least an interval scale (calculating a mean or a variance makes no sense otherwise).

Frequently, however, there are research problems in which one wants to make direct inferences about two or more distributions, either by asking if a population distribution has some particular specifiable form, or by asking if two or more population distributions are identical. These questions occur most often when variables are qualitative in nature, making it impossible to carry out the usual inferences in terms of means or variances. For such problems, we use nonparametric methods. Nonparametric methods (1) do not depend on any assumptions about the parameters of the parent population (2) generally assume data are only measured at the nominal or ordinal level.

There are two common types of hypothesis-testing problems that are addressed with nonparametric methods:

(1) How well does a sample distribution correspond with a hypothetical population distribution? As you might guess, the best evidence one has about a population distribution is the sample distribution. The greater the discrepancy between the sample and theoretical distributions, the more we question the “goodness” of the theory.

EX: Suppose we wanted to see whether the distribution of educational achievement had changed over the last 25 years. We might take as our null hypothesis that the distribution of educational achievement had not changed, and see how well our modern-day sample supported that theory.

(2) We often wish to find evidence for association between two qualitative variables - hence we analyze cross-classifications of two discrete distributions.

EX: What is the relationship between sex and party vote - are women more likely than men to support Democratic party candidates?

CASE I. COMPARING SAMPLE AND POPULATION DISTRIBUTIONS.

Suppose that a study of educational achievement of American men were being carried on. The population studied is the set of all American males who are 25 years old at the time of the

study. Each subject observed can be put into 1 and only 1 of the following categories, based on his maximum formal educational achievement:

- 1 = college grad
- 2 = some college
- 3 = high school grad
- 4 = some high school
- 5 = finished 8th grade
- 6 = did not finish 8th grade

Note that these categories are mutually exclusive and exhaustive.

The researcher happens to know that 10 years ago the distribution of educational achievement on this scale for 25 year old men was:

- 1 - 18%
- 2 - 17%
- 3 - 32%
- 4 - 13%
- 5 - 17%
- 6 - 3%

A random sample of 200 subjects is drawn from the current population of 25 year old males, and the following frequency distribution obtained:

- 1 - 35
- 2 - 40
- 3 - 83
- 4 - 16
- 5 - 26
- 6 - 0

The researcher would like to ask if the present population distribution on this scale is exactly like that of 10 years ago. That is, he would like to test

- H_0 : There has been no change across time. The distribution of education in the present population is the same as the distribution of education in the population 10 years ago
- H_A : There has been change across time. The present population distribution differs from the population distribution of 10 years ago.

PROCEDURE: Assume that there has been “no change” over the last 10 years. In a sample of 200, how many men would be expected to fall into each category?

For each category, the expected frequency is

$$N * p_j = E_j = \text{expected frequency for } j\text{th category,}$$

where N = sample size = 200 (for this sample), and p_j = the relative frequency for category j dictated by the null hypothesis. For example, since 18% of all 25 year old males 10 years ago were college graduates, we would expect 18% of the current sample, or 36 males, to be college graduates today if there has been no change. We can therefore construct the following table:

Category	Observed freq (O_j)	Expected freq (E_j)
1	35	$36 = 200 * .18$
2	40	$34 = 200 * .17$
3	83	$64 = 200 * .32$
4	16	$26 = 200 * .13$
5	26	$34 = 200 * .17$
6	0	$6 = 200 * .03$

Question: The observed and expected frequencies obviously differ from each other - but we expect some discrepancies, just because of sampling variability. How do we decide whether the discrepancies are too large to attribute simply to chance?

Answer: We need a test statistic that measures the “goodness of fit” between the observed frequencies and the frequencies expected under the null hypothesis. The Pearson chi-square statistic is one appropriate choice. (The Likelihood Ratio Chi-Square, sometimes referred to as L^2 , is another commonly used alternative, but we won’t discuss it this semester.) The formula for this statistic is

$$\chi^2_{c-1} = \sum (O_j - E_j)^2 / E_j$$

Calculating χ^2_{c-1} for the above, we get

Category	O_j	E_j	$(O_j - E_j)$	$(O_j - E_j)^2 / E_j$
1	35	36	-1	$1/36 = 0.0278$
2	40	34	6	$36/34 = 1.0588$
3	83	64	19	$361/64 = 5.6406$
4	16	26	-10	$100/26 = 3.8462$
5	26	34	-8	$64/34 = 1.8824$
6	0	6	-6	$36/6 = 6.0000$

Summing the last column, we get $\chi^2_{c-1} = 18.46$.

Q: Now that we have computed χ^2_{c-1} , what do we do with it???

A: Note that, the closer O_j is to E_j , the smaller χ^2_{c-1} is. Hence, small values of χ^2_{c-1} imply good fits (i.e. the distribution specified in the null hypothesis is similar to the distribution found in the sample), big values imply poor fits (implying that the hypothesized distribution and the sample distribution are probably not one and the same).

To determine what “small” and “big” are, note that, when each expected frequency is as little as 5 or more (and possibly as little as 1 or more),

$\chi^2_{c-1} \sim \text{Chi-square}(c-1)$, where
c = the number of categories,
c - 1 = v = degrees of freedom

Q: Why does d.f. = c - 1?

A: When working with tabled data (a frequency distribution can be thought of as a 1 dimensional table) the general formula for degrees of freedom is

*d.f. = number of cells - # of pieces of sample information required
for computing expected cell frequencies.*

In the present example, there are c = 6 cells (or categories). In order to come up with expected frequencies for those 6 cells, we only had to have 1 piece of sample information, namely, N, the sample size. (The values for p_j were all contained in the null hypothesis.)

Q: What is a chi-square distribution, and how does one work with it?

Appendix E, Table IV (Hayes pp. 933-934) gives critical values for the Chi-square distribution. The second page of the table has the values you will be most interested in, e.g. Q = .05, Q = .01.

A: The chi-square distribution is easy to work with, but there are some important differences between it and the Normal distribution or the T distribution. Note that

- ✓ The chi-square distribution is NOT symmetric
- ✓ All chi-square values are positive
- ✓ As with the T distribution, the shape of the chi-square distribution depends on the degrees of freedom.
- ✓ Hypothesis tests involving chi-square are usually one-tailed. We are only interested in whether the observed sample distribution significantly differs from the hypothesized distribution. We therefore look at values that occur in the upper tail of the chi-square distribution. That is, low values of chi-square indicate that the sample distribution and the hypothetical distribution are similar to each other, high values indicate that the distributions are dissimilar.
- ✓ A random variable has a chi-square distribution with N degrees of freedom if it has the same distribution as the sum of the squares of N independent variables, each

normally distributed, and each having expectation 0 and variance 1. For example, if $Z \sim N(0,1)$, then $Z^2 \sim \text{Chi-square}(1)$. If Z_1 and Z_2 are both $\sim N(0,1)$, then $Z_1^2 + Z_2^2 \sim \text{Chi-square}(2)$.

