3-18-2009

Evaluation of Air Force Aircraft Maintenance Metrics for Integration into the Expeditionary Combat Support System

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AFIT/GLM/ENS/09-13

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Wright-Patterson Air Force Base, Ohio

AFIT/GLM/ENS/09-13

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THESIS

Presented to the Faculty

Department of Operational Sciences

Graduate School of Engineering and Management

Air Force Institute of Technology

Air University

Air Education and Training Command

In Partial Fulfillment of the Requirements for the

Degree of Master of Science in Logistics Management

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March 2009

AFIT/GLM/ENS/09-13

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Abstract

All organizations face the continuous challenge of a dynamic and ever-changing operations environment. They must adapt to new paradigms quickly or end up on the road to obsolescence. Never has this been truer for the U.S. Air Force than in the 21st century. The logistics organization of the Air Force supports a worldwide, 24/7 operation, executing the national directive of US Policy. Past logistics operation policies have now been proven to no longer be sufficient to meet the needs of the war-fighter. Shrinking budgets, aging equipment, and the austere, disparate operating locations demand sweeping changes in how the logistic machine operates. The Expeditionary Combat Support System (ECSS) is the Air Force wide Enterprise Resource Planning (ERP) system designed to tackle these very challenges. An ERP implementation endeavor consists of a large number of critical areas that have to be addressed. Management Support, Business Process Reengineering, Strategy and Governance modeling, and Legacy Systems Evaluation and Conversion are just a few of the key areas that need to be managed successfully for effective ERP implementation. This study focuses on one area, Legacy Systems Evaluation and Conversion. This study explores the transition of 28 current Air Force Maintenance metrics into the Oracle ERP software platform. Evaluation of these metrics by operational maintenance managers provides insight into the importance and effectiveness of the current metrics as well as the clarity and potential success for translating the proposed new metrics for the ECSS program.

Acknowledgments

To my advisors -- for your guidance, support, and patients during this journey. You showed me how to expand my horizons, painfully sometimes, and learn to ask the questions that need to be asked…

To my sponsors -- without you this problem would never have been asked and I would not have graduated…

To the Maintainers -- the true heroes of the Air Force. Whose blood, sweat and tears are the fuel, oil, and grease that make the mission happen every day around the world…

To God – who gave me the faith to endure any challenge and the strength to succeed…

Thank You

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Dedication

To my Wife, whose love, support and patients allowed me to brave the slings and arrows of war and the slings and arrows of graduate school, for without whom this opportunity would have ever been realized

And

To my Sons, for even when completely entrenched in this journey, never let me forget that life is truly fun, exciting and should never be taken too seriously…

Thank you

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I. Introduction

Background

All organizations face the continuous challenge of a dynamic and ever-changing operations environment. They must adapt to new paradigms quickly or end up on the road to obsolescence. Never has this been truer for the U.S. Air Force than in the 21st century. The logistics organization of the Air Force supports a worldwide, 24/7 operation, executing the national directive of US Policy. Past logistics operation policies are no longer be sufficient to meet the needs of the war-fighter. Shrinking budgets, aging equipment, and the austere, disparate operating location demand sweeping changes in how the logistic machine operates. Expeditionary Combat Support System (ECSS) is the Air Force wide Enterprise Resource Planning (ERP) system designed to tackle these very challenges.

ECSS will replace over 250 legacy logistics support systems currently in operation. The Air Force has selected the Oracle Software Suite as the vehicle of choice to provide the platform to support this ERP effort. As ECSS moves closer to execution, many fundamental questions arise on how to effectively transition from the current legacy systems to the Commercial-Off-The-Shelf (COTS) provided framework.

One of the cornerstone programs of the logistics machine is the Air Force Aircraft Maintenance Metrics Program. The mission of the United States Air Force is to fly, fight and win...in air, space and cyberspace. (Air Force, 2003). In order to achieve this mission, the Air Force must fly aircraft, but to fly aircraft it has to be able to perform maintenance. Maintenance managers must know how well maintenance is being performed in order to generate the aircraft needed to accomplish the core mission. The U.S. Air Force has established a comprehensive framework of performance measures in order to manage its maintenance activities.

Problem Statement

At this time it is not known if any of the current process control measures have any comparison with those established in the Oracle ERP suite. This knowledge will be critical to the success of ECSS, since one of the fundamental concepts of ERP implementation is to avoid creating any customized program code beyond what is provided in the ERP software.

Research Objectives

The objective of this research is to recommend both a method to effectively integrate the current AF Aircraft Metrics Program requirements into the Expeditionary Combat Support System as well as recommend which metrics should be integrated. To accomplish this, the study developed a comparison framework between current metrics in use today and the best-practice metrics provided in the Supply Chain Organization

Reference model and the Oracle software suite. Researchers then leveraged subject matter expert evaluations of the metrics in order to determine suitability for integration.

Research Questions

In order to provide focus and direction for the study two research questions were proposed:

1. How well do current Air Force maintenance metrics translate into the proposed Expeditionary Combat Support System Enterprise Resource Planning framework?

2. Which current Air Force maintenance metrics should be translated into the proposed Expeditionary Combat Support System Enterprise Resource Planning framework?

Investigative Questions

Four investigative questions were derived from the initial research questions:

1. How important is the current metric for managing aircraft maintenance?
2. How effective is the current metric in managing aircraft maintenance?
3. How adequately does the proposed metric replace the current metric?
4. How easily understood is the new proposed metric?

These investigative questions were used to evaluate Air Force maintenance metrics as seen in Appendix A.

Methodology

A qualitative research methodology was applied to this research problem. Specifically a first-degree multi-case study analysis was performed to evaluate 26 current Air Force metrics and 2 SCOR metrics and then develop a translation framework. Subject matter experts were interviewed and data compiled to validate the effectiveness of the comparison framework and evaluate the importance and effectiveness of the current metrics.

Implications

One of the key critical successes of ERP implementation is effective translation of current legacy performance systems into the selected ERP program. This study has developed a method that can be used to translate current aircraft maintenance to the available metrics in the new system. However, this is but one system of measures used by the Air Force logistics community. This framework can also be replicated in order to integrate other performance measure programs into the ECSS architecture.

Summary

The Expeditionary Combat Support System is one of the cornerstones of logistics transformation in the US Air Force. The establishment of an Enterprise Resource Planning program will allow future logisticians to better understand and efficiently manage logistics processes. An ERP implementation endeavor consists of a large number of critical areas that have to be addressed. However, this study will focus on one area - the integration of the Air Force Aircraft Maintenance Metrics Program into ECSS.

The first chapter of this study has outlined the impetus and direction of the research to be discussed. Chapter 2 will provide an in depth review of the relevant literature covering the problem statement and research questions. Chapter 3 will outline the methodology framework and establish the criteria for answering the research question, while Chapter 4 discusses the collected and analyzed data. Chapter 5 will summarize the conclusions and results of the research analysis and provide any relevant limitations discovered.

II. Literature Review

Overview

An old adage states "The only constant in life is change". Never is this truer than in the world of logistics management. All organizations face the continuous challenge of the dynamic and ever changing operations environment. They must adapt to new paradigms or end up on the road to obsolescence. Never has this been truer for the U.S. Air Force than in the 21st century. The logistics organization of the Air Force supports a worldwide, 24/7 operation, executing the national directive of US Policy. Past logistics operation policies are no longer sufficient to meet the needs of the future war-fighter. Shrinking budgets, aging equipment, and austere, disparate operating location demand sweeping changes in how the logistic enterprise operates.

One way these organizations are adapting to this need for change is by implementing Enterprise Resource Planning (ERP) programs. In order to facilitate effective ERP systems, organizations must be able to convert their current operation systems into their new ERP programs. This literature review will outline the drive for change in the Department of Defense and its effect on future US Air Force operational planning. These directives are the purpose behind the Air Force developing an enterprise wide managements system. The review will then discuss the critical success for ERP implementation. Critical success factors must be effectively addressed in order for an ERP implementation to be successful. The final sections will discuss the characteristics of logistics process measures and review the Air Force's Aircraft Maintenance metrics program that provides guidance and feedback to Air Force maintenance managers.

Transformation and the United States Air Force

It has been estimated that the Air Force spends 20 to 30 Billion dollars on current supply chain processes supporting the war fighter (CSC, 2007). Air Force logisticians operate 24 hours a day 7 days a week, on every continent on the globe. They support Army, Navy, Marine and other government agencies across the full spectrums of military operations. Air Mobility Command, primary provider of strategic airlift capability, have aircraft flying 24 hrs a day, 365 days a year from anywhere to frozen Antarctica to 120 degree Iraq. This is a truly monumental operation that is coordinated daily, sometimes even hourly by the dedicated men and women serving in all logistics capacities.

In 2003 Department of Defense Secretary Donald Rumsfeld laid out the Transformation Planning Guidance (TPG), a comprehensive roadmap to transition the US Military from the industrial age to the information age (DoD, 2003). DoD TPG outlined the reason for Transformation as follows:

> *Transformation is necessary to ensure U.S. forces continue to operate from a position of overwhelming military advantage in support of strategic objectives. We cannot afford to react to threats slowly or have large forces tied down for lengthy periods. Our strategy requires transformed forces that can take action from a forward position and, rapidly reinforced from other areas, defeat adversaries swiftly and decisively while conducting an active defense of U.S. territory. Transformed forces also are essential for deterring conflict, dissuading adversaries, and assuring others of our commitment to a peaceful world. Over the long term, our security and the prospects for peace and stability for much of the rest of the world depend upon the success of transformation.*

In 2003, in direct response to the Secretary's charge the Air Force leadership presented its own plan for transformation, the Transformation Flight Plan. The Flight Plan is a reporting document and program in order to fully capitalize on the knowledge and innovation within the United Stated Air Force and translate its efforts directly into the TPG (Air Force, 2004). Following the Flight Plan, Air Force leadership codified the transformation directive into Air Force Smart Operations for the 21st Century (AFSO21). Under the purview of AFSO21, the Air Force Headquarters Department of Installation and Logistics established the Expeditionary Logistics for the 21st Century (ELog21) program to guide and direct logistics transformation within the logistics community (Air Force, 2004). ELog21 is the primary logistics transformation program focused on creating leaner, more lethal combat support capabilities in order to fully capitalize on current and future air and space resources (Bergdolt, 2007).

ELog21 focuses on four desired areas of effect: Enterprise View, Integrated Processes, Optimized Resources, and Integrated Technology. In order to achieve these interrelated end-states, the ELog21 program has established over 20 transformation initiatives to fundamentally change the current logistics support environment (Dunn, 2007). Unfortunately, the system in which the dedicated logistics professionals operate, while not broken, does not provide the necessary capability to meet the desired end state. The system maintains legacy programs born out of a bygone area of military process control. Air Force logistics processes are reactionary, functionally stove-piped operating from over 400 disparate information systems (Dunn, 2007). In order to create a new paradigm of logistics capability and thought, a new system has to be initiated to fully integrate the logistics enterprise, the Expeditionary Combat Support System.

Expeditionary Combat Support System

The Expeditionary Combat Support System (ECSS) is the information technology baseline for logistic systems modernization. Table 1 outlines the twelve core capabilities that ECSS will provide to the future logistics community.

Table 2.1. ECSS Capabilities (Bergdolt, 2007)

Capability	
Advanced Planning and Scheduling	Demand forcasting and collaborate plans development
Material Management, Contracting and Logistics Finance	Procurement and purchasing, contract management, repair and maintenance support, and finance transactions
Configuration and Bill of Materials	Primary, Alternate, common and phantom planning and confiquation BOMs
Repair and Maintenance	Planning and operations, visibility into maintenace costs, equipment history, and mainteainability and reliability data
Product Life-Cycle management	Integrated enginneering and execution functions; life-cycle view of assets
Customer Relationship Management and Order Management	Order fulfillment processes and tracking form material requests to fulfillment of the order
Distiribution and Transportation	Physical control of material to include cycle counting, storage, shipping, transporting, and tracking
Facilities Management	Track and maintain equipment; provide asset visability
Quality Control	Data collection; reporting with traceability back to transaction; trend analysis
Document Management	Identify and maintain documents use in current and future state processes; data cleansing standardizes formats and methods used to link data

The 12 capabilities outlined in Table 2.1 will be the end result of the migration of the 400 legacy systems currently in place. ECSS is at its core an Enterprise Resource Planning program built around a Commercial-off-the-Shelf (COTS) software suite. By effectively converting current legacy process requirements to the COTS best-business practices established within the software, true logistics transformation breakthroughs may be achieved (Cain, 2007).

Enterprise Resource Planning

Enterprise resource planning (ERP), like all innovation, was born out of necessity. The business world had experienced a major paradigm shift. Gone was the era of single product factories, large unskilled labor pools and simple logistics process management. Today's business world is dynamic and ever changing. Multi-product corporations, ever changing mergers, hostile takeovers, and global consumer market operations demand a total integrated planning system.

Blackstone and Cox (2005) defined ERP as a "framework for organizing, defining, and standardizing the business processes necessary to effectively plan and control an organization so the organization can use its internal knowledge to seek external advantage". Most ERP system frameworks focus on the manufacturing planning and control, integrating finance and accounting, human resources, payroll, and sales/marketing with production and distribution (Jacobs and Weston, 2006). Essentially an ERP system provides a unified interface across the entire enterprise (Davenport, 1998)

The evolution of the modern day ERP architecture began in the early 1960's. The development of commercial computer mainframes and the introduction of the Reorder point (ROP) systems put efficient manufacturing planning and control programs (MPC) in the hand of industry. However these systems, dubbed Material Requirements planning (MRP), were large, resource intensive and expensive, necessitating a large investment by the manufacture industry (Fawcett, Ellram, and Ogden, 2007).

The next revolution occurred in the late 1970s. Business strategy shifted away from cost minimization to more of a marketing focus creating emphasis on production integration and planning (Jacobs and Weston, 2007). This shift also was driven forward by the fielding of IBM's COPICS software and the Model 360 mainframe computer with higher capacity random access storage. This shrunk the support footprint and allowed the development of third party programming software by companies such as Oracle, J.D. Edwards and Lawson software.

In the 1980s, low cost mainframes and the introduction of flexible disk drive made MRP systems available to medium to small manufacturing enterprises. Designated MRP-II, manufacturing resource planning II, the newer systems provided more functions and capability than the previous MRP system (Fawcett, Ellram, and Ogden, 2007).. The rise of quality management during this time also played a large role in the continuing evolution of manufacturing control systems, further widening the scope of control these systems provided to the industry

1990 saw the first true designation of the ERP nomenclature, these early ERP systems replaced several legacy systems within an enterprise (Venkatachalam, 2006). New unified database architecture was provided by single vendors, such as SAP, Oracle or J.D. Edwards, increasing the capability of total integration significantly. One key advantage of the new systems was the incorporation of open architecture programming, which allowed third-party development companies to integrate seamlessly (Rainer and Turbin, 2008). This characteristic in conjunction with the year 2000 data problem created a dramatic growth of ERP implementation within both large and small manufacturing industry.

ERP Critical Success Factors

As with the implementation of any new system, failure is as much a companion as success. The key to achieving the latter while avoiding the former lies in careful planning and identifying the key areas for focused management attention.

Bullen and Rockart (1986) defined these areas in ERP implementation as Critical Success Factors (CSF). Specifically, they define "the limited number of areas in which satisfactory results will ensure successful competitive performance for the organization."

(Bullen an Rockart, 1986) Essentially CSFs are the areas where “things must go right” for the ERP goals to be realized (Ngai, 2008)

A common mantra of business is anything can be done with enough money and time, but most of the time businesses have neither enough time nor enough money. This is especially true of ERP implementation. Over 90 percent of companies that have implemented an ERP system failed on the first time. Failure of an ERP implementation was defined as a company not achieving their original stated goals for cost, utilization and expected performance improvement (Sun et al, 2005). Compound that figure with the fact that by the end of 2008 over 15.8 billion dollars will be spent on ERP programs (Ehie, 2005), successful implementation is absolutely critical. However while the literature reveals extensive study into defining CSFs, there is little consistent agreement on the number of CSFs required or the order of importance. Ngai et al (2008) has developed a framework of 18 factors, in contrast Sun et al (2005) has only outlined 5 core CSFs as necessary for implementation success.

Table 2.2 represents the predominant CSFs as defined in the reviewed literature. While each author has titled each CSF differently the categories outlined below represent the common definition used by sources reviewed.

Table 2.2. Rank Order of CSF Importance

	Ngai et al	Motwani et al	Venkatachalam	Sun et al	Ehie and Madsen	Caruso	Welch and Kordysh
Management Support	X	X	X	X	X		X
Legacy Systems Evaluation and Conversion	X	X	X	X	X		X
Strategy and Governance model	X	X		X		X	X
Business Process Reengineering	X		X	X	X		X
Change Management	X	X	X	X	X		
Implementation Teamwork and Composition	X	X	X	X		X	
Project Management	X		X		X	X	
Process and Software Development	X		X	X	X		
Data Management	X		X	X		X	
Organizational Characteristics	X	X				X	X
Monitoring and Evaluation	X	X	X				
Project Champion	X	X		X			
ERP Vendor	X				X	X	
Communication	X	X					
Implementaion Methodology	X						X
Budget and EPR cost					X		
National Culture	X						

Based on the Table 2, the top six CSFs for ERP implementation, in order of importance, are 1. Management Support, 2. Legacy System Evaluation and Conversion, 3. Strategy and Governance Model, 4. Business Process Reengineering, 5. Change Management, and 6. Implementation Teamwork and Composition. While a business enterprise implementing an ERP needs to focus on all the CSFs, the reality dictates a organization does not have enough resources to focus on all areas equally. This framework will allow the ERP implementation team to effectively prioritize time and resources to get the most out of their efforts. While all of these factors are critical to implementation success this study will focus on Legacy Systems Evaluation and Conversion, specifically how to translate current Air Force metrics into the ECSS system.

Process Measurement and Evaluation

Implementing an ERP can be a monumental undertaking. Organizations devote great time, effort and money to establishing their systems. One of the critical success factors indicated previously is Legacy System Evaluation and Conversion. Essentially, it means codifying how an enterprise operates, then effectively correlating those operating measures into the new ERP product suite. This requires a solid understanding of what and how an organization tracks their operation processes.

Every organization has a purpose; otherwise it would not be an organization. According to the Encyclopedia Britannica (2008), an organization is defined as "an entity formed for the purpose of carrying on commercial enterprise". In order to accomplish its purpose a logistics organization has to know where it has been and where it needs to go. In other words it has to be able to effectively measure its performance in delivering its product or service (Keebler et al., 1999). Performance metrics represent critical elements in translating an organizations strategy across the enterprise; they link the individual behavior to the organizational goals (Boyd and Cox, 1997).

Performance measures or metrics are a verifiable measure, quantitative or qualitative in nature, defined with respect to a fixed maintenance point (Melnyk et al., 2004) However in this era of high technology and fast paced business world, there are several challenges to the effective and appropriate use of metrics. Some of the more prominent challenges to industry are: increasing needs to manage the total supply chain, shrinking product lifecycles, huge quantities of data that lack quality, and new opportunity alternatives and markets. All this leads to a need for companies to critically evaluate their metrics programs.

There are hundreds of metrics available to managers today (Griffis et al., 2004). This means the hard job of any manager is not choosing a metric but choosing the right metric for their production process. At its most basic level metrics should provide two things, they should be meaningful and meet the organizational needs. While these two ideas may seem to be common sense, often companies regularly violate them. One way companies deviate from these premises is they consult the wrong metrics for the process being evaluated (Griffis et al., 2004). A plant manager has no use for financial based metrics to evaluate how his plant is running, likely as not, he cannot control or influence them effectively anyway (Beiscel and Smith, 1991). Another common pitfall of metrics selection is when organizations use proxy measures selected for convenience, but which are often unrelated to true division performance (Tsang, 1999).

As defined by Callahan (2007), meaningful metrics meet a specific objective for an organization. Metrics must be measured against a clear standard, a set or range of values that give direction to the metric user. Metrics also must be meaningful in how they measure not just what processes they measure. Tracking customer satisfaction thru On-Time-Delivery of orders may be a meaningful goal. However if the measurement is taken at order departure from the factory, regardless if they make it to the customer on time, is it truly meaningful for measuring customer satisfaction.

Metrics must meet the organizations needs through three key aspects (Atkinson et al, 1997; Melnyk et al, 2004, Fawcett et al, 2007).:

1. They must correctly drive decision behavior and provide control
2. They must communicate the process clearly and create understanding
3. They must be able to lead to improvement within the process

Metrics exist as tools to be used by the appropriate level of user to control their logistics process. If the metric provides no information to change a process at the user level, it is useless and worse a waste of resources (Griffis, 2004). The best metrics communicate performance not only to internal sources but also to external users. Well-designed metrics will provide users with information on a process without needing to know the nuts and bolts of the operation (Melnyk, 2004). Finally a metric must lead to desired results. If a company uses metrics that reflect their overall strategic direction, then improvement towards those goals will happen (Fawcett et al.,2007). Table 2.2 establishes a checklist to evaluate metrics for effectiveness.

Table 2.3. Characteristics of an Effective Metric (adapted from Fawcett et al, 2007)

The Metric is….		
Yes	No	
		Aligned with organizational goals
		Customer oriented
		Meaningful to workers, managers, and customers
		Consistent across appropriate functions or departments
		Promoting cooperative behavior both horizontally and vertically
		Communicated to all relevant individuals
		Simple, Straightforward, and understandable
		Easy to collect the needed data
		Easy to calculate
		Available on a timely basis
		Strategic and tactical
		Quantifiable
		Designed to drive appropriate behavior
		Designed to drive learning and continuous improvement
		Desinged to provide information that is actuallly used in decision making

Ultimately metrics are meant to indicate how a process is working. In order to do this, an organization must establish baseline standards of performance measurement that align with the goals of the organization. By establishing this standard, metrics can easily indicate gaps between performance and expectation as well as define the size of those gaps (Melnyk, 2004; Callahan, 2007; Tsang, 1999).

Air Force Aircraft Maintenance Metrics

The core mission of the air force is to defend and secure the free use of the air and space in the execution of national objectives. In order to achieve this mission, the Air Force must fly aircraft, but to fly aircraft they have to be able to perform maintenance. Maintenance consists of all the activities dedicated to maintaining and restoring the physical state necessary to fulfill its production mission (Tsang, 1999). The U.S. Air Force has established a comprehensive framework of performance measures in order to manage its maintenance activities.

The Metrics Handbook for Maintenance Leaders (2001), defines the two cornerstones of maintenance metric – Aircraft Fleet Availability and Flying Program Execution. Under these two primary headings, individual metrics are categorized as leading or lagging indicators. Leading indicators are metrics that directly impact capability to provide resources, while lagging indicators show firmly established trends in past maintenance activities (Air Force, 2006).

Aircraft Fleet Availability is measured by 9 leading indicators and 10 lagging indicators. Table 2.3 outlines each metrics and provides both the definition and calculation equation for each metric. Leading measures are Abort Rate, Code 3 Break Rate, Fix Rate, Repeat Rate, Recur Rate, Logistics Departure Reliability, Average Deferred discrepancies per Aircraft, Maintenance Scheduling Effectiveness Rate, Cannibalization (CANN) Rate, and Phase/Isochronal flow rate. Mission Capable Rate with its derivative sub-measures Fully Mission Capable Rate, Partially Mission Capable Rate - Supply, Maintenance and Both, Not Mission Capable Rate – Supply, Maintenance, and Both, and Total Non Mission Capable Rate – Supply and Maintenance make up the list of lagging indicators.

Table 2.4. Aircraft Fleet Availability Metrics (Air Force, 2006)

	Metric	Definition	Equation
Leading Indicators	Abort Rate	Percentage of mission that end prematurely and must be re-accomplished	(Air + Ground Aborts/Total Sorties Flown + Ground Aborts) x 100
	Break Rate	Percentage of aircraft that land in Code-3 or Alpha-3 (NMC) status	(Number of Sorties that land Code-3/Total Sorties Flown) x 100
	Fix Rate	Percentage of aircraft that landed Alpha-3 and returned to flyable (FMC/PMC) status within set time window, either 4, 8, or 12 hours	(Alpha-3 Breaks fixed within window/Total Alpha-3 Breaks) x 100
	Repeat Rate	Percentage of maintenace discrepencies that occur again after next sortie attempt after being fixed	(Total Repeats/Total Reported Discrepencies) x 100
	Recur Rate	Percentage of maintenace discrepencies that occur the 2nd thru 4th sortie attempts after being fixed	(Total Recurs/Total Reported Discrepencies) x 100
	Logistics Departure Reliability Rate	Percentage of on-time aircraft departures due to logistics	(Number of Departures-Number of Logistics Delays/Number of departures) x 100
	Average Delayed Discrepency Rate	Average Number of defered maintenance actions	(Total (snapshot) maintenace actions/Average Aircraft Possesed)
	Maintenace Scheduling Effectiveness Rate	Percentage of scheduled maintenace actions verses accomplished scheduled maintenance actions based on assigne points be maintenace action	(Total points earned/total points assigned) x 100
	CANN Rate	Percentage of cannibalization actions to replace parts on other aircraft	(Number of CANNs/Total Sorties Flown) x 100
Lagging Indicators	Mission Capable Rate	Percentage of hours aircraft are mission capable, has derivaties of Partial, Non, Total Non, as well as sub catagories of Due to Maintenace or Due to Supply	(FMC Hours + PMC Hours/Possessed hours) x 100
	Fully Mission Capable Rate	Percentage of hours aircraft can perform all assigned missions	(FMC Hours/Total Possessed Hours) x 100
	Partially Mission Capable Rate	Percentage of hours aircraft can perform some but not all assigned missions, due to Supply, Maintenace or Both	PMC Hours/Total Possessed Hours) x 100
	Non Mission Capable Rate	percentage of hours aircraft cannot perform any assigned missions due to Supply, Maintenace or Both	(NMC Hours/Total Possessed Hours) x 100
	Total Non Mission Capable Rate	Percentage of total NMC hours -Supply, Maintenance or Both	(total NMC Hours/Total Possessed Hours) x 100

Flying Program Execution is measured by 7 leading and 2 lagging indicators. Primary Table 4 outlines each metrics and provides both the definition and calculation equation for each metric. Aircraft Inventory, Possessed Aircraft Rate, Programmed Average Sortie Duration (ASD), Actual ASD, Flying Hour Execution, Flying Scheduling Effectiveness (FSE) rate, and Chargeable Deviation Rate are all leading cause indicators.

Lagging indicators of program execution are UTE Rate and Logistics Departure Reliability Rate.

Table 2.5. Flying Program Execution Metrics (Air Force, 2006)

	Metric	Definition	Equation
Leading Indicators	Flying Hour Execution Rate	Percentage of Actual Flying hours executed verses planned flying hours	(Total Flying hours executed/Total Flying Hours Scheduled) x 100
	Flying-scheduling Effectiveness Rate	Percentage of deviations from planned flying schedule to actual flying schedule	(Actual Flying Schedule - Deviations/Actual Flying Schedule) x 100
	Chargable Deviation Rate	Percentage of Deviations due to Maintenace or Operations actions	(Total Mx deviations+total Ops deviations/Total sorties Scheduled) x 100
	Primary Aircraft Inventory	Assigned number of aircraft by MDS per designated organization	Snapshot of number of aircraft assigned
	Possessed Aircraft Rate	Aircraft under control of owning designated organization	Snapshot of number of aircraft controled by organization
	Programed Average Sortie Duration	Average Sorte length scheduled	(Number of Sorties/Total scheduled Sortie Hours)
	Actual Average Sortie Duration	Average Sortie length executed	(Number of Sorties executed/Total executed Sortie Hours
Lagging	Logistics Departure Reliablity Rate	Percentage of on-time aircraft departures due to logistics	((# of Departures - # Logistics delays)/# of Departures x 100)
	Utilization Rate	Average number of Sorties flown per Primary Aircraft Inventory	(Sorties/Hours flown per month/PAI per Month)

These represent the core metrics utilized by most aircraft maintenance mangers to run their maintenance management processes. They are the ones most discussed and talked about from the flight line to the Pentagon. Based on these observations these metrics were selected by this study for evaluation and analysis.

Summary

The impetus for change in operating processes to any organization can come from many sources. New customer requirements, changes in corporate policy, increasing global competition, and shrinking operational budgets are driving the need to change in the business world. The next evolution in logistics management created to meet this need for change is Enterprise Resource Planning. Organizations are spending billions of dollars on establishing new programs in order to fully integrate all aspects of their operations in order to realize the fruits of system wide optimization. The US Air Force is not immune to these same change characteristics as it is seeking the similar operational changes through ECSS.

This literature review has outlined the drive for change in the Department of Defense logistics operations and its effect on future US Air Force logistical programming and planning. The review then discussed the Critical Success Factor for successful ERP implementation as proposed by the academic and operational community. The final sections discussed the characteristics of effective logistics process measurements and reviewed the Air Force’s Aircraft Maintenance metrics program that will need to be converted into the proposed ERP implementation program. Effective integration of the legacy aircraft metrics system will allow true process oversight and control across the maintenance enterprise, providing one step in achieving true logistics collaboration and control envisioned by the Department of the Air Force and the Department of Defence.

III. Methodology

Overview

All journeys have a goal and in order to reach that goal they must begin with a plan. Research is no different, it is merely a journey of the mind, and so it also requires a map. This chapter outlines the path this study will use to accomplish this journey of discovery. The goal of this study is to develop a comparison framework for translating current maintenance metrics into the new ECSS system and to validate this framework by conducting field interviews of aircraft maintenance managers. The first section in this chapter, the methodology paradigm chosen to frame the research has been outlined and discussed. This study has chosen to use a Qualitative Analysis based Multiple Case approach as the most suitable for the problem posed. Second, the chapter details the research questions and lays out the research design, to include the development of the comparison framework, thereby setting the roadmap to accomplish the goal of this study. As the study seeks to validate the framework developed, a structured interview guide for use by individual subject matter experts to evaluate the selected metric cases was developed. Finally, data collection methods, analysis of the collected data, and validity and reliability requirements that support the study's conclusions have been addressed.

Methodology

Methodology, as defined by Strauss and Corbin (1998), is a way of thinking about and studying reality, and will gradually move us towards a greater understanding of the world. Qualitative Field Research is one of the many defined methods of researching reality. Qualitative research provides insight into questions involving the “how” and “why” of a subject of interest (Yin, 2009).   Typically, data collected does not result in data that can be used in statistical or quantitative analysis (Babbie, 2005). While this does not preclude quantitative analysis of qualitative data, the primary focus should be on uncovering and understanding the underlying patterns and structures revealed, not the numerical results (Babbie, 2005).

Under the qualitative field research method, there exist several approaches that can be used to accomplish the researcher’s goals. This study was based on the Grounded Theory Approach accomplishing a multiple case study analysis of the developed comparison framework. By using the underlying principles of Grounded Theory, units of analysis and subject matter experts can be selected based on their relevance to evaluate the proposed framework under question.

Research Questions

While research usually begins with some problem being defined, in order to achieve the systematic structure that is research, a research question whose answer provides a solution to the problem is needed (Booth et al, 2008). Therefore, this study has proposed the following questions:

1. How well do current Air Force maintenance metrics translate into the proposed Expeditionary Combat Support System Enterprise Resource Planning framework?

2. Which current Air Force maintenance metrics should be translated into the proposed Expeditionary Combat Support System Enterprise Resource Planning framework?

These questions provide the overall framework to structure this study in order to provide solutions to the initial problem statement from Chapter 1. However, in order to answer the questions, several investigative questions were developed to further refine the direction of the study.

Investigative Questions

The following questions were derived directly from the initial research questions.

1. How important is the current metric for managing aircraft maintenance?
2. How effective is the current metric in managing aircraft maintenance?
3. How adequately does the proposed translated metric replace the current metric?
4. How easily understood is the new proposed metric?

These questions further focused the direction of the research and provided a basis to accomplish both the proposed framework construction and to fully leverage the subject matter experts in the evaluation of the framework.

Unit of Analysis

Babbie states "In social research, there is virtually no limit to what or whom can be studied, or units of analysis." Fortunately, for most research the units of analysis are fairly obvious and intrinsic to the research question (Babbie, 2005). In an organization as large as the Air Force, there exist thousand of management programs with tens of thousands of potential metrics, Figure 3.1. In order to conduct a realistic study a small portion of this organization will be looked at. For this study the units of analysis selected are two maintenance metrics sub programs, Aircraft Fleet Availability and Flying Program Execution.

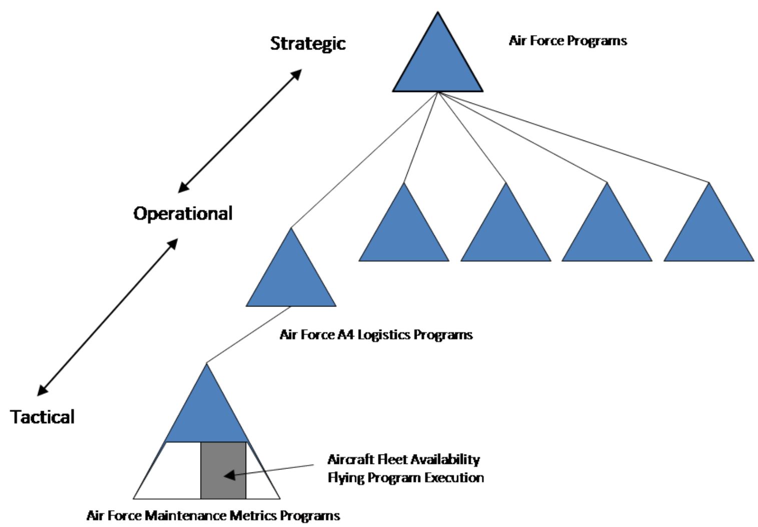


Figure 3.1. Unit of Analysis Selection

Research Design

As stated previously, the strategy of this study is to develop a comparative framework for incorporating current metrics into the new ECSS system and to validate this comparison by leveraging aircraft maintenance subject matter expert field interviews. This goal defines two areas of execution; the first part involved the development of the comparison framework to translate the existing system of measurement to the future state system. This process will leverage the experiences of the ECSS development team to create a clear and complete matrix to provide to the selected experts for evaluation. The second part is to conduct qualitative field interviews of the experts to collect data on their evaluation of the proposed metrics. The results of this field research will substantiate and validate the framework and provide recommendation for disposition of the metrics.

Metrics Comparison Framework

The twenty eight metrics identified in Chapter 2 (see Tables 2.3 and 2.4), were selected for translation by this study. In order to translate these metrics clearly, a three step process was developed. Each metric was analyzed for key attributes, and then compared to the performance measures provided by the Logistics Transformation Office based on the SCOR model. Finally each SCOR metric is compared with the Key Performance Indicators identified by the Oracle software suite operation manuals.

First each metric was identified by three key attributes:

1. Nomenclature
2. Definition
3. Equation

These three attributes provide the core identity for each metric and existed across all three models. Comparative pattern analysis was then used to evaluate each metric against the list of potential SCOR model metrics in Appendix B. Once these attribute patterns were compared across all selected metrics, each was categorized based on number of similarities of these key attributes, either level 3, level 2, level 1, or no similarity. Level 3 pairings matched on all three key attributes, Level 2 across two attributes, Level 1 matched on only one key attribute category, and No Connection had no matching attributes. This process was then repeated comparing the attributes between the SCOR model metrics and the Key Performance Indicators built into the Oracle software platform. The results of the comparative analysis and the metric evaluations are discussed in Chapter 4.

Once the comparison framework was developed for all 28 metrics, it was then incorporated into the interview guide. Each of the four investigative questions was evaluated on a 5 point Likert scale for each metric comparison. Figure 3.2 shows a sample of one interview question set, the full interview guide can be found in Appendix A.

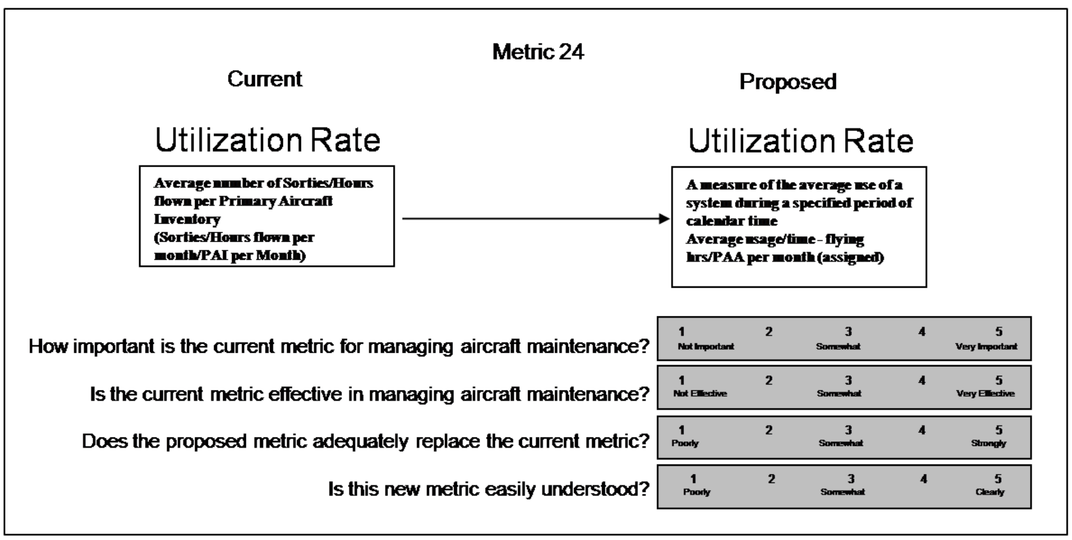


Figure 3.2 Sample Interview Guide Question Set

Data Source Selection

As with all other areas of qualitative research, selection of the sources of data must be systematic and purposeful. Selection of the wrong characteristics can lead to faulty conclusions or invalid findings, thus the following criteria were used in SME selection:

1. The SME should be or have been an aircraft maintenance manager for 7 years.
2. The SME should have experience with maintenance metrics.
3. The SME must be available to be interviewed by the researchers.

The most important of these criteria is SME availability, if the subject is not available for interview than this research cannot be completed. Following this, experience and familiarity with the subject are critical. While this study proposes new translations of current performance measurements, the fundamental principles of aircraft maintenance remain the same. The SME collective experience in the aircraft maintenance enterprise should allow them to effectively evaluate the metrics and their proposed translations.

Data Collection

The primary source of data collection was qualitative interviews with experts in the field. The study collected data from one population, Senior Maintenance Managers. 12 Subject Matter Experts were selected from Charleston AFB due to the ease of access to the location, time constraints and available personnel schedules. Senior managers were selected in order to capture a mix of operational experience. Air Force operations encompass a diverse range of aircraft mission functions, from Fighter to Strategic Airlift.

Senior managers will have a greater range of experience across these diverse mission environments, verses less experienced managers who may only understand one mission type. The total cumulative experience of the SMEs was 211 years, at an average of 16.3. While the predominate experience was in Airlift – 51%, there was 21% with Fighter experience, 9% with Staff Experience, 6% in Special Operations with the remainder in Tanker, Command and Control, Acquisitions and Trainer aircraft. Figure 3.1 shows the breakdown of respondent experience by type category.

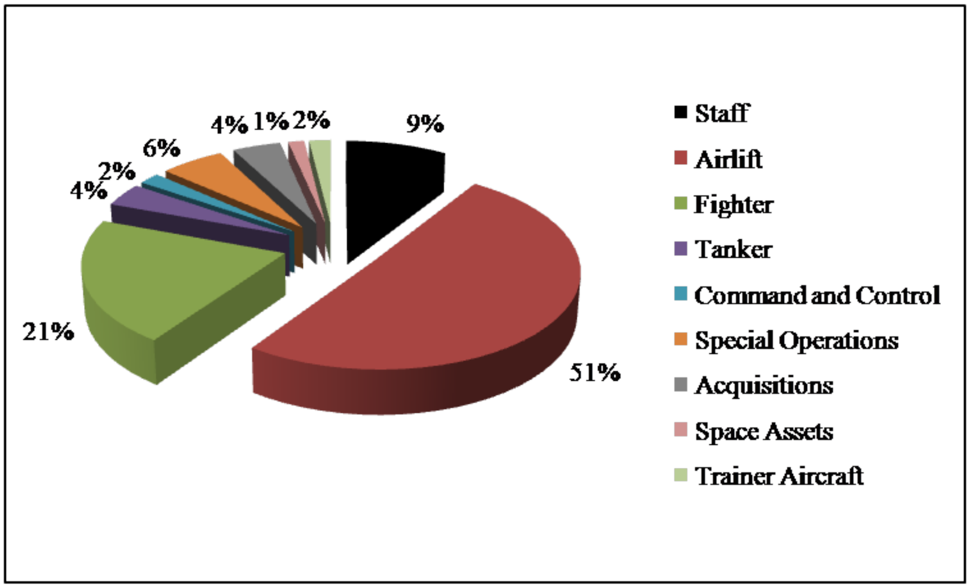


Figure 3.3 Respondent Experience Type by Category

The experts were selected via requests to their respective commanders (Appendix D). Then individual requests were sent to perspective managers (Appendix E). Once an agreement to be interviewed was reached, interview times were established and the interviewees were provided the translation framework prior to the interview. The interviews were conducted from November 2008 to January 2009 and recorded for ease of data capture. After all interviews were completed, the researchers transcribed and then summarized each interview. Each transcript was sent to the respective interviewee to verify the areas discussed and ensure their words were captured accurately.

Data Analysis

All researchers, just as artists and engineers, need tools to help them accomplish their goals (Strauss and Corbin, 2008). The tools of the artist are the brush and palette, while the engineer will use the calculator and T-square. Just as the tools to the trades are many and varied, so are the analytical tools of the researcher. Analyses by questioning, analysis of words, or even via comparisons are just a few of the tools available to comprehend the huge amount of data that can be collected in qualitative research.

This study has chosen to apply a *systematic comparison of two or more phenomena*, in order to quantify and categorize the provided data (Strauss and Corbin, 2008). The study developed a coding sequence in order to organize the field data results. Each SME was provided the metrics framework and then interviewed on their evaluation of the new metrics. The interview data results were then consolidated and evaluated for common underlying theme or patterns of positive or negative evaluations. Further detailed analysis and the results of the data findings can be found in Chapter 4.

Validity and Reliability

Every study seeks two underlying goals when accomplishing their research, establish validity and reliability. Four tests have been identified as common to all social science research; construct validity, internal validity, external validity, and reliability (Yin, 2007). Each of these tests has its own techniques and tactics for maximizing their presence in any research. Table 3.1 outlines the four tests and how this study will address each one.

Table 3.1, Validity and Reliability Table (adapted from Yin, 2009)

Test	Tactic	Phase of tactic
Construct Validity	Multiple sources of evidence	Data Collection
	Chain of eveidence	Data Collection
	Key informants review draft interview summaries	Compsition/analysis
Internal Validity	Pattern matching	Analysis
	Explanation building	Analysis
	Logic models	Analysis
External Validity	Replication logic	Research design
Reliability	Use case study protocal	Research design

Construct validity was achieved for this study by selecting 12 maintenance management experts to evaluate the proposed framework, maintaining the linkages from respondents data through to the summary analysis, and each respondent reviewed and approved their interview transcript summaries. Internal validity was maintained in the development of the framework through use of pattern matching of the three key attributes for comparison of the metrics.   Additional development of the coding analysis framework in Appendix C allowed for pattern matching analysis of the interview data. External validity is established though repeated application of translation framework and interview guide and comparing results to this initial pilot exploration.

Reliability in qualitative studies has been the harder of the two properties to establish. Reliability in any qualitative study can be heavily influenced by researcher bias. This study has attempted to achieve reliability by two means. First, the translation framework has been built through close evaluation of metric attributes and clearly documented. Second, the field interview guide was developed based on the investigative questions. The guide was built for each metric using a standard format that may be easily replicated for the metrics studied or on any other metrics of interest.

Summary

This chapter has outlined the plan used to accomplish the strategy of this study – developing a framework for translating metrics into the new ECSS system and validating this comparison by conducting field interviews aircraft maintenance experts. All the necessary steps to achieve satisfactory results have been outlined above. The initial problem statement and subsequent research questions have established the need for a qualitative research paradigm. The grounded theory approach was used to develop the translation framework and validate it through systematic interviews to generate an solution to answer the research questions. Finally the discussion of data source collection and analysis has defined the necessary steps that will lead to establishing validity and reliability within the study.

IV. Analysis

Overview

"If you can't measure it, you can't manage it". This is the classic saying that captures the essential reality of the maintenance manager. Good performance measurement is critical to the effective control of any logistics process. It is important to ensure current process metrics are reviewed and evaluated before incorporating them into a new management system. This chapter will outline the empirical results of the comparison and evaluations of the 28 aircraft maintenance metrics selected for this thesis. The chapter will first provide the analysis of each metric case. Then cross case analysis of the metric characteristics derived from the interviews will be presented. Finally the significant findings of the research questions will be discussed.

Metric Case Evaluation

Each metric was evaluated by aircraft maintenance managers on a 5 point Likert scale for each investigative question. Questions 1 and 2 evaluated the importance and effectiveness of the metric, while questions 3 and 4 evaluated the clarity of the translation and understanding of the metric. Evaluation scores had a possible range of 2 points to 10 points for individual ratings, and a range of 24 points to 120 points possible for the aggregate scores. Metric evaluation score and interview findings were used to categorize each metric as high, moderate, or low for importance and effectiveness and clear, moderate or unclear for translation and understanding. Aggregate scores for high rated metrics were between 90 to 120, Moderate metric scores were between 80 and 89, and

Low rated scores were 79 and below. Aggregate scores for Clear evaluations were between 100 and 120, Moderate between 80 to 99, and Unclear metrics were scored below 79. Metrics with no comparisons did not receive translation and understanding evaluations, hence no scores. Summary tables of all metric evaluations can be found in Tables 4.5 and 4.6.

Abort rate

Comparison

Abort rate as defined by the literature is the percentage of missions that end prematurely and must be re-accomplished (Air Force, 2006). This metric is calculated by the summation of Air and Ground aborts divided by Total sorties flown plus Ground aborts. After comparing all three key attributes no metric was found to be match in either the SCOR model or Oracle system. This metric was only evaluated for importance and effectives in the current system.

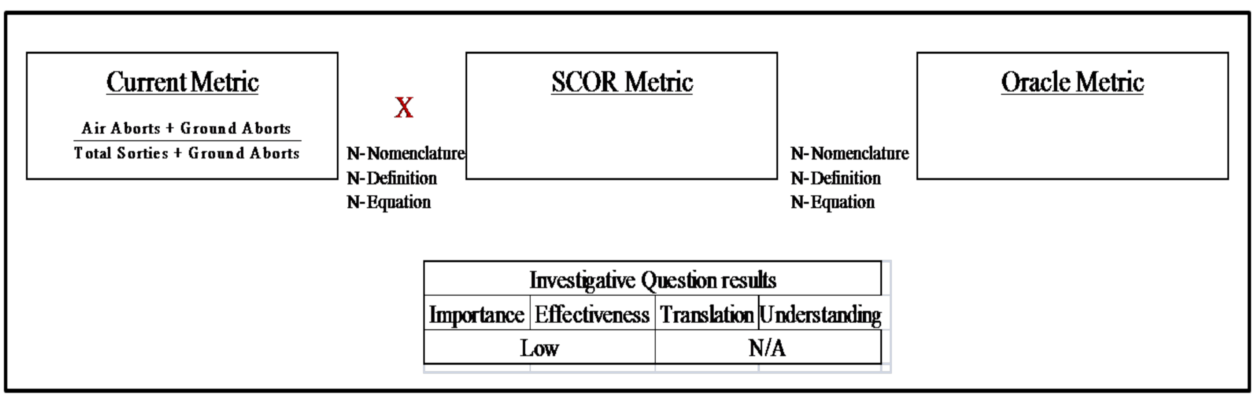


Figure 4.1 Abort Rate Metric Summary

Importance and Effectiveness

This metric consistently rated low in importance and effectiveness across most interviewees. Data captured by this metric was noted to also be captured by other metrics, such as Break rate under Code/Alpha-4 landing status. Respondents also identified that this metric was not used for any management decision, it was tracked and reported but no actions were taken in response to this metric. Abort rate seems to have aircraft system, or Mission Design Series (MDS), specific impacts. For example, on older systems such as the C-5 or F-15 this metric was important due to higher incidents of abort events, but in newer systems such as the C-17 it had so few events that Abort rate was identified as being meaningless. One respondent felt that abort rate was both important and effective but did not provide any reasoning into why they marked it high. Two respondents stated while they think the metric is not important, it does play a role in mission forecasting. With an increased abort rate, more missions will have to be generated, this in turn means more airframes will have to be scheduled to fill these lines.

Translation and Understanding

After reviewing the SCOR metrics list and Oracle software manuals provided by the Logistics Transformation Office (Appendix B), the study found that there is no metric to correlate with abort rate. Therefore this metric was evaluated only on Importance and Effectiveness investigative questions.

Break rate

Comparison

Break rate is the percentage of airframes that land broken or in landing status Code/Alpha-3 (Air Force, 2006). When aircraft land they are given landing status codes based on what maintenance is required for the aircraft. Aircraft are given status Code/Alpha-1 for fully mission capable, status Code/Alpha-2 for partially maintenance capable and status Code/Alpha-3 for non mission capable. This metric is calculated by taking the number of sorties that arrive in Code/Aplha-3 divided by total sorties flown. By comparing the 3 key attributes identified in Chapter 3, to the metrics available in the SCOR database (Appendix B), one comparison was identified, Break rate (Metric 729). Break rate matched the current metric on all three key attributes, Nomenclature, Definition, and Equation; making it a Level 3 comparison. No metrics were found in the Oracle software similar to break rate. This trend was found throughout most of the metrics. The Break Rate set was then evaluated by all 4 investigative questions.

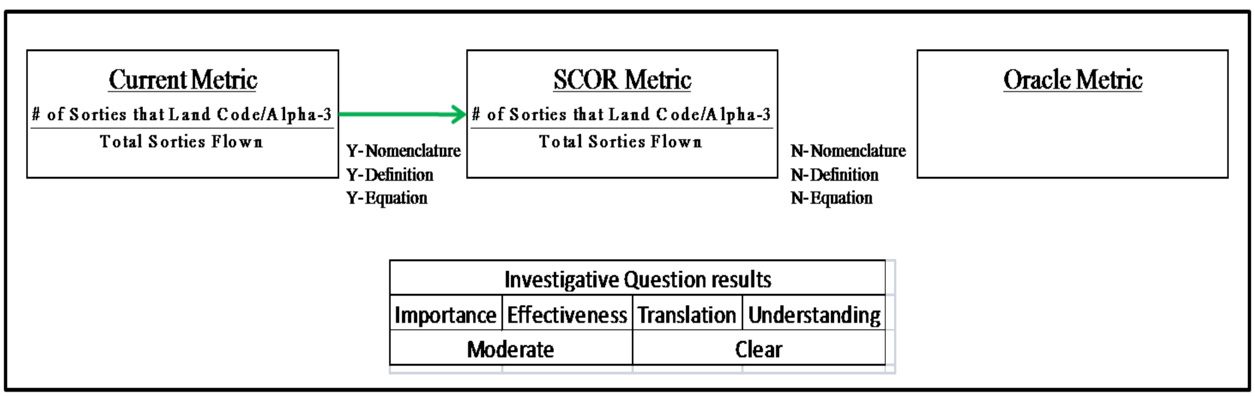


Figure 4.2 Break Rate Metric Summary

Importance and Effectiveness

Break rate appeared to have mixed reaction among the interview ratings for importance/effectiveness. Respondents identified several factors that make break rate an unimportant/in-effective metric. They stated that the metric may be important at a strategic staff level because it could lead to decisions on how to budget and allocate for parts and equipment. On a tactical decision level one respondent rated it not important and not effective because "things break and you can't control when things break". Additionally this metric was found to be susceptible to manipulation through intentional acts or personnel misunderstanding how to capture this data. When an aircraft lands the crew is debriefed on its maintenance performance, if an maintainer does not correctly status the aircraft Code/Alpha-3 then the data may be skewed. Several respondents rated the metric important and effective due to the metrics ability to easily trends captured maintenance information and provide detailed histories by aircraft. Additionally the metric is important to MDS scheduling because planes with certain maintenance histories are kept from important and high profile missions. This metric was also found to be a barometer of maintenance response to measure how effective personnel were at responding to and correcting maintenance issues.

Translation and Understanding

Break rate did measure consistently clear in translation/understanding across all interviews. Respondents found the proposed change from the old to the new metric sufficient and understandable. By being able to maintain the same nomenclature, definitions and equation, they felt it maintained the essence of the original metric.

Fix rate

Comparison

Fix rate is defined as the percentage of aircraft that landed in status Code/Alpha-3 and returned to flyable status within a set time range, either 4, 8, or 12 hours (Air Force, 2006). When aircraft land they are given landing status codes based on what maintenance is required for the aircraft. Fix rate is calculated by taking the number of code 3 breaks fixed within the defined period divided by total code-3 breaks. In comparing the key attributes to the SCOR list (Appendix B), the study found Fix Rate (Metric 732) matched on all three criteria. Nomenclature, definition, and equations all matched exactly; therefore Fix rate merits a Level 3 comparison.

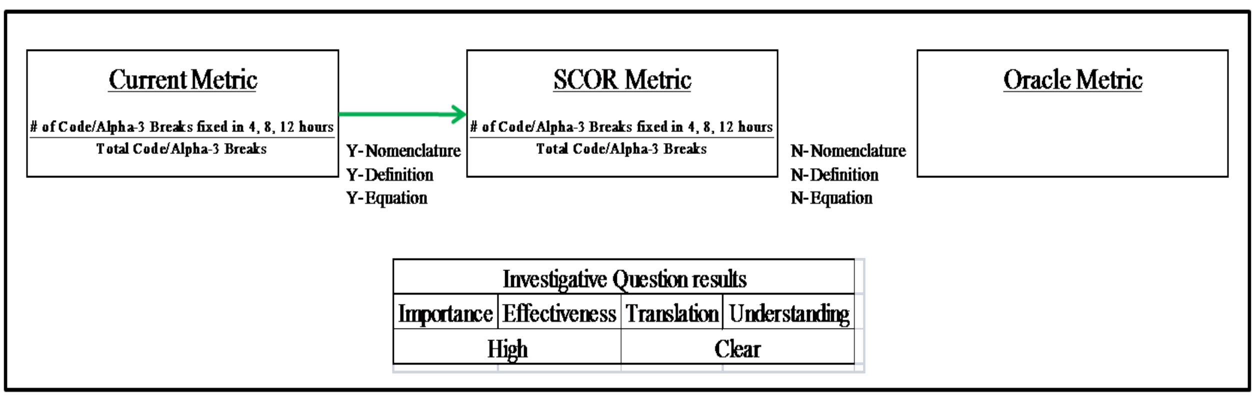


Figure 4.3 Fix Rate Metric Summary

Importance and Effectiveness

Fix rate scored consistently high across respondents for importance/effectiveness. This metric seems to have the strongest impact on management's ability to utilize personnel capabilities. Fix rate can tell you where training deficiencies lie, as well as where you have skill assignment imbalances either shift to shift or unit to unit. Additionally respondents spoke to how fix rate can allow production managers to determine maintenance repair priorities, a critical need in maintenance planning. This metric also seems to be aircraft specific in how important it was rated. Maintenance managers of older airframes seem to rate a higher level of attention to fix rate than managers of newer systems. These results are probably due to the nature of older aircraft. They tend to break more frequently and repairs are more difficult. In spite of the overall importance placed on this metric, two respondents rated this metric low because they don't use it to make management decisions. There was a clear understanding of the metric but lack of senior level attention deemed it unimportant.

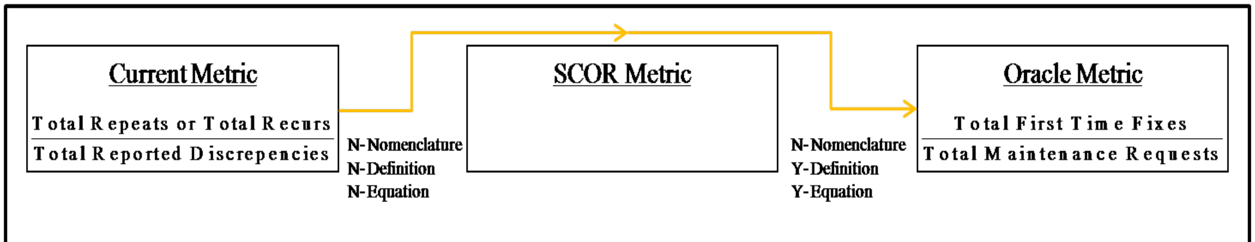
Translation and Understanding

As found in the previous metric, fix rate is rated a level 3 comparison, this seems to contribute to a clear rating of translation/understanding across all interviews. Respondents found the proposed change from the old to the new metric sufficient and understandable. By being able to maintain the same nomenclature, definitions and equation, they felt it maintained the essence of the original metric.

Repeat rate and Recur rate

Comparison

Repeat rate is the percentage of maintenance discrepancies that occur again during the next sortie attempt after being fixed (Air Force, 2006). Recur rate is the percentage of maintenance discrepancies that occur on the second thru fourth sorties after being fixed. Both metrics use a similar equation for calculation. Total repeats (Total Recurs) divided by total reported discrepancies. After using the key attributes from both equations, no metric was found in the SCOR list that corresponded to either repeat rate or recur rate. However upon review of the Oracle key performance indicator listing (Oracle, 2007), the metric First Time Fix rate was selected as a suitable candidate for conversion. This metric did not correlate on nomenclature with repeat and recur; but the study found that the definitions had an inverse relationship. While Repeat/Recurs captured data based on failed fixes, First Time Fix Rate captured the data based on successful fixes. First time fix rate is calculated by taking the total first time fixes divided by total maintenance requests, where requests were equal to discrepancies. The equations were equivalent if one takes into account the inverse relationship between the two metrics. Therefore this metric was categorized as a Level 2 comparison. An added bonus of the inverse relationship is that both current metrics can be combined in the translation allowing for fewer metrics for the user to have to track and manage.



Investigative Question results			
Importance	Effectiveness	Translation	Understanding
High		Moderate	

Figure 4.4 Repeat and Recur Rate Metric Summary

Importance and Effectiveness

Repeat/Recur was again consistently rated high across all interviews for importance and effectiveness of both current metrics. This metric was found to contribute directly to Manning utilization management. Respondents identified that this metric will tell managers how well the maintenance personnel are accomplishing their assigned task. It will help flag critical maintenance issues and help manager's determine if there are skill proficiency, equipment, or technical data problems. Repeat/Recur rates impact operational readiness through its ability to identify maintenance issues that may be systemic across the fleet. While all interviews rated repeat/recur rates as important, several also identified potential downsides to their effective implementation. One of the most frequently mentioned was its relevance across different MDS's. Fighter aircraft are fairly static in terms of off station verses home station operations, thus management systems are more likely to capture all repeat events. However in the airlift world, airframes often spend more time off station than at home, sometimes over 45 days at a time, and usually never more than 1-2 days in one location. This creates a problem for capturing repeat maintenance events.

Translation and Understanding

Respondent's ratings of First Time Fix Rate were consistent across most interviews; however the metric was rated moderate for translation/understandability. Most of those surveyed required a second look to see how the metrics changed from Repeat/Recur to First Time Fix Rate. The fact that they have an inverse relationship was identified as the primary reason for marking it down in this category. Once they had time to assimilate the new metric it was found to be favored over the current metrics as a tool for maintenance management.

Logistics Departure Reliability Rate

Comparison

Logistics Departure Reliability (LDR) or sometimes known as Departure Reliability is percentage of on time aircraft departures due to logistics (Air Force, 2006). Departure Reliability is calculated by taking the number of aircraft departures minus number of logistics delays divided by the number of departures. Based on the key attribute coding, On time Operation Starts (Metric 744) in the SCOR list was similar to Departure Reliability along two attributes: metric definition and equation (Appendix B). On Time Operation Starts is defined as the percentage of operations started on time, and calculates it by dividing the number of operation on time starts by the number of operations. By equating aircraft departures to operation starts, this study has found they are equivalent metrics along two aspects, and are consequently categorized as a Level 2 comparison.

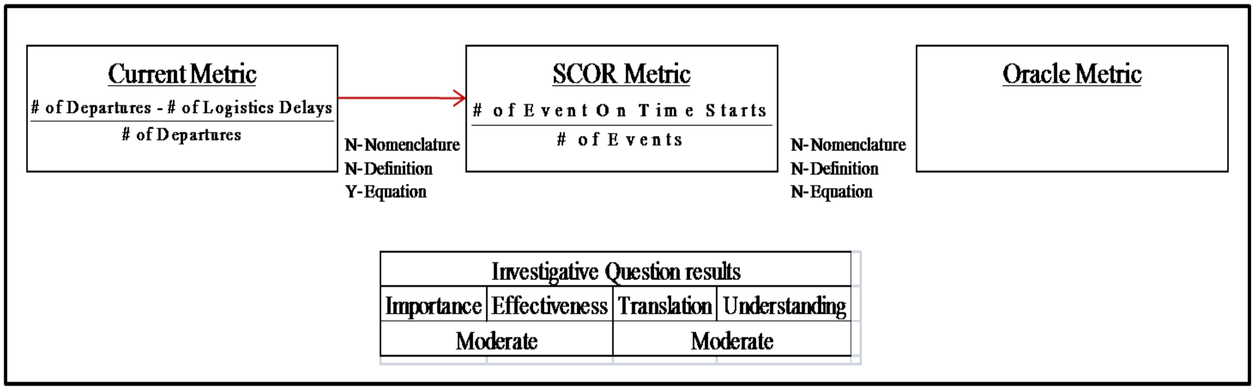


Figure 4.5 LDR Rate Metric Summary

Importance and Effectiveness

Departure Reliability was rated consistently as moderately important/effective across the interviews, with only two rating it moderately low in importance and effectiveness. While Departure Reliability was found to be able to identify mission execution issues, respondents stated it fails to capture the total picture of an aircraft launch operation. The metric would be more effective if it were to capture all the launch events within the established schedule of events. In doing this specific process breakdowns could be highlighted and appropriate management fixes implemented. Ultimately policy decisions would dictate how effective this metric could be. One potential alternative to Departure Reliability rate offered was On Time Operation Completion. Respondents indicated that the more important issue is not if an aircraft launched on time, but did it deliver its intended mission when required. As one manager put it “did we get it to the customer when they asked for it? This is applicable whether it was a tank, bomb, aerial refueling or surveillance asset.”

Translation and Understanding

Translation/understanding was rated moderate for this metric. Determining what constitutes operation starts was a key item identified that negatively affected the understanding of this metric set. Most respondents found the proposed metric to be more effective in managing the mission execution process than the previous metric. They also stated that the new metric would be more conducive to cross functional cooperation between operations, maintenance and logistics readiness units.

Average Delayed Discrepancy rate

Comparison

Average Delayed Discrepancy Rate is defined as the average number of deferred maintenance actions (Air Force, 2006). Deferred actions are those maintenance issues not affecting safety of flight, which are selectively kept open until an opportune time to repair is available. It is calculated by capturing a current snapshot of open maintenance actions divided by the average number of aircraft possessed. Based on the key attributes analysis no metric was found in the SCOR list that corresponded with this metric. The key attributes were compared to the key performance indicators established in the Oracle software. Work Order (Maintenance request) Backlog was found to be similar to Average Delay Discrepancies along the metric definitions, indicating a Level 1 comparison (Oracle, 2007). Oracle defines Work Order (Maintenance request) Backlog as the number of open maintenance requests on a selected date. The calculation is simply the snapshot of open requests.

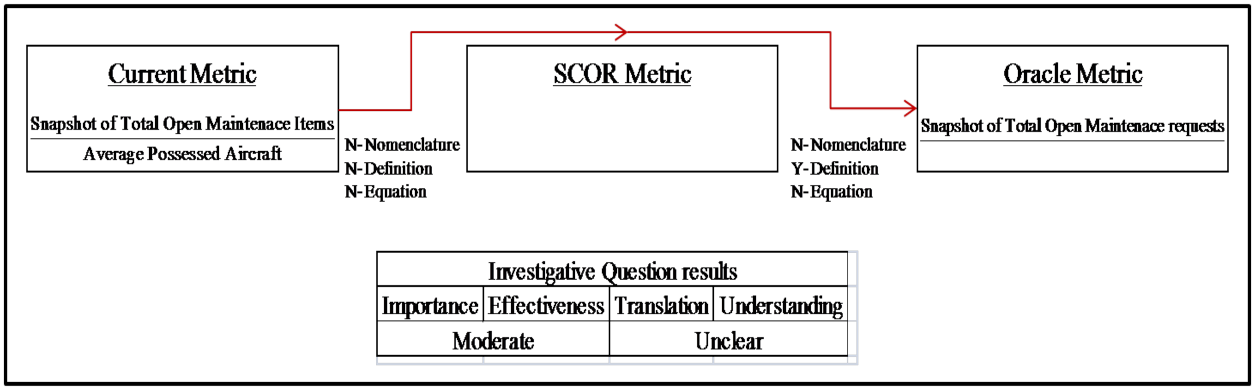


Figure 4.6 Average Delayed Discrepancy Rate Metric Summary

Importance and Effectiveness

Interview subjects rated Average Delay Discrepancies as moderate in importance and effectiveness. The majority of the interviewees described delay discrepancies as a strong indicator of how well a unit manages their airframes. Being able to effectively manage and work these items will provide long term MDS operational readiness. However the main issue that reduced its importance/effectiveness ratings was the fact that this metric as currently defined is a snapshot in time. This fails to provide any trend analysis of delay discrepancies to allow managers to see patterns or other long term effects. Most respondents felt that keeping Delay Discrepancies was important but the metric needed to be changed to allow for trending by airframe.

Translation and Understanding

Respondents rated Work Order (Maintenance request) Backlog relatively low on the translation evaluation scale. The responses indicated this was due more to the fact the snapshot method was insufficient for management of the process, than the metric not translating well. Understanding was also lower as respondents had some difficulty equating maintenance actions for maintenance requests. One respondent did rate the Translation as very adequate due to the fact the new measure captures the metric data by individual aircraft instead of being averaged across all possessed airframes.

Maintenance Scheduling Effectiveness Rate

Comparison

Maintenance Scheduling Effectiveness (MSE) is the percentage of scheduled maintenance action verses accomplished scheduled maintenance actions based on the assigned points by action (Air Force, 2006). Each scheduled maintenance action is given a set point value for completion. The values of all completed actions are then compared to total possible values for the set time period, usually a week. It is calculated by taking total points earned divided by total points assigned. Attainment to Plan (Metric 190) from the SCOR model list was found to be the best match to MSE based on comparison of the equation, making it a Level 1 comparison (Appendix B). Attainment to Plan is defined as measuring how well a unit meets its respective planned actions. It is calculated by dividing the number of actual accomplished events by number of planned events.

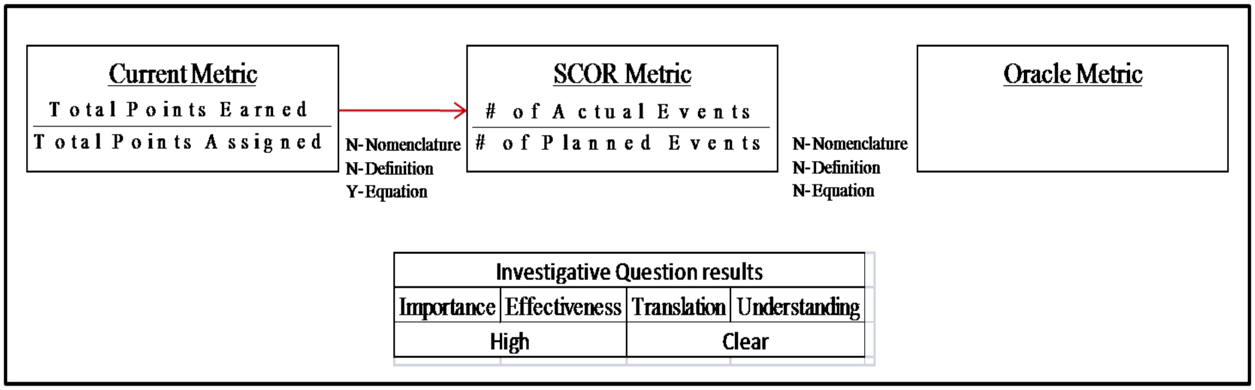


Figure 4.7 MSE Rate Metric Summary

Importance and Effectiveness

MSE was rated high in importance and effectiveness across respondents. As stated by one respondent “there is nothing any more important than scheduled maintenance. You will cancel your flying activities to do your scheduled maintenance.” MSE is a critical part of ensuring this activity is managed effectively. Even with the importance placed on scheduled maintenance by most respondents, its relative importance appears to be MDS specific. In a fighter world where schedules are set a month out, MSE will play a much stronger role than in an airlift environment where schedules are set days or sometimes a week out. However, for maintenance managers, the ability to maintain a planned schedule is critical to reducing flux within the process, and MSE will directly reflect this

Translation and Understanding

Respondents rated MSE high on both translation and understanding. Responses indicated the new metric was at least equivalent to the current metric. A few interviews stated that they felt the new metric was actually clearer than the current metric. By removing the element of the points system from the current metric, this would make the metric easier to use for maintenance managers.

Cannibalization Rate

Comparison

Cannibalization Rate or CANN Rate is the percentage cannibalization actions to replace parts on other aircraft. Essentially this is the measure that tracks how often good parts are removed from aircraft to be used to repair other aircraft with a higher maintenance priority. CANN rate is calculated by dividing the total number of CANN actions by Total Sorties flown. Nomenclature, Definition and Equation were all compared to the available metrics in the SCOR model list (Appendix B). Cannibalization rate (Metric 192) was found to be a Level 3 comparison by matching across all three key attributes. SCOR defines Cannibalization rate as the average number of CANN actions per 100 sorties flown for flying assets. It is calculated by dividing the sum of the number of aircraft to aircraft CANN's plus number of engine to aircraft CANN's by Total Sorties flown.

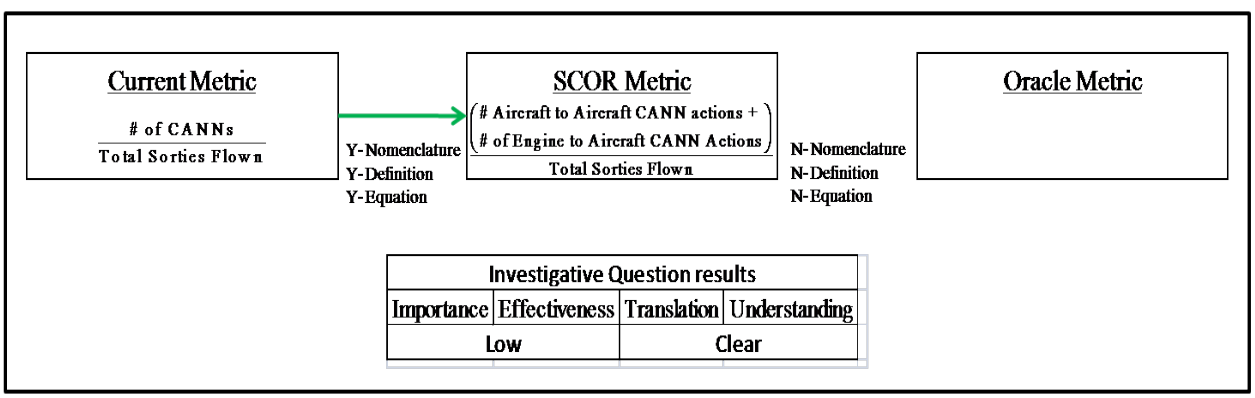


Figure 4.8 CANN Rate Metric Summary

Importance and Effectiveness

CANN rate was found to rate low in importance and effectiveness. Respondents found that the metric was not effective due to the fact that it had little effect on the decision process. The study found that while cannibalizations action were manpower intensive based on the fact you essentially had to do double maintenance, they would occur no matter how many had been done before due to lack of parts. A few managers stated that CANN rate is good indicator of the health of the supply support system, but the data is captured in other metrics such as MICAP status. Similarly to MSE this metric may also shift its importance based on MDS application, older airframes with less robust supply pipelines may rely on it more for maintenance planning.

Translation and Understanding

Even due to the low ratings of importance this metric rated moderately high for both translation and understanding. The new CANN rate was viewed as a better format providing more detail into where cannibalizations were occurring. Several interviewees, while rating the metrics as good, felt that the denominators of the equations were irrelevant. A better comparison, such as number of maintenance actions or number of aircraft as the denominator would provide a more stable and clearer picture of the impact of cannibalization actions.

Mission Capable Rate

Comparison

Mission Capable rate is the percentage of hours aircraft are mission capable, the amount of time an aircraft can do what it was designed to do (Air Force, 2007). Mission capable rate is calculated by adding the Fully Mission Capable hours plus the Partially Mission Capable hours dividing by total possessed aircraft hours. After reviewing the metrics provide in the SCOR list (Appendix B), Weapon System Availability (Metric 800) was found to connect along two attributes, definition and equation, making it a Level 2 comparison. No metric was found to match within the Oracle system. Weapon System Availability (WSA) is the percentage of hours a reported unit possessed weapon system was capable of performing any assigned mission. It is calculated by dividing MC hours by Total Active Inventory hours.

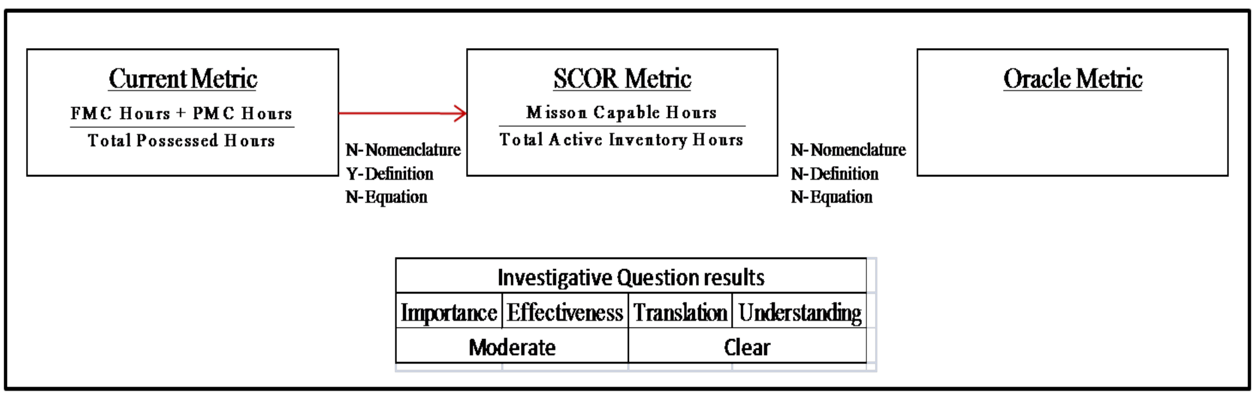


Figure 4.9 Mission Capable Rate Metric Summary

Importance and Effectiveness

Mission Capable rate was rated as moderate across the interviews with some SME's rating it as unimportant. Mission Capable rate was described as the "ultimate report card" for maintenance managers. It is a key metric into providing a clear picture of what a unit can provide in terms of MDS capability. Respondents stated that MC rate is core to the management decision process, and is truly powerful when combined with other metrics. Also mission capable rate was found more relevant to a combat forces unit than to an airlift forces unit. However the interviews revealed equally strong opinions on how Mission Capable rate was not important to maintenance managers. This metric was often over emphasized by senior leadership to the detriment of other metrics. Because of this, the data that drives this metric is susceptible to manipulation in order to satisfy some artificial standard. Managers may be driven to make poor decisions that waste resources and manpower on fixing aircraft in order to "chase" this metric.

Translation and Understanding

The study found that Weapon System Availability rated moderately strong on translatability. Managers found the new metric more closely aligns with the strategic goals from executive leadership. By being able to track what a unit can offer in terms of weapon systems, a better picture of how to meet taskings is provided. Several respondents identified that with the new metric having a different focus from the current, there is a need for sufficient training and education at all levels in order to smoothly facilitate the transition.

Fully Mission Capable Rate

Comparison

Fully Mission Capable rate is the percentage of hours an aircraft can perform all assigned missions (Air Force, 2007). It is calculated by taking total FMC hours divided by total possessed hours. After comparing all three key attributes no metric was found to match in either the SCOR model or Oracle system. This metric was then only evaluated for importance and effectives in the current system.

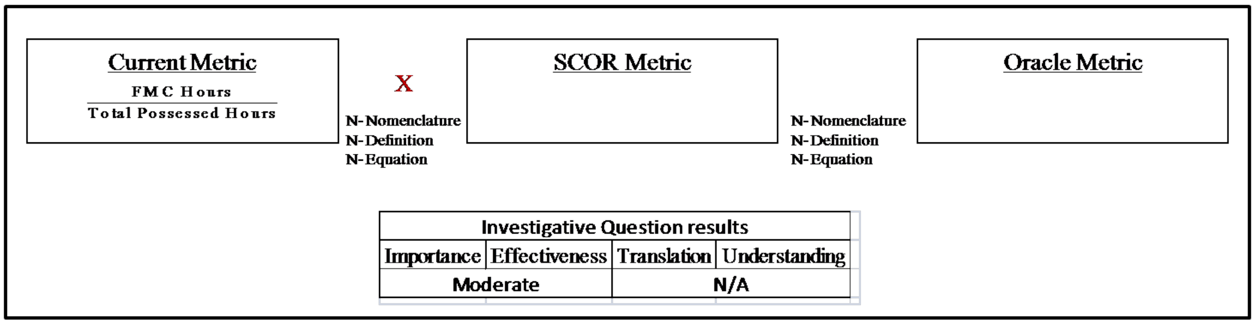


Figure 4.10 FMC Rate Metric Summary

Importance and Effectiveness

Respondents rate Fully Mission Capable as moderate in importance and effectiveness, but most of the observations discount this metrics use in managing aircraft. A few managers identified this metric as important in its ability to assist in assigning airframes to mission schedules, especially in a combat forces unit, where system requirements are much more stringent. However, most comments stated that this metric is rarely used for management decisions. It is a “nice to look at, feel good metric” but the information provided is already captured in Weapon System Availability better. Additionally, this metric can be subjective across operational environments. An aircraft may be FMC at a home station base, but be PMC or NMC at a deployed location for exactly the same system capability. Respondents indicated that they saw no real need to translate FMC into the new system.

Translation and Understanding

After reviewing the SCOR metrics list and Oracle software manuals provided by the Logistics Transformation Office (Appendix B), the study found that there is no metric similar to fully mission capable rate. Therefore this metric was evaluated only on importance and effectiveness investigative questions.

Partially Mission Capable Rate

Comparison

Partially Mission Capable (PMC) Rate is the percentage of hours an aircraft can perform some but not all of its assigned missions (Air Force, 2007). PMC rate is calculated by dividing PMC hours by total possessed hours. As in the case of FMC rate no metric was found in either SCOR or Oracle to correlate. This metric was then also only evaluated terms of the current system.

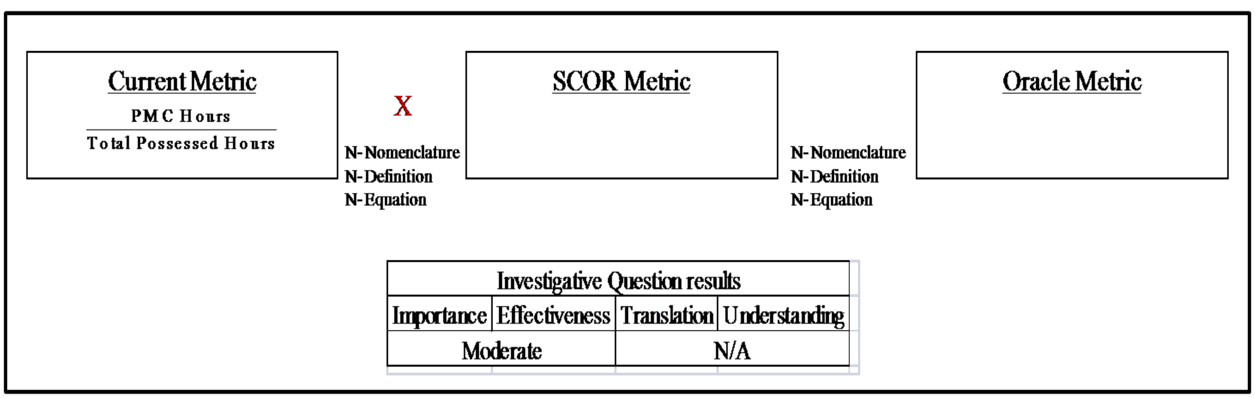


Figure 4.1 PMC Rate Metric Summary

Importance and Effectiveness

Partially Mission Capable was rated moderate in importance across the interviews. Most respondents felt that PMC was important as it does not allow any hiding of maintenance conditions on the airframes. They stated this was a critical factor in whether an aircraft could be assigned to particular missions, thus affecting aircraft availability. If an airframe has a system broken and cannot do a portion of a mission, but could then accomplish two other missions, maintenance schedulers and higher headquarters agencies need to know this. Additionally PMC will give managers insight into how well they execute maintenance plans, as well as to any deficiencies in manning or support equipment. Of all the metrics with no comparable proposed metric at present, PMC was the one that managers strongly felt needed a new metric. A variation on Weapon System Availability that would account for partially available aircraft seems to be needed.

Translation and Understanding

After reviewing the SCOR metrics list and Oracle software manuals provided by the Logistics Transformation Office (Appendix B), the study found that there is no metric similar to partially mission capable rate. Therefore this metric was evaluated only on importance and effectiveness investigative questions.

Non-Mission Capable Rate

Non-Mission Capable (NMC) Rate is the percentage of aircraft that cannot perform any assigned mission due to supply and maintenance or both (Air Force, 2007). It is calculated by dividing NMC hours by total possessed hours. Not Mission Capable Both (Metric 813), from the SCOR list (Appendix B) was determined to be the best match for the current metric. Not Mission Capable Both is calculated by dividing the sum of NMCS hours and NMCM hours by total possessed hours. As a Level 3 comparison, it matched across all three key attributes. However no metric within the Oracle software was found to match it.

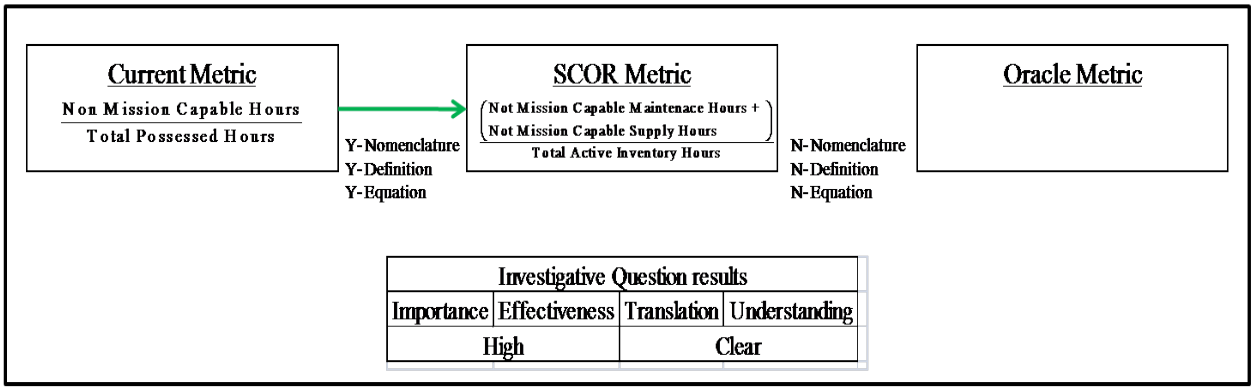


Figure 4.12 Non Mission Capable Rate Metric Summary

Importance and Effectiveness

Respondents rated this metric high across all evaluations. Most managers found this metric was a good way to flag and evaluate the characteristics of aircraft down time. It represents the other side of the coin from MC rate, and is just as important. Again, just as with MC rate, they warned of the propensity to “chase” numbers, rather than perform effective thoughtful maintenance planning.

Translation and Understanding

NMC measured consistently clear in translation and understanding across all interviews. Respondents found the proposed change from the old to the new metric sufficient and understandable. By being able to maintain the same nomenclature, definitions and clarifying the equation, they felt it improved upon the original metric.

Non-Mission Capable Rate Supply

Comparison

Non-Mission Capable Supply (NMCS) Rate is the percentage of aircraft that cannot perform any assigned mission due to supply (Air Force, 2007). Not Mission Capable Supply (Metric 808), from the SCOR list (Appendix B) was determined to be the best match for the current metric. Both metrics are calculated by dividing NMCS hours by total possessed hours. The only difference is the Air Force definition uses Non while the SCOR definition uses Not. As a Level 3 comparison, it matched across all three key attributes. However no metric within the Oracle software was found to correlate.

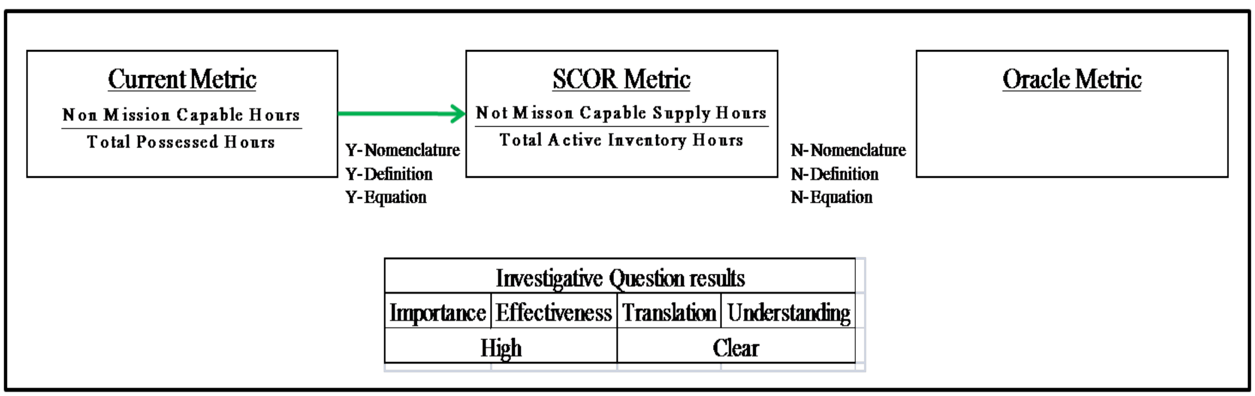


Figure 4.13 NMCS Rate Metric Summary

Importance and Effectiveness

As a portion of NMCB, Non Mission Capable Supply was rated as highly important across most interviews. This metric was found to be one of the critical tools cited for the maintenance manager second only to Non Mission Capable Maintenance. NMCS plays a large role in being able to evaluate the robustness of the supply support provided by either contractor or in house blue suite personnel. As a manager you have to know what, if any, supply issues may affect repairs to your aircraft and be able to identify them. While the process that this metric monitors is controlled by other entities, its impact to the maintenance enterprise makes it important. Managers cited the need to have visibility on when needed parts would arrive, so that they could plan around the arrival dates, thus better utilizing their limited manning resources.

Translation and Understanding

NMCS measured consistently clear in translation/understanding across all interviews. Respondents found the proposed change from the old to the new metric sufficient and understandable. By being able to maintain the same nomenclature, definitions and equation, they felt it maintained the essence of the original metric.

Non-Mission Capable Rate Maintenance

Comparison

Non-Mission Capable Maintenance (NMCM) Rate is the percentage of aircraft that cannot perform any assigned mission due to maintenance (Air Force, 2007). Not Mission

Capable Maintenance (Metric 812), from the SCOR list (Appendix B) was determined to be the best match for the current metric. Both metrics are calculated by dividing the sum NMCM hours by sum of possessed hours. As a Level 3 comparison, it matched across all three key attributes. The only difference is the Air Force definition uses Non while the SCOR definition uses Not. No metric within the Oracle software was found to correlate.

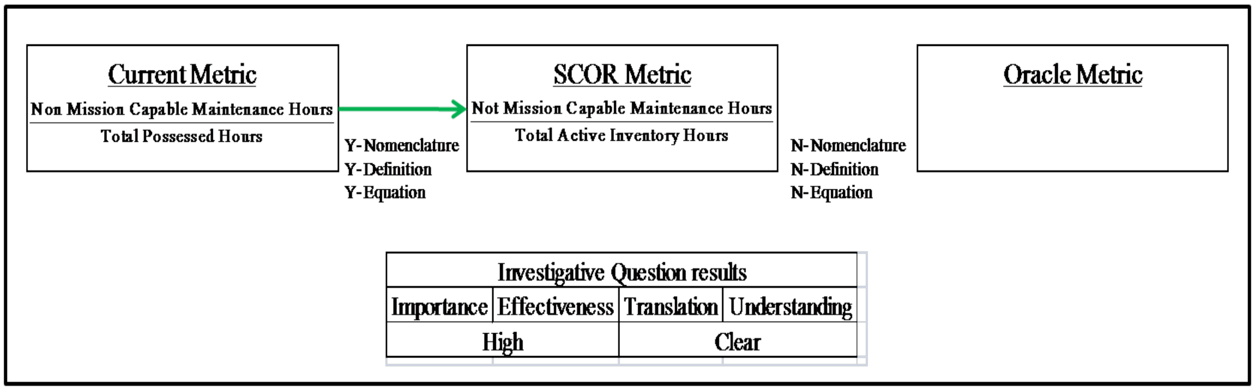


Figure 4.14 NMCM Rate Metric Summary

Importance and Effectiveness

Non Mission Capable Maintenance was rated as highly important across most interviews. This metric was also cited as one of the critical tools for the maintenance manager. NMCM plays a large role in being able to evaluate the robustness of the maintenance program at the unit level, making it one of the cornerstone metrics for maintenance managers.   Maintenance mangers stated this metric was the most important as it was able to identify what was broken, how often it was broken and was key to formulating maintenance plans.

Translation and Understanding

NMCM measured consistently clear in translation/understanding across most interviews. Respondents found the proposed change from the old to the new metric sufficient and understandable. By being able to maintain the same nomenclature, definitions and equation, they felt it maintained the essence of the original metric. Only one respondent felt the translation was not adequate and did not think it was clear in its definition.

Total Non-Mission Capable Rate

Comparison

Total Non-Mission Capable (TNMC) Rate is the percentage of total NMC hours (Air Force, 2007). It is calculated by dividing total NMC Maintenance hours by total possessed hours. No metric within the Oracle software or the SCOR model list was found to correlate with TNMC.

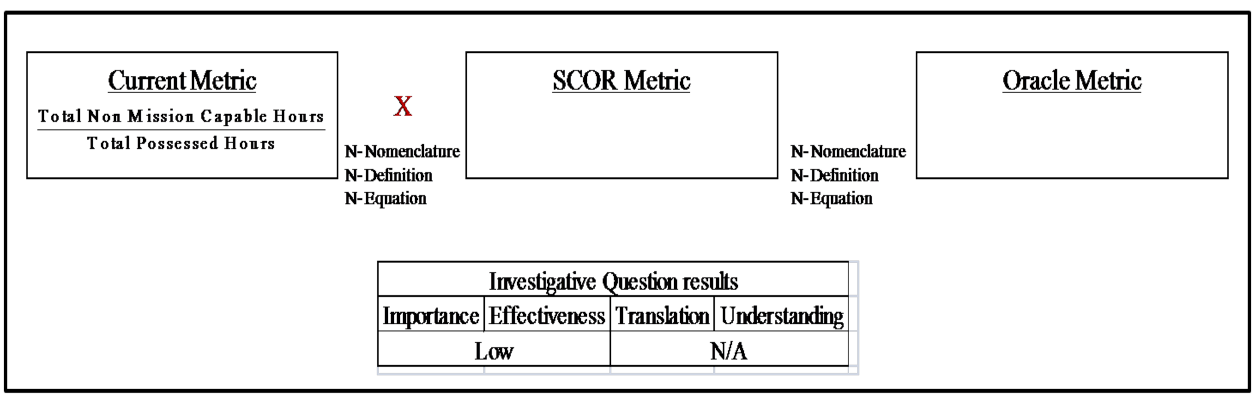


Figure 4.15 TNMC Rate Metric Summary

Importance and Effectiveness

TNMC rate was evaluated as one of the lowest in importance and effectiveness by maintenance managers sampled. This metrics was found to be unimportant as it was a repeat of other metrics, one respondent stated “I can do public math and can tell 1+1=2. I don’t need someone to tell me 2 when I can see it for myself”. TNMC was also found to be unused in any management decision process, citing the story was told better and clearer by other metrics.

Translation and Understanding

After reviewing the SCOR metrics list and Oracle software manuals provided by the Logistics Transformation Office (Appendix B), the study found that there is no metric similar to total non mission capable rate. Therefore this metric was evaluated only on importance and effectiveness investigative questions.

Total Non-Mission Capable Maintenance Rate

Comparison

Total Non-Mission Capable Maintenance (TNMCM) Rate is the percentage of total NMCM hours (Air Force, 2007). It is calculated by dividing total NMC Maintenance hours by total possessed hours. The metric Total Not Mission Capable Maintenance, from the SCOR list (Appendix B) was determined to be the best match for the current metric. Total Not Mission Capable Maintenance is calculated by dividing the sum of NMCM plus the sum of NMCB hours by sum of possessed hours. As a Level 3 comparison, it matched across all three key attributes. The one difference found, is the SCOR equation also incorporates any accumulated Both time, as it has a component of maintenance time in it. This metric is typically used to aggregate on a month time frame for a unit or multiple units if used at a higher headquarters. No metric within the Oracle software was found to correlate.

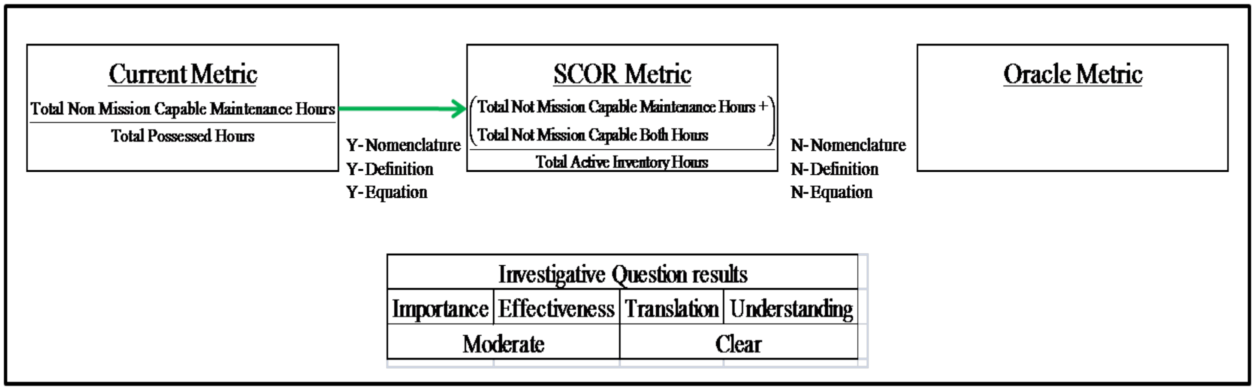


Figure 4.16 TNCM Rate Metric Summary

Importance and Effectiveness

TNMCM rate, like TNMC, was identified as a duplicate metric by respondents, and was accordingly rated as moderate in importance and effectiveness. Having a second metric was a waste of collection effort that could be put towards other endeavors. They also found that putting all NMC hours into one lump did not allow the effective analysis by airframe in order to spot aircraft specific trends.

Translation and Understanding

The respondents did rate this metric fairly clear in both translation and understanding. Respondents found the proposed change from the old to the new metric sufficient and understandable. They found the new metric to actually be better, in that it incorporated the NMCB time which contains some maintenance time which the current metric did not capture.

Total Non-Mission Capable Supply Rate

Total Non-Mission Capable Supply (TNMCS) Rate is the percentage of total NMCS hours (Air Force, 2007). It is calculated by dividing total NMC Supply hours by total possessed hours. Total Not Mission Capable Supply (Metric 811), from the SCOR list (Appendix B) was determined to be the best match for the current metric. Total Not Mission Capable Supply is calculated by dividing the sum of NMCS plus the sum of NMCB hours by sum of possessed hours. The one difference found, is the SCOR equation also incorporates any accumulated Both time, as it has a component of supply time in it. This metric is typically used to aggregate on a month time frame for a unit or multiple units if used at a higher headquarters. As a Level 3 comparison, it matched across all three key attributes. However no metric within the Oracle software was found to match.

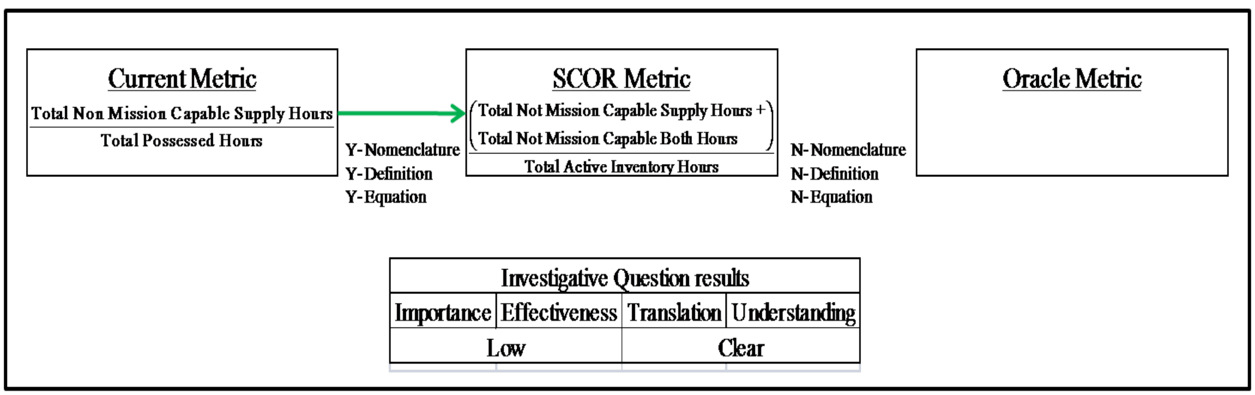


Figure 4.17 TNMCS Rate Metric Summary

Importance and Effectiveness

TNMCS rate, like TNMCM, was identified as a duplicate metric by respondents, and was accordingly rated as low in importance and effectiveness. Having a second metric was a waste of collection effort that could be put towards other endeavors. The metric doesn’t provide sufficient detail to support management decisions. One interviewee felt the metric "would miss the trees, in spite of the forest". While this metric could be used to influence CANN decisions, the same information was also garnered from the NMCS rate.

Translation and Understanding

The respondents did rate this metric clear in both translation and understanding. Respondents found the proposed change from the old to the new metric sufficient and understandable. They found the new metric to actually be better with its incorporation of the NMCB time, which contains some supply time that the current metric did not capture.

Flying Hour Execution Rate

Comparison

Flying Hour Execution (FHE) is the percentage of actual flying hours executed verses the planned flying hours (Air Force, 2007), and is calculated by taking the total flying hours executed divided by total flying hours scheduled. Operational Programmed Time Accuracy, (OPTA) from the SCOR list (Appendix B) was found to be a Level 2 comparison, matching on definition and equation. OPTA is the comparison of future Operational Time (i.e. scheduled flying hours) to actual Operational Time (i.e. executed flying hours) by location or group. It is calculated by dividing actual executed flying hours by programmed flying hours. No metric was found in the Oracle listing to match to FHE.

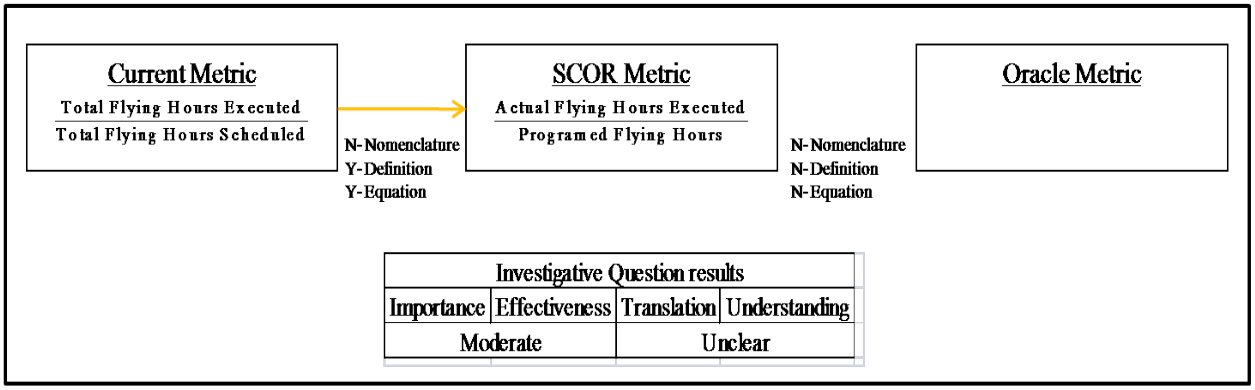


Figure 4.18 FHE Rate Metric Summary

Importance and Effectiveness

FHE is one of the metrics where SME's were split on rating the importance and effectiveness, but this metric was rated low overall. The split occurred between application in a combat aircraft unit and a mobility aircraft unit. Fighter units placed a high value on this metric, while airlift units almost never use this metric. In a high importance/effectiveness environment this metric dictates all aspects of management planning. Flying schedules and maintenance planning are done month by month and any over or under flying will add flux into these schedules. Flux, in turn, means more effort by maintenance personnel to compensate for the changes. FHE also determines budget allocation in the fighter community. So executing on target is critical for effective utilization and acquisition of operations and maintenance funds. In direct contrast, within the airlift community the majority of flying hours are dictated by the Tanker and Airlift Control Center based on mission execution needs, so managers in airlift have found little use for this metric at the unit level.

Translation and Understanding

This study found that the respondents were divided on rating the translation and understanding. While some members clearly understood the new proposed metric and felt the translation was adequate, others did not. The language used in both the definition and equation was identified as the largest issue with understanding the new metric. Respondents cited confusion in trying to understand the terminology of the SCOR definition and how it related to their understanding of the Air Force definition. They identified a need for strong training and education in order to comprehend this metric.

Flying Scheduling Effectiveness rate and Chargeable Deviation rate

Comparison

Flying Scheduling Effectiveness (FSE) is the percentage of deviations from the planned flying schedule to what was actually flown, and is calculated by subtracting schedule deviations from scheduled flights then divided by actual executed flights. Chargeable Deviation rate is the percentage of deviations due to maintenance or operations actions, calculated by dividing the sum of maintenance deviations and operations deviations by total sorties scheduled (Air Force, 2007). Chargeable Deviation is essentially a derivative of FSE that reports on two possible deviation types; because of this the study chose to combine these metrics. Based on their key attributes, Planning Changes within Execution Window (Metric 181) was determined to be a Level 2 comparison. Planning Changes within Execution Window is the number of changes to a schedule within the execution window. While labeled as a rate this metric currently is a count of event deviations. This metric can be converted to a rate by dividing number of events minus number of changes by number of total events.

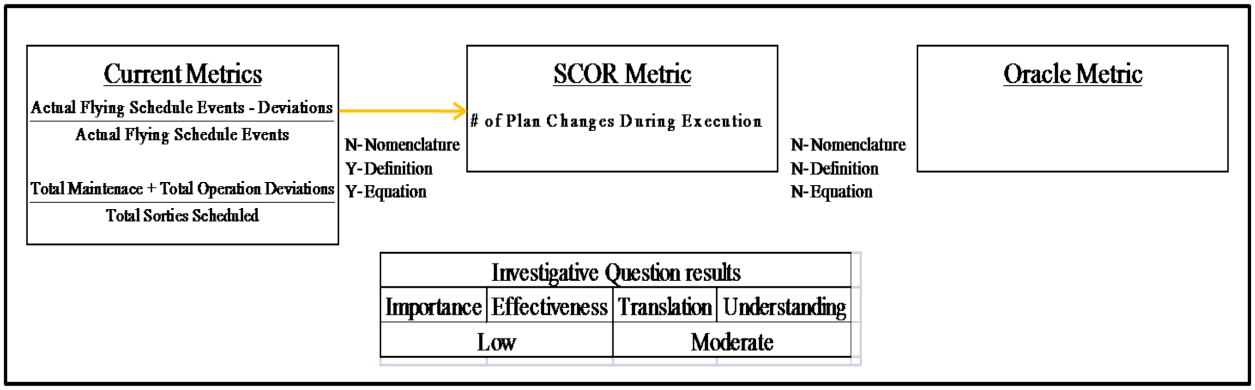


Figure 4.19 FSE and CD Rate Metric Summary

Importance and Effectiveness

Overall FSE and Chargeable Deviation rates were marked as low for both importance and effectiveness. Some of the respondents had never even heard of chargeable deviation outside of the Air Force instruction manuals. This metric was felt to be more important to senior managers than to folks at lower tactical levels. When used FSE can provide a fairly accurate report card on how units execute their given taskings, the key being *when used.* The metric received more attention in a fighter operating environment than a mobility one. It was also observed that FSE also may not tell the full story of launch or recovery operations.

Translation and Understanding

Case study interviews also showed that FSE/CD was rated moderate compared to other metrics for translation and understanding. However, between respondents this metric set was split in its ratings, it was rated either to the right of the scale or the left, with no ratings in the middle. Low rated observations felt that some fidelity was lost in the combination of the two metrics, and data on deviations would not be able to be extracted. Managers who rated the translation high felt the new metric captured more of the process events instead of just whether the aircraft made it off on time. If the aircraft took off on time, but each step in the Schedule of Events busted time, you would then see the flux in the system and be able to better identify where resources need to be applied.

Primary Aircraft Inventory

Comparison

Primary Aircraft Inventory (PAI) is the assigned number of aircraft by MDS per designated organization. This is simply a snapshot of the number of aircraft assigned. PAI is used in comparison to Possessed Aircraft Rate to determine a unit's ability to meet assigned taskings. The metric Total Active Inventory (TAI) was found to match along two key attributes, setting this at a Level 2 comparison. Total Active Inventory is the possessed number of aircraft by weapon system with possession purpose code = CA, CB, CC, CF, EH, EI, IF, PJ, PL, PR, TF, TJ, ZA, ZB. Possession purpose codes are the two letter codes within the maintenance data systems that identify who the controlling organization is for aircraft. The codes listed above all indicated possession of an aircraft by the base level organization. As with PAI it is simply a snapshot count of assets possessed.

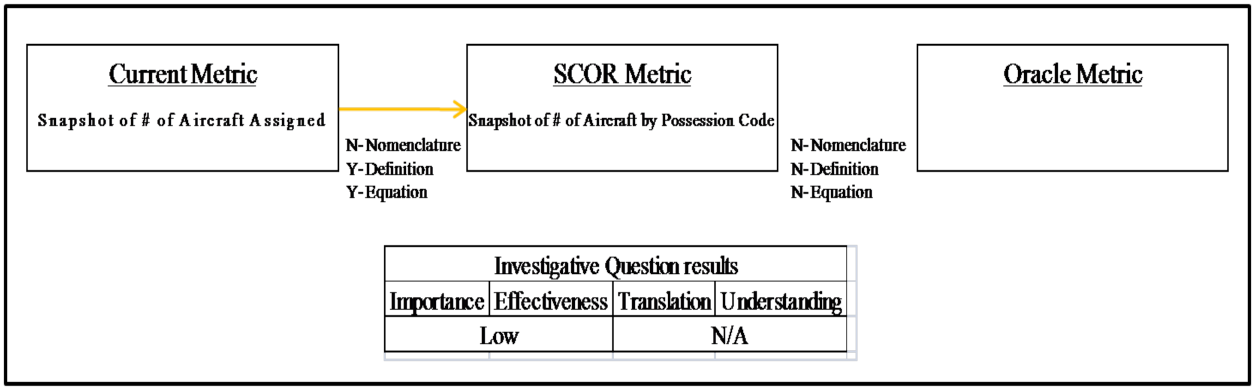


Figure 4.20 PAI Rate Metric Summary

Importance and Effectiveness

PAI was rated the lowest metric in importance and effectiveness by interview respondents. The primary reason stated for the low rating was the fact that at the unit level there is no control over this metric and it is not used for any decision level. PAI is set by higher headquarters and directed down to units. PAI was also marked as not effective because it only tells part of the story for the data it reports on. PAI is the number of aircraft that higher headquarters use to establish manning and equipment support levels. However many units also have more airframes assigned than PAI indicates, this excess is termed Backup Aircraft Inventory (BAI). BAI aircraft while being utilized just like PAI aircraft do not get any manning or equipment authorizations, and BAI counts are not utilized in metric decisions. So in essence units may operate more systems than they are equipped or manned to support. One respondent stated he had never seen a unit have more than its PAI number of aircraft. Additionally TAI also comprises part of the many other metrics equations discussed earlier.

Translation and Understanding

Respondents did rate TAI clear for both Translation and Understanding. The possession codes did cause some respondents to not understand the new metric at first, as they did not know or understand the purpose of the possession codes. However, most respondents thought the new metric was better because it eliminated the PAI/BAI conflict. The new metric tracked what you own and have to operate, which they felt was a better way of tracking true utilization.

Possessed Aircraft Rate

Comparison

Possessed Aircraft Rate is the aircraft under control of an owning organization. It is simply the snapshot of aircraft at an organization for a given time window. Possessed Aircraft Rate is used in comparison to PAI to determine a unit's ability to meet assigned taskings. Depot Possessed Percentage rate (Metric 815), although an inverse of Possessed Aircraft rate, was found to match across all three key attributes, warranting a Level 3 comparison. Depot Possessed Percentage rate is the percentage of the total active inventory hours that are in depot possessed status, calculated by month for possession purpose codes = DJ, DK, DL, DM, DO, DR.

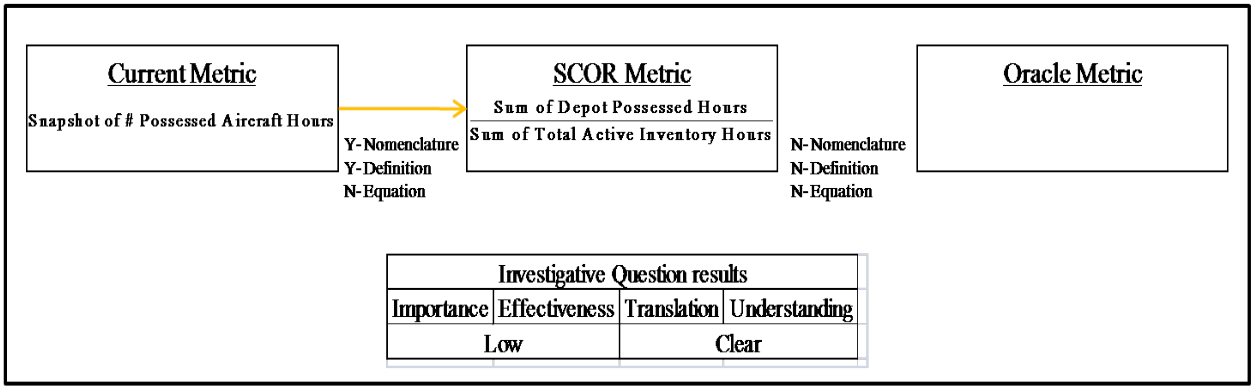


Figure 4.21 Possessed Aircraft Rate Metric Summary

Importance and Effectiveness

Possessed Aircraft rate was also rated low by the interviewed SME's. While a few managers felt this metric was important from a scheduling perspective for forecasting future mission scheduling, most managers never used this metric for any decision making processes. This is a metric that is controlled at a strategic level and plays no real role at a tactical execution unit. Additionally, respondents identified that policy places a cap on how many aircraft can be in depot status. This may also lead to masking of true capabilities of units if there is a need for more airframes to be in depot repair possession than policy would allow.

Translation and Understanding

While the current metric was rated low in importance and effectiveness, it rated high on translation and understanding. Maintenance managers felt that even with the inverse flip in reported data, the metric was easily understood and the proposed metric was adequate.

Programmed Average Sortie Duration

Comparison

Programmed Average Sortie Duration (PASD) is the measure of the average sortie length scheduled for execution. It is calculated by dividing the number of sorties planned by total scheduled sorties hours (Air Force, 2007). After reviewing the available metrics in both the SCOR listing in Appendix B and the Oracle software manuals, no metric was found to correlate with PASD. This metric was only evaluated by managers on importance and effectiveness of the current metric.

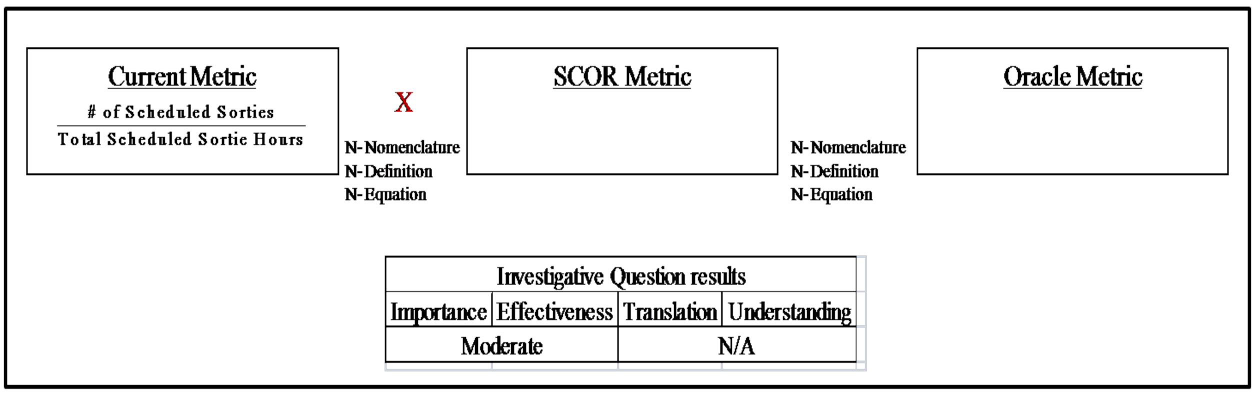


Figure 4.22 PASD Rate Metric Summary

Importance and Effectiveness

PASD was another metric that was found to have a split evaluation among the maintenance managers interviewed. Several respondents found this metric to be highly important and effective if you operate in combat forces organization, but not important or effective in mobility forces organization. Combat forces sorties can last 1 to 2 hours with multiple launches in a day. In contrast, in the mobility airlift organizations sorties can last anywhere from 4 hours to more than 14 hours when the aircraft leave home station. PAS was identified as a strong tool for monitoring and managing mission execution, specifically the flying schedule. In addition it was also found to play a large role in personnel management. Being able to know when to provide launch and recovery support was identified as one of the core responsibilities of maintenance management. Respondents stated that this metric should have a translation built for it in the ECSS system program transition.

Translation and Understanding

After reviewing the SCOR metrics list and Oracle software manuals provided by the Logistics Transformation Office (Appendix B), the study found that there is no metric similar to PASD. Therefore this metric was evaluated only on importance and effectiveness investigative questions.

Actual Average Sortie Duration

Comparison

Actual Average Sortie Duration (AASD) is the measure of the average sortie length executed by a unit. It is calculated by dividing the number of sorties executed by total executed sorties hours (Air Force, 2007). After reviewing the available metrics in both the SCOR listing in Appendix B and the Oracle software manuals, no metric was found to correlate with AASD. This metric was only evaluated by interview on importance and effectiveness of the current metric.

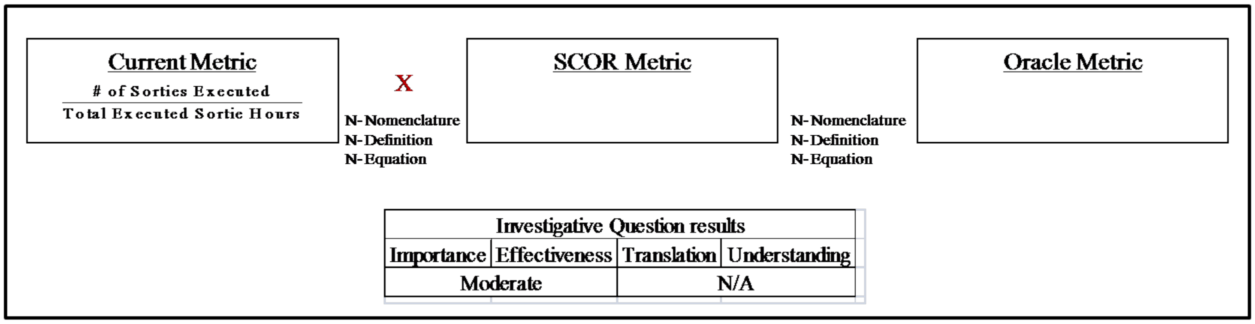


Figure 4.23 AASD Rate Metric Summary

Importance and Effectiveness

AASD was also found to have a split evaluation among the maintenance managers interviewed. The same respondents that found PASD important also rated this metric as highly important and effective if you operate in a combat forces organization, but not important or effective in mobility forces organization. For the same reasons stated for PASD, maintenance managers identified this metric as being ineffective due to incompatibility of data exchange between maintenance systems and operations systems. Respondents stated that this metric should have a translation built for it in the ECSS system program transition.

Translation and Understanding

After reviewing the SCOR metrics list and Oracle software manuals provided by the Logistics Transformation Office (Appendix B), the study found that there is no metric similar to AASD. Therefore this metric was evaluated only on importance and effectiveness investigative questions.

Utilization Rate

Comparison

Utilization (UTE) Rate is the average number of sorties flown per primary aircraft inventory, calculated by dividing number of sorties by hours flown per month then dividing by PAI per month (Air Force, 2007). Utilization rate (Metric 766) from the SCOR metric model was found to match across all three key attributes, a Level 3 comparison. Utilization rate is defined as the measure of the average use of a system during a specified period of calendar time. It is calculated as the average usage divided by flying hours divided by TAI for the month.

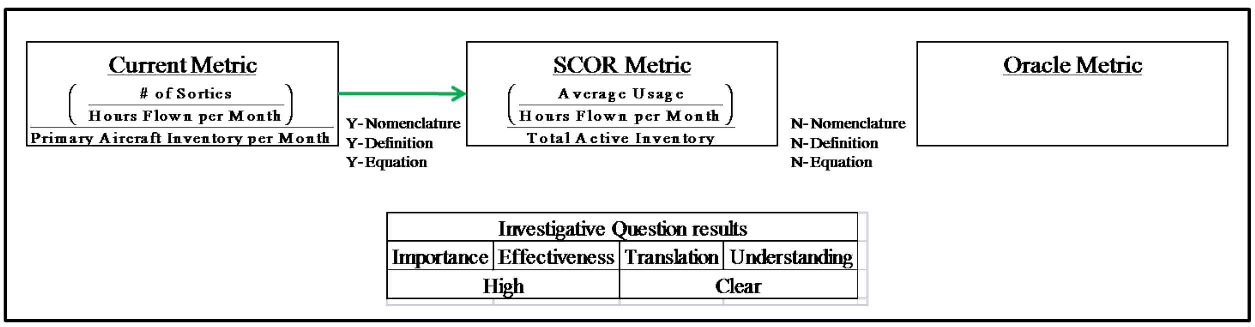


Figure 4.24 UTE Rate Metric Summary

Importance and Effectiveness

UTE rate was rated moderately high by the majority of interviews. UTE rate was a key tool cited to provide critical information on fleet mission scheduling management, especially in the fighter community. In combat forces UTE is a driving factor for when aircraft enters scheduled maintenance and overhaul, which is dictated by flying hours accumulated on the airframes. In the mobility community this is not applicable as scheduled maintenance programming is based on a calendar time not flying hour targets. However, it was identified as being important at the strategic level for fleet management and ensuring longevity of airframes across units. It will also determine where allocation of assets needs to occur. High UTE rates mean more flying, requiring more airframes and more manning to be able to meet mission taskings.

Translation and Understanding

UTE rate measured consistently clear in translation/understanding across most interviews. Respondents found the proposed metric sufficient and understandable. By being able to maintain the same nomenclature, definitions and clarifying the equation, they felt it improved upon the original metric.

MICAP Hours

Comparison

MICAP or Mission Capability Aircraft Parts Hours are the hours that are accrued in a given month for items designated as affecting mission capability that are on backorder. This is metric 817 from the SCOR database list. This metric is not a translation of any current metric but was evaluated on its potential use if introduced to the system.

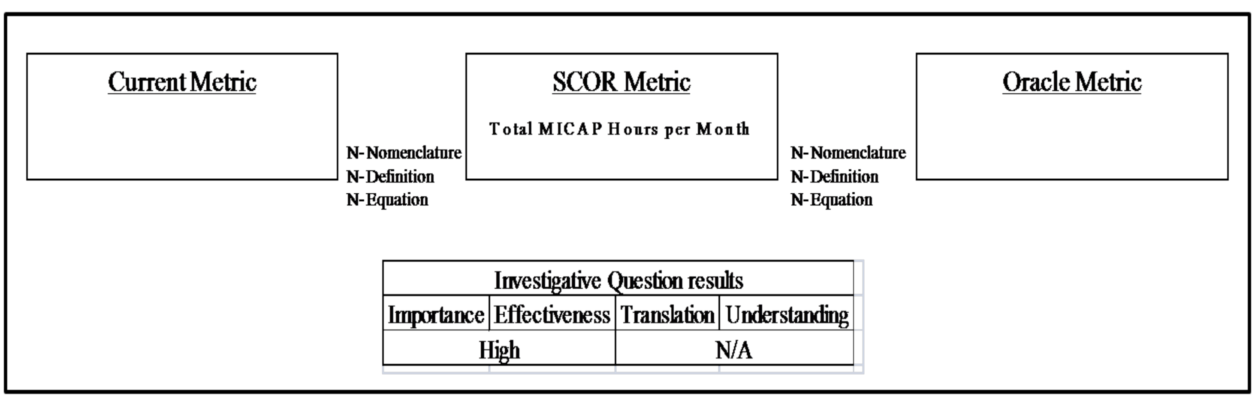


Figure 4.25 MICAP Rate Metric Summary

Importance and Effectiveness

Respondents found this metric could be important and effective if incorporated into the ECSS program. It was rated high in most interviews. MICAP Hours was identified as providing greater visibility into the MICAP issue process, than current metrics. If managed properly it would assist maintenance managers in making CANN process decisions as well as encourage interfacing with supply process managers. However, one respondent felt this data was already tracked and captured in the NMCS rate.

Translation and Understanding

This metric was a new metric identified for evaluation. It was not translated from an existing metric. Therefore this metric was evaluated only on importance and effectiveness investigative questions.

Average Age of ETAR

Average Age or Engineering Technical Assistance Request is the average by unit of time of open requests for engineering assistance, also known as 107 or Request for Engineering Disposition (REDI) requests. This is metric 899 from the SCOR database provided by the LTO office. This metric is not a translation of any current metric but was evaluated on its potential use if introduced into the system.

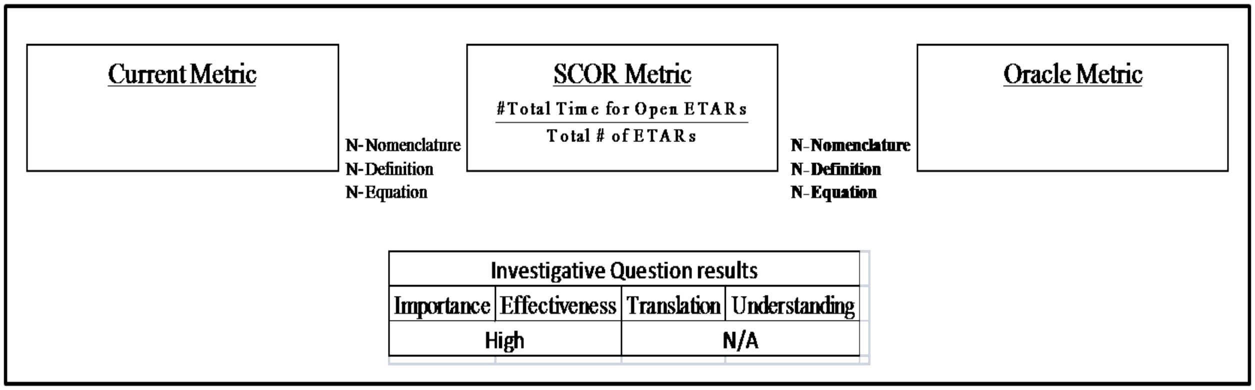


Figure 4.26 Average Age of ETAR Rate Metric Summary

Importance and Effectiveness

Average Age of ETAR was evaluated high among most interviewed managers. This metric would be able to provide the case for system mangers to increase budgets for engineering support as well as provide justification to contract supported units for continuation of those contracts. This would also create visibility at a strategic level of the reliance the current force structure has on civilian and contract engineers.

Translation and Understanding

This metric was a new metric identified for evaluation. It was not translated from an existing metric. Therefore this metric was evaluated only on importance and effectiveness investigative questions.

Analysis of Evaluation Factors

After discussion of each individual metric case, the study sought to define the underlying themes or factors that influenced respondent's evaluations of the studied metrics. Through systematic coding analysis of the interview results, the researcher indentified several themes that carried through multiple metrics. Evaluation factors were found to fall into two major categories: Process Management and Valuation Characteristics. Process Management factors are the underlying themes identified by respondents that metrics impacts in their use. Valuation Characteristic factors are underlying themes identified by respondents that impact the value of a metric. Figure 4.30 shows the relationship of these to factors to performance measures.

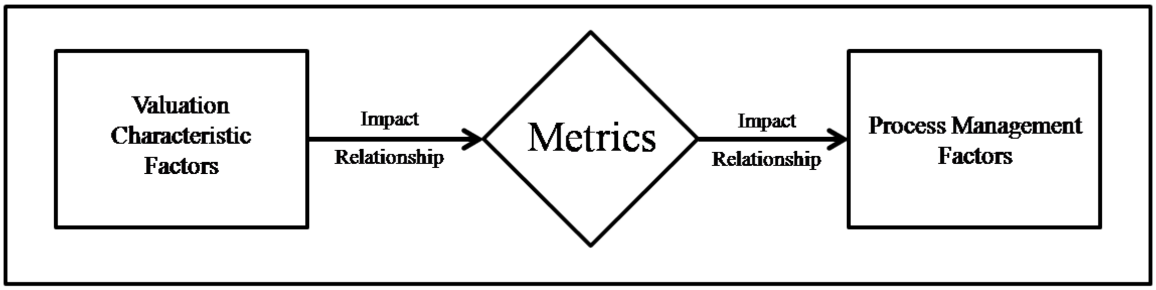


Figure 4.30 Evaluation Factor Relation Diagram

Each factor was evaluated on content and how they impacted or were impacted by metrics. Additionally, each factor was evaluated on its role in a metric achieving the three goals of metrics: drive behavior, create understanding, and lead to improvement. Each of these factor categories and sub-categories will be discuss in the following sections. Finally, a summary analysis of the overall distribution of the factors in relation to their influence on achieving the three metric goals is discussed. The coding factor outline can be found in Appendix C.

Process Management Factors

Process Management factors are the areas within the maintenance enterprise that metrics play a key role in managing and overseeing. These are the factors that respondents identified as areas that metrics directly impact, either positively or negatively. The distribution of each Process Management factor category within the selected metrics is shown in Table 4.4. The categories were sorted in order of most mentioned at 50 times to least, at 1 time. Each category is defined and evaluated for relevance to the 3 goals of metrics below.

Table 4.1, Process Management Factor Distribution

	Non-Mission Capable Maintenance rate	Repeat rate Recur rate	Non-Mission Capable Supply rate	Avg Age of ETAR	Utilization rate	MICAP Hours	Maint Scheduling Effectiveness rate	Fix rate	Non-Mission Capable rate	Logistiscs Departure Reliablility rate	Avg Delay Discrepency	Partially Mission Capable rate	Fully Mission Capable rate	Mission Capable rate	Total Non-Mission Capable Maint rate	Programmed Avg Sortie Duration rate	Actual Avg Sortie Duration rate	Total Non-Mission Capable Supply rate	Break rate	Flying Scheduling Effectiveness rate Chargeable Deviation rate	Flying Hour Execution rate	Possessed Aircraft rate	Cannibalization rate	Total Non-Mission Capable rate	Abort rate	Primary Aircraft Inventory rate	Total Count
Mission Execution Managegment		1	1	5	4		3		1	5		7	1	3		3	1		3	3	3	2			3	1	50
Maintenance Plan Execution Managemet	5	2	2	1			7	2			6			1		3			2								31
MDS Application		1			3		4	2			1		1	1		3				1	5		3		2		27
Manning Utilization Management	1	3		3	1	2	1	5			1	1				2		1			1	1	1			2	26
Support Asset Management			2	4		3						1					1	2					4				17
Budget Management																					2						2

Mission Execution Management

Mission Execution Management factors were cited 50 times by respondents. Mission Execution is the process category that was associated with metrics that have an impact on the scheduling, launch, and recovery of aircraft to meet flying taskings. The ultimate job of any Air Force unit is to launch aircraft. Maintainers must be able to measure and analyze the aircraft generation process.

The effects of metrics on this category are diverse. Metrics identified with this process provide oversight into meeting flying plans, as well as to be able to forecast any major hiccups that occur do to over or under flying the plan. For example, the use of UTE rate and Flying Hour Execution in the fighter unit is used determine whether to input surge or down days to adjust flying hours. It was also cited in metrics that allowed managers to determine how to allocate aircraft to mission profiles. Break rate, PMC rate and others were found to be able to identify limitations on aircraft that would not allow them to be assigned certain missions. The ability to look back at an executed plan to determine areas of improvement was mentioned by several respondents.

Metrics that were identified with the Mission Execution Management process appear to meet the three goals of performance measures. The metrics allows managers to understand the overall mission execution process, where they can make the appropriate decisions in order to meet strategic goals, and in turn make improvements within this process.

Maintenance Planning Management

Maintenance Planning Management was mentioned 31 times as a process impacted by metrics. Metrics that influenced this factor were identified as providing insight and control over how managers planned for scheduled and unscheduled maintenance. Indicators of how well managers executed response management of maintenance activities, as well provide key points to decision making.

Respondents cited Fix rate and Repeat/Recur rate as metrics that affected this theme. By being able to track these rates data, managers could effectively determine what resources they would need to work new maintenance issues. Being able to prioritize maintenance actions was also identified as a benefit of metrics like NMCS and CANN rates. These metric were stated to provide key information on the best way to accomplish tasks in order to minimize unnecessary maintenance. Being able to plan maintenance effectively and stay to the plans was found to have underlying impacts to most other management process, such as mission execution and manning utilization management.

As with Mission Execution, metrics that align with the Maintenance Planning process appear to meet the three goals of performance measures. The metrics give managers control and insight into this process, this aligns the decision behaviors with established strategic goals, and has allowed managers to practice continuous improvement within the process.

Mission Design Series Management

Mission Design Series (MDS) Management was mentioned 27 times as a process impacted by the evaluated metrics. MDS management is the process of executing maintenance plans by air frame type. Respondents categorized the impact of metrics by mission type, either Combat Air Forces (CAF) which include F-15, F-16, B-1 airframes or Mobility Air Forces (MAF) which operate C-17, C-5, or KC-135 aircraft. Additionally, analysis revealed this process was also categorized by system age, divided between newer and older aircraft. Table 4.2 provides a breakdown of importance as attributed to fighter units or airlift units. The metrics identified were ones that were specifically given split ratings by respondents as applied to Combat Air Forces and Mobility Air Forces.

Table 4.2 Metric MDS Importance

Combat Air Forces	Important	Flying Scheduling Effectivness Programmed Average Sortie Duration Actual Average Sortie Duration Utilization Rate Fully Mission Capable Flying Hour Execution Maintenance Scheduling Effectiveness	
	Not Important		Partially Mission Capable Logistics Departure Reliability
		Not Importanat →	Important
		Mobility Air Forces	

Metrics that were identified with the MDS management process were usually found with a split rating. These splits would occur either between MAF application and CAF application or Older Airframes and Newer Airframes. Metrics such as Fix rate, CANN rate, and Abort rate were given much high ratings for older systems such as the C-141 or the C-5 versus the C-17. For example, one respondent described the use of Abort rate: “In C-5s you live your life around [the question] is the aircraft an hour out from home station? If not it could still be coming back. Whereas, with the C-17, if it breaks ground it is gone". Additionally the nature of systems on aircraft also was cited to impact this process. Larger airframes were cited as having more redundant systems than small aircraft. This made them less susceptible to events tracked by Abort rate or Repeat/Recur rate. How taskings are accomplished was cited as factors for MDS management processes. Similar to Mission Execution, various mission profiles are programmed differently. The CAF environment has a more rigid fix process, where schedules are created weeks, even months in advance, making metrics like FSE and MSE more important. In the MAF world schedules are more fluid and don't coalesce until days and even hours before execution, therefore little attention is given to MSE or FSE.

The metrics identified with MDS Management are split on achieving the 3 goals of metrics. While across each MDS sub-category the metrics provide understanding, they are not utilized for driving behavior the same. In CAF forces, metrics drive the required behaviors in response to the processes, but in MAF they have less impact. While regardless of MDS, maintenance managers look for improvements, the metrics impacting this process are favored more in CAF than MAF environments.;

Manning Utilization Management

Manning Utilization Management was identified 26 times within the interviews. Manning Utilization management is the process by which maintenance supervisors effectively put their people to work. Metrics that impact Manning Utilization processes provides managers the information to effectively assign personnel in order to maximize their capabilities to fix aircraft.

Respondents cited this process as the biggest player in planning maintenance personnel task assignments. Metrics like Repeat/Recur rate, MICAP rate, MSE rate provide identifiers on where supervisors need to place people, whether by aircraft job or by work shift. For example, if aircraft mission windows shift from day operation to night, then manning needs to be adjusted to account for heavier recovery activity during the early morning as opposed to the midnight shift. It also allows managers to evaluate skill training and ensure maintainers have all necessary equipment to complete any assigned tasks. Metrics such as Fix rate and ETAR rate that impact the Manning Utilization process will provide insight into where to best apply limited training and equipment resources to get the most improvement.

Overall assessment finds that metrics impacting this category align with the three goals of metrics. These metrics give managers an understanding of how to best manage personnel under them. They can provide information on area than may need improvement, and will drive the decision process to achieve these improvements.

Support Management Process

Support Management was found to be a factor that also had split ratings. The study found 17 instances discussed within the data. Support Management is the process of managing the organizations and programs that directly support the maintenance enterprise, but are not necessarily controlled by the maintenance manager.

Under Support Management, the respondents identified that while they do not control these processes, the metrics associated with them allowed them to plan for and influence the process from a customer perspective. Respondents identified metrics like MICAP hours, NMCS rate and CANN rate as key measurements to monitor and hold accountable upstream supply organizations. For Example, managers must know how effective the parts supply process is in order to make good decisions on CANN priorities, in order to avoid unnecessary maintenance. This process theme was often cited in conjunction with the Valuation Characteristic Process Control Value, specifically the NMCS rate. While respondents had to track and report on this metric they had little to no control over the process.

Additionally, metrics that impact Support Management, like ETAR rate, were also cited as being able to provide oversight into how third party contractors are executing their designated contract responsibility. This is important for senior manager's decisions on contract negotiations and cancellations, as well determination of any fiscal bonuses or penalties. But like the NMCS rate, this decision process was cited as beyond the purview of the respondents, so were rated as less important.

Overall, metrics connected with the Support Process Management were found to meet the criteria for good metrics at a more strategic level. They allowed senior level decision makers and weapon system managers to closely monitor the affected processes, thus allowing them to make the appropriate decision behaviors that lead to improvement within the enterprise. However from the respondent's point of view, these metrics only provide understanding of processes, not control or ability to make improvements.

Budget Management Process

Budget Management was only identified 2 times in the interviews as a process factor. Budget Management is the process of managing a units flying hour program as it related to distributed operation and maintenance (O&M) funds. Essentially, for aircraft units that operate almost entirely on O&M money, flying hours equals to dollars. Emphasis on this process factor seems to be mostly identified with Combat Air Force units. Mobility Air Force units, while having O&M funds, primarily acquire and spend budget from other sources, such as real world mission taskings. Customers using MAF assets pay for them, which then is added to the unit's accounts to recoup mission costs.

One respondent stated best the impact metrics like FHE have on the Budget Management Process: "For the CAF guy tied to the O&M budget – flying hours = money". FHE was the only metric where this theme was identified. It is critical for aircraft managers in a CAF unit to effectively control the flying hour execution process to ensure they remain on target in order to meet all established goals on budget. Due to tight budgets, and rising maintenance costs, deviations either above the line or below may lead to failure to achieve mission targets. FHE was also cited as important to managers at higher headquarters levels, such as AMC or ACC, to determine how the enterprise is meeting the established flying hour goals. This in turn would determine how budget dollars are disseminated.

Metrics connected with the Budget Management factor were found to meet the criteria for good metrics at a both a strategic and tactical level. They allowed senior level decision makers and weapon system managers to closely monitor the affected processes, but also allow base level managers to effectively execute the their process that impacted this factor.

Valuation Characteristic Factors

Valuation Characteristic factors are the underlying themes identified by respondents that impact how a metric was perceived. These are the common characteristic found in this study that directly impacted, either positively or negatively the value placed on a metric. The distribution of each Valuation Characteristic factor by metric is shown in Table 4.5. As with the previous themes, the categories indentified were sorted in order of mention. Each category is discussed below.

Table 4.3, Valuation Characteristic Factor Distribution

Valuation Characteristics	Non-Mission Capable Maintenance rate	Repeat rate Recur rate	Non-Mission Capable Supply rate	Avg Age of ETAR	Utilization rate	MICAP Hours	Maint Scheduling Effectiveness rate	Fix rate	Non-Mission Capable rate	Logistiscs Departure Reliablility rate	Avg Delay Discrepency	Partially Mission Capable rate	Fully Mission Capable rate	Mission Capable rate	Total Non-Mission Capable Maint rate	Programmed Avg Sortie Duration rate	Actual Avg Sortie Duration rate	Total Non-Mission Capable Supply rate	Break rate	Flying Scheduling Effectiveness rate Chargeable Deviation rate	Flying Hour Execution rate	Possessed Aircraft rate	Cannibalization rate	Total Non-Mission Capable rate	Abort rate	Primary Aircraft Inventory rate	Total Count
Eshelon Value				1						2	1			2	1			1		1	3			1		2	15
Data Reporting Value								2	4		1			1	3					2						1	14
Poor Decision Value			1						2				2	6					1			1		1			14
Metric Distortion Value		1	1						1				1	4					1			1		1			11
Specificity Value										2	1			1				2	2	1					1		10
Poor Criteria Value							1				1		1	1	3							1	1				9
Redundancy Value		1				1						1	1		1			1						1	1		8
Clarity Value		1			1			1		1									1							1	6
Process Control Value						1				1								1	1				1			1	6
Understanding Value		2							1										1								4

Echelon Value Factor

Echelon value was identified 15 times by respondents. Echelon value was identified as the characteristic of a metric having value at different levels of the chain of command. This is where a metric can meet the 3 goals from both the strategic level through to the tactical level.

It was found to be a factor that was associated with split evaluations of the metrics. Some metrics were identified as effective across both tactical and strategic fields of influence, such a Average Delayed Discrepancy and Mission Capable rate. Others were cited as to being only important to the strategic level, such as Total Non Mission Capable rate and Flying Hour Execution rate. Logistics Departure reliability was cited as relating to this factor. One respondent stated “If I am General Merchant at AMC A4 because this all falls under my portfolio then this is important…but to me at the field level it is not. As I don’t have an aerial port and don’t control the fleet service trucks, I only care about maintenance delays”. Metrics, such as MC rate and ETAR, were also identified as playing a role as a managers score card. Senior level executives placed high emphasis on these metrics as indications of units performance.

Echelon value was found to have a mixed ability in affecting how metrics achieved the 3 goals. Metrics that displayed echelon value characteristics that spanned both strategic and tactical focus, led to driving the correct behaviors, provided understanding, and led to improvements. However there are other metrics that are only associated with the strategic side of this echelon pairing. Those metrics need to be closely evaluated to see how to better align them across all levels, whether they are tracked and reported only at the strategic level, or are changed to be better aligned across all levels.

Redundancy Value Factor

Redundancy Value was cited 8 times within the interviews. Redundancy Value is the factor that was associated with metrics that repeated the same information as other metrics. These metrics were found to have little value by respondents. Redundant metrics add no values as it takes time and resources to report on the same information given by another source. Many metrics were identified as being redundant by respondents. Abort rate, Partially Mission Capable, Fully Mission Capable, Total Non Mission Capable M/B/S were all identified a redundant metrics. These metrics all had data captured and reported in other measures. They all were evaluated low, and several specifically identified as needing to be removed due to the large numbers of metrics that respondents are already having to answer to.

While redundant measures provide the same capabilities as other metrics for meeting the 3 goals, they are not needed. If a metric already drives the correct behavior, creates understanding and leads to improvement, a second one that does the exact same thing should be considered waste.

Data Reporting Value Factor

Data Reporting Value factors were cited 14 times by respondents during the conducted interviews. These factors were cited as the characteristics of metrics that effectively capture the correct data required by maintenance managers.

Data Reporting factors were found to rate positively when they allowed metrics to trend historical data, had clear data goals that tied them to key processes, and in the case of the new proposed metrics eliminated data ambiguity and captured all the data in the process. However in addition to the positive factors, respondents also cited that some metrics, such as Mission Capable rate, do not provide the right information to make good decisions. While Mission Capable rate will tell how much of the aircraft fleet is fixed, it may not paint the whole picture of what is truly available. It does not align effectively with the strategic direction of provide airframe capability. Thus in this case, data reporting characteristics resulted in lower ratings by respondents.

As with echelon value discussed previously, whether a metric has the positive or negative aspect of the factor determines its effectiveness in helping metrics achieve the 3 goals. Based on what was identified from the interviews, more often than not Data Reporting Value factors will lead to achieving the 3 goals, but each metric with this characteristic will need to be evaluated closely.

Specificity Value Factor

Specificity Value was identified 9 times by respondents as characteristic within the metrics evaluated. Specificity Value is the ability of metrics to provide a specific and complete picture of the processes they report on. Specificity was cited for how metrics effectively told the story of a process.

Metrics associated with the Specificity Value factor, were found to have poor reflection of the true processes or capabilities of the enterprise. These metrics, such as Mission Capable rate, did not always convey the true story of a process. For example, an aircraft could be reported partially mission capable or even fully mission capable for an inoperative sub system by regulation. However, when given to an aircrew they would not take the plane, as they would need that sub-system for the mission assigned. This could be due to different rule for operation areas, such as home station verses in CENTCOM, or differences between what maintenance manager and operations manager consider mission required systems.

Metrics that had subjective or unclear input standards were also cited under specificity. Additionally metrics that captured data on a process that the manager could not effect were rated lower. Abort rate is a metric that was provided as an example. While an aircraft can abort for a maintenance issue, they also abort for crew issues such a pilot getting sick. Maintenance managers cannot control this issue, but still have to answer to the metric. Additionally, metrics that only reported on part of a process were associated with this factor. Logistics Departure Reliability reports only on missions taking off on time, however there are many process steps prior to take off that are not captured. This fails to provide managers the complete picture, and may lead to loss opportunities for improvement.

Specificity Value factor was found to inhibit metrics to achieve the three goals or metrics. While sometimes these metrics will drive behavior, by not showing managers the total picture, understanding and improvement cannot happen.

Poor Criteria Value

Poor Criteria was identified 9 times by respondents as a characteristic factor of metrics Metric criteria are the underlying requirements for what information is reported by metrics. They define how data is pulled for the processes monitored as well as how it is calculated. Poor Criteria also determine how well metrics align with the strategic intent for the maintenance enterprise.

Respondents identified metrics with this factor as having non-relevant data captured, such as with Average Delayed Discrepancies, where information on future scheduled maintenance activities are included in the count of open maintenance requests, thus skewing the data. Metrics were found to have equation components that appeared to have no relevancy to what was being measured. One example provided was the case of Cannibalization rate. The denominator for that equation is based on 100 sorties. Respondents asked what the numbers of sorties has to do with the number of CANNs. A better measure might be per number of parts ordered, or per number of maintenance actions. Additionally, differences in policy and regulations impede a metrics ability to tell the true story. Often conflicts between the Mission Essential System List used by maintenance and Mission Essential List used by operations to status aircraft have conflicting requirements. This then leads to false data on status of aircraft to be reported.

Poor Criteria was found to have no positive effect on metrics ability to achieve the 3 goals. Correct behavior cannot be developed if the metrics lead managers to focus on non-critical processes. Additionally, any improvements made based on bad criteria may not hold value, as it may not align with the strategic goals of the enterprise.

Poor Decision Value Factor

Poor Decision Value Factors were identified 7 times by respondents in their evaluation of the 28 metrics.   Poor Decision Value factors are the characteristics found in metrics that lead mangers into making the wrong decisions based on the metrics.

Metrics that lend themselves to “Chasing numbers” were identified as being associated with this factor. Chasing numbers was defined as when managers waste excessive manpower and resources to fix aircraft that aren’t need to meet any mission requirements, often Mission Capable rate is “chased”. Often managers will make decisions to chase a lagging indicator without any consideration to other factors, such as events beyond the control of any maintenance personnel that cannot be overcome until the situation resolves itself. Also, a few metrics were cited as being used for personnel performance reports, but not for any real process decisions. Again, these are examples of attempting to improve metrics for reasons other than improving the maintenance enterprise.

Poor Decision Value factors associated with metrics do not allow metric to meet the three goals. While these metrics may lead to improvement, it is often in the wrong area, thus wasting effort and resources. This metric factor leads to driving the wrong behavior, and potentially clouds understanding of what is really going on in the observed processes.

Clarity Value Factor

Clarity Value factors were cited 6 times by respondents in their evaluation of the selected metrics. Clarity Value factor are the characteristics of metrics that provide clear and unambiguous understanding. These factors were mostly found in evaluations of translation and understanding within the interviews.

Respondents were found to associate Clarity value with the positive aspects of metrics. Proposed metrics were found to provide clear concise definitions over previous metrics. Thus were rated high on the translation and understanding scale. Additionally, these factors were also cited in proposed metrics that were almost exactly equivalent to current metrics, such as with Break or Fix rate.

Clarity Value factors were found to allow metrics to achieve all three goals. Metrics with these factors were all rated high in their ability to direct the correct behaviors. They provide clear understanding and control of processes. Finally these metrics effectively lead to improvement within the maintenance management enterprise.

Understanding Value Factor

Understanding factors are those characteristics that affect a metric's ability to be clearly understood as well as how it can be used to improve processes. Understanding factors were cited 4 times by respondents during the interviews.

These factors were not only cited directly by respondents, but were also found to be a characteristic with many new proposed metrics. Lack of understanding was stated to be responsible for metrics being used ineffectively, such as when personnel don't know the rules for identifying landing codes in order to populate Break Rate correctly. Also many lower ratings for translation and understanding were attributed to manager's lack of understanding the civilian metric terminology found in the SCOR and Oracle metrics.

Understanding factors were found to not allow the metrics they were associated with to meet the three goals. By failing to provide clear understanding, managers could not use metrics to make to correct process decisions, thus failing to create improvement within their maintenance processes.

Metric Distortion Value Factor

Metric Distortion Value is the characteristic of a metric determining how easily it can be intentionally or unintentionally manipulated. It was cited 4 times by respondents in discussions about the 28 evaluated metrics.

Metrics associated with this factor were all identified as having subjective or unclear data input standards. The lack of clear, defined, concrete data entry rules can lead maintenance personnel to enter metric data wrong. One example given was input parameters for Break Rate. Break Rate tracks landing status Code/Alpha -3 maintenance issues. However not every identified maintenance issue is caught during debrief. One respondent asked “If problem is found 1 hour after landing, is it still a Code/Alpha – 3 break?”. This is the essential problem with metrics that are affected by Distortion Value factors.

Metrics that are associated with Metric Distortion factors may seem to achieve the 3 goals at first look. However if the data captured and reported is bad, does the metric really direct the correct behavior, provide understanding or lead to improvement? Based on what was identified by respondents, it does not seem to meet these goals.

Process Control Value Factor

Process Control Value factors were cited by respondents 8 times. Process control is the characteristic of metrics that indicates how much or how little control is given by the metric. It also was cited in response to what portion of a process the metrics measured and oversaw.

Metrics associated with this factor were found to only capture one or two steps in a process, leaving others unseen by managers. Logistics Departure Reliability (LDR) is one of these metrics. Aircraft launches use schedule of events (SOE) to drive this process. Each SOE can have over 8 separate process managers involved. The current metric, LDR, will only track the last step in that chain, the actual launch time. Thus managers may never have true insight into any problems that may have been overcome by extraordinary means in order to launch the aircraft on time, because the metrics mask the process.

Also respondents cited that certain metrics have no value to lower echelons as they are controlled by more senior managers or by other agencies, such as with Primary Aircraft Inventory rate or MICAP rate. They may give insight into those process but since they provide no control to maintenance managers they hold little value.

Process Control factors were found to be split in their ability to help metrics achieve the three goals. While they do provide control, understanding and lead to improvement, they often do this for agencies other than the maintenance manager that has to report on these metrics. These metrics may need to be tracked and monitored, but more likely not within in the tactical maintenance management level.

Metric Evaluation Factor Summary

While not an all encompassing list of themes, the previous categories discussed give insight into how to evaluate metrics in terms of the three goals of metrics: To drive behavior, to create understanding and to lead to improvement. These themes identified can be used to take an in-depth look at metrics that are being considered for inclusion into management systems, like ECSS. Being able to evaluate a metric's association with these themes, it may assist in determining its suitability for inclusion into a management program. Table 4.4 provides a summary distribution by category and goal impact.

Table 4.4 Summary of Theme Distribution by Goal Impact

Evaluation Factors	Process Management	Maintenance Plan Execution Mission Execution Manning Utilization Budget Management		MDS Management Support Management
Evaluation Factors	Valuation Characteristics	Clartiy Value	Eschelon Value Redundancy Value Data Reporting Value Process Control Value	Specificity Value Poor Criteria Value Poor Decision Value Metric Distortion Value Understanding Value
		Yes	Partially	No
		ability to meet 3 goals of metrics		

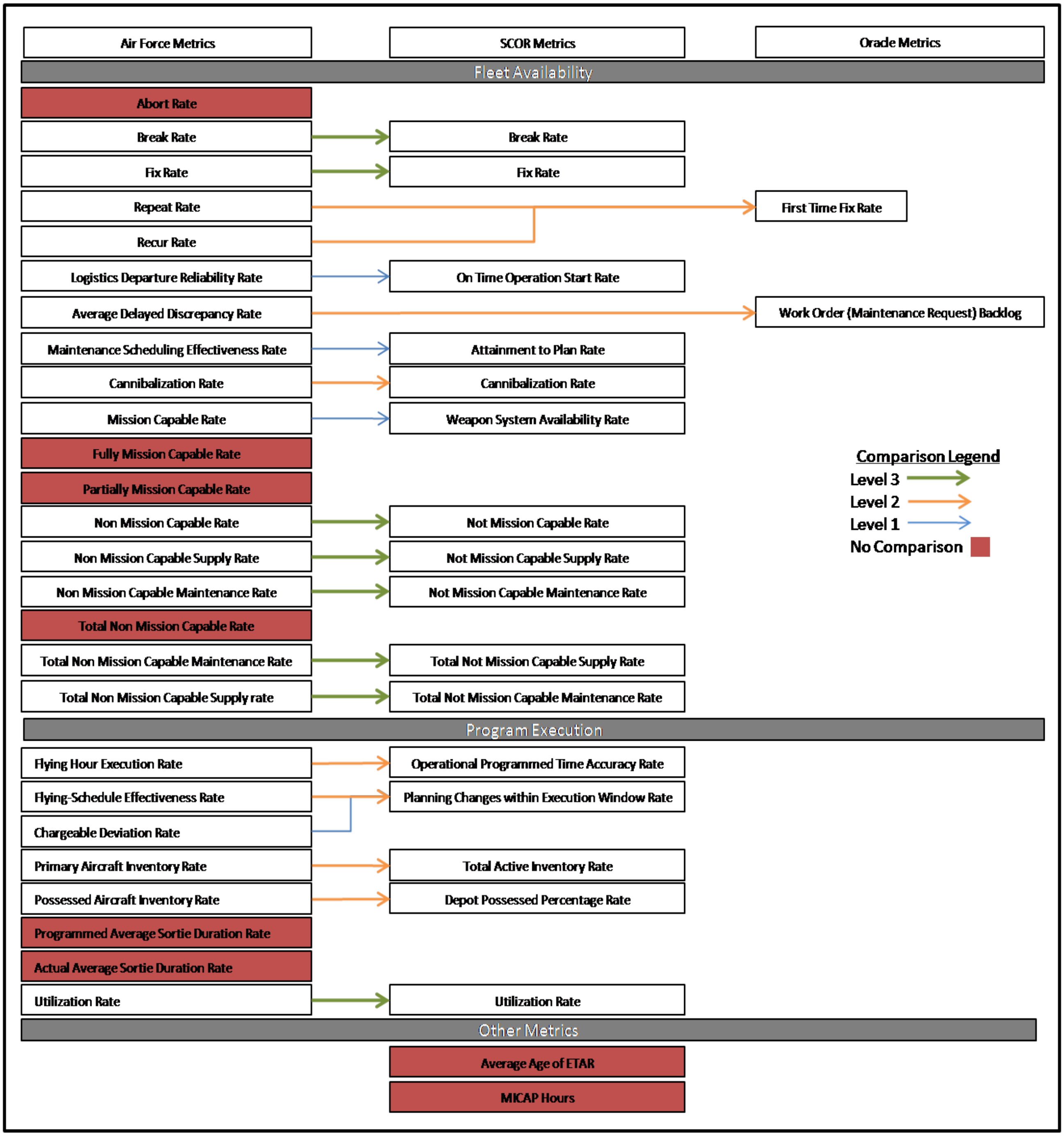
If metrics are associated with a category on the left side of the table that achieves the three goals then it may be considered for inclusion with little modification. Metrics associated with the middle category of Partial ability, should be evaluated to how these factors impact metrics. If the impact is positive then the metrics can be considered for inclusion, but if negative then serious re-evaluation may be needed. If the metric associates with the right side of the table then serious evaluation of the metric should be accomplished in order to better align it with the three goals of metrics before inclusion into a management system.

Cross Metric Analysis of Translation and Understanding

After completing the comparison framework with the 28 metrics, the study found eight Level 3 metric comparisons from current metrics to the SCOR list. Eight Level 2 comparisons were established between current maintenance metrics and the SCOR list. Four current maintenance metrics were found as Level One comparisons with the SCOR list metrics. Nine metrics did not have any counterpart metrics in the SCOR metrics list.

In terms of SCOR list metric compared to the key performance measures outlined by the Oracle software manuals, none of the 18 SCOR metrics translated to Oracle. The study found that 2 metrics actually matched from current Air Force metrics directly to the Oracle software, but these metrics had no counterpart in the SCOR metric list. The remaining 6 of the air force metrics were found to have no viable comparison metrics. The results of this analysis are summarized in Table 4.4, showing each connection across the three models.

Table 4.5. Summary Comparison Framework



Each metric set was evaluated by maintenance management experts using a 5 point Likert rating scale. Each interview rating was tabulated and summed up across all twelve interviews to produce a total composite score for Translation and Understanding of the proposed metrics as shown in Table 4.5.

Table 4.6. Translation/Understanding Evaluation Results

		Interviews 1		2		3		4		5		6		7		8		9		10		11		12				
		T	U	T	U	T	U	T	U	T	U	T	U	T	U	T	U	T	U	T	U	T	U	T	U	T	U	Total
Clear	Non-Mission Capable Rate Supply to Not Mission Capable Supply	5	5	5	5	5	5	4	4	4	5	5	5	5	5	5	5	4	4	5	5	5	5	3	5	55	58	113
Clear	Fix rate to Fix rate	5	5	5	5	4	4	4	4	4	5	5	5	5	5	5	5	4	5	5	5	5	5	2	5	53	58	111
Clear	Non-Mission Capable Rate Maint to Not Mission Capable Maint	5	5	4	5	5	5	4	4	5	5	5	4	5	5	5	5	5	5	5	5	5	5	2	2	55	55	110
Clear	Break rate to Break rate	5	5	5	5	3	5	4	4	4	5	4	5	5	5	5	5	4	4	5	5	4	4	1	5	49	57	106
Clear	Non-Mission Capable Rate to Not Mission Capable Both	4	4	4	5	4	4	4	4	5	5	5	5	5	5	4	3	5	5	5	5	4	5	3	3	52	53	105
Clear	Total Non-Mission Capable Maint Rate to Total Not Mission Capable Maint	4	4	5	5	4	4	4	4	4	4	5	5	4	5	4	4	5	5	4	5	4	5	4	4	51	54	105
Clear	Total Non-Mission Capable Supply Rate to Total Not Mission Capable Supply	4	4	5	5	3	4	4	4	4	4	5	5	3	5	5	5	5	5	5	5	3	5	4	4	50	55	105
Clear	Maint Scheduling Effectiveness to Attainment to Plan	3	2	5	5	4	4	5	5	5	5	5	5	5	5	4	2	5	5	5	5	3	3	1	5	50	51	101
Clear	Utilization Rate to Utilization Rate	4	1	5	5	4	4	4	4	5	5	5	4	4	5	5	4	5	4	4	5	3	2	4	5	52	48	100
Moderate	Possessed Aircraft Rate to Depot Possesed Percentage	4	4	4	4	3	4	4	4	4	5	3	5	4	5	5	5	1	5	5	5	3	2	4	5	44	53	97
Moderate	Mission Capable to Weapon System Availability	4	3	4	2	4	4	3	4	5	5	5	4	5	5	4	5	3	5	5	5	3	3	2	4	47	49	96
Moderate	Repeat/Recur rate to First time Fix rate	4	3	5	5	2	4	3	2	4	5	5	5	4	4	4	3	3	2	5	5	4	4	2	5	45	47	92
Moderate	Primary Aircraft Inventory to Total Active Inventory	4	4	5	5	2	2	4	4	4	3	5	4	4	5	2	4	4	2	5	3	5	2	3	5	47	43	90
Moderate	Logistiscs Departure Reliablility Rate to On-time Operations Starts*	4	4	4	3	4	4	4	4	4	5	2	3	4	5	3	5	4	5	3	1	2	3	3	5	41	47	88
Moderate	Cannibalization Rate to Canibalization Rate	3	3	5	5	4	4	5	4	2	2	5	4	4	5	4	4	4	2	1	5	2	2	2	5	41	45	86
Moderate	Flying Scheduling Effectiveness/Chargeable Deviation rate to Plan Changes within Execution Window	5	5	5	5	4	4	5	5	5	5	3	2	2	2	3	5	1	2	1	2	3	2	2	5	39	44	83
Moderate	Flying Hour Execution Rate to Operational Programmed Time Accuracy	3	2	5	4	4	4	3	3	4	3	3	3	2	2	5	4	3	2	5	5	5	3	3	3	45	38	83
Moderate	Avg Delay Discrepency to Maintenance Request Backlog	2	4	2	5	4	4	4	4	5	5	2	2	4	4	2	3	4	2	2	3	3	2	5	5	39	43	82
	Avg Age of ETAR																									0	0	0
	MICAP Hours																									0	0	0
	Partially Mission Capable Rate																									0	0	0
	Fully Mission Capable Rate																									0	0	0
	Programmed Avg Sortie Duration																									0	0	0
	Actual Avg Sortie Duration																									0	0	0
	Total Non-Mission Capable Rate																									0	0	0
	Abort rate																									0	0	0

Legend		
10 to 8 (dark)	7 to 5 (grey)	4 to 2 (white)
T - Investigative Question 3	U - Investigative Question 4	

Scores had a possible range of 2 points to 10 points for individual ratings, and a range of 24 points to 120 points possible for the aggregated total across all interviews. In the Translation/Understanding categories, metric total score values ranged from 82 points on the bottom to a maximum of 113 points. The lowest scored metric Average Delayed Discrepancies on the composite table was still relatively high in value in terms of the absolute scoring range, indicating that all evaluated metrics were found to be adequately translated and were understandable.   This shows that the developed method of translating metrics based on key attribute pattern matching was valid and produced satisfactory results. Eight metric sets did not have any Translation/Understanding scores because they either did not have translations into the new system or were new metrics proposed to the SME.

The compiled metrics table was then cross referenced to the comparison framework in Table 4.1 to determine if level of comparison had any relation to rating score. The study found that Level 3 translations scored highest within the table, while Level 2 and Level 1 translation sets comprised the lower half of the table. While some of the Level 1 metrics did score higher than most Level 2, this was attributed to the clear and precise definitions provided in the SCOR definitions. The metrics that were scored the lowest were the metrics that had appeared to have the biggest difference in terminology between Air Force and SCOR model metrics.

Cross Metric Analysis for Importance and Effectiveness

In order to determine which of the Air Force aircraft maintenance metrics evaluated should be transitioned into ECSS, each metric was evaluated by subject matter experts on the question of importance and effectiveness of the metric. Each metric analysis was evaluated against the Metrics Effectiveness Checklist found in Chapter 2 (Table 2.3) based on the interview data provided in addition to the Likert scale rating. Each interview rating was tabulated and summed up across all twelve interviews to produce a total composite score for Translation and Understanding of the proposed metrics as shown in Table 4.6.

Scores had a possible range of 2 points to 10 points for individual ratings, and a range of 24 points to 120 points possible for the aggregate score. In the Importance/Effectiveness categories metric total score values ranged from 60 points on the low end to a maximum of 120 points.

Table 4.7. Importance/Effectiveness Evaluation Results

		Interview																										
		1		2		3		4		5		6		7		8		9		10		11		12				
		I	E	I	E	I	E	I	E	I	E	I	E	I	E	I	E	I	E	I	E	I	E	I	E	I	E	Total Score
High	Non-Mission Capable Rate Maint to Not Mission Capable Maint	5	5	5	4	4	4	3	3	5	5	5	5	5	5	4	3	5	5	5	5	2	2	4	4	52	50	102
	Repeat/Recur rate to First time Fix rate	4	4	4	2	4	4	3	3	4	4	5	5	5	5	5	4	4	2	5	5	4	4	5	5	52	47	99
	Non-Mission Capable Rate Supply to Not Mission Capable Supply	5	5	4	4	4	4	3	3	4	3	5	5	5	4	4	4	4	4	5	5	2	2	5	5	50	48	98
	Avg Age of ETAR	3	4	5	5	4	3	4	4	4	4	5	5	5	4	3	3	5	5	5	5	3	3	2	2	48	47	95
	Utilization Rate to Utilization Rate	4	4	5	1	4	4	5	5	5	3	5	5	5	5	5	5	4	2	1	1	4	2	5	5	52	42	94
	MICAP Hours	4	3	4	5	3	3	5	5	5	4	5	5	3	3	4	4	4	5	5	5	3	3	1	2	46	47	93
	Maint Scheduling Effectiveness to Attainment to Plan	4	3	4	4	3	2	4	4	5	4	5	5	3	5	4	3	2	2	5	5	3	3	5	5	47	45	92
	Fix rate to Fix rate	4	4	5	5	3	3	4	4	5	4	5	4	5	5	4	3	1	1	5	5	4	4	2	2	47	44	91
	Non-Mission Capable Rate to Not Mission Capable Both	4	5	4	4	4	4	3	3	5	3	4	4	5	5	3	2	5	5	4	4	2	2	3	3	46	44	90
	Logistiscs Departure Reliablility Rate to On-time Operations Starts*	4	4	5	3	4	4	4	4	4	4	5	5	5	5	4	3	2	2	3	4	2	2	4	4	46	44	90
Moderate	Avg Delay Discrepency to Maintenance Request Backlog	3	4	1	1	4	4	3	3	5	5	4	3	3	4	4	4	5	4	4	5	3	3	4	4	43	44	87
	Partially Mission Capable Rate	4	4	4	5	3	3	4	4	4	4	4	4	3	3	2	2	5	5	5	5	2	1	2	3	42	43	85
	Fully Mission Capable Rate	3	2	3	3	4	4	3	3	5	5	4	4	4	3	2	2	5	5	5	5	2	2	2	2	42	40	82
	Mission Capable to Weapon System Availability	5	4	5	3	4	3	4	3	5	3	5	4	5	5	2	3	3	1	4	2	2	2	2	2	46	35	81
	Total Non-Mission Capable Maint Rate to Total Not Mission Capable Maint Rate	4	4	4	4	3	3	3	3	3	3	5	3	3	3	3	3	5	4	3	3	2	2	4	4	42	39	81
Low	Programmed Avg Sortie Duration	4	4	5	5	2	2	4	4	5	5	5	5	4	3	4	3	1	1	5	5	1	1	1	1	41	39	80
	Actual Avg Sortie Duration	4	4	5	3	2	2	4	4	5	5	5	5	5	4	4	2	1	1	5	5	1	1	1	1	42	37	79
	Total Non-Mission Capable Supply Rate to Total Not Mission Capable Supply Rate	4	4	3	3	3	3	3	3	3	3	4	4	3	3	3	4	3	3	4	4	2	2	4	4	39	40	79
	Break rate to Break rate	4	4	1	1	3	4	4	4	5	4	4	2	5	4	3	3	4	1	5	2	4	4	1	1	43	34	77
	Flying Scheduling Effectiveness/Chargeable Deviation rate to Plan Changes within Execution Window	4	4	4	4	3	3	3	3	4	3	5	3	5	5	4	2	4	1	3	3	1	1	2	2	42	34	76
	Flying Hour Execution Rate to Operational Programmed Time Accuracy	4	4	3	3	2	2	5	5	5	4	5	5	3	3	2	2	1	1	5	5	1	1	2	2	38	37	75
	Possessed Aircraft Rate to Depot Possesed Percentage	4	4	4	4	4	4	3	3	4	3	5	2	3	3	4	4	4	4	3	2	1	1	1	1	40	35	75
	Cannibalization Rate to Canibalization Rate	4	4	4	5	3	3	4	4	3	4	5	4	1	3	4	3	2	2	1	1	2	3	2	1	35	37	72
	Total Non-Mission Capable Rate	1	3	4	4	3	3	3	3	2	2	3	3	3	3	2	2	3	2	2	3	2	2	3	3	31	33	64
	Abort rate	3	1	4	1	3	3	3	3	5	5	2	3	3	3	4	3	1	1	1	3	1	1	2	2	32	29	61
	Primary Aircraft Inventory to Total Active Inventory	4	3	4	4	3	3	3	3	2	2	5	5	2	1	1	1	2	2	5	1	1	1	1	1	33	27	60

Legend		
10 to 8 (dark)	7 to 5 (grey)	4 to 2 (white)
I - Investigative Question 1	E - Investigative Question 2	

The table appears to have two distinct separation points among the metrics. These points divide the metrics into three groups with the high group falling between 102 to 90 points, the moderate group between 87 to 80 points and the low group composite scores between 79 to 60. The table also shows that most of the metrics had composite scores that gravitated towards the higher end of the point scale. This indicates that while the metrics are clearly ordered in importance and effectiveness within the table, the SME's hold most of the metrics as important and effective in terms of the absolute scale of the evaluations.

Each metric summary was then applied to the adapted Metrics Effectiveness Checklist (Table 2.3). Each metric evaluation was subjected to the series of 15 yes/no questions based on the information provided by the field interview analysis. The results are displayed in Table 4.7.

Table 4.8 Metrics Effectiveness checklist evaluation results.

Checklist results			
	YES	NO	Ratio
Avg Age of ETAR	14	1	14
MICAP Hours	13	2	6.5
Partially Mission Capable Rate	13	2	6.5
Non-Mission Capable Rate Supply to Not Mission Capable Supply	12	3	4
Maint Scheduling Effectiveness to Attainment to Plan	12	3	4
Fix rate to Fix rate	11	3	3.67
Non-Mission Capable Rate Maint to Not Mission Capable Maint	11	4	2.75
Repeat/Recur rate to First time Fix rate	11	4	2.75
Avg Delay Discrepency to Maintenance Request Backlog	11	4	2.75
Mission Capable to Weapon System Availability	11	4	2.75
Flying Scheduling Effectiveness/Chargeable Deviation rate to Plan Changes within Execution Window	11	4	2.75
Non-Mission Capable Rate to Not Mission Capable Both	10	5	2
Programmed Avg Sortie Duration	10	5	2
Break rate to Break rate	10	5	2
Actual Avg Sortie Duration	9	6	1.5
Utilization Rate to Utilization Rate	9	6	1.5
Logistiscs Departure Reliablility Rate to On-time Operations Starts*	9	6	1.5
Flying Hour Execution Rate to Operational Programmed Time Accuracy	8	6	1.33
Possessed Aircraft Rate to Depot Possesed Percentage	8	7	1.14
Primary Aircraft Inventory to Total Active Inventory	8	7	1.14
Fully Mission Capable Rate	7	8	0.88
Total Non-Mission Capable Supply Rate to Total Not Mission Capable Supply Rate	7	8	0.88
Cannibalization Rate to Canibalization Rate	7	8	0.88
Total Non-Mission Capable Maint Rate to Total Not Mission Capable Maint Rate	5	10	0.5
Total Non-Mission Capable Rate	5	10	0.5
Abort rate	4	10	0.4

This study determined that, based on the ratio of yes to no responses, 11 metrics had a ratio greater than 2. When compared with Table 4.6, 7 had high evaluation scores, 3 had moderate evaluation scores, and 1 metric had a low evaluation score. Nine Metrics had ratios between 1 and 2. When compared with Table 4.6, 3 had high evaluation scores and 6 had low evaluation scores. Six Metrics were found to have ratios less than 1. When compared with Table 4.6, 2 had moderate evaluation scores and 4 were had low evaluation scores.

The study found that the metric did trend together on both the numerical evaluations and the checklist evaluations. Discrepancies were noted however, but are believed to relate to the response rates of the evaluation questions. All respondents provided numerical ratings of every metric, but not all provided supporting discussion as to the supporting factors of the ratings. Therefore those supporting comments could not be factored into the checklist evaluation. However, based on what was extracted from both the numerical and qualitative evaluations given, the metrics checklist in conjunction with expert evaluation can be utilized as an effective tool for evaluating the metrics importance and effectiveness.

Summary

This chapter presented the analysis results of the translation and empirical study of the 28 selected aircraft maintenance metrics. The development of the translation framework and results of the structured interviews were presented. Analysis of the metric characteristics was discussed. Finally, cross case analysis of the metric evaluations was performed in order to determine the effectiveness of the comparison framework and to provide recommendations for metric disposition.

V. Conclusions

Overview

This final chapter will summarize and present the conclusions of this study. It will present the final results and recommendations of the two research questions. In addition discussion of the assumptions and limitations will be presented along with the significance of the research and recommendations for future studies.

As organizations evolve and grow new and better ways must be developed to meet future challenges. One of these ways is the implementation of an Enterprise Resources Planning (ERP) program. For the US Air Force, The Expeditionary Combat Support System will be one cornerstone of Logistics Transformation. The establishment of this program will allow future logisticians to fully understand and efficiently manage any and all logistics processes.

An ERP implementation endeavor consists of a large number of critical areas that have to be addressed. Management Support, Business Process Reengineering, Strategy and Governance modeling, and Legacy Systems Evaluation and Conversion are just a few of the key areas that need to be managed successfully for effective ERP implementation. This study has focused on one area, Legacy Systems Evaluation and Conversion, specifically the integration of the Air Force Aircraft Maintenance Metrics program into ECSS.

Research Conclusions

The purpose of this study was to develop a method to translate current Air Force Metrics into the ECSS program. In order to do this a comparison framework was developed and validated through structured field interview evaluations of maintenance management professionals.

Research Question One

> *How well do current metrics program measures translate into the Expeditionary Combat Support System Enterprise Resource Planning framework?*

This question was answered in two parts. First a theoretical framework was developed based on the key metric attributes: Nomenclature, Definition and Equation. Once the selected units of analysis were fit within the framework, the metric translation sets were presented to subject matter experts in the field of aircraft maintenance management in order to determine the validity and success of the translations.

The study has concluded that using pattern matching analysis of three key attributes, Nomenclature, Definition and Equations, current Air Force metrics can be translated to the metrics identified by the Logistics Transformation Office (LTO) in the Supply Chain Organization Reference (SCOR) Model and then to the Oracle ERP software Suite. However the study found that while 17 of the 26 current metrics translated into the SCOR model, they did not have any translations into Oracle. In order to convert these metrics the LTO will have to build them into the software package. 3 metrics did translate into

Oracle and can be incorporated directly into ECSS. Ultimately, 23 metrics will have to be built into the Oracle software platform.

Research Question Two

> *Which maintenance metrics should be translated into the new enterprise resource planning framework?*

Metrics, as discussed in Chapter 2, ultimately need to serve three purposes. Metrics must:

1. Correctly drive decision behavior and provide control
2. Communicate the process clearly and create understanding
3. Be able to lead to improvement within the process

Each of the 28 metrics was evaluated for importance and effectiveness in order to determine their suitability for translation into ECSS. Ten metrics were found to be suitable for incorporation into ECSS. These metrics were able to have at least 11 yes answers on the Metrics Effectiveness Checklist, resulting in yes/no ratios of at least 2.75.

Ten Metrics need to be re-evaluated by senior maintenance mangers in order to better align them with the strategic intent of the maintenance metrics program. While these metrics did have more yes answers than no, they will require further analysis in order to determine how to improve their effectiveness for maintenance management.

Finally six metrics were recommended for removal from consideration. These metrics all had yes/no ratios of less than one. As indicated by the analysis these metrics are either redundant or have little value to maintenance managers. Table 5.1 shows the results break down for each metric.

Table 5.1 Metric Recommendations

Avg Age of ETAR	Incorporate
MICAP Hours	Incorporate
Partially Mission Capable Rate	Incorporate
Non-Mission Capable Rate Supply to Not Mission Capable Supply	Incorporate
Maint Scheduling Effectiveness to Attainment to Plan	Incorporate
Fix rate to Fix rate	Incorporate
Non-Mission Capable Rate Maint to Not Mission Capable Maint	Incorporate
Repeat/Recur rate to First time Fix rate	Incorporate
Avg Delay Discrepency to Maintenance Request Backlog	Incorporate
Mission Capable to Weapon System Availability	Incorporate
Flying Scheduling Effectiveness/Chargeable Deviation rate to Plan Changes within Execution Window	Re-evaluate
Non-Mission Capable Rate to Not Mission Capable Both	Re-evaluate
Programmed Avg Sortie Duration	Re-evaluate
Break rate to Break rate	Re-evaluate
Actual Avg Sortie Duration	Re-evaluate
Utilization Rate to Utilization Rate	Re-evaluate
Logistiscs Departure Reliablility Rate to On-time Operations Starts*	Re-evaluate
Flying Hour Execution Rate to Operational Programmed Time Accuracy	Re-evaluate
Possessed Aircraft Rate to Depot Possesed Percentage	Re-evaluate
Primary Aircraft Inventory to Total Active Inventory	Re-evaluate
Fully Mission Capable Rate	Remove
Total Non-Mission Capable Supply Rate to Total Not Mission Capable Supply Rate	Remove
Cannibalization Rate to Canibalization Rate	Remove
Total Non-Mission Capable Maint Rate to Total Not Mission Capable Maint Rate	Remove
Total Non-Mission Capable Rate	Remove
Abort rate	Remove

Assumptions/Limitations

Several assumptions were made in the scope of this research. 1) The established Air Force metrics program will be used to baseline the transition into ECSS. 2) The data collected is to be considered accurate and valid and the interviewed experts have depth and breadth of experience in aircraft maintenance management. 3) The Oracle software evaluated will be the program implemented by the ECSS transition team.

Additionally several limitations of this study were identified. 1) This is an exploratory study, so only 12 subjects were interviewed, therefore results may not be attributable across the entire maintenance community. 2) The potential for bias on behalf of the researcher may be a factor as experience with the subject matter may impact the analysis. 3) It was also to be understood that not all information pertaining to this study may have been revealed during the course of this research.

Additional Findings

This study found in addition to the answers to the original research questions, several other findings were identified that did not fit within the scope of this research.   During the interview evaluations of the Air Force Maintenance metrics, over half of the respondents described a need for better personnel management metrics. The air force currently has one metric that tracks authorized manning verses assigned.   Maintenance managers described a need for metrics that will track and project actual manning capability.

While units may have 85 to 95 percent of authorized personnel, the true availability of those maintainers is not known or tracked. Personnel are often out of pocket for leadership schools, duties unrelated to aircraft maintenance, or just out sick. Due to these factors, maintenance managers often cite this lack of people as constraints in accomplishing tasks, but cannot truly quantify this pain. By creating such a metric a better understanding of true enterprise capability may me realized, thus providing an accurate picture of inherent aircraft capability.

Significance of Research

The United Stated Air Force has invested hundreds of personnel hours, and millions of dollars in developing new logistics management systems. As discussed earlier, past logistics operation policies are no longer sufficient to meet the needs of the war-fighter. Shrinking budgets, aging equipment, and the austere, disparate operating location demand sweeping changes in how the logistic machine operates. The Expeditionary Combat Support System (ECSS) is the Air Force wide Enterprise Resource Planning (ERP) system designed to tackle these very challenges**.**

In order to effectively create and field this system, current management programs and processes must be evaluated and reengineered if necessary. In meeting this directive, this study has endeavored to develop a framework for the successful translation of current Air Force maintenance metrics into the ECSS system. Successful execution of this study will provide recommendations to the Logistics Transformation Office for disposition of the selected metrics. By effectively transitioning from the old metric program to the new, one section of the ECSS program will have been accomplished. Additionally, it is hoped this study will provide the tools that can be used for evaluating other Logistics metrics that are expected to be translated into the ECSS program.

Recommendations for Future Research

The study has developed an effective framework for evaluating the translation of current Air Force maintenance metrics into ECSS. However this is not the complete list of metrics in use by the logistics community. Future studies should be undertaken to address these other Air Force metrics. This will allow further validation of the framework and will provide the Logistics Transformation Office a complete evaluation of Air Force metrics.

Another recommendation for further studies is to expand this case study into a statistical survey by a larger population of maintenance experts. As this was an exploratory study, the researchers selected a small pool of interview subjects. Further revelations may be developed by expanding the expert pool to include maintenance managers from other organizations, such as fighter or special operations units was well as evaluations from managers at higher-level headquarters.

The results of this study have found a number of metrics that need re-evaluation if no re-engineering. Further exploration should be undertaken in order to determine how to best change these metrics to align better with the strategic goals of the Air Force and well as the goals for effective metrics.

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Appendix A Interview Guide

In this interview you will be asked to evaluate the translation from the current metrics as outlined in Air Force Instruction 21-101 Aircraft and Equipment Maintenance Management to the new metrics incorporated into the Oracle Business Initiative Software as part of the Expeditionary Combat Support System program.

Each traditional logistics measure is provided with its new translated metric, please evaluate based on the provide criteria and your experience with maintenance metrics.

28 aircraft maintenance metrics are outlined on the following pages

The current metric, proposed metric, and definitions of each are shown at the top of each page

There are 4 evaluative questions to answer about each metric

During the interview we will rate the metrics on the provided 5 point scale and discuss the selected answers.

In additions to the metric evaluations there will be additional supporting questions about this study.

Thank you for your time and support in completing this study.

Metric 1

Current → **Proposed**

Missions Capable Rate

Percentage of hours aircraft are mission capable, has derivatives of Partial, Non, Total Non, as well as sub categories of Due to Maintenance or Due to Supply

(FMC Hours + PMC Hours)/Possessed hours) x 100

Weapon System Availability

Percentage of hours a reported unit possessed weapon system was capable of performing any assigned mission

(MC hours/Total Active Inventory hours) x 100

Question	1	2	3	4	5
How important is the current metric for managing aircraft maintenance?	1 Not Important	2	3 Somewhat	4	5 Very Important
Is the current metric effective in managing aircraft maintenance?	1 Not Effective	2	3 Somewhat	4	5 Very Effective
Does the proposed metric adequately replace the current metric?	1 Poorly	2	3 Somewhat	4	5 Strongly
Is this new metric easily understood?	1 Poorly	2	3 Somewhat	4	5 Clearly

Metric 2

Current → **Proposed**

Break Rate

Percentage of aircraft that land in Code-3 or Alpha-3 (NMC) status

(Number of Sorties that land Code-3/Total Sorties Flown) x 100

Break Rate

The break rate is the percentage of sorties that land in a Code 3 status. Several indicators that follow break rate are MC, TNMCS, CANN, and R/R.

(Number of Sorties that land Code-3/Total Sorties Flown) x 100

Question	1	2	3	4	5
How important is the current metric for managing aircraft maintenance?	1 Not Important	2	3 Somewhat	4	5 Very Important
Is the current metric effective in managing aircraft maintenance?	1 Not Effective	2	3 Somewhat	4	5 Very Effective
Does the proposed metric adequately replace the current metric?	1 Poorly	2	3 Somewhat	4	5 Strongly
Is this new metric easily understood?	1 Poorly	2	3 Somewhat	4	5 Clearly

Metric 3

Current	Proposed
Fix Rate	**Fix Rate**
Percentage of aircraft that landed Alpha-3 and returned to flyable (FMC/PMC) status within set time window, either 4, 8, or 12 hours (Code-3 Breaks fixed within window/Total Alpha-3 Breaks) x 100	It is a percentage of aircraft with a landing status code of 3 (includes system cap codes 3 and 4) returned to a flyable status in a certain amount of time (clock hours) (Code-3 Breaks Fixed Within 4, 8 or 12 Hours of Landing/ Total Code-3 Breaks) x 100

Question	1	2	3	4	5
How important is the current metric for managing aircraft maintenance?	1 Not Important	2	3 Somewhat	4	5 Very Important
Is the current metric effective in managing aircraft maintenance?	1 Not Effective	2	3 Somewhat	4	5 Very Effective
Does the proposed metric adequately replace the current metric?	1 Poorly	2	3 Somewhat	4	5 Strongly
Is this new metric easily understood?	1 Poorly	2	3 Somewhat	4	5 Clearly

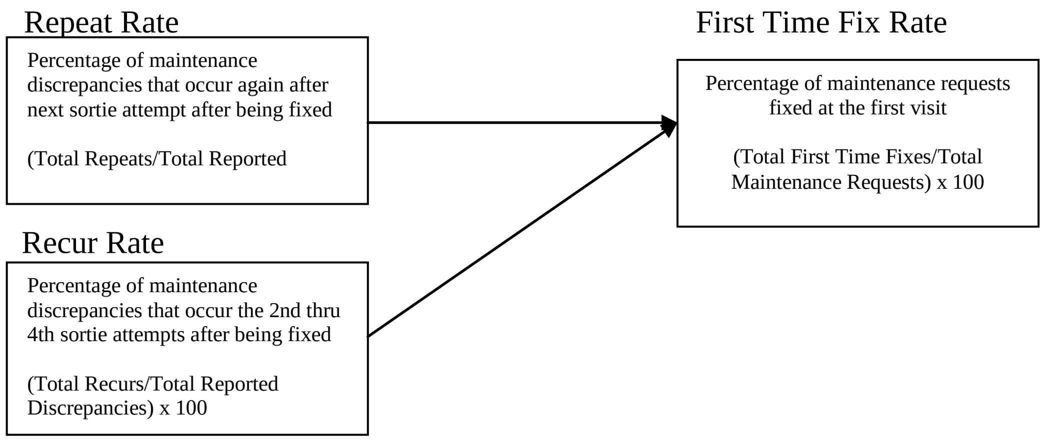
Metric 4

Current	Proposed
Average Delayed Discrepancy Rate	**Maintenance Request Backlog**
Average Number of deferred maintenance actions (Total (snapshot) maintenance actions/Average Aircraft Possessed)	Number of open maintenance requests on selected date (Snapshot of number of open maintenance requests)

Question	1	2	3	4	5
How important is the current metric for managing aircraft maintenance?	1 Not Important	2	3 Somewhat	4	5 Very Important
Is the current metric effective in managing aircraft maintenance?	1 Not Effective	2	3 Somewhat	4	5 Very Effective
Does the proposed metric adequately replace the current metric?	1 Poorly	2	3 Somewhat	4	5 Strongly
Is this new metric easily understood?	1 Poorly	2	3 Somewhat	4	5 Clearly

Metric 5

Current	Proposed



How important is the 1st current metric for managing aircraft maintenance? — 1 Not Effective, 2, 3 Somewhat, 4, 5 Very Effective

Is the 1st current metric effective in managing aircraft maintenance? — 1 Not Effective, 2, 3 Somewhat, 4, 5 Very Effective

How important is the 2nd current metric for managing aircraft maintenance? — 1 Not Important, 2, 3 Somewhat, 4, 5 Very Important

Is the 2nd current metric effective in managing aircraft maintenance? — 1 Not Effective, 2, 3 Somewhat, 4, 5 Very Effective

Does the proposed metric adequately replace the current metric? — 1 Poorly, 2, 3 Somewhat, 4, 5 Strongly

Is this new metric easily understood? — 1 Poorly, 2, 3 Somewhat, 4, 5 Clearly

Metric 6

Current	Proposed
Abort Rate	no new metric

Percentage of missions that end prematurely and must be re-accomplished

(Air + Ground Aborts/Total Sorties Flown + Ground Aborts) x 100

How important is the current metric for managing aircraft maintenance? — 1 Not Important, 2, 3 Somewhat, 4, 5 Very Important

Is the current metric effective in managing aircraft maintenance? — 1 Not Effective, 2, 3 Somewhat, 4, 5 Very Effective

Metric 7

Current		Proposed
Maintenance Scheduling Effectiveness Rate	→	**Attainment to Plan**
Percentage of scheduled maintenance actions verses accomplished scheduled maintenance actions based on assigned points be maintenance action (Total points earned/total points assigned) x 100	→	Measures how well the execution are meeting their respective-planned actions (# Actual Events/# Planned Events)*100

Question	1	2	3	4	5
How important is the current metric for managing aircraft maintenance?	1 Not Important	2	3 Somewhat	4	5 Very Important
s the current metric effective in managing aircraft maintenance?	1 Not Effective	2	3 Somewhat	4	5 Very Effective
Does the proposed metric adequately replace the current metric?	1 Poorly	2	3 Somewhat	4	5 Strongly
Is this new metric easily understood?	1 Poorly	2	3 Somewhat	4	5 Clearly

Metric 8

Current		Proposed
CANN Rate	→	**CANN Rate**
Percentage of cannibalization actions to replace parts on other aircraft (Number of CANNs/Total Sorties Flown) x 100	→	Average number of CANN actions per 100 sorties flown for flying assets [(Number of Aircraft-to-Aircraft CANNs) + (Number of Engine-to-Aircraft CANNs) / Total Sorties Flown] x 100

Question	1	2	3	4	5
How important is the current metric for managing aircraft maintenance?	1 Not Important	2	3 Somewhat	4	5 Very Important
Is the current metric effective in managing aircraft maintenance?	1 Not Effective	2	3 Somewhat	4	5 Very Effective
Does the proposed metric adequately replace the current metric?	1 Poorly	2	3 Somewhat	4	5 Strongly
Is this new metric easily understood?	1 Poorly	2	3 Somewhat	4	5 Clearly

Metric 9

Current	Proposed
Partially Mission Capable Rate	No new Metric

Percentage of hours aircraft can perform some but not all assigned missions, due to Supply, Maintenance or Both

(PMC Hours/Total Possessed Hours) x 100

How important is the current metric for managing aircraft maintenance?

1	2	3	4	5
Not Important		Somewhat		Very Important

Is the current metric effective in managing aircraft maintenance?

1	2	3	4	5
Not Effective		Somewhat		Very Effective

Metric 10

Current	Proposed
Non Mission Capable Rate	Not Mission Capable - Both
Percentage of hours aircraft cannot perform any assigned missions due to Supply, Maintenance or Both (NMC Hours/Total Possessed Hours) x 100	Percentage of time a reported unit possessed weapon system cannot perform any assigned mission due to supply and maintenance (NMCS Hours + NMCM Hours/Total Possessed Hours) x 100

How important is the current metric for managing aircraft maintenance?

1	2	3	4	5
Not Important		Somewhat		Very Important

Is the current metric effective in managing aircraft maintenance?

1	2	3	4	5
Not Effective		Somewhat		Very Effective

Does the proposed metric adequately replace the current metric?

1	2	3	4	5
Poorly		Somewhat		Strongly

Is this new metric easily understood?

1	2	3	4	5
Poorly		Somewhat		Clearly

Metric 11

Current

NMC - Supply

Percentage of hours aircraft cannot perform any assigned missions due to Supply

(NMCS Hours/Total Possessed Hours) x 100

→

Proposed

NMC - Supply

Percentage of time a reported unit possessed weapon system cannot perform any assigned mission due to just supply

(NMCS Hours/Total Possessed Hours) x 100

Question	1	2	3	4	5
How important is the current metric for managing aircraft maintenance?	1 Not Important	2	3 Somewhat	4	5 Very Important
Is the current metric effective in managing aircraft maintenance?	1 Not Effective	2	3 Somewhat	4	5 Very Effective
Does the proposed metric adequately replace the current metric?	1 Poorly	2	3 Somewhat	4	5 Strongly
Is this new metric easily understood?	1 Poorly	2	3 Somewhat	4	5 Clearly

Metric 12

Current

NMC - Maintenance

Percentage of hours aircraft cannot perform any assigned missions due to maintenance

(NMCM Hours/Total Possessed Hours) x 100

→

Proposed

NMC - Maintenance

Percentage of time a reported unit possessed weapon system cannot perform any assigned mission due to only maintenance

(NMCM Hours/Total Possessed Hours) x 100

Question	1	2	3	4	5
How important is the current metric for managing aircraft maintenance?	1 Not Important	2	3 Somewhat	4	5 Very Important
Is the current metric effective in managing aircraft maintenance?	1 Not Effective	2	3 Somewhat	4	5 Very Effective
Does the proposed metric adequately replace the current metric?	1 Poorly	2	3 Somewhat	4	5 Strongly
Is this new metric easily understood?	1 Poorly	2	3 Somewhat	4	5 Clearly

Metric 13

Current | **Proposed**

Current: Total Non Mission Capable Rate

Percentage of total NMC hours

(Total NMC Hours/Total Possessed Hours) x 100

Proposed: No new Metric

How important is the current metric for managing aircraft maintenance?	1 Not Important · 2 · 3 Somewhat · 4 · 5 Very Important
Is the current metric effective in managing aircraft maintenance?	1 Not Effective · 2 · 3 Somewhat · 4 · 5 Very Effective
Does the proposed metric adequately replace the current metric?	1 Poorly · 2 · 3 Somewhat · 4 · 5 Strongly
Is this new metric easily understood?	1 Poorly · 2 · 3 Somewhat · 4 · 5 Clearly

Metric 14

Current | **Proposed**

Current: TNMC - Maintenance

Percentage of total NMC hours due to Maintenance

(Total NMCM Hours/Total Possessed Hours) x 100

→

Proposed: TNMC - Maintenance

Percentage of time a reported unit possessed weapon system cannot perform any assigned mission due to maintenance or both supply and maintenance

(Sum of NMCM Hours + Sum of NMCB Hours/Total Possessed Hours) x 100

How important is the current metric for managing aircraft maintenance?	1 Not Important · 2 · 3 Somewhat · 4 · 5 Very Important
Is the current metric effective in managing aircraft maintenance?	1 Not Effective · 2 · 3 Somewhat · 4 · 5 Very Effective
Does the proposed metric adequately replace the current metric?	1 Poorly · 2 · 3 Somewhat · 4 · 5 Strongly
Is this new metric easily understood?	1 Poorly · 2 · 3 Somewhat · 4 · 5 Clearly

Metric 15

Current		Proposed
TNMC - Supply	→	**TNMC - Supply**
Percentage of total NMC hours due to Supply (Total NMCS Hours/Total Possessed Hours) x 100	→	Percentage of time a reported unit possessed weapon system cannot perform any assigned mission due to supply or both supply and maintenance (Sum of NMCs Hours + Sum of NMCB Hours/Total Possessed Hours) x 100

Question	1	2	3	4	5
How important is the current metric for managing aircraft maintenance?	1 Not Important	2	3 Somewhat	4	5 Very Important
Is the current metric effective in managing aircraft maintenance?	1 Not Effective	2	3 Somewhat	4	5 Very Effective
Does the proposed metric adequately replace the current metric?	1 Poorly	2	3 Somewhat	4	5 Strongly
Is this new metric easily understood?	1 Poorly	2	3 Somewhat	4	5 Clearly

Metric 16

Current		Proposed
Flying Hour Execution Rate	→	**Operational Programmed Time Accuracy**
Percentage of Actual Flying hours executed verses planned flying hours (Total Flying hours executed/Total Flying Hours Scheduled) x 100	→	Compares future Operational Time (i.e. Actual FHs) to actual Operational Time (i.e. Actual FHs flown) by location or group

Question	1	2	3	4	5
How important is the current metric for managing aircraft maintenance?	1 Not Important	2	3 Somewhat	4	5 Very Important
Is the current metric effective in managing aircraft maintenance?	1 Not Effective	2	3 Somewhat	4	5 Very Effective
Does the proposed metric adequately replace the current metric?	1 Poorly	2	3 Somewhat	4	5 Strongly
Is this new metric easily understood?	1 Poorly	2	3 Somewhat	4	5 Clearly

Metric 17

Current	Proposed
Flying Scheduling Effectiveness Rate	**Planning Changes within Execution Window**

Flying Scheduling Effectiveness Rate

Percentage of deviations from planned flying schedule to actual flying schedule

(Actual Flying Schedule events - Deviations/Actual Flying Schedule events) x 100

Chargeable Deviation Rate

Percentage of Deviations due to Maintenance or Operations actions

(Total Mx deviations + total Ops deviations/Total sorties Scheduled) x 100

Planning Changes within Execution Window

Number of planning changes within Execution Window

Question	1	2	3	4	5
How important is the 1st current metric for managing aircraft maintenance?	1 Not Important	2	3 Somewhat	4	5 Very Important
Is the 1st current metric effective in managing aircraft maintenance?	1 Not Effective	2	3 Somewhat	4	5 Very Effective
How important is the 2nd current metric for managing aircraft maintenance?	1 Not Important	2	3 Somewhat	4	5 Very Important
Is the 2nd current metric effective in managing aircraft maintenance?	1 Not Effective	2	3 Somewhat	4	5 Very Effective
Does the proposed metric adequately replace the current metric?	1 Poorly	2	3 Somewhat	4	5 Strongly
Is this new metric easily understood?	1 Poorly	2	3 Somewhat	4	5 Clearly

Metric 18

Current	Proposed
Fully Mission Capable Rate	**No new Metric**

Percentage of hours aircraft can perform all assigned missions

(FMC Hours/Total Possessed Hours) x 100

Question	1	2	3	4	5
How important is the current metric for managing aircraft maintenance?	1 Not Important	2	3 Somewhat	4	5 Very Important
Is the current metric effective in managing aircraft maintenance?	1 Not Effective	2	3 Somewhat	4	5 Very Effective

Metric 19

Current	Proposed
Primary Aircraft Inventory	**Total Active Inventory**
Assigned number of aircraft by MDS per designated organization Snapshot of number of aircraft assigned	Inventory assets with Possession Purpose Code = CA, CB, CC, CF, EH, EI, IF, PJ, PL, PR, TF, TJ, ZA, ZB

Question	1	2	3	4	5
How important is the current metric for managing aircraft maintenance?	1 Not Important	2	3 Somewhat	4	5 Very Important
Is the current metric effective in managing aircraft maintenance?	1 Not Effective	2	3 Somewhat	4	5 Very Effective
Does the proposed metric adequately replace the current metric?	1 Poorly	2	3 Somewhat	4	5 Strongly
Is this new metric easily understood?	1 Poorly	2	3 Somewhat	4	5 Clearly

Metric 20

Current	Proposed
Logistics Departure Reliability Rate	**On time Operations Starts**
Percentage of on-time aircraft departures due to logistics (Number of Departures-Number of Logistics Delays/Number of departures) x 100	Percent of Operations started on time (Number of Operations on time starts/Number of Operations) x 100

Question	1	2	3	4	5
How important is the current metric for managing aircraft maintenance?	1 Not Important	2	3 Somewhat	4	5 Very Important
Is the current metric effective in managing aircraft maintenance?	1 Not Effective	2	3 Somewhat	4	5 Very Effective
Does the proposed metric adequately replace the current metric?	1 Poorly	2	3 Somewhat	4	5 Strongly
Is this new metric easily understood?	1 Poorly	2	3 Somewhat	4	5 Clearly

Metric 21

Current — Possessed Aircraft Rate

Aircraft under control of owning designated organization

Snapshot of number of aircraft controlled by organization

→

Proposed — Depot Possessed Percent

Percentage of the total active inventory hours that are in depot possessed status

(Sum of Possessed hours/Sum of TAI hours)*100

How important is the current metric for managing aircraft maintenance?

1	2	3	4	5
Not Important		Somewhat		Very Important

Is the current metric effective in managing aircraft maintenance?

1	2	3	4	5
Not Effective		Somewhat		Very Effective

Does the proposed metric adequately replace the current metric?

1	2	3	4	5
Poorly		Somewhat		Strongly

Is this new metric easily understood?

1	2	3	4	5
Poorly		Somewhat		Clearly

Metric 22

Current — Programmed Average Sortie Duration

Average Sortie length scheduled

(Number of Scheduled Sorties/Total Scheduled Sortie Hours)

Proposed — no new metric

How important is the current metric for managing aircraft maintenance?

1	2	3	4	5
Not Important		Somewhat		Very Important

Is the current metric effective in managing aircraft maintenance?

1	2	3	4	5
Not Effective		Somewhat		Very Effective

Metric 23

Current

Actual Average Sortie Duration

Average Sortie length executed

(Number of Sorties executed/Total executed Sortie Hours)

Proposed

no new metric

Question	1	2	3	4	5
How important is the current metric for managing aircraft maintenance?	1 Not Important	2	3 Somewhat	4	5 Very Important
Is the current metric effective in managing aircraft maintenance?	1 Not Effective	2	3 Somewhat	4	5 Very Effective

Metric 24

Current

Utilization Rate

Average number of Sorties/Hours flown per Primary Aircraft Inventory

(Sorties/Hours flown per month/PAI per Month)

→

Proposed

Utilization Rate

A measure of the average use of a system during a specified period of calendar time

Average usage/time - flying hrs/PAA per month (assigned)

Question	1	2	3	4	5
How important is the current metric for managing aircraft maintenance?	1 Not Important	2	3 Somewhat	4	5 Very Important
Is the current metric effective in managing aircraft maintenance?	1 Not Effective	2	3 Somewhat	4	5 Very Effective
Does the proposed metric adequately replace the current metric?	1 Poorly	2	3 Somewhat	4	5 Strongly
Is this new metric easily understood?	1 Poorly	2	3 Somewhat	4	5 Clearly

Metric 25

Current	Proposed
	Average Age of ETAR
	Average by Day of open requests for engineering (Total number of days for open ETARs/Total number of ETARs)

Question	1	2	3	4	5
How important is the proposed metric for managing aircraft maintenance?	1 Not Important	2	3 Somewhat	4	5 Very Important
Would the proposed metric be effective in managing aircraft maintenance?	1 Not Effective	2	3 Somewhat	4	5 Very Effective
Is this new metric easily understood?	1 Poorly	2	3 Somewhat	4	5 Clearly

Metric 26

Current	Proposed
	MICAP Hours
	Total MICAP Hours attributed to parts delay (Total MICAP Hours per Month)

Question	1	2	3	4	5
How important is the proposed metric for managing aircraft maintenance?	1 Not Important	2	3 Somewhat	4	5 Very Important
Would the proposed metric be effective in managing aircraft maintenance?	1 Not Effective	2	3 Somewhat	4	5 Very Effective
Is this new metric easily understood?	1 Poorly	2	3 Somewhat	4	5 Clearly

What is your understanding of the Expeditionary Combat Support System program (ECSS) and its effect on the aircraft maintenance community?

What are the metrics you would select a most important if you could only have 5?

What are the metrics you would select if you had to eliminate 5?

Are there any metrics not included in this list that you deem necessary to managing aircraft maintenance?

What areas of concerns or fears do you perceive in moving from the current metrics program to the new ECSS system?

Appendix B SCOR Metrics List

Metric _ID	Metric Name	Definition	Supplemental Definition	Business Rules/Formula	Frequency	Measurement Unit
181	Number of Planning changes within Execution Window	The number of times the plan had to be re-ran, or changed within the Execution Window. Desired trend is minimum number of times	N/A	N/A	Daily	Percentage
182	Operational Programmed Time Accuracy (e.g. Flying Hours)	Compares future Operational Time (i.e. Actual FHs) to actual Operational Time (i.e. Actual FHs flown) by location or group. Can be used to calculate the accuracy of EOH and PDM schedules	(* NOTE: We need to send this metric to M/R *)	N/A	Monthly	Percentage
190	Attainment to Plan	Attainment to Plan measures how well the execution organizations (Source, MRO site, Deliver/Return) are meeting their respective-planned dates and quantities in support of the enterprise TPMP.	As attainment to plan increases, the supply plans are more reliable, and less safety stock is required to cover supply variability. Can measure Source Plans, Production to MPS Plans, and Distribution Plans.	(Actual Event/Planned Event)*100	Daily	Percentage
192	Cannibalization (CANN) Rates	The CANN rate is the average number of CANN actions per 100 sorties flown for flying assets. Can also have a CANN rate for non-fly assets.	A CANN action is the removal of a serviceable part from an aircraft or engine to replace an unserviceable part on another aircraft or engine, or removal of a serviceable part to put into a readiness spares package for deployments.	CANN Rate = [(Number of Aircraft-to-Aircraft CANNs) + (Number of Engine-to-Aircraft CANNs) / Total Sorties Flown] x 100	Daily	Percentage
680	Average age of ETARs	Average by day of open requests for engineering assistance		Total number of days for open ETARs divided by total of open ETARs	Semi-Annualy	Day
729	Break Rate (Leading Indicator) - landing status codes are not finalized; mx and ops need to handshake	The break rate is the percentage of sorties that land in a Code 3 status. Several indicators that follow break rate are MC, TNMCS, CANN, and R/R.	See definition column	Number of Sorties that Land Code 3 /Sorties Flown x 100	Monthly	Percentage

732	Fix Rate	A leading indicator showing how well the repair process is managed. It is a percentage of aircraft with a landing status code of 3 (includes system cap codes 3 and 4) returned to a flyable status in a certain amount of time (clock hours). For example 4,8.	See definition column	Code-3 Breaks Fixed Within 4, 8 or 12 Hours of Landing/ Total Code-3 Breaks x 100	Daily	Percentage
744	On-Time Operation Starts	On time Operation starts	See definition column	Percent of Operations started on time	Daily	Count
766	Utilization Rate (UR)	A measure of the average use of a system during a specified period of calendar time.Where usage and Time is a variable.	See definition column	Average usage/time - flying hrs/PAA per month (assigned)	Monthly	Percentage
800	Weapon System Availability (WSA)	Percent of hours a reported unit possessed weapon system was capable of performing any assigned mission compared to the Total Active Inventory hours for the fleet. This calculated by month and retained for trend analysis.	Data Required: Mission Capable (MC) Hours for assets with Possession Purpose Code = CA, CB, CC, CF, EH, EI, IF, PJ, PL, PR, TF, TJ, ZA, ZB and Total Active Inventory (TAI) Hrs. Drill down capability to the following levels is also required:MAJCOM and Base	Sum of MC Hours WSA = [-------------] X 100 (%) Sum of TAI Hours	Monthly	Percentage
808	Not Mission Capable – Supply (NMCS)	The percentage of time a reported unit possessed weapon system cannot perform any assigned mission due to just supply (lack of parts). This calculated by month and retained for trend analysis.	Data Required: Not Mission Capable Hours due to Supply (NMCS) and total Possessed Hours for assets with Possession Purpose Code = CA, CB, CC, CF, EH, EI, IF, PJ, PL, PR, TF, TJ, ZA, ZB.	Sum of NMCS Hours NMCS = [-----------------------] X 100 (%) Sum of Possessed Hours	Monthly	Percentage
811	Total Not Mission Capable – Supply (TNMCS)	The percentage of time a reported unit possessed weapon system cannot perform any assigned mission due to supply or both supply and maintenance. This calculated by month and retained for trend analysis.	Drill down capability to the following levels is also required: MAJCOM and Base.	Sum of (NMCS Hours + NMCB Hours) TNMCS = [--------------------------------------] X 100 (%) Sum of Possessed Hours	Monthly	Percentage

	Total Not Mission Capable – Maintenance (TNMCM)	The percentage of time a reported unit possessed weapon system cannot perform any assigned mission due to maintenance or both supply and maintenance. This calculated by month and retained for trend analysis.	Drill down capability to the following levels is also required: MAJCOM and Base.	Sum of (NMCM Hours + NMCB Hours) TNMCM = [--------------------------------------] X 100 (%) Sum of Possessed Hours	Monthly	Percentage
812	Not Mission Capable – Maintenance (NMCM)	The percentage of time a reported unit possessed weapon system cannot perform any assigned mission due to only maintenance. This calculated by month and retained for trend analysis.	Data Required: Not Mission Capable Hours due to Maintenance (NMCM) and total Possessed Hours for assets with Possession Purpose Code = CA, CB, CC, CF, EH, EI, IF, PJ, PL, PR, TF, TJ, ZA, ZB.	Sum of NMCM Hours NMCM = [------------------------] X 100 (%) Sum of Possessed Hours		Percentage
813	Not Mission Capable – Both (NMCB)	The percentage of time a reported unit possessed weapon system cannot perform any assigned mission due to supply (lack of parts) and maintenance. This calculated by month and retained for trend analysis.	Data Required: Not Mission Capable Hours due to both Supply (NMCS), Not Mission Capable Hours due to Maintenance (NMCM), and total Possessed Hours for assets with Possession Purpose Code = CA, CB, CC, CF, EH, EI, IF, PJ, PL, PR, TF, TJ, ZA, ZB.	Sum of NMCS Hours + NMCM Hours NMCB = [--------------------------------------] X 100 (%) Sum of Possessed Hours	Monthly	Percentage
815	Depot Possessed Percent	The percentage of the total active inventory hours that are in depot possessed status. This calculated by month and retained for trend analysis.	Data Required: Possessed Hours for assets with Possession Purpose Codes = DJ, DK, DL, DM, DO, DR, and Total Active Inventory (TAI) Hours.	Sum of Possessed Hours Depot Possessed % = [-----------------------] X 100 (%) Sum of TAI Hours	Monthly	Percentage
817	MICAP Hours	MICAP hours are accrued in a given month for items designated as affecting mission capability that are on backorder. For every day during the month the requisition is unfilled, 24 hours are assigned to the requisition.	Month-to-date (MTD) MICAP hours are reported by budget code. The MICAP information reported is a snapshot of MTD hours for the previous month taken on the fifth day of each month.	MICAP Hours = [(stop day – start day – 1) x 24] + [(24 – start hour) + stop hour]	Monthly	Hours
	Total Acitve Inventory	Possessed number of aircraft by weapon system	Assets with Possession Purpose Code = CA, CB, CC, CF, EH, EI, IF, PJ, PL, PR, TF, TJ, ZA, ZB	Number of Active weopon system assets	Monthly	

Appendix C Metric Characteristic Coding

Process Management Factors

1. Manning Utilization Management
    a. Forecasting
    b. Dispatching
    c. Skill Management
        i. Training
        ii. Equipping
    d. Accountability
2. Maintenance Plan Execution Management
    a. Response management
    b. Key to decision making process
    c. MDS maintenance planning
3. Mission Execution Management
    a. Mission Forecasting Management
    b. Airframe Operational Readiness
    c. Airframe Asset Scheduling
4. Support Asset management
    a. Supply Process visibility
        i. Asset Level Management
        ii. Forecasting/planning
    b. Organic Support monitoring
        i. Blue Suit
        ii. Contractor
    c. Contract Execution Oversight
        i. Warranty issues
        ii. Fiscal distributions
5. Mission Design Series specific applications
    a. CAF aircraft
    b. MAF aircraft
    c. New MDS
    d. Old MDS
6. Budget management
    a. Budget validation
    b. Budget Execution

Valuation Characteristic Factors

7. Data Reporting Value
    a. Trends historical data
    b. Failure to Trend data
    c. Specific data capture/application
    d.
8. Echelon Value
    a. Important to Senior Level Managers

    b. Key Management Scorecard
    c. No tactical level control/response
9. Clarity Value
    a. Clear Definition
    b. Similarity to Current Metric
    c. Requires Policy definition to Determine effectiveness
10. Distortion Value
11. Redundancy Value
12. Criteria Value
    a. Double Counting of data
    b. Irrelevant measurements criteria
13. Specificity Value
14. Process Control Value
    a. Tracks wrong process
    b. Fails to track entire process
    c. Responsibility beyond sphere of control
15. Decision Process Value
    a. Cultural Bias
        i. Cultural Perception of Importance
        ii. Distracter to other process measures
16. Understanding Value
    a. Unclear language

Appendix D Commander Authorization Memorandum

24 Nov 2008

MEMORANDUM FOR AFIT IRB/ASCB

FROM: Captain Brian Waller, AFIT/ENS1

SUBJECT: Request for permission to interview members of your command for Thesis: *Integration of the Air Force Aircraft Maintenance Metrics Program into ECSS.*

1. The purpose of this study is to determine the optimal translation of current AF aircraft Maintenance metrics into the new ECSS ERP system. The objective is to leverage Subject Matter Experts in evaluating the propose metrics construct to validate the translation. The results of this study will result in a signed and publish thesis in order to meet the graduation requirements of AFIT.

2. This request is to allow Capt Brian Waller to conduct interviews of members of your command. The subject of these interviews will be to gather data on the impressions and professional evaluation of the developed performance measures. All information collected by this interview is for the sole purpose of the above named thesis. All participation is voluntary and all participants will, to the best ability of this study, be kept anonymous and all information will not be attributable to any individual.

3. If you have any questions about this request, please contact Dr. Jeffery Ogden, DSN 225-3636 x 4653/Jeffery.ogden@afit.edu, or Capt Brian Waller (primary investigator) – Phone 843-819-3383/brian.waller@afti.af.mil.

BRIAN D. WALLER, Captain, USAF
Graduate Student, AFIT/ENS.

1st Ind, XXXXXXXXXX
MEMORANDUM FOR CAPTAIN BRIAN WALLER
Permission Granted/Declined

"*Name*", Rank, USAF
Commander, XXX XXXXXXXX

Appendix E Study Introduction and Permission Memorandum

19 Nov 2008

MEMORANDUM FOR AFRL/Wright Site IRB

FROM: Capt Brian Waller
AFIT/ENS1

SUBJECT: Request for consent to participate in study interview for Thesis: *Integration of the Air Force Aircraft Maintenance Metrics Program into ECSS.*

1. The purpose of this study is to determine the optimal translation of current AF aircraft Maintenance metrics into the new ECSS ERP system. The objective is to leverage Subject Matter Experts in evaluating the propose metrics construct to validate the translation. The results of this study will result in a signed and publish thesis in order to meet the graduation requirements of AFIT.

2. This request is for participant consent to be interviewed. The purpose of this interview will be to gather data on the impressions and professional evaluation of the performance measure correlation. All information collected by this interview is for the sole purpose of the above study. All participation is voluntary and no penalties exist for refusal to participate. All participants will, to the best ability of this study, be kept anonymous and all information will not be attributable to any individuals and be destroyed after a period of 3 years. Participants may choose at anytime to decline participation with this study.

3. Permission to conduct this interview was granted by "*Unit commander*".

4. If you have any questions about this request, please contact Dr. Jeffery Ogden, DSN 225-3636 x 4653/Jeffery.ogden@afit.edu, or Capt Brian Waller (primary investigator) – Phone 843-819-3383/brian.waller@afti.af.mil.

BRIAN D. WALLER, Capt, USAF
Graduate Student, AFIT/ENS.

I herby give consent to be interviewed for the purpose of the study Thesis: *Integration of the Air Force Aircraft Maintenance Metrics Program into ECSS.*

Vita

Captain Brian David Waller graduated from Rutherford High School in Panama City, Florida. He was accepted into Southern Illinois University, Carbondale. In May 2001, he graduated with a Bachelor of Science in Architectural Studies and an Associates of Applied Arts in Graphic Design and was commissioned through AFROTC Detachment 205. His first assignment was the 86th Airlift Wing at Ramstein AB, Germany. He held several positions including Aerospace Ground Equipment Flight and Fabrication Flight Commanders, as well as 76th Aircraft Maintenance Unit Officer in Charge. During this assignment he deployed in support OPERATION ENDURING FREEDOM as the C-130 stage maintenance officer. In Sep 2004, he was assigned to the 437th Air Mobility Wing at Charleston AFB, South Carolina where he served as Shark Aircraft Maintenance Unit Officer in Charge, Maintenance Flight Officer in Charge, and Maintenance Operations Flight Commander. While stationed at Charleston, he deployed in support of OPERATION IRAQI FREEDOM as Commander, 447th Aircraft Maintenance Squadron. In Aug 2007, he entered the Graduate School of Engineering and Management, Air Force Institute of Technology. Upon graduation, he will be assigned to the Air Force Logistics Management Agency (AFLMA) at Maxwell AFB-Gunter Annex in Montgomery, Alabama.

Study Participant

REPORT DOCUMENTATION PAGE			Form Approved OMB No. 074-0188
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1. REPORT DATE *(DD-MM-YYYY)* 26-03-2009	**2. REPORT TYPE** **Master's Thesis**		**3. DATES COVERED** *(From – To)* Sep 2007- Mar 2009
4. TITLE AND SUBTITLE Evaluation of Air Force Aircraft Maintenance Metrics for Integration into the Expeditionary Combat Support System AFIT/GLM/ENS/09-13			**5a. CONTRACT NUMBER**
			5b. GRANT NUMBER
			5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S) Waller, Brian D., Captain, USAF			**5d. PROJECT NUMBER**
			5e. TASK NUMBER
			5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAMES(S) AND ADDRESS(S) Air Force Institute of Technology Graduate School of Engineering and Management (AFIT/EN) 2950 Hobson Street, Building 642 WPAFB OH 45433-7765			**8. PERFORMING ORGANIZATION REPORT NUMBER** AFIT/GLM/ENS/09-13
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES) Logistics Transformation Office Attn: Mr. Steven Cain 4375 Chidlaw Rd Bldg 262 DSN: 785-4539 WPAFB OH 45433-7765 e-mail: steven.cain@wpafb.af.mil			**10. SPONSOR/MONITOR'S ACRONYM(S)**
			11. SPONSOR/MONITOR'S REPORT NUMBER(S)
12. DISTRIBUTION/AVAILABILITY STATEMENT APPROVED FOR PUBLIC RELEASE; DISTRIBUTION UNLIMITED.			
13. SUPPLEMENTARY NOTES			
14. ABSTRACT Implementation of an ERP is a large time and resources consuming endeavor, with many areas the require evaluation and planning. One of these critical areas are Legacy Systems Evaluation and Conversion. This study will explore the transition of 28 current legacy Air Force Maintenance metrics into the ECSS ERP system. Evaluation of these metrics by operational maintenance managers will provide insight into the importance and effectiveness of the current metrics as well as the clarity and success of the proposed new metrics for the ECSS program.			
15. SUBJECT TERMS Metrics, Maintenance Metrics, ERP, Expeditionary Combat Support System (ECSS), Transformation,			

16. SECURITY CLASSIFICATION OF:			**17. LIMITATION OF ABSTRACT**	**18. NUMBER OF PAGES**	**19a. NAME OF RESPONSIBLE PERSON** Jeffrey Ogden, PhD (ENS)
a. REPORT U	**b. ABSTRACT** U	**c. THIS PAGE** U	UU	159	**19b. TELEPHONE NUMBER** *(Include area code)* 937-255-3636

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