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AN ANALYSIS OF THE REQUIREMENTS CORRELATION MATRIX (RCM) AND BASELINE CORRELATION MATRIX (BCM)

THESIS

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AFIT/GSM/LSY/90S-29

The opinions and conclusions in this paper are those of the author and are not intended to represent the official position of the DOD, USAF, or any other government agency.

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David K. Struck

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Abstract

This purpose of this research was to analyze the Requirements Correlation Matrix (RCM) and Baseline Correlation Matrix (BCM). The specific question addressed by the research was "What improvements can be made to better define and document the operational performance requirements during the acquisition of aeronautical weapon systems?" Requirements personnel at using commands, the developing command, and the operational test agency were surveyed to determine who selects the parameters and values in RCMs and BCMs, and whether these personnel had differing interpretations of both requirements and specifications. The results indicated there was not a clear understanding of parameters and values as requirements or specifications by all requirements personnel, and a lack of sufficient acquisition education opportunities existed for requirements personnel at the using commands. The recommendations were that requirements personnel must understand the implications of the selection of parameters in RCMs/BCMs, more requirements oriented acquisition education for using command personnel is necessary to enhance the effectiveness of the RCM/BCM, and that a formal general officer review of requirements should be conducted for major weapon systems to ensure that they are mission essential.

AN ANALYSIS OF THE
REQUIREMENTS CORRELATION MATRIX (RCM)
AND
BASELINE CORRELATION MATRIX (BCM)

I. INTRODUCTION

General Issue

The purpose of the Air Force weapon system acquisition process is to develop, produce, test, and field a weapon system that meets a user's valid need. "Acquisition of the tools of defense is an immense and complex enterprise" (23:60). The acquisition of a major weapon system usually involves numerous Air Force organizations, civilian contractors, and Congress, and may span a period of time as long as ten to fifteen years. Studies of program management both within and outside the Department of Defense (DOD) have consistently found that close ties to the user are essential for successful programs (1; 18; 20; 23; 26). The Packard Commission noted that, in most cases, the development and production of weapon systems cost too much, took too long, and the systems did not perform as they were originally intended (23:xxii). The weapon system process is influenced by factors such as requirements stability, funding availability and stability, cost stability, and schedule constraints. The definition of program requirements sets the stage for the entire program. "How can the acquisition process be improved?" is an important question to be addressed in an effort to make the acquisition process more efficient and effective.

Specific Problem

The Air Force has established policies and procedures which govern the definition of requirements at program inception and the periodic reviewing/updating of these requirements as the program matures. However, following these policies and procedures to the letter will not guarantee success if the program requirements are not stated in meaningful terms. In answering the general question posed above, a more specific question must be addressed: "What improvements can be made to better define and document the operational performance requirements associated with the acquisition of weapon systems?"

Research Objectives

In addressing this specific question, the following objectives were considered.

1. Identify the important issues of the operational requirements process within the Air Force systems acquisition lifecycle.

2. Determine who selects the RCM/BCM parameters and the associated values, which should identify the user's

requirements, the contractual specifications, and the IOT&E criteria for the weapon system.

3. Determine if requirements personnel at using commands, the developing command, and the operational test agency have differing interpretations of both operational requirements and specifications.

Scope

Initially, this thesis describes the broad topic of the Air Force acquisition process. A thorough understanding of this process is necessary before addressing the problem outlined earlier. This is accomplished in the literature review by addressing the first research objective. The review of literature for this paper consists mainly of professional military journals, DoD publications, Air Force regulations, and two lessons learned databases. Next, the thesis focuses on Air Force aeronautical requirements personnel at the using commands (MAC, SAC, and TAC), the developing command (ASD), and the operational test agency (AFOTEC) who are involved in the selection of parameters and values for RCMs and BCMs. The procedures for conducting this phase of the research are presented in Chapter III, Methodology.

II. LITERATURE REVIEW

Overview

This chapter presents a review of the literature and provides the background information necessary for a study of the selection of the parameters and their associated values found in RCMs/BCMs which are used to evaluate aeronautical systems being acquired through the Air Force systems acquisition process. This was accomplished by addressing the first research objective. Specific Air Force regulations and documents were reviewed to provide an understanding of the Air Force systems acquisition process at an important stage: the selection of the parameters and values for RCMs and BCMs. Additional material from professional military journals and two Air Force lessons learned databases was used to describe the merits and shortcomings that are inherent in this process. The methodology for answering the remaining research objectives is provided in Chapter III, Methodology.

Program Management

Program management is generally associated with the undertaking of a complex, nonrepetitive task that occurs during a discrete period of time. It is distinctly different from product management because the latter concerns managing the repetitive production and merchandising of an item. Program management, by comparison, is much more complex because it generally involves the planning, execution and direction of an organization's activities in the attainment of its objectives. Weapon systems acquisition within DoD is a process well suited to program management. The objectives of Air Force acquisition program management are:

1) Field the most cost effective combat and combat support capability that fulfills the user's need.

2) Field fully supported systems that are reliable and maintainable.

3) Maintain acquisition excellence through innovative and aggressive approaches addressing user needs.

4) Develop alternatives to meet the user's need.

5) In concert with laboratory or air logistic center commanders, support and pursue technological advances.

6) Balance available resources against program requirements and direction. (2:6)

Within the Air Force, a program is managed by an individual who may be referred to as a project manager, program manager, or program director. Throughout the remainder of this paper, this individual is referred to as the program director. The program director is charged with a wide variety of responsibilities including developing the acquisition strategy, providing budgetary estimates and alternatives, establishing a program schedule, developing contractual agreements, and conducting the day-to-day management of the program. The organization which manages a development program is known as a system program office (SPO).

Military Program Management

In July 1970, a Blue Ribbon Defense Panel established by the President and the Secretary of Defense reported on the organization and management of DoD procurement policies and practices (17:v). One of the findings of the Panel stated that the development and procurement of military hardware was traumatized by the "now familiar" symptoms of trouble:

1) Major cost growth or overruns;
2) Schedule slips; and
3) Failures in performance. (17:62)

Sixteen years later, the Packard Blue-Ribbon Commission came to the same conclusion that weapon system acquisition generally takes too long, costs too much, and the weapon system does not perform as it was originally intended (23:xxii). The problems of program management are not limited to DoD. A well-respected book by Thomas J. Peters and Robert H. Waterman, In Search of Excellence: Lessons from America's Best-Run Companies, provides insight into the attributes of a successful company or organization. As defined by Peters and Waterman, an "excellent company" must thoroughly understand its objectives (19:26). This philosophy is easily translated to Air Force program management.

A study of commercial programs by the Packard Blue-Ribbon Commission identified six common characteristics which were present in successful programs:

1) Clear command channels;

2) Program stability;

3) Limited reporting requirements;

4) Small, high-quality staffs;

5) Close communication with the user; and

6) Prototyping and testing. (23:50)

Baumgartner, Brown, and Kelly conducted a study of DoD programs that were considered to be successful and identified the key factors that they felt led to success:

1) Good people;

2) Stable requirements and funding;

3) Continuity of key personnel;

5) Acquisition strategy;

6) Resources;

7) State-of-the-art technology;

8) Use of an integrating contractor;

9) Influence of outside agencies; and

10) DoD directives and regulations. (1:32)

A commonly held belief is that technical problems have been the cause of cost and schedule growth. Studies by DoD and independent agencies show that, in actuality, the main cause of cost and schedule growth has been instability in establishing requirements, planning, and budgeting for programs (18:3).

Air Force acquisition programs are, by their nature, enormous undertakings. Clearly, no one factor can be singled out as being responsible for program success or failure; however, the importance of communication with the user was a recurring theme in the literature (1; 18; 20; 23; 26). Baumgartner, Brown, and Kelly surveyed DoD program managers for their definition of program success. Sixty-eight percent responded with "works well when fielded" (1:32). The users will make the ultimate determination of the adequacy of the system; their involvement throughout the acquisition process is critical to program success (20:21). This communication must be a two way process. The user must clearly identify its needs and the developer must let the user know when requirements cannot be met so that trade-offs can be made (26:122). This is an important consideration even before the program begins. The Packard Blue-Ribbon Commission found that, in too many cases, the user requirements for new systems were overstated and resulted in cost growths (23:xxiii).