EXAMPLES:

- Q. If $v = \text{d.f.} = 1$, what is $P(\chi^2_1 \geq 3.84)$?
- A. Note that, for $v = 1$ and $\chi^2_1 = 3.84$, $Q = .05$. i.e. $F(3.84) = P(\chi^2_1 \leq 3.84) = .95$, hence $P(\chi^2_1 \geq 3.84) = 1 - .95 = .05$. (Incidentally, note that $1.96^2 = 3.84$. If $Z \sim N(0,1)$, then $P(-1.96 \leq Z \leq 1.96) = .95 = P(Z^2 \leq 3.84)$. Recall that $Z^2 \sim \text{Chi-square}(1)$.)
- Q. If $v = 5$, what is the critical value for χ^2_5 such that $P(\chi^2_5 \geq \chi^2_{.01}) = .01$?
- A. Note that, for $v = 5$ and $Q = .01$, the critical value is 15.0863. Ergo, $P(\chi^2_5 \geq 15.1) = 1 - .99 = .01$

Returning to our present problem - we had six categories of education. Hence, we want to know $P(\chi^2_5 \geq 18.46)$. That is, how likely is it, if the null hypothesis is true, that we could get a Pearson chi-square value of this big or bigger in a sample? Looking at Table IV, $v = 5$, we see that this value is around .003 (look at $Q = .005$ and $Q = .001$). That is, if the null hypothesis is true, we would expect to observe a sample distribution that differed this much from the hypothesized distribution fewer than 3 times out of a thousand. Hence, we should probably reject the null hypothesis.

To put this problem in our usual hypothesis testing format,

- Step 1:** H_0 : Distribution now is the same as 10 years ago
 H_A : Distribution now and 10 years ago differ

Step 2: An appropriate test statistic is

$$\chi^2_{c-1} = \sum (O_j - E_j)^2 / E_j, \quad \text{where } E_j = Np_j$$

Step 3: Acceptance region: Accept H_0 if

$$P(\chi^2_{c-1} \leq \chi^2_{c-1}) = 1 - \alpha.$$

In the present example, let us use $\alpha = .01$. Since $v = 5$, accept H_0 if

$$\chi^2_{c-1} \leq 15.1 \quad (\text{see } v=5, Q = .01)$$

Step 4. The computed test statistic = 18.46.

Step 5. Reject H_0 . The value of the computed test statistic lies outside of the acceptance region.

SPSS Solution. The NPAR TESTS Command can be used to estimate this model in SPSS. If using the pull-down menus in SPSS, choose ANALYZE/ NONPARAMETRIC TESTS/ CHI-SQUARE.

```
* Case I: Comparing sample and population distributions
* Educ distribution same as 10 years ago.
data list free / educ wgt.
begin data.
1 35
2 40
3 83
4 16
5 26
end data.
weight by wgt.
```

```
NPAR TEST
  /CHISQUARE=educ (1,6)
  /EXPECTED=36 34 64 26 34 6
  /STATISTICS DESCRIPTIVES
  /MISSING ANALYSIS.
```

NPar Tests

Descriptive Statistics

	N	Mean	Std. Deviation	Minimum	Maximum
EDUC	200	2.7900	1.20963	1.00	5.00

Chi-Square Test

Frequencies

	EDUC			
	Category	Observed N	Expected N	Residual
1	1.00	35	36.0	-1.0
2	2.00	40	34.0	6.0
3	3.00	83	64.0	19.0
4	4.00	16	26.0	-10.0
5	5.00	26	34.0	-8.0
6		0	6.0	-6.0
Total		200		

Test Statistics

	EDUC
Chi-Square ^a	18.456
df	5
Asymp. Sig.	.002

a. 0 cells (.0%) have expected frequencies less than 5. The minimum expected cell frequency is 6.0.

OTHER HYPOTHETICAL DISTRIBUTIONS: In the above example, the hypothetical distribution we used was the known population distribution of 10 years ago. Another possible hypothetical distribution that is sometimes used is specified by the equi-probability model. The equi-probability model claims that the expected number of cases is the same for each category; that is, we test

$H_0: E_1 = E_2 = \dots = E_c$

$H_A: \text{The frequencies are not all equal.}$

The expected frequency for each cell is (Sample size/Number of categories). Such a model might be plausible if we were interested in, say, whether birth rates differed across months. If we believed the equi-probability model might apply to educational achievement, we would hypothesize that 33.33 people would fall into each of our 6 categories.

Calculating χ^2_{c-1} for the equi-probability model, we get

Category	O_j	E_j	$(O_j - E_j)^2/E_j$
1	35	33.33	0.0837
2	40	33.33	1.3348
3	83	33.33	74.0207
4	16	33.33	9.0108
5	26	33.33	1.6120
6	0	33.33	33.3333

Summing the last column, we get $\chi^2_{c-1} = 119.39$. Obviously, the equi-probability model does not provide a very good description of educational achievement in the United States.

SPSS Solution. Again use the NPAR TESTS Command.

* Equi-probability model. Same observed data as before.

```

NPAR TEST
  /CHISQUARE=educ (1,6)
  /EXPECTED=EQUAL
  /STATISTICS DESCRIPTIVES
  /MISSING ANALYSIS.

```

NPar Tests

Descriptive Statistics

	N	Mean	Std. Deviation	Minimum	Maximum
EDUC	200	2.7900	1.20963	1.00	5.00

Chi-Square Test

Frequencies

	EDUC			
	Category	Observed N	Expected N	Residual
1	1.00	35	33.3	1.7
2	2.00	40	33.3	6.7
3	3.00	83	33.3	49.7
4	4.00	16	33.3	-17.3
5	5.00	26	33.3	-7.3
6		0	33.3	-33.3
Total		200		

Test Statistics

	EDUC
Chi-Square ^a	119.380
df	5
Asymp. Sig.	.000

a. 0 cells (.0%) have expected frequencies less than 5. The minimum expected cell frequency is 33.3.

CASE II. TESTS OF ASSOCIATION

A researcher wants to know whether men and women in a particular community differ in their political party preferences. She collects data from a random sample of 200 registered voters, and observes the following:

	Dem	Rep
Male	55	65
Female	50	30

Do men and women significantly differ in their political preferences? Use $\alpha = .05$.

PROCEDURE. The researcher wants to test what we call the model of independence (the reason for that name will become apparent in a moment). That is, she wants to test

H₀: Men and women do not differ in their political preferences

H_A: Men and women do differ in their political preferences.

Suppose H₀ (the model of independence) were true. What joint distribution of sex and party preference would we expect to observe?

Let A = Sex, A₁ = male, A₂ = female, B = political party preference, B₁ = Democrat, B₂ = Republican. Note that P(A₁) = .6 (since there are 120 males in a sample of 200), P(A₂) = .4, P(B₁) = .525 (105 Democrats out of a sample of 200) and P(B₂) = .475.

If men and women do not differ, then the variables A (sex) and B (party vote) should be independent of each other. That is, P(A_i ∩ B_j) = P(A_i)P(B_j). Hence, for a sample of size N,

$$E_{ij} = P(A_i) * P(B_j) * N$$

For example, if the null hypothesis were true, we would expect 31.5% of the sample (i.e. 63 of the 200 sample members) to consist of male democrats, since 60% of the sample is male and 52.5% of the sample is Democratic. The complete set of observed and expected frequencies is

Sex/Party	Observed	Expected
Male Dem	55	P(Male)*P(Dem) = .6 * .525 * 200 = 63
Male Rep	65	P(Male)*P(Rep) = .6 * .475 * 200 = 57
Female Dem	50	P(Fem)*P(Dem) = .4 * .525 * 200 = 42
Female Rep	30	P(Fem)*P(Rep) = .4 * .475 * 200 = 38

Q: The observed and expected frequencies obviously differ - but we expect some differences, just because of sampling variability. How do we decide if the differences are too large to attribute simply to chance?

A: Once again, the Pearson chi-square is an appropriate test statistic. The appropriate formula is

$$\chi^2_v = \sum \sum (O_{ij} - E_{ij})^2 / E_{ij},$$

where r is the number of rows (i.e. the number of different possible values for sex), c is the number of columns (i.e. the number of different possible values for party preference), and v = degrees of freedom = rc - 1 - (r-1) - (c-1) = (r-1)(c-1).

Q: Why does d.f. = rc - 1 - (r-1) - (c-1) = (r-1)(c-1)?

A: Recall our general formula from above:

$$d.f. = \text{number of cells} - \text{\# of pieces of sample information required for computing expected cell frequencies.}$$

In this example, the number of cells is $rc = 2 \times 2 = 4$. The pieces of sample information required for computing the expected cell frequencies are N , the sample size; $P(A_1) = P(\text{Male}) = .6$; and $P(B_1) = P(\text{Democrat}) = .525$. Note that, once we knew $P(A_1)$ and $P(B_1)$, we immediately knew $P(A_2)$ and $P(B_2)$, since probabilities sum to 1; we don't have to use additional degrees of freedom to estimate them. Hence, there are 4 cells, we had to know 3 pieces of sample information to get expected frequencies for those 4 cells, hence there is 1 d.f. NOTE: In a 2-dimensional table, it happens to work out that, for the model of independence, $d.f. = (r-1)(c-1)$. It is NOT the case that in a 3-dimensional table $d.f. = (r-1)(c-1)(l-1)$, where l is the number of categories for the 3rd variable; rather, $d.f. = rcl - 1 - (r-1) - (c-1) - (l-1)$.

Returning to the problem - we can compute

Sex/Party	Observed	Expected	$(O_{ij} - E_{ij})^2/E_{ij}$
Male Dem	55	63	$64/63 = 1.0159$
Male Rep	65	57	$64/57 = 0.9552$
Female Dem	50	42	$64/42 = 1.5238$
Female Rep	30	38	$64/38 = 1.6842$

Note that $v = (r - 1)(c - 1) = 1$. Adding up the numbers on the right-hand column, we get $\chi^2_1 = 5.347$. Looking at table IV, we see that we would get a test statistic this large only about 2% of the time if H_0 were true, hence we reject H_0 .

To put things more formally then,

Step 1.

H_0 : Men and women do not differ in their political preferences

H_A : Men and women do differ in their political preferences.

or, equivalently,

H_0 : $P(A_i \cap B_j) = P(A_i)P(B_j)$ (Model of independence)

H_A : $P(A_i \cap B_j) \neq P(A_i)P(B_j)$ for some i, j

Step 2. An appropriate test statistic is

$$\chi^2_v = \sum \sum (O_{ij} - E_{ij})^2/E_{ij}, \quad v = rc - 1 - (r-1) - (c-1) = (r-1)(c-1)$$

Step 3. For $\alpha = .05$ and $v = 1$, accept H_0 if $\chi^2_v \leq 3.84$

Step 4. The computed value of the test statistic is 5.347

Step 5. Reject H_0 , the computed test statistic is too high.

Yates Correction for Continuity. Sometimes in a 1 X 2 or 2 X 2 table (but not for other size tables), Yates Correction for Continuity is applied. This involves subtracting 0.5 from positive differences between observed and expected frequencies, and adding .5 to negative differences before squaring. This will reduce the magnitude of the test statistic. To apply the correction in the above example,

Sex/Party	Observed	Expected (with correction)	$(O_{ij} - E_{ij})^2/E_{ij}$
Male Dem	55	62.5	$-7.5^2/62.5 = .9$
Male Rep	65	57.5	$7.5^2/57.5 = .9783$
Female Dem	50	42.5	$7.5^2/42.5 = 1.3235$
Female Rep	30	37.5	$-7.5^2/37.5 = 1.5$

After applying the correction, the computed value of the test statistic is 4.70.

Fisher's Exact Test. The Pearson Chi-Square test and the Yates Correction for Continuity are actually just approximations of the exact probability; and particularly when some expected frequencies are small (5 or less) they may be somewhat inaccurate. As Stata 8's Reference Manual S-Z, p. 219 notes, "Fisher's exact test yields the probability of observing a table that gives at least as much evidence of association as the one actually observed under the assumption of no association." In other words, if the model of independence holds, how likely would you be to see a table that deviated this much or more from the expected frequencies?

You are most likely to see Fisher's exact test used with 2 X 2 tables where one or more expected frequencies is less than 5, but it can be computed in other situations. It can be hard to do by hand though and even computers can have problems when the sample size or number of cells is large. SPSS can optionally report Fisher's exact test for 2 X 2 tables but apparently won't do it for larger tables (unless perhaps you buy some of its additional modules). Stata can, by request, compute Fisher's exact test for any size two dimensional table, but it may take a while to do so.

You don't get a test statistic with Fisher's exact test; instead, you just get the probabilities. For the current example, the 2-sided probability of getting a table where the observed frequencies differed this much or more from the expected frequencies if the model of independence is true is .022; the one-sided probability is .015.

SPSS Solution. SPSS Has a couple of ways of doing this. The easiest is probably the crosstabs command. On the SPSS pulldown menus, look for ANALYZE/ DESCRIPTIVE STATISTICS/ CROSSTABS.

* Case II: Tests of association.

Data list free / Sex Party Wgt.

Begin data.

1 1 55

2 1 50

1 2 65

2 2 30

End data.

Weight by Wgt.

CROSSTABS

/TABLES=sex BY party

/FORMAT= AVALUE NOINDEX BOX LABELS TABLES

/STATISTIC=CHISQ

/CELLS= COUNT EXPECTED .

Crosstabs

Case Processing Summary

	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
SEX * PARTY	200	100.0%	0	.0%	200	100.0%

SEX * PARTY Crosstabulation

			PARTY		Total
			1.00	2.00	
SEX	1.00	Count	55	65	120
		Expected Count	63.0	57.0	120.0
	2.00	Count	50	30	80
		Expected Count	42.0	38.0	80.0
Total	Count		105	95	200
	Expected Count		105.0	95.0	200.0

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	5.347 ^b	1	.021		
Continuity Correction ^a	4.699	1	.030		
Likelihood Ratio	5.388	1	.020		
Fisher's Exact Test				.022	.015
Linear-by-Linear Association	5.320	1	.021		
N of Valid Cases	200				

a. Computed only for a 2x2 table

b. 0 cells (.0%) have expected count less than 5. The minimum expected count is 38.00.

CHI-SQUARE TESTS OF ASSOCIATION FOR 2 X 2 TABLES (NONPARAMETRIC TESTS, CASE II) VS. TWO SAMPLE TESTS, CASE V, TEST OF $p_1 - p_2 = 0$.

Consider again the following sample data.

	Dem	Rep
Male	55	65
Female	50	30

Note that, instead of viewing this as one sample of 200 men and women, we could view it as two samples, a sample of 120 men and another sample of 80 women. Further, since there are only two categories for political party, testing whether men and women have the same distribution of party preferences is equivalent to testing whether the same proportion of men and women support the Democratic party. Hence, we could also treat this as a two sample problem, case V, test of $p_1 = p_2$. The computed test statistic is

$$z = \frac{\frac{X_1}{N_1} - \frac{X_2}{N_2}}{\sqrt{\left(\frac{N_1 + N_2}{N_1 N_2}\right) \left(\frac{X_1 + X_2}{N_1 + N_2}\right) \left(1 - \frac{X_1 + X_2}{N_1 + N_2}\right)}} = \frac{\frac{55}{120} - \frac{50}{80}}{\sqrt{\left(\frac{120 + 80}{120 * 80}\right) \left(\frac{55 + 50}{120 + 80}\right) \left(1 - \frac{55 + 50}{120 + 80}\right)}} = 2.31$$

Hence, using $\alpha = .05$, we again reject H_0 .

NOTE: Recall that if $Z \sim N(0,1)$, $Z^2 \sim \text{Chi-square}(1)$. If we square 2.31229, we get 5.347 - which was the value we got for χ^2 with 1 d.f. when we did the chi-square test for association. For a 2 X 2 table, a chi-square test for the model of independence and a 2 sample test of $p_1 - p_2 = 0$ (with a 2-tailed alternative) will yield the same results. Once you get bigger tables, of course, the tests are no longer equivalent (since you either have more than 2 samples, or you have more than just p_1 and p_2).

CASE III: CHI-SQUARE TESTS OF ASSOCIATION FOR N-DIMENSIONAL TABLES

A researcher collects the following data:

Gender/Party	Republican		Democrat	
	W	NW	W	NW
Male	20	5	20	15
Female	18	2	15	5

Test the hypothesis that sex, race, and party affiliation are independent of each other. Use $\alpha = .10$.

Solution. Let A = Sex, A_1 = male, A_2 = female, B = Race, B_1 = white, B_2 = nonwhite, C = Party affiliation, C_1 = Republican, C_2 = Democrat. Note that $N = 100$, $P(A_1) = .60$, $P(A_2) = 1 - .60 = .40$, $P(B_1) = .73$, $P(B_2) = 1 - .73 = .27$, $P(C_1) = .45$, $P(C_2) = 1 - .45 = .55$.

Step 1.

$H_0: P(A_i \cap B_j \cap C_k) = P(A_i) * P(B_j) * P(C_k)$ (Independence model)

$H_A: P(A_i \cap B_j \cap C_k) > P(A_i) * P(B_j) * P(C_k)$ for some i, j, k

Step 2. The appropriate test statistic is

$$\chi^2_v = \sum \sum \sum (O_{ijk} - E_{ijk})^2 / E_{ijk}$$

Note that $E_{ijk} = P(A_i) * P(B_j) * P(C_k) * N$.

Since A , B , and C each have two categories, the sample information required for computing the expected frequencies is $P(A_1)$, $P(B_1)$, $P(C_1)$, and N . (Note that once we know $P(A_1)$, $P(B_1)$, and $P(C_1)$, we automatically know $P(A_2)$, $P(B_2)$, and $P(C_2)$). Hence, there are 8 cells in the table, we need 4 pieces of sample information to compute the expected frequencies for those 8 cells, hence d.f. = 8 - 4. More generally, for a three-dimensional table, the model of independence has d.f. = $v = rcl - 1 - (r - 1) - (c - 1) - (l - 1)$.

Step 3. Accept H_0 if $\chi^2_4 \leq 7.78$ (see $v = 4$ and $Q = .10$)

Step 4. To compute the Pearson Chi-square:

Sex/Race/Party	O_{ijk}	E_{ijk}	$(O-E)^2/E$
M / W / R	20	$19.71 = .6*.73*.45*100$	0.0043
F / W / R	18	$13.14 = .4*.73*.45*100$	1.7975
M / NW/ R	5	$7.29 = .6*.27*.45*100$	0.7194
F / NW/ R	2	$4.86 = .4*.27*.45*100$	1.6830
M / W / D	20	$24.09 = .6*.73*.55*100$	0.6944
F / W / D	15	$16.06 = .4*.73*.55*100$	0.0700
M / NW/ D	15	$8.91 = .6*.27*.55*100$	4.1625
F / NW/ D	5	$5.94 = .4*.27*.55*100$	0.1488

Summing the last column, we get a computed test statistic value of 9.28.

Step 5. Reject H_0 , the computed test statistic value lies outside the acceptance region. (Note that we would not reject if we used $\alpha = .05$.)

SPSS Solution. You can still do Crosstabs but SPSS doesn't report the test statistics in a particularly useful fashion. The SPSS GENLOG command provides one way of dealing with more complicated tables, and lets you also estimate more sophisticated models. On the SPSS menus, use ANALYZE/ LOGLINEAR/ GENERAL. I'm only showing the most important parts of the printout below.

* N-Dimensional tables.

```
Data list free / sex party race wgt.
begin data.
1 1 1 20
1 1 2 5
1 2 1 20
1 2 2 15
2 1 1 18
2 1 2 2
2 2 1 15
2 2 2 5
end data.
weight by wgt.
```

* Model of independence.

```
GENLOG
  party race sex
  /MODEL=POISSON
  /PRINT FREQ
  /PLOT NONE
  /CRITERIA =CIN(95) ITERATE(20) CONVERGE(.001) DELTA(.5)
  /DESIGN party race sex .
```

General Loglinear

Table Information

Factor	Value	Observed Count	%	Expected Count	%
PARTY	1.00				
RACE	1.00				
SEX	1.00	20.00 (20.00)		19.71 (19.71)	
SEX	2.00	18.00 (18.00)		13.14 (13.14)	
RACE	2.00				
SEX	1.00	5.00 (5.00)		7.29 (7.29)	
SEX	2.00	2.00 (2.00)		4.86 (4.86)	
PARTY	2.00				
RACE	1.00				
SEX	1.00	20.00 (20.00)		24.09 (24.09)	
SEX	2.00	15.00 (15.00)		16.06 (16.06)	
RACE	2.00				
SEX	1.00	15.00 (15.00)		8.91 (8.91)	
SEX	2.00	5.00 (5.00)		5.94 (5.94)	

Goodness-of-fit Statistics

	Chi-Square	DF	Sig.
Likelihood Ratio	9.0042	4	.0610
Pearson	9.2798	4	.0545

CONDITIONAL INDEPENDENCE IN N-DIMENSIONAL TABLES

Using the same data as in the last problem, test whether party vote is independent of sex and race, WITHOUT assuming that sex and race are independent of each other. Use $\alpha = .05$.

Solution. We are being asked to test the model of conditional independence. This model says that party vote is not affected by either race or sex, although race and sex may be associated with each other. Such a model makes sense if we are primarily interested in the determinants of party vote, and do not care whether other variables happen to be associated with each other.

Note that $P(A_1 \cap B_1) = .40$, $P(A_2 \cap B_1) = .33$, $P(A_1 \cap B_2) = .20$, $P(A_2 \cap B_2) = 1 - .40 - .33 - .20 = .07$, $P(C_1) = .45$, $P(C_2) = 1 - .45 = .55$, and $N = 100$.

Step 1.

$$H_0: P(A_i \cap B_j \cap C_k) = P(A_i \cap B_j) * P(C_k)$$

$$H_A: P(A_i \cap B_j \cap C_k) <> P(A_i \cap B_j) * P(C_k) \text{ for some } i, j, k$$

Step 2. The Pearson chi-square is again an appropriate test statistic. However, the expected values for the model of conditional independence are

$$E_{ijk} = P(A_i \cap B_j) * P(C_k) * N.$$

To compute the expected values, we need 5 pieces of sample information (N , $P(C_1)$, $P(A_1 \cap B_1)$, $P(A_2 \cap B_1)$, and $P(A_1 \cap B_2)$), hence d.f. =

$$v = rcl - 1 - (rc - 1) - (l - 1) = 8 - 1 - (4 - 1) - (2 - 1) = 3.$$

Step 3. For $\alpha = .05$ and $v = 3$, accept H_0 if $\chi^2_3 \leq 7.81$.

Step 4. To compute the Pearson Chi-square:

Sex-Race/Party	O_{ijk}	E_{ijk}	$(O-E)^2/E$
M-W / R	20	$18.00 = .40 * .45 * 100$	0.2222
F-W / R	18	$14.85 = .33 * .45 * 100$	0.6682
M-NW/ R	5	$9.00 = .20 * .45 * 100$	1.7778
F-NW/ R	2	$3.15 = .07 * .45 * 100$	0.4198
M-W / D	20	$22.00 = .40 * .55 * 100$	0.1818
F-W / D	15	$18.15 = .33 * .55 * 100$	0.5467
M-NW/ D	15	$11.00 = .20 * .55 * 100$	1.4545
F-NW/ D	5	$3.85 = .07 * .55 * 100$	0.3435

Summing the last column, the computed test statistic = 5.61.

Step 5. Accept H_0 ; the computed test statistic falls within the acceptance region.

SPSS Solution. You can again use GENLOG.

* Model of conditional independence. Same data as above.

```
GENLOG
  party race sex
  /MODEL=POISSON
  /PRINT FREQ
  /PLOT NONE
  /CRITERIA =CIN(95) ITERATE(20) CONVERGE(.001) DELTA(.5)
  /DESIGN party race sex race*sex .
```

General Loglinear

Table Information

Factor	Value	Observed Count	%	Expected Count	%
PARTY	1.00				
RACE	1.00				
SEX	1.00	20.00 (20.00)		18.00 (18.00)	
SEX	2.00	18.00 (18.00)		14.85 (14.85)	
RACE	2.00				
SEX	1.00	5.00 (5.00)		9.00 (9.00)	
SEX	2.00	2.00 (2.00)		3.15 (3.15)	
PARTY	2.00				
RACE	1.00				
SEX	1.00	20.00 (20.00)		22.00 (22.00)	
SEX	2.00	15.00 (15.00)		18.15 (18.15)	
RACE	2.00				
SEX	1.00	15.00 (15.00)		11.00 (11.00)	
SEX	2.00	5.00 (5.00)		3.85 (3.85)	

Goodness-of-fit Statistics

	Chi-Square	DF	Sig.
Likelihood Ratio	5.8322	3	.1201
Pearson	5.6146	3	.1319

Attachment 2: Targeted Factor Theory Surveys



FACTOR THEORY PILOT (11X) SURVEY QUESTIONS

AFSC (ie, 11M, 11F):

YEARS OF SERVICE:

BIRTH YEAR:

MY ADSC EXPIRES IN (Mo/Yr; or unknown):

A. Have you established a Date of Separation (DOS)?

Yes

No

Please answer the following questions based on their influence in making you stay or leave Active Duty Air Force service. Please answer based on your present feelings.

Q2. Promotion opportunity (1.28)

N/A

Did not consider this when making my decision

Very strong influence to leave

Strong influence to leave

Slight influence to leave

Neither an influence to stay nor leave

Slight influence to stay

Strong influence to stay

Very strong influence to stay

Q3. Number of PCS moves (1.21)

N/A

Did not consider this when making my decision

Very strong influence to leave

Strong influence to leave

Slight influence to leave

Neither an influence to stay nor leave

Slight influence to stay

Strong influence to stay

Very strong influence to stay

Q4. Deployment locations (1.25)

N/A

Did not consider this when making my decision

Very strong influence to leave

Strong influence to leave

Slight influence to leave

Neither an influence to stay nor leave

Slight influence to stay

Strong influence to stay
Very strong influence to stay

Q5. Length of deployments (1.61)

N/A
Did not consider this when making my decision
Very strong influence to leave
Strong influence to leave
Slight influence to leave
Neither an influence to stay nor leave
Slight influence to stay
Strong influence to stay
Very strong influence to stay

Q6. Number of deployments (1.53)

N/A
Did not consider this when making my decision
Very strong influence to leave
Strong influence to leave
Slight influence to leave
Neither an influence to stay nor leave
Slight influence to stay
Strong influence to stay
Very strong influence to stay

Q7. The potential requirement to leave your family for a deployment (1.74)

N/A
Did not consider this when making my decision
Very strong influence to leave
Strong influence to leave
Slight influence to leave
Neither an influence to stay nor leave
Slight influence to stay
Strong influence to stay
Very strong influence to stay

Q11. Maintaining work/life balance and meeting family commitments (1.46)

N/A
Did not consider this when making my decision
Very strong influence to leave
Strong influence to leave
Slight influence to leave
Neither an influence to stay nor leave
Slight influence to stay

Strong influence to stay
Very strong influence to stay

Q12. Your child(ren)'s needs (1.44)

N/A
Did not consider this when making my decision
Very strong influence to leave
Strong influence to leave
Slight influence to leave
Neither an influence to stay nor leave
Slight influence to stay
Strong influence to stay
Very strong influence to stay

Q13. Choice of job assignment (1.67)

N/A
Did not consider this when making my decision
Very strong influence to leave
Strong influence to leave
Slight influence to leave
Neither an influence to stay nor leave
Slight influence to stay
Strong influence to stay
Very strong influence to stay

Q1. Immediate supervisor (1.26)

N/A
Did not consider this when making my decision
Very strong influence to leave
Strong influence to leave
Slight influence to leave
Neither an influence to stay nor leave
Slight influence to stay
Strong influence to stay
Very strong influence to stay

Q2. Leadership at unit level (1.21)

N/A
Did not consider this when making my decision
Very strong influence to leave
Strong influence to leave
Slight influence to leave
Neither an influence to stay nor leave
Slight influence to stay
Strong influence to stay
Very strong influence to stay

Q3. Overall job satisfaction (1.66)

N/A

Did not consider this when making my decision

Very strong influence to leave

Strong influence to leave

Slight influence to leave

Neither an influence to stay nor leave

Slight influence to stay

Strong influence to stay

Very strong influence to stay

Q4. Satisfaction with my current career field (1.61)

N/A

Did not consider this when making my decision

Very strong influence to leave

Strong influence to leave

Slight influence to leave

Neither an influence to stay nor leave

Slight influence to stay

Strong influence to stay

Very strong influence to stay

Q5. Ability to contribute to the mission (1.74)

N/A

Did not consider this when making my decision

Very strong influence to leave

Strong influence to leave

Slight influence to leave

Neither an influence to stay nor leave

Slight influence to stay

Strong influence to stay

Very strong influence to stay

Q6. Utilization of my skills within my unit (1.44)

N/A

Did not consider this when making my decision

Very strong influence to leave

Strong influence to leave

Slight influence to leave

Neither an influence to stay nor leave

Slight influence to stay

Strong influence to stay

Very strong influence to stay

Q8. Relationship with personnel currently working in my unit (1.34)

N/A

Did not consider this when making my decision

Very strong influence to leave

Strong influence to leave

Slight influence to leave

Neither an influence to stay nor leave

Slight influence to stay

Strong influence to stay

Very strong influence to stay

Q9. Training/experience of personnel in my unit (1.63)

N/A

Did not consider this when making my decision

Very strong influence to leave

Strong influence to leave

Slight influence to leave

Neither an influence to stay nor leave

Slight influence to stay

Strong influence to stay

Very strong influence to stay

Q10. Unit climate - Unit members' shared perceptions about formal or informal practices of the unit and its members (1.34)

N/A

Did not consider this when making my decision

Very strong influence to leave

Strong influence to leave

Slight influence to leave

Neither an influence to stay nor leave

Slight influence to stay

Strong influence to stay

Very strong influence to stay

Q11. Bonuses/Special Pay (1.21)

N/A

Did not consider this when making my decision

Very strong influence to leave

Strong influence to leave

Slight influence to leave

Neither an influence to stay nor leave

Slight influence to stay

Strong influence to stay

Very strong influence to stay

Q12. Retirement program (1.67)

N/A

Did not consider this when making my decision

Very strong influence to leave

Strong influence to leave

Slight influence to leave

Neither an influence to stay nor leave

Slight influence to stay

Strong influence to stay

Very strong influence to stay

Q13. Patriotism (1.37)

N/A

Did not consider this when making my decision

Very strong influence to leave

Strong influence to leave

Slight influence to leave

Neither an influence to stay nor leave

Slight influence to stay

Strong influence to stay

Very strong influence to stay

Q14. Tricare benefits upon retirement (1.67)

N/A

Did not consider this when making my decision

Very strong influence to leave

Strong influence to leave

Slight influence to leave

Neither an influence to stay nor leave

Slight influence to stay

Strong influence to stay

Very strong influence to stay

B. If there were no penalty for leaving the Air Force right this moment (ADSC, bonus pay-backs, etc.), would you leave?

Yes, I would leave

No, I would stay

No decision either way

FACTOR THEORY CSO (12X) SURVEY QUESTIONS

AFSC (ie, 11M, 11F):

YEARS OF SERVICE:

BIRTH YEAR:

MY ADSC EXPIRES IN (Mo/Yr; or unknown):

A. Have you established a Date of Separation (DOS)?

Yes

No

Please answer the following questions based on their influence in making you stay or leave Active Duty Air Force service. Please answer based on your present feelings.

Q1. Promotion opportunity (1.46)

N/A

Did not consider this when making my decision

Very strong influence to leave

Strong influence to leave

Slight influence to leave

Neither an influence to stay nor leave

Slight influence to stay

Strong influence to stay

Very strong influence to stay

Q2. Opportunities for career field/skills training and professional development (1.30)

N/A

Did not consider this when making my decision

Very strong influence to leave

Strong influence to leave

Slight influence to leave

Neither an influence to stay nor leave

Slight influence to stay

Strong influence to stay

Very strong influence to stay

Q4. Number of PCS moves (1.38)

N/A

Did not consider this when making my decision

Very strong influence to leave

Strong influence to leave

Slight influence to leave

Neither an influence to stay nor leave

Slight influence to stay

Strong influence to stay
Very strong influence to stay

Q6. Deployment locations (1.32)

N/A
Did not consider this when making my decision
Very strong influence to leave
Strong influence to leave
Slight influence to leave
Neither an influence to stay nor leave
Slight influence to stay
Strong influence to stay
Very strong influence to stay

Q9. The potential requirement to leave your family for a deployment (1.27)

N/A
Did not consider this when making my decision
Very strong influence to leave
Strong influence to leave
Slight influence to leave
Neither an influence to stay nor leave
Slight influence to stay
Strong influence to stay
Very strong influence to stay

Q10. Leadership at MAJCOM/HQ USAF level (1.25)

N/A
Did not consider this when making my decision
Very strong influence to leave
Strong influence to leave
Slight influence to leave
Neither an influence to stay nor leave
Slight influence to stay
Strong influence to stay
Very strong influence to stay

Q12. Unit resources (e.g., equipment, supplies, parts, etc.) (1.33)

N/A
Did not consider this when making my decision
Very strong influence to leave
Strong influence to leave
Slight influence to leave

Neither an influence to stay nor leave
Slight influence to stay
Strong influence to stay
Very strong influence to stay

Q14. TEMPO away (number/duration of TDYs) **(1.20)**

N/A
Did not consider this when making my decision
Very strong influence to leave
Strong influence to leave
Slight influence to leave
Neither an influence to stay nor leave
Slight influence to stay
Strong influence to stay
Very strong influence to stay

Q16. Maintaining work/life balance and meeting family commitments **(1.35)**

N/A
Did not consider this when making my decision
Very strong influence to leave
Strong influence to leave
Slight influence to leave
Neither an influence to stay nor leave
Slight influence to stay
Strong influence to stay
Very strong influence to stay

Q1. Opportunities to further your academic education **(1.40)**

N/A
Did not consider this when making my decision
Very strong influence to leave
Strong influence to leave
Slight influence to leave
Neither an influence to stay nor leave
Slight influence to stay
Strong influence to stay
Very strong influence to stay

Q2. Opportunities to command/lead **(1.46)**

N/A
Did not consider this when making my decision
Very strong influence to leave
Strong influence to leave

Slight influence to leave
Neither an influence to stay nor leave
Slight influence to stay
Strong influence to stay
Very strong influence to stay

Q3. Choice of job assignment (1.55)

N/A
Did not consider this when making my decision
Very strong influence to leave
Strong influence to leave
Slight influence to leave
Neither an influence to stay nor leave
Slight influence to stay
Strong influence to stay
Very strong influence to stay

Q4. Option to remain in one location for a longer period of time (homestead) (1.38)

N/A
Did not consider this when making my decision
Very strong influence to leave
Strong influence to leave
Slight influence to leave
Neither an influence to stay nor leave
Slight influence to stay
Strong influence to stay
Very strong influence to stay

Q5. Your experiences while deployed (1.44)

N/A
Did not consider this when making my decision
Very strong influence to leave
Strong influence to leave
Slight influence to leave
Neither an influence to stay nor leave
Slight influence to stay
Strong influence to stay
Very strong influence to stay

Q7. Overall job satisfaction (1.66)

N/A
Did not consider this when making my decision

Very strong influence to leave
Strong influence to leave
Slight influence to leave
Neither an influence to stay nor leave
Slight influence to stay
Strong influence to stay
Very strong influence to stay

Q8. Satisfaction with my current career field **(1.33)**

N/A
Did not consider this when making my decision
Very strong influence to leave
Strong influence to leave
Slight influence to leave
Neither an influence to stay nor leave
Slight influence to stay
Strong influence to stay
Very strong influence to stay

10. Utilization of my skills within my unit **(1.38)**

N/A
Did not consider this when making my decision
Very strong influence to leave
Strong influence to leave
Slight influence to leave
Neither an influence to stay nor leave
Slight influence to stay
Strong influence to stay
Very strong influence to stay

Q12. Unit climate - Unit members' shared perceptions about formal or informal practices of the unit and its members **(1.18)**

N/A
Did not consider this when making my decision
Very strong influence to leave
Strong influence to leave
Slight influence to leave
Neither an influence to stay nor leave
Slight influence to stay
Strong influence to stay
Very strong influence to stay

Q14. Basic Pay **(1.28)**

N/A

Did not consider this when making my decision

Very strong influence to leave

Strong influence to leave

Slight influence to leave

Neither an influence to stay nor leave

Slight influence to stay

Strong influence to stay

Very strong influence to stay

Q15. Retirement program (1.33)

N/A

Did not consider this when making my decision

Very strong influence to leave

Strong influence to leave

Slight influence to leave

Neither an influence to stay nor leave

Slight influence to stay

Strong influence to stay

Very strong influence to stay

Q16. Overall compensation and benefits package, i.e., pay, leave, medical, retirement, etc. (1.87)

N/A

Did not consider this when making my decision

Very strong influence to leave

Strong influence to leave

Slight influence to leave

Neither an influence to stay nor leave

Slight influence to stay

Strong influence to stay

Very strong influence to stay

Q17. Patriotism (1.24)

N/A

Did not consider this when making my decision

Very strong influence to leave

Strong influence to leave

Slight influence to leave

Neither an influence to stay nor leave

Slight influence to stay

Strong influence to stay

Very strong influence to stay

Q19. Tricare benefits upon retirement (1.22)

N/A

Did not consider this when making my decision

Very strong influence to leave

Strong influence to leave

Slight influence to leave

Neither an influence to stay nor leave

Slight influence to stay

Strong influence to stay

Very strong influence to stay

Q21. Aviator Pay (commonly known as flight pay) (1.29)

N/A

Did not consider this when making my decision

Very strong influence to leave

Strong influence to leave

Slight influence to leave

Neither an influence to stay nor leave

Slight influence to stay

Strong influence to stay

Very strong influence to stay

B. If there were no penalty for leaving the Air Force right this moment (ADSC, bonus pay-backs, etc.), would you leave?

Yes, I would leave

No, I would stay

No decision either way

FACTOR THEORY PHYSICIAN (44X) SURVEY QUESTIONS

AFSC (ie, 11M, 11F):

YEARS OF SERVICE:

BIRTH YEAR:

MY ADSC EXPIRES IN (Mo/Yr; or unknown):

A. Have you established a Date of Separation (DOS)?

Yes

No

Please answer the following questions based on their influence in making you stay or leave Active Duty Air Force service. Please answer based on your present feelings.

Q1. Maintaining work/life balance and meeting family commitments (1.33)

N/A

Did not consider this when making my decision

Very strong influence to leave

Strong influence to leave

Slight influence to leave

Neither an influence to stay nor leave

Slight influence to stay

Strong influence to stay

Very strong influence to stay

Q2. Your child(ren)'s needs (1.29)

N/A

Did not consider this when making my decision

Very strong influence to leave

Strong influence to leave

Slight influence to leave

Neither an influence to stay nor leave

Slight influence to stay

Strong influence to stay

Very strong influence to stay

Q4. Job stress (1.42)

N/A

Did not consider this when making my decision

Very strong influence to leave

Strong influence to leave

Slight influence to leave

Neither an influence to stay nor leave

Slight influence to stay

Strong influence to stay
Very strong influence to stay

Q10. Active duty service commitments associated with the compensation programs listed above
(1.34)

N/A
Did not consider this when making my decision
Very strong influence to leave
Strong influence to leave
Slight influence to leave
Neither an influence to stay nor leave
Slight influence to stay
Strong influence to stay
Very strong influence to stay

Q11. Leadership at unit level **(1.36)**

N/A
Did not consider this when making my decision
Very strong influence to leave
Strong influence to leave
Slight influence to leave
Neither an influence to stay nor leave
Slight influence to stay
Strong influence to stay
Very strong influence to stay

Q12. Senior Air Force leadership **(1.20)**

N/A
Did not consider this when making my decision
Very strong influence to leave
Strong influence to leave
Slight influence to leave
Neither an influence to stay nor leave
Slight influence to stay
Strong influence to stay
Very strong influence to stay

Q15. The potential requirement to leave your family for a deployment **(1.38)**

N/A
Did not consider this when making my decision
Very strong influence to leave
Strong influence to leave

Slight influence to leave
Neither an influence to stay nor leave
Slight influence to stay
Strong influence to stay
Very strong influence to stay

Q16. Bonuses/Special Pay (1.27)

N/A
Did not consider this when making my decision
Very strong influence to leave
Strong influence to leave
Slight influence to leave
Neither an influence to stay nor leave
Slight influence to stay
Strong influence to stay
Very strong influence to stay

Q17. Number of PCS moves (1.56)

N/A
Did not consider this when making my decision
Very strong influence to leave
Strong influence to leave
Slight influence to leave
Neither an influence to stay nor leave
Slight influence to stay
Strong influence to stay
Very strong influence to stay

Q18. Choice of location (1.74)

N/A
Did not consider this when making my decision
Very strong influence to leave
Strong influence to leave
Slight influence to leave
Neither an influence to stay nor leave
Slight influence to stay
Strong influence to stay
Very strong influence to stay

Q1. Choice of job assignment (1.60)

N/A
Did not consider this when making my decision

Very strong influence to leave
Strong influence to leave
Slight influence to leave
Neither an influence to stay nor leave
Slight influence to stay
Strong influence to stay
Very strong influence to stay

Q4. Overall job satisfaction (1.47)

N/A
Did not consider this when making my decision
Very strong influence to leave
Strong influence to leave
Slight influence to leave
Neither an influence to stay nor leave
Slight influence to stay
Strong influence to stay
Very strong influence to stay

Q5. Job security (1.24)

N/A
Did not consider this when making my decision
Very strong influence to leave
Strong influence to leave
Slight influence to leave
Neither an influence to stay nor leave
Slight influence to stay
Strong influence to stay
Very strong influence to stay

Q6. Satisfaction with my current career field (1.25)

N/A
Did not consider this when making my decision
Very strong influence to leave
Strong influence to leave
Slight influence to leave
Neither an influence to stay nor leave
Slight influence to stay
Strong influence to stay
Very strong influence to stay

Q7. Ability to contribute to the mission (1.27)

N/A

Did not consider this when making my decision

Very strong influence to leave

Strong influence to leave

Slight influence to leave

Neither an influence to stay nor leave

Slight influence to stay

Strong influence to stay

Very strong influence to stay

Q8. Utilization of my skills within my unit (1.42)

N/A

Did not consider this when making my decision

Very strong influence to leave

Strong influence to leave

Slight influence to leave

Neither an influence to stay nor leave

Slight influence to stay

Strong influence to stay

Very strong influence to stay

Q9. Cohesion (working together as a team of my unit) (1.32)

N/A

Did not consider this when making my decision

Very strong influence to leave

Strong influence to leave

Slight influence to leave

Neither an influence to stay nor leave

Slight influence to stay

Strong influence to stay

Very strong influence to stay

Q10. Relationship with personnel currently working in my unit (1.24)

N/A

Did not consider this when making my decision

Very strong influence to leave

Strong influence to leave

Slight influence to leave

Neither an influence to stay nor leave

Slight influence to stay

Strong influence to stay

Very strong influence to stay

Q12. Basic Pay (1.24)

N/A

Did not consider this when making my decision

Very strong influence to leave

Strong influence to leave

Slight influence to leave

Neither an influence to stay nor leave

Slight influence to stay

Strong influence to stay

Very strong influence to stay

Q13. Retirement program (1.28)

N/A

Did not consider this when making my decision

Very strong influence to leave

Strong influence to leave

Slight influence to leave

Neither an influence to stay nor leave

Slight influence to stay

Strong influence to stay

Very strong influence to stay

Q14. Overall compensation and benefits package, i.e., pay, leave, medical, retirement, etc. (1.30)

N/A

Did not consider this when making my decision

Very strong influence to leave

Strong influence to leave

Slight influence to leave

Neither an influence to stay nor leave

Slight influence to stay

Strong influence to stay

Very strong influence to stay

Q15. Patriotism (1.29)

N/A

Did not consider this when making my decision

Very strong influence to leave

Strong influence to leave

Slight influence to leave

Neither an influence to stay nor leave

Slight influence to stay

Strong influence to stay
Very strong influence to stay

Q17. Medical specialty care (1.42)

N/A
Did not consider this when making my decision
Very strong influence to leave
Strong influence to leave
Slight influence to leave
Neither an influence to stay nor leave
Slight influence to stay
Strong influence to stay
Very strong influence to stay

Q18. Tricare benefits upon retirement (1.26)

N/A
Did not consider this when making my decision
Very strong influence to leave
Strong influence to leave
Slight influence to leave
Neither an influence to stay nor leave
Slight influence to stay
Strong influence to stay
Very strong influence to stay

B. If there were no penalty for leaving the Air Force right this moment (ADSC, bonus pay-backs, etc.), would you leave?

Yes, I would leave
No, I would stay
No decision either way

Attachment 3: Turnover Prediction Models

11X Airmen Separation Prediction Tool.xlsx

Click the paper-clip icon below to open the tool in Excel



12X Airmen Separation Prediction Tool.xlsx

Click the paper-clip icon below to open the tool in Excel



44X Airmen Separation Prediction Tool.xlsx

Click the paper-clip icon below to open the tool in Excel



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- ⁴⁴ Holding all other influence factors constant.
- ⁴⁵ I would like to thank Dr. Ryan Kramer and Dr. Rajesh Naik, 711th Human Performance Wing, for their gracious assistance in this research.
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- ⁷⁸ Master's degree IQ of 120 was estimated by interpolating between a Bachelor's degree value of 120 and a Ph.D./M.D. degree of 125.
- ⁷⁹ Retrieved from AFPC RAW application sorting by degree type and FY.
- ⁸⁰ The term SD-15 - WAIS, WISC refers to the Wechsler Adult Intelligence Scale (WAIS), the Wechsler Intelligence Scale for Children (WISC), and the use of the Wechsler scale (sd-15). Analysis assumes that the IQ of Air Force personnel are statistically identical to that of Wechsler's and Matarazzo's study groups. Evidence from other studies indicates that the IQ scores of higher educated people differ little across race, ethnicity, and country. In all cases reviewed, the IQ of degree holders increased with type of degree in sequence (Bachelors, Masters, Ph.D.). In no case was the score hierarchy violated (Masters and Ph.D. holders always had higher IQs than Bachelors holders).
- ⁸¹ Ployhart, *Acquiring and Developing Human Capital*, 357.
- ⁸² Based on AFPC RAW application query on age group and rank of personnel in FY17.
- ⁸³ ACSC AY18 student with previous experience as B52H Instructor Pilot.
- ⁸⁴ Stephen Losey, "Air Force: Pilots recalled under Trump order will serve as instructors, staff," *Air Force Times*, 13 October 2017, <https://www.airforcetimes.com/news/your-air-force/2017/10/23/air-force-pilots-recalled-under-trump-order-will-serve-as-instructors-staff/>.
- ⁸⁵ Jyotsna Bhatnagar, and Pallavi Srivastava. "Strategy for Staffing: Employer Branding & Person Organization Fit." *Indian Journal of Industrial Relations* 44 no. 1 (2008): 36. .
- ⁸⁶ TRADOC Pamphlet 525-3-7. *The U.S. Army Human Dimension Concept*, 21 May 2014, 12.
- ⁸⁷ *Ibid.*
- ⁸⁸ *Ibid.*, 13.
- ⁸⁹ *Ibid.*, 14.
- ⁹⁰ *Ibid.*
- ⁹¹ *Ibid.*
- ⁹² Sastry G. Pantula, "Statistics: A Key to Innovation in a Data-Centric World!" *Journal of the American Statistical Association* 106, no. 493 (2011): 2. <http://www.jstor.org/stable/41415528>.
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- ¹⁰⁶ Melissa A. Schilling, Patricia Vidal, Robert E. Ployhart, and Alexandre Marangoni. "Learning by Doing Something Else: Variation, Relatedness, and the Learning Curve." *Management Science* 49, no. 1 (2003): 42.
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- ¹⁰⁹ Kae H. Chung, and Monica F. Ross. "Differences in Motivational Properties between Job Enlargement and Job Enrichment." *Academy of Management Review* 2, no. 1 (1977): 118.
- ¹¹⁰ Schilling, *Learning by Doing Something Else*, 44.
- ¹¹¹ Ibid.
- ¹¹² Ibid., 46.
- ¹¹³ Ibid.
- ¹¹⁴ Ibid., 115.
- ¹¹⁵ *Air Force future operating concept: a view of the Air Force in 2035*. September 2015, 43.
- ¹¹⁶ S. Craig Moore, and Marygail K. Brauner. 2007. *Advancing the U.S. Air Force's Force-Development Initiative*. Santa Monica, Calif: RAND Corp, 1.
- ¹¹⁷ Ibid.
- ¹¹⁸ Ibid., 2.
- ¹¹⁹ *Air Force, future operating concept*, 43.
- ¹²⁰ Jeffrey M. Reilly, Department of Joint Warfare Studies, Air University, Air Command and Staff College. (lecture, Command and Control, Maxwell AFB, AL, 15 February 2018).
- ¹²¹ Moore, *force-development initiative*, 9.
- ¹²² Air Force Instruction (AFI) 36-2640, *Executing Total Force Development*, 29 December 2011, 2.
- ¹²³ Ibid., 2-7.
- ¹²⁴ AFSC 21R Functional Manager, interview by the author, 25 August 2017.
- ¹²⁵ Ibid.
- ¹²⁶ Ibid.
- ¹²⁷ Ibid.
- ¹²⁸ Ibid.
- ¹²⁹ Ibid.
- ¹³⁰ TRADOC, *The U.S. Army Human Dimension Concept*, 12.
- ¹³¹ Ibid., 14.
- ¹³² Moore, *force-development initiative*, 2.
- ¹³³ Secretary Ash Carter, Secretary of Defense, Department of Defense, to secretaries of the military departments, memorandum, subject: Forging Two New Links to the Force of the Future, 1 November 2016.