Commander's Policies

The majority of acquisition within the Air Force is conducted by Air Force Systems Command (AFSC). In 1987 the AFSC Commander, General Bernard P. Randolph, established the AFSC 550-series of regulations as a means of documenting and communicating his Command policies to the members of AFSC (9:1). These regulations cover a variety of subjects, all aimed at describing his philosophy on the way that AFSC should conduct business in order to be successful. The second regulation in the series, AFSCR 550-2, identifies three goals that AFSC must focus on. The importance of the user is clearly stated in the first AFSC goal: "To meet the users' needs by keeping close to our users, knowledgeable of their environment, and fully responsive to their requirements" (6:1). This philosophy permeates many of the regulations throughout the 550-series.

AFSC must be committed to focusing on the user. AFSCR 550-10 emphasizes AFSC's role of supporting the using commands. It states that program directors must consider the users' needs when making programmatic decisions, brief the AFSC Commander on issues which impact operational capability, and maintain close contact with AFOTEC to insure that appropriate operational test planning is conducted (7:1). AFSCR 550-11 adds to this the concept that, in addition to simply meeting the users' needs, AFSC should strive to provide the user with value. This means that a variety of solutions should be proposed by AFSC before the best solution is selected by the user (10:1; 11:1). Once this is accomplished, the solution must be pursued using a cost effective acquisition strategy in order to provide the most capability for the money spent (8:1).

Close communication between the SPO and the user is facilitated by the existence of using command representatives stationed at the base where the SPO is located. At Wright Patterson AFB for instance, Aeronautical Systems Division (ASD) SPOs are supported by Military Airlift Command (MAC), Strategic Air Command (SAC), and Tactical Air Command (TAC) systems offices (i.e. MACSO, SACSO, and TACSO). These support offices advise the SPOs of the using commands' interests and concerns relating to the development and future operation of the weapon systems. In addition to the support offices, many of the SPOs have a using command representative located directly in the program office.

Operational Requirements Process

The weapon systems acquisition process informally begins when a major command (MAJCOM), as the user, identifies an operational deficiency through a mission analysis. An operational deficiency may result from a myriad of reasons including:

1) changes in the threat or national security policy,
2) technological advances, or
3) poor cost efficiency or operational effectiveness.

The identification of operational requirements is a critical step. The Packard Blue-Ribbon Commission found that a better method of generating requirements was needed at the beginning of the acquisition process (23:xxiii). Indeed, the definition of requirements has plagued DoD for years. In his report to the President in 1970, Fitzhugh noted that the requirements process is critical at the start of an acquisition program (17:68). The Air Force requirements process was revised in 1987 in response to the observations and recommendations of the 1985 Defense Science Board (DSB) and the 1986 Packard Commission report. Additional cause for change was identified as a result of the system acquisition management inspections (SAMIs) that were conducted between 1979 and 1984. The SAMI inspectors documented 55 distinct cases where requirements were improperly defined or communicated (14:1). These findings resulted in the direction of a SAMI of the requirements process in 1987 by The Inspector General (TIG).

An operational need may be identified by either the user or HQ USAF. Once an operational need is validated, there are many options available to compensate for the deficiency. Among these options are:

1) changing military doctrine or tactics,
2) modifying existing systems,
3) using modified commercial ("off-the-shelf") equipment,
4) developing a new system.

An operational requirement which must be fulfilled through one of the aforementioned options marks the beginning of the long and complicated acquisition process. The requirement must first be validated by the originating organization and is then formally documented in a Statement of Operational Need (SON). Development of the SON is directed by Air Force Regulation (AFR) 57-1, Operational Needs, Requirements, and Concepts (12:3). The SON describes the need in operational terms and, when approved, provides official validation of the need.

The SON provides the mission need, basis of the need, assessment of current capabilities, operational performance requirements, and a proposed solution in a standardized format (12:29). Prior to being published, and thus validated as a legitimate need, the originator of the SON must coordinate it with the organizations which are identified in Attachment 4 to AFR 57-1 (12:26). Approval of a mission need occurs at Milestone 0 (MO) and allows the effort to proceed into the concept exploration/definition phase (Figure 1). Entry into this phase does not guarantee that a new weapon system will be acquired; it simply allows alternative systems to be identified and evaluated.

Three attachments must be included with the draft SON: a draft Program Decision Package (PDP) which provides a preliminary estimate of the funds required to pursue development of the weapon system, a threat assessment, and a Requirements Correlation Matrix (RCM). The RCM was developed from, and is essentially the same as, an Air Force Systems Command (AFSC) and Air Force Operational Test and Evaluation Center (AFOTEC) initiative known as the Baseline

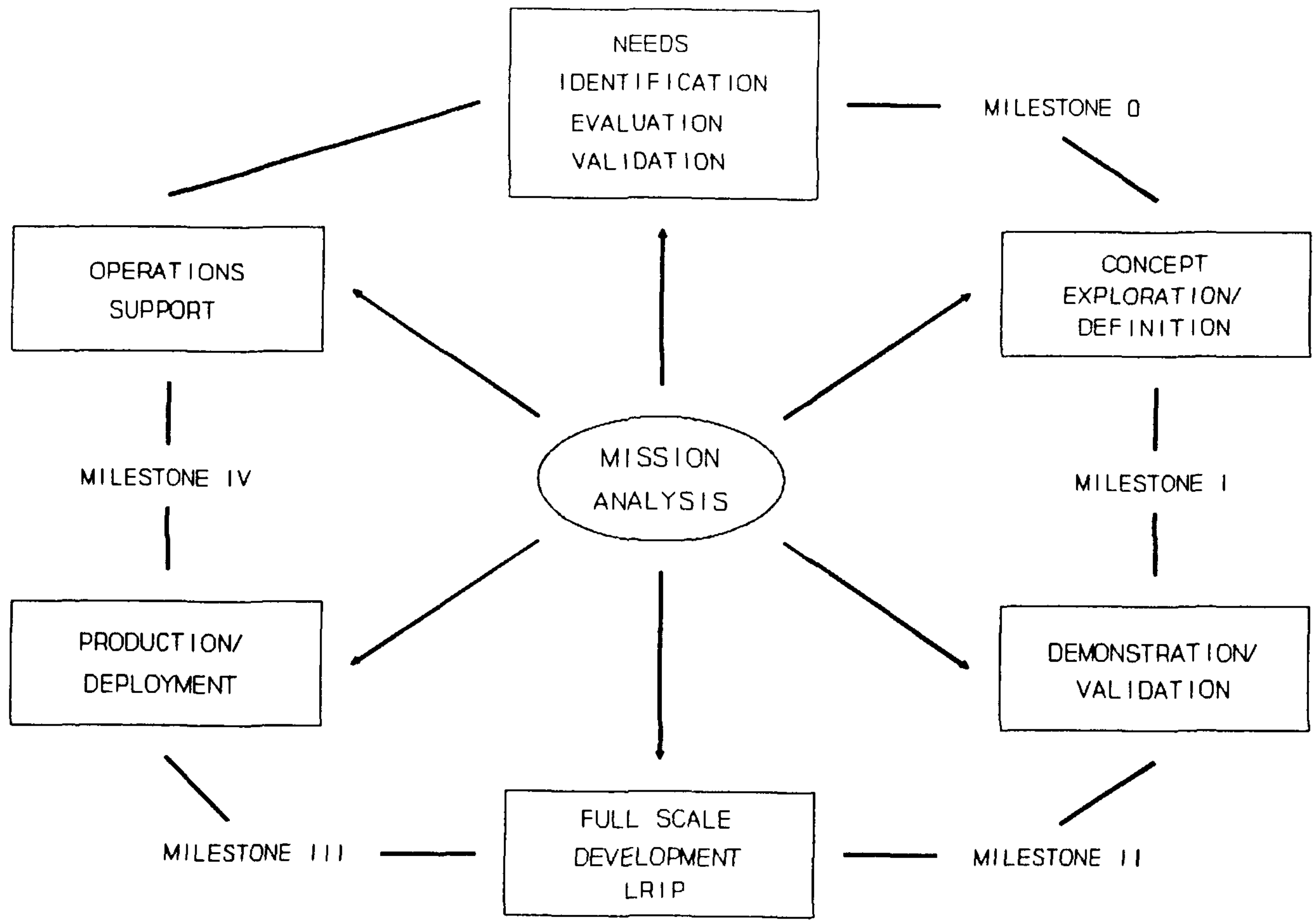

Figure 1. Acquisition Lifecycle

Correlation Matrix (BCM). The RCM and BCM are management tools which document the user's requirements and any changes that occur to them throughout the acquisition process. One striking difference between the RCM and BCM is that the RCM is developed by the user (operating command) and the BCM is developed by the implementing (developing) command. In addition, the BCM was designed to document the program baseline while the RCM was designed to provide an audit trail of the requirements as the program matures.

Requirements Correlation Matrix

The RCM was developed to increase management visibility of, and provide a formal means for communication of, program requirements. There are two parts to the RCM.

Part I is a matrix, similar to a spreadsheet, which consists of four columns to identify the top-level performance parameters, user requirements, contractual specifications, and operational test criteria. The requirements must be identified as "firm" or as "goals." Wherever possible, these requirements should be stated in general terms (goals) to allow for cost and performance trade-offs (2:5; 12:9). The requirements are used as a basis for developing design specifications and test criteria. This format provides an easy means of highlighting any disconnects that occur between requirements, specifications, and test criteria.

Part II provides the rationale, to include results of any trade-off studies or other factors considered, for any changes in Part I (12:39). This section documents the evolution of the requirements and hence can be used as an audit trail for any changes that occur throughout the program.

Baseline Correlation Matrix

The BCM was formalized in 1987 when its governing regulation, AFR 800-46, Baseline Correlation Matrix, was published. The BCM was designed to supplement the program baseline, highlight program requirements, and provide a channel of communication between the user, developer, development tester, and operational tester. The BCM, like the RCM, contains two parts. Part I is a five column spreadsheet which identifies the program parameters, requirements, specifications, IOT&E evaluation criteria. The fifth column is reserved for remarks. Part II contains the rationale for the parameters identified in Part I and a description of the methodology used to demonstrate each parameter (3:5). The rationale sheet must identify the original source document for the parameters.

One of the findings of the SAMI of the requirements process, conducted 23 February to 6 May 1987, was that the RCM and BCM were redundant. The SAMI recommended that the RCM and BCM be combined into one document because of the similarity of information presented and timing of issuance (14:10). The apparent duplication of information in the two documents resulted in the cancellation of the requirement for a BCM in late 1989.

Lessons Learned

The Air Force Lessons Learned Program was established in 1977 to provide a means of documenting feedback on the experience of current and past acquisition programs and the operation and support of fielded systems (4:1). The Lessons Learned Data Bank is located at Wright Patterson AFB, Ohio, and is maintained by the Air Force Acquisition Logistics Division (ALD/LSE). This data bank maintains a collection of approximately 2000 lessons learned from Air Force, Army, and Navy programs which are organized into 49 subject areas referred to as "impact areas." The impact areas are listed in Appendix B.

RCM Lessons Learned. One lesson learned in the Data Bank which discusses the importance of the RCM is located in the impact area of Program Management. This lesson, which discusses the topic of effective test planning, states that understanding the operational requirements of the system is critical and that care must be taken to develop test criteria that truly reflect these operational requirements. Disconnects between the operational requirements and the test criteria will result in ineffective testing of the system. The lesson concludes by stating that the RCM is the appropriate tool for documenting this process (15:1). The abstract for this lesson learned in provided in Appendix B.

The OT&E Lessons Learned program is located at Kirtland AFB, New Mexico, and is maintained by the AFOTEC Plans and Policies Division (AFOTEC/XPX). The objective of the program is to ensure that future OT&E test efforts benefit from past experiences. The data base contains management, operations security (OPSEC), and technical-oriented lessons learned for programs in OT&E or joint test and evaluation (JT&E). The governing regulation for this program recommends that lessons learned for AFOTEC-conducted tests be submitted at the following times:

1. When the program transfers from advanced planning to the test manager;

2. when the program begins test execution; and

3. at the end of test execution and reporting/termination.

Lessons learned for JT&E programs should be submitted at the end of the test repo ting phase (5:1).

<u>BCM Lessons Learned</u>. One lesson learned in the OT&E lessons Learned data base which discusses the importance of the BCM was submitted by the Automated Remote Tracking Station (ARTS) program. This lesson states that rushing the BCM process will result in "poorly designed and/or inappropriate user requirements and test criteria." (13) An additional issue that was discussed was related to making

changes to the BCM once it had been signed by the developer. Different interpretations of the user's requirements, which were identified during IOT&E, were difficult to resolve because the changes to the BCM would have to be coordinated by the developers and they did not feel that they had adequate time to do so. The conclusion of this lesson was that the BCM should be written early enough to preclude problems during testing (13). Another point that stands out is that the criteria identified in the BCM must be clearly written so that there will not be differing interpretations. The complete lesson learned is provided in Appendix B.

Operational Test and Evaluation (OT&E)

OT&E is conducted, by AFOTEC or the user, throughout the acquisition lifecycle to assess the operational effectiveness and suitability of a new weapon system (Figure 2). Two distinct categories of OT&E exist: Initial OT&E (IOT&E) and Follow-on OT&E (FOT&E). IOT&E, the earliest assessment of the system performance, occurs prior to the full-rate production decision and is conducted on production representative systems. FOT&E occurs after the full rate production decision and is conducted during production and deployment of the system. The objective of FOT&E is to verify the correction of any deficiencies identified in IOT&E and to refine estimates of performance. The refinement of estimates is necessary due to the inherent differences in production-representative and production

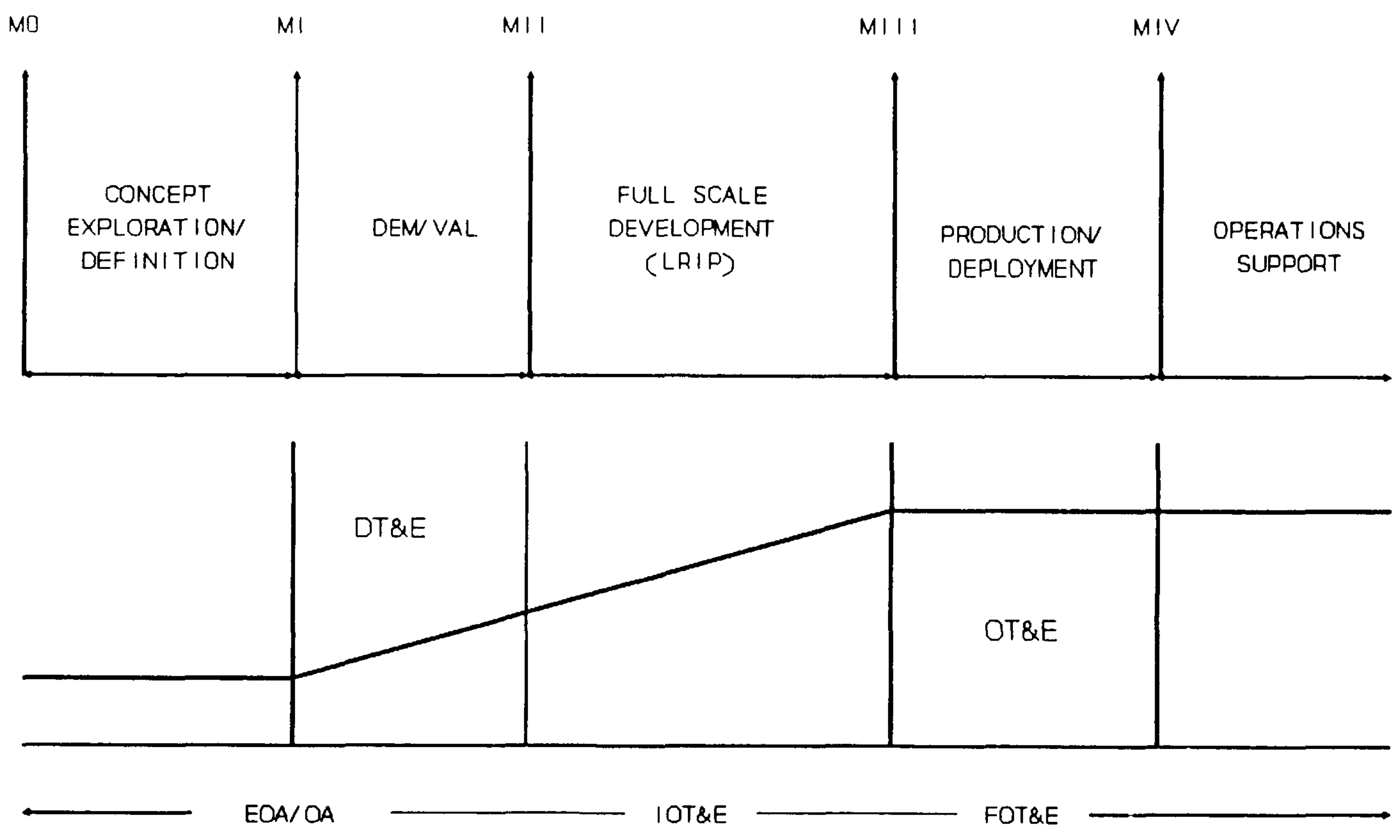

Figure 2. T&E and the Acquisition Lifecycle

systems. FOT&E may continue throughout the life of a system to evaluate any future changes to the system or military doctrine and tactics.

Effective use of operational testing is essential to improving the performance of new systems (23:xxvi). Operational testing is meant to be a constructive process that leads to the fielding of a system that meets the user's needs. Dr. Kimmel, Assistant Deputy Director of Defense Research and Engineering for Test and Evaluation (DDDRE(T&E)), notes that operational testing has become a critical element of the acquisition process (21:3). The problem that has arisen is that Congress tends to view operational testing as a pass/fail exam. In this context, a "failed" test may prompt Congress to cancel or reduce funding for the program. The services become wary of conducting tests that are too likely to fail (22:57). In other words, operational testing should not be an end unto itself (21:2).

The first step that must be taken to develop an effective operational test program is to evaluate the weapon system and decide which performance features are required by the user. These performance features must be the basis for the operational evaluation to ensure that the system meets the user's requirements. In other words, the users must state their requirements for the system clearly so that the operational testers know what to test. In the past, AFOTEC has been faced with the problem that a requirement has not been stated where they felt there should be one (24). Although this approach filled the gap for inadequate or inappropriate requirements, it was not AFOTEC's responsibility and it did not fix the problem. AFOTEC has since taken the approach that they will refuse to accept inadequate or inappropriate requirements and insist that the user fulfill this responsibility (24). The key performance features for a system that are required by the user and must be tested by AFOTEC should be documented in the RCM/BCM. These requirements must then be prioritized to ensure that the most important features of the system are tested (24). Once prioritized, these requirements must be reviewed to ensure that they reflect the operational capabilities that are necessary to fulfill the mission and are not simply a re-statement of the specifications (24). Prioritizing the requirements for the system and stating them in operational terms will help ensure that the operational test program provides a meaningful evaluation of the weapon system by eliminating unnecessary and/or inappropriate test objectives. A successful operational test program will determine whether or not the system meets the users requirements rather than the appropriateness of the system's requirements.

Conclusion

Acquisition of new weapon systems within the Air Force is a complex process. Cost overruns and schedule slips have plagued the acquisition process for many years. Studies have been conducted within and outside DoD on military and civilian programs to determine what causes a program to succeed or fail. One characteristic that is consistently identified as essential to program success is good communication with the user.

The developer is in business to serve the user. It is essential that the user's needs be carefully addressed. Failure to deliver a product which satisfies the user means that the developer has not fulfilled its duties. Establishing close communications with the user is only the first step. The developer must then listen to the user and be responsive to his needs. Trade-offs must be made when the developer cannot deliver what the user needs.

The development of user requirements, and the subsequent acquisition program, have an inherent flaw. The program manager must "sell" his program to Congress to get initial funding established. This usually results in the overstatement of the requirements. Overstating requirements inevitably leads to program "failure" in the eyes of Congress when the system enters operational testing and does not perform as promised. The result is program cancellation, decreased funding, or schedule delays which result in cost overruns. This is a cyclical process which often dooms the acquisition process to failure.

The RCM and BCM are the management tools used to identify the top-level performance parameters and the associated user requirements, contractual specifications, and operational test criteria. They are used by the developing command to write specifications and the operational tester to develop the test program and therefore are important to the success of OT&E and, in general, the acquisition program. Inadequate and/or inappropriate requirements in these documents serve only as an impediment to the development program.

An analysis of the selection of parameters found in RCMs/BCMs, which should reflect the user's requirements, is in order to learn how to improve the requirements process. As was discovered in the literature, this is not the ultimate solution to the Air Force's program management problems, but is certainly an area which merits further investigation.

III. Methodology

Overview

This research effort was divided into two phases. The first phase consisted of personal interviews and a review of literature on the acquisition process, with the main emphasis placed on the user and the requirements for new or improved weapon systems. The second phase constituted the primary data collection for the research effort and consisted of an opinion questionnaire distributed to appropriate subjects. The purpose of this chapter is to limit the scope of the research by establishing the methodology that was used in addressing the research objectives during the two phases of the research effort.

Phase One

The first phase of the research effort addressed research objective one. This objective was to identify the important issues of the operational requirements process within the Air Force weapon systems acquisition lifecycle. This was accomplished through the literature review and interviews with AFOTEC personnel.

The literature reviewed consisted of professional military journals, DoD publications, Air Force regulations, and two lessons learned data bases. The professional military journals were chosen because of their focus on current program management issues relating to the acquisition of DoD weapon systems. These publications provided valuable insight into and analysis of the DoD acquisition process. The Air Force regulations served to focus the study by outlining the policies and procedures that govern the conduct of the requirements process within the Air Force weapon system acquisition lifecycle. Finally, two lessons learned data bases were searched to find specific problems, and their recommended solutions, relating to the requirements process that have been encountered by acquisition personnel. These data bases included the USAF Lessons Learned Program at Wright Patterson AFB, Ohio, and the OT&E Lessons Learned Program at Kirtland AFB, New Mexico. One lesson learned in the USAF Lessons Learned data base dealt specifically with the RCM and one lesson learned in the OT&E Lessons Learned data base dealt specifically with the BCM. These lessons learned, which are provided in Appendix B, served to further focus the study on various problems that have arisen. While the literature review identified the RCM and BCM as areas of potential study, the subject required further refinement. This final refinement was obtained by conducting personal interviews with key AFOTEC personnel including the AFOTEC Commander, Major General Cecil W. Powell.

AFOTEC was chosen because it is the Air Force organization tasked to evaluate the operational performance of Air Force weapon systems. The first interview was of an informal and non-structured nature. The individual interviewed, Mr Larry Benson, is the Director of the AFOTEC Directorate of Research Services (AFOTEC/RS). This directorate was chosen because two of its functions provide information directly relevant to this research. First, it is responsible for maintaining the OT&E Data Bank (AFOTEC/RSD), which is the USAF repository for OT&E records. Second, it is responsible for compiling the History of AFOTEC on a yearly basis. This document serves as a historical summary of major events which are pertinent to the conduct of AFOTEC's business. Mr Benson, as head of this Directorate, was a valuable source of information on issues relevant to the requirements process and the operational evaluation of weapon systems. The purpose of this interview was to use his expertise on the micro level of the requirements process and OT&E to develop and refine questions to be addressed to Major General Cecil W. Powell. During the interview with General Powell, micro issues as well as some macro issues of both the requirements process and the conduct of OT&E were addressed. The purpose of this second interview was to better identify what he felt were problem areas of the requirements process that affected the conduct of OT&E.

Based on the literature review and these two interviews, a questionnaire was developed to solicit information from key personnel involved in the requirements process. The administration of this questionnaire occurred during the second phase of the methodology.

Phase Two

The second phase constituted the primary data collection of the research effort. This phase addressed research objectives two and three through the distribution of a questionnaire to appropriate personnel.

Objective two was to determine how and by whom the RCM/BCM parameters and the associated values, which should identify the user's requirements, the contractual specifications, and the IOT&E criteria for the weapon system, are selected. Objective three was to determine if requirements personnel in the using commands, the developing command, and the operational test agency have differing interpretations of both operational requirements and specifications. These objectives were addressed by distributing a questionnaire to working-level requirements personnel at using commands, the developing command, and the operational test agency.

Population/Sample. In order to find facts related to, and opinions concerning, the selection of parameters and values found in RCMs and BCMs, it was desirable to reach the population which had the greatest experience in this area. For this reason, requirements personnel at using commands, the developing command, and the operational test agency were selected. These personnel were assigned to the following organizations:

1. HQ Military Airlift Command, DCS/Requirements (HQ MAC/XR), Scott AFB, Illinois.

2. HQ Strategic Air Command, DCS/Requirements (HQ SAC/XR), Offutt AFB, Nebraska.

3. HQ Tactical Air Command, DCS/Requirements (HQ TAC/XR), Langley AFB, Virginia.

4. Aeronautical Systems Division, Directorate of Advanced Planning (ASD/XR), Wright Patterson AFB, Ohio.

5. HQ Air Force Operational Test and Evaluation Center, Plans and Policy Directorate (HQ AFOTEC/XP), Kirtland AFB, New Mexico.

A total of 95 questionnaires were distributed to randomly selected individuals at these five locations. The using commands (MAC, SAC, and TAC) received 60; ASD received 20, and AFOTEC received 15. The small number of questionnaires sent to ASD and AFOTEC was due to the relatively low number of advance planners in these organizations.

Questionnaire. The purpose of the questionnaire was to gather demographics and solicit opinions about several topics. The questionnaire was divided into two parts. Part I consisted of a mix of demographics and opinion questions. Part II consisted strictly of opinion questions.

There were four demographic questions in Part I. The first question asked for the current AFSC, rank/grade, and aeronautical rating. The respondent's aeronautical rating was solicited because the items in Part II of the questionnaire pertained to aeronautical systems (versus space or land systems). It was used to determine if those with flying experience responded differently than those without flying experience. The second question asked for the respondent's current position title and a brief description of their duties. The third question asked for the length of time that the respondent had been working in their current organization. The responses were ranked as:

1. Less than one year;
2. At least one year but less than two years;
3. At least two years but less than three years;
4. At least three years but less than four years; or
5. More than four years.

The fourth question asked for the respondent's previous assignment history. The third and fourth questions were primarily used to determine the levels of current and past experience.

The fifth and sixth questions asked the respondents to give their definitions of a requirement and a specification, respectively. The responses were used to determine if there was a basic understanding of what constitutes a requirement and a specification. They were also used to determine if there was a consensus opinion within the commands as well as between the commands.

Question seven asked the respondents to identify the basis used for the definitions of a requirement and a specification that they provided in questions five and six. The purpose of this question was to determine from where their understanding of the two terms had come. Two suggestions, personal experience and professional continuing education (PCE) classes, were offered although the question was open-ended.

For the AFOTEC and ASD personnel, question eight asked the respondents to identify whether they provided any assistance in the selection of parameters and/or values to the developers of requirements documents. This was the final question of Part I for these personnel.

For the using command personnel, question eight asked the respondents if they personally were involved in the development of RCMs. Question nine, the final question of Part I for the using command personnel, asked the respondents to identify if they sought assistance in the preparation of RCMs from personnel outside of their organization. Part I of the questionnaire is provided in Appendix D.

Part II of the questionnaire contained only opinion questions. This part consisted of a list of fifteen parameters and their associated values as would be found in a typical RCM or BCM. These items were selected from actual RCMs and/or BCMs from aeronautical programs managed at ASD.

The parameters were taken from the RCMs/BCMs exactly as they appeared, while the values were changed slightly to protect any sensitive information about the programs. The subjects were asked to categorize each parameter and its associated value as a requirement (R), a specification (S), both a requirement and a specification (B), or neither a requirement nor a specification (N). Part II of the questionnaire is provided in Appendix E.

Statistical Tests

The data obtained from the questionnaire were analyzed using several statistical techniques.

Frequency counts were obtained for the demographic questions in Part I. These counts were totaled for each organization as well as for the sample as a whole.

The parameter and value categorizations for Part II of the questionnaire were first totaled for the respondents without any consideration of the demographics. The parameter and value categorizations were then totaled based on the respondent's aeronautical rating, current experience level, and organization. A statistical test for independence was conducted on each question for all three demographic groups to determine whether or not the responses were independent with respect to the factors.

The independence tests for rated and non-rated personnel categorizations considered the following two hypotheses:

H_0: The categorizations by the rated personnel were independent of those by non-rated personnel.

H_a: The null hypothesis is not true.

The responses were totaled for the using commands, ASD, and AFOTEC. The independence tests for these response groupings considered the following two hypotheses:

H_0: The categorizations by the personnel were independent of their organization.

H_a: The null hypothesis is not true.

Finally, the responses were totaled based on the level of experience in the respondent's current organization. To facilitate the test, the responses were grouped in three groups, as opposed to five groups as had been done previously. These groups were

1) less than two years,

2) two years but less than four, and

3) four years or more.

The independence tests for these response groupings considered the following two hypotheses:

H_0: The categorizations by the personnel were independent of experience level.

H_a: The null hypothesis is not true.

A two-way contingency table was constructed for each question with i factors and j categories. The test statistic was a Chi-squared value (16:587):

$$X^2 = \frac{\text{sum}_i \ \text{sum}_j \ (n_{ij} - \hat{e}_{ij})}{\hat{e}_{ij}}$$

where n = sample size

n_{ij} = the number of responses in sample i that fell in category j

$\hat{e}_{ij}$ = estimated expected count in cell (i,j)

$= n_i * n_j / n$

n_i = the total for row i

n_j = the total for column j

The decision rule was (16:636):

$$\text{reject } H_0 \text{ if } X^2 >= X^2_{alpha,(I-1)*(J-1)}$$

The values of X^2 and $X^2_{alpha,(I-1)*(J-1)}$ were compared for each test and the decision rule was applied. If the null hypothesis is rejected, it can be concluded that the two groups are not independent and that their responses differed significantly. If the null hypothesis is not rejected, it can be concluded that the categorizations by the different response groupings did not differ significantly.

IV. Findings and Analysis

Overview

This chapter presents the findings and analysis of the data collected through the questionnaire which was distributed to personnel at AFOTEC, ASD, and the using commands (MAC, SAC, and TAC). The data from the questionnaire was analyzed using the methodology described in Chapter III. The questionnaire response data is presented first, followed by the applicable questionnaire findings and analysis.

Questicnnaire Response Data

Table 1 displays the participation results for the questionnaire. All of the questionnaires returned were received by the cutoff date, 31 July 1990.

TABLE 1

Participation Results

	Number	Percentage
Questionnaires Distributed	95	---
Questionnaires Returned	53	55.8
AFOTEC	7	46.7
ASD	14	70.0
Using Commands	32	53.3

Questionnaire Findings and Analysis

Demographic Questions. The first series of questions asked for some demographic information about the respondents.

Table 2 shows the flying rating of the respondents. The number of rated and non-rated respondents was fairly close; slightly more respondents were non-rated. Table 3 shows the ranks/grades of the respondents. One of the 53 respondents did not provide an aeronautical rating and two did not identify their rank/grade.

TABLE 2

Aeronautical Rating (%)

Rating	Using Commands	ASD	AFOTEC	TOTAL
Rated	45.2	21.4	71.4	42.3
Non-rated	54.8	78.6	28.6	57.7

TABLE 3

Ranks/Grades (%)

Rank/Grade	Using Commands	ASD	AFOTEC	TOTAL
Lt Col/GM-14	23.3	50.0	28.6	31.4
Maj/GS-13	26.7	28.6	42.8	29.4
Capt/GS-12	20.0	14.3	28.6	19.6
Lt	6.7	7.1	0.0	5.9
NCO	23.3	0.0	0.0	13.7

Table 4 shows the length of time that the respondents have been working in their requirements organization. Exactly half of the respondents reported that they had less than two years experience in their current organization.

TABLE 4

Current Organization Experience Level (%)

Level (years)	Using Commands	ASD	AFOTEC	Total
L < 1	29.0	14.3	28.6	25.0
1 <= L < 2	35.5	7.1	14.2	25.0
2 <= L < 3	16.1	21.5	28.6	19.2
3 <= L < 4	19.4	7.1	0.0	13.5
L > 4	0.0	50.0	28.6	17.3

Slightly less than half (45.2%) of the personnel in the using command organizations identified that they had an aeronautical rating. This might seem unusually low given the fact that the commands are operationally oriented; however, this might be explained by the fact that these organizations are staff functions. The personnel in these organizations also tended to be higher ranking. Exactly half (50%) of the personnel were major/GS-13 or lieutenant colonel/GS-14. A rank of major generally requires at least 10 years of Air Force experience to obtain; the grade of GS-13 might require slightly less. The respondents that identified themselves as non-commissioned officers (NCOs) were all master sergeant or above and accounted for another 23.3 percent. As a minimum, these ranks also require at least 10 years of Air Force experience to obtain. On the other hand, none of these personnel had more than four years experience in the their current organization and over half (64.5%) of the respondents indicated that they had less than two years of experience in their current organization.

The demographics for the ASD and AFOTEC indicate a different profile. The number of higher ranking personnel was greater than for the using commands; ASD reported 78.6% and AFOTEC reported 71.4% as being major/GS-13 and above. The level of experience for the ASD and AFOTEC respondents was also distributed differently than was the using commands'. While over half of the using command respondents indicated having less than two years of experience in their current organization, the reverse was shown for ASD and AFOTEC. ASD reported 78.6% and AFOTEC reported 57.2% of their personnel having two or more years of experience in their current organization. In fact, half of the ASD respondents and a quarter of the AFOTEC respondents had more than four years experience in their current organization. This was due to the larger number of civilian personnel in these organizations.

Opinion Questions. The remaining questions of Part I asked respondents to provide their opinion on several items, including the definitions of a requirement and a specification, and where they acquired those definitions.

Additionally, it addressed the level of assistance provided during RCM/BCM preparation.

One question asked respondents for their definition of a requirement. The responses for this question are provided in Appendix F. The definitions of a requirement provided by the respondents varied greatly. The definitions tended to describe a requirement on three different levels. The first level was that of a requirement as an operational characteristic or capability of a system. The second level was that of a requirement as a solution, in the form of a system, to an operational need or deficiency. Finally, the third and the highest level was that of a requirement as a user's operational need or a mission capability. The responses from AFOTEC were almost wholly oriented towards the first level while those from ASD and the using commands were a mix of all three levels.

A second question asked respondents for their definition of a specification. The responses for this question are provided in Appendix G. Specifications can generally be characterized as either functional, design, or performance in nature, or a combination of the three. Functional specifications describe the essential physical characteristics and functions necessary to meet minimum needs. Design specifications describe in detail the materials, dimensions, and manufacturing process for an item. Performance specifications describe requirements in terms of ranges of acceptable characteristics or minimum acceptable standards. While some of the definitions of a specification were focused solely on the performance aspect, they were few in number. Most of the definitions encompassed all three aspects.

Table 5 shows the basis that was used for the definitions of a requirement and a specification that were provided by the respondents. The table shows the totals for each location as well as the overall total.

TABLE 5

Basis of Definitions (%)

Basis	Using Commands	ASD	AFOTEC	TOTAL
Personal Experience	67.4	59.1	87.5	67.1
PCE Classes	23.3	18.2	0.0	19.2
Other	9.3	22.7	12.5	13.7

The questionnaire provided personal experience and professional continuing education (PCE) classes as examples to provide clarification of what was being asked. Although the question was open-ended beyond these suggestions, the respondents chose them most often. Also, respondents were not limited to providing only one response for this question. For this question, there were 43 responses from the using commands, 22 responses from ASD, and eight responses from AFOTEC for a total of 73 responses. The third category, "other," was included to account for things such as regulations and a dictionary.

The responses for all three groups was heavily weighted towards personal experience as the basis (67.1%). Considerably less (19.2%) indicated that PCE classes (e.g. AFIT SYS 100-400 and DSMC) were an influence. The remaining responses (13.7%) were grouped into the category "other." This category included things such as AFR 57-1, MIL STD 490A, and a dictionary.

Table 6 shows the results of the question concerning assistance for the seven AFOTEC and fourteen ASD respondents. This question asked respondents if they provided assistance in the selection of parameters and/or values to the developers of RCMs and BCMs. AFOTEC indicated slightly more involvement than did ASD, although both were close to 50 percent.

TABLE 6

Assistance in Selection of Parameters/Values (%)

	AFOTEC	ASD	Total
Provide assistance	57.1	54.5	55.6
Do not provide assistance	42.9	45.5	44.4

Table 7 shows the results of the question concerning involvement for the 31 using command (MAC, SAC, and TAC) respondents. This question asked respondents if they were currently involved in the development of user requirements for RCMs.

TABLE 7

Development of User Requirements for RCMs (%)

	MAC	SAC	TAC	Total
Involved	77.8	78.6	75.0	77.4
Not involved	22.2	21.4	25.0	12.6

Slightly more than half (55.6%) of the ASD and AFOTEC respondents indicated that they provided assistance in the selection of parameters and/or values to the developers of RCMs and BCMs. Conversely, the using commands indicated that a fairly high number of personnel (77.4%) were "currently" involved in the development of requirements for RCMs. This figure would have been slightly higher had the word "currently" been omitted; some of the responses counted as "not involved" were stated as "not currently." This figure indicates that a large number of the personnel had some exposure to the RCM in the conduct of their work, despite the fact that a relatively large number of the personnel had less than two years of experience in their current organization.

The final question for the using command personnel asked them to identify from whom they sought assistance when developing requirements documents. The responses generally included various using command staff offices, product division engineering offices, operational testers, and operating units. On the other hand, comments about the coordination process ranged from "poor response" to "more help than I need." The responses for this question are provided in Appendix H.

Categorization Questions. The second part of the questionnaire contained only opinion questions and consisted of a list of fifteen parameters and their associated values as would be found in a typical RCM or BCM. Respondents were asked to categorize each parameter and its associated value as a requirement (R), specification (S), both a requirement and a specification (B), or neither a requirement nor a specification (N). These items were selected from actual RCMs and BCMs for aeronautical programs managed at ASD. The parameters were taken from the RCMs/BCMs exactly as they appeared, while the values were changed slightly to protect any sensitive information about the programs. Figures 3, 4, 5, and 6 show the relative frequency histograms of the categorizations of the parameters and values given for Part II of the questionnaire for all of the respondents. Appendix I shows the responses in tables of percentages. The relative frequency histograms in figures 3, 4 , 5, and 6 were prepared using the Quattro Pro spreadsheet program (25).

Appendix J shows the categorizations of the parameters and values in Part II of the questionnaire for the respondents grouped by aeronautical rating. The percentages in these tables were calculated based on the aeronautical rating alone. Similarly, the responses are shown as percentages for each organization in Appendix K and for the three experience level groups in Appendix L.

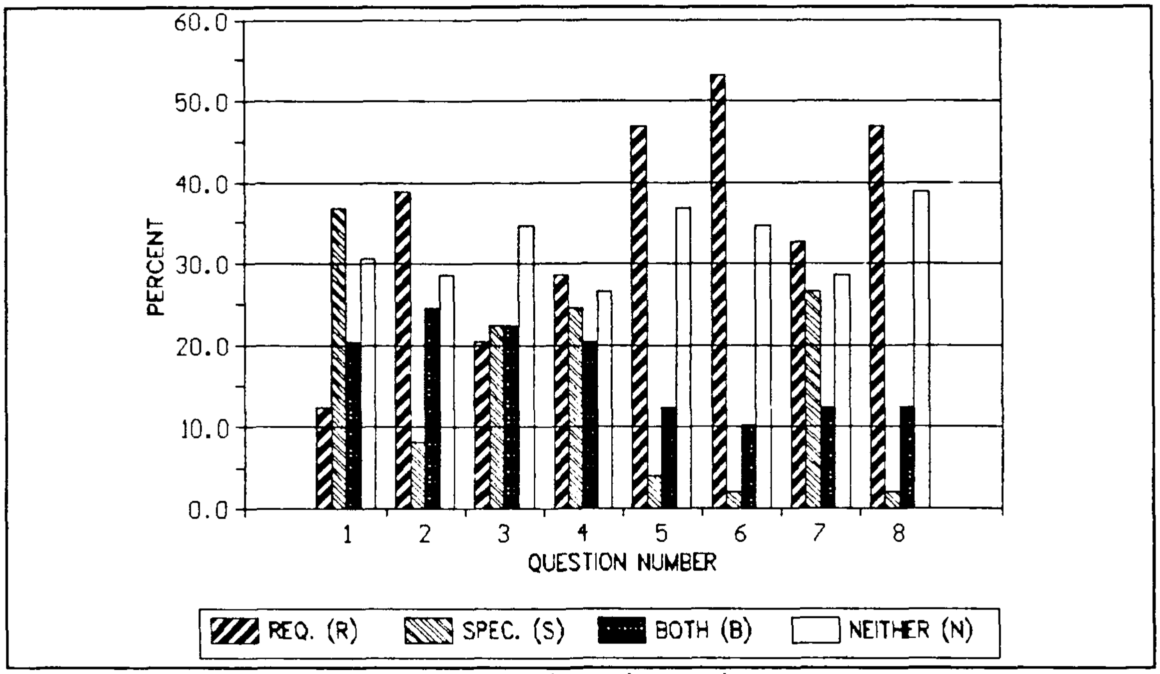

Figure 3. Parameter Categorization Histogram for Questions 1 to 8

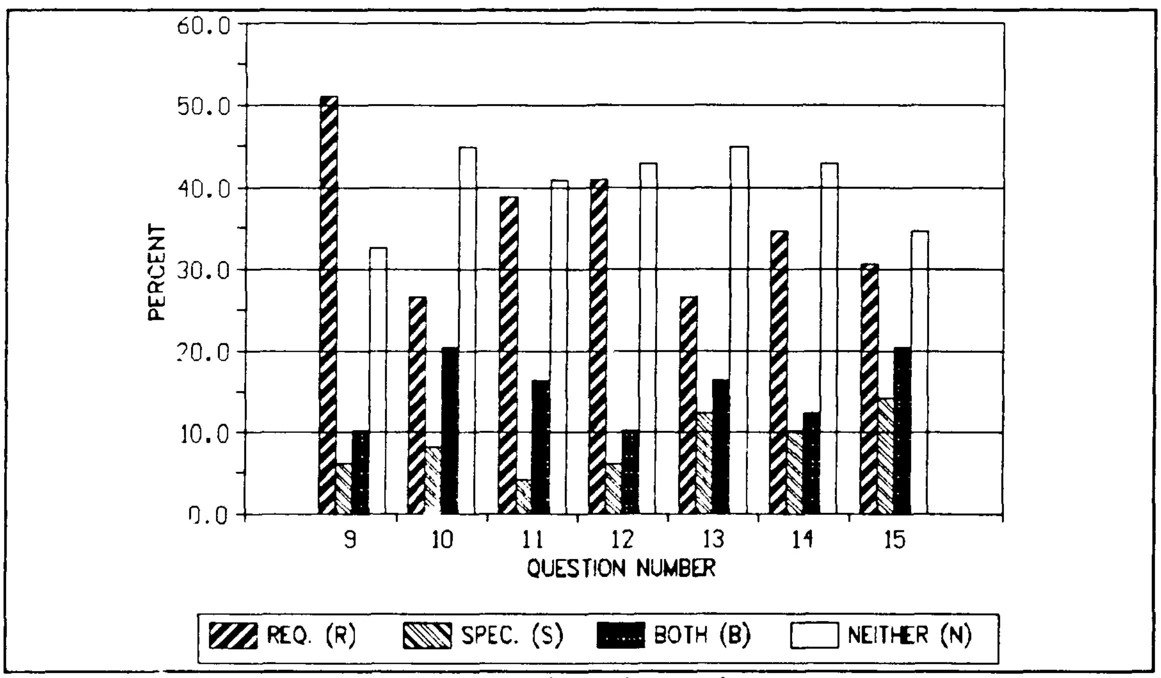

Figure 4. Parameter Categorization Histogram for Questions 9 to 15

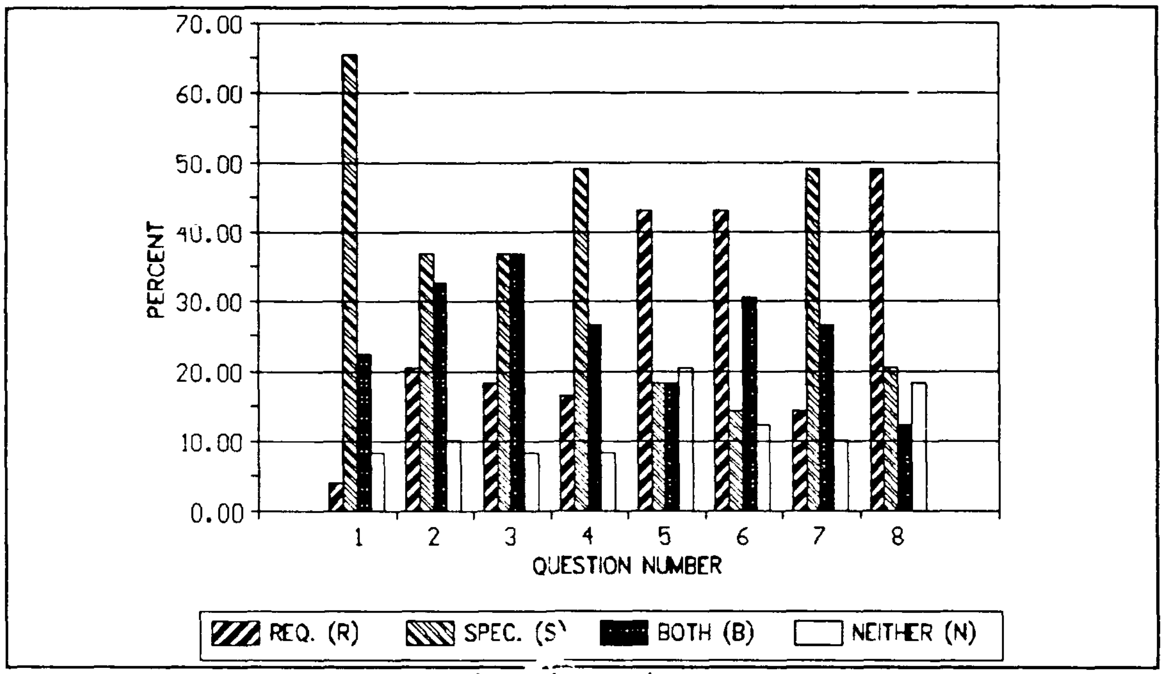

Figure 5. Value Categorization Histogram for Questions 1 to 8

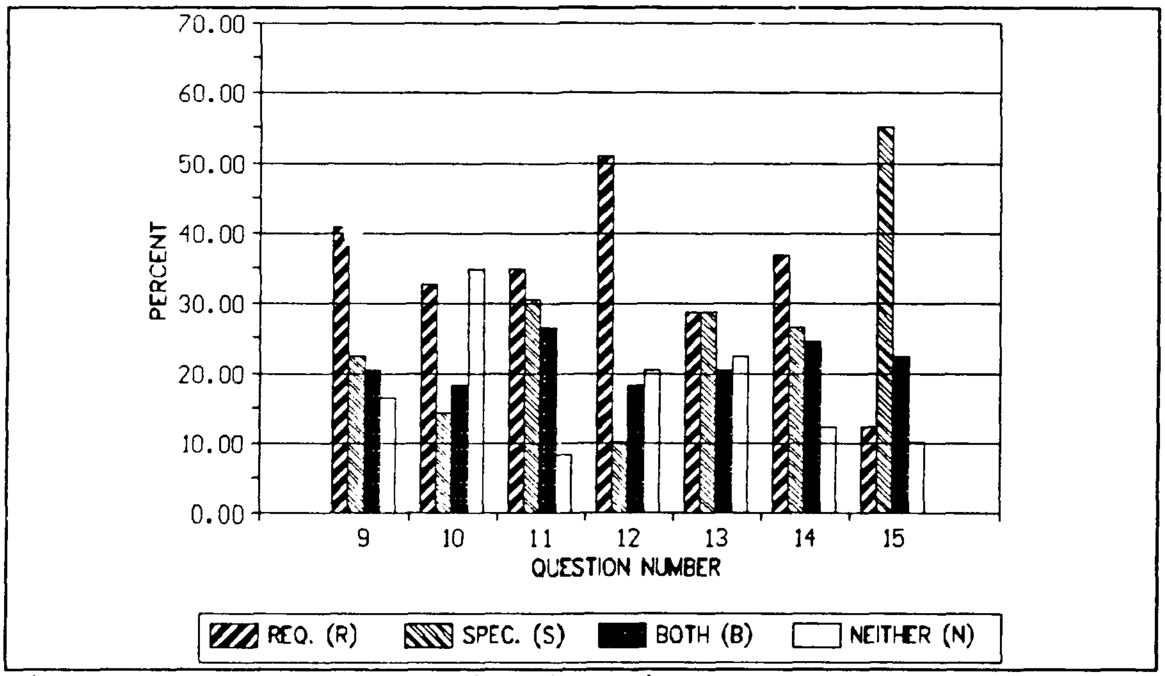

Figure 6. Value Categorization Histogram for Questions 9 to 15

The results for the independence test for categorizations grouped by aeronautical rating are presented in Table 8. At the level of significance, alpha = .05, the critical value of the test statistic used in the decision rule was 7.779 and was obtained from a table of Chi-squared critical values (16:636). The test for each question resulted in accepting the null hypothesis and indicates that there is not a significant difference in the categorizations by the rated and non-rated respondents.

TABLE 8

Independence Test Results of Categorizations by Aeronautical Rating

Question	X^2, Parameters	X^2, Values
1	.244	2.370
2	.982	2.895
3	1.434	1.509
4	3.622	.731
5	1.934	3.212
6	2.139	2.774
7	2.534	.275
8	1.781	2.268
9	1.905	.481
10	2.449	.135
11	5.090	.835
12	1.148	3.298
13	2.240	2.534
14	3.477	2.738
15	7.107	5.120

The results for the independence test for categorizations grouped by organization type are presented in Table 9. At the level of significance, alpha = .05, the critical value of the test statistic used in the decision rule was 12.592

and was obtained from a table of Chi-squared critical values (16:636). The test for each question resulted in rejecting the null hypothesis for the parameter categorization of question 3 and the value categorization of question 11. The remaining 28 tests resulted in accepting the null hypothesis, which indicates that there was not a significant difference in the categorizations by the respondents when grouped by organization.

TABLE 9

Independence Test Results of Categorizations by Organization

Question	X^2, Parameters	X^2, Values
1	6.378	3.530
2	6.377	1.227
3	20.790	6.368
4	6.512	8.638
5	3.859	7.144
6	9.202	5.308
7	7.544	9.075
8	10.741	4.210
9	11.642	8.655
10	3.974	7.399
11	2.858	14.147
12	8.813	3.858
13	5.142	2.539
14	9.072	4.667
15	5.604	3.252

The results for the independence test for categorizations grouped by their experience level in their current organization are presented in Table 10. At the level of significance, alpha = .05, the critical value of the test statistic used in the decision rule was 12.592 and was obtained from a table of Chi-squared critical values (16:636). The test for each question resulted in rejecting the null hypothesis for the value categorizations of questions 2, 11, and 15. The tests for these three questions resulted in rejecting the null hypothesis which indicates that there is a significant difference in the categorizations when grouped by the respondents' experience level in their current organization. The remaining 27 tests resulted in accepting the null hypothesis which indicates that there is not a significant difference in the categorizations when grouped by the respondents' experience level in their current organization.

TABLE 10

Independence Test Results of
Categorizations by Experience Level

Question	X^2, Parameters	X^2, Values
1	7.050	12.369
2	2.074	18.530
3	2.939	11.016
4	4.641	10.693
5	2.869	6.533
6	1.644	8.340
7	1.856	8.227
8	1.428	9.669
9	3.940	7.305
10	4.051	7.376
11	1.968	16.717
12	3.515	5.547
13	3.249	8.404
14	5.079	11.662
15	1.639	13.184

The results of Part II of the questionnaire generally indicated that there was no consensus as to how a parameter or a value should be categorized. The parameter categorizations were consistently ranked as neither a requirement nor a specification by 26 to 45 percent of the respondents. Although all of the parameters are "user requirements," each of the 15 parameters was categorized as a requirement by an average of only 35% of the responses. In general, the respondents (regardless of aeronautical rating, organization, and experience level) believed the parameters were neither requirements nor specifications.

The opinion on the categorizations of the values also indicated a general lack of consensus, although there was a greater tendency for the values to be termed a requirement, a specification, or both than to be termed neither. Many of the respondents who chose "both" indicated that the value was too constrained and therefore could be either a requirement or a specification.

<u>Summary</u>

The typical using command requirements personnel had at least ten years of Air Force experience, but less than two years of experience in their current organization. More than half of these personnel did not have an aeronautical rating, although they develop the requirements for aeronautical systems. The typical ASD advance planners also had at least ten years of Air Force experience and half had more than four years of experience in their current organization. Most of the ASD respondents did not have an aeronautical rating. The typical AFOTEC advance planners had at least ten years of Air Force experience, but less than three years of experience in their current organization. Most of the AFOTEC personnel had an aeronautical rating.

The lack of a clear understanding of parameters and values as requirements or specifications is evident in the second part of the study. In general, the respondents, regardless of aeronautical rating, organization, and experience level, were inconsistent with regard to the categorizations.

The implications of these findings and the answers to the original research objectives are provided in the next chapter.

V. Conclusions and Recommendations

Overview

The general question behind this thesis was "How can the acquisition process be improved?" The more specific question of this research was "What improvements can be made to better define and document the operational performance requirements associated with the acquisition of weapon systems?" To address this question, three research objectives were established. This chapter presents the conclusions to these research questions by addressing each of the three research objectives. Additionally, implications for managers are made based on the results of the research effort. Finally, recommendations for further study in this area are presented.

Research Objective One

Identify the important issues of the operational requirements definition process within the Air Force weapon systems acquisition lifecycle.

The using commands are required to conduct mission analyses on a continuing basis to make a determination of the capability of weapon systems to meet the projected threat. An operational deficiency occurs when the current weapon systems cannot meet this threat. This operational deficiency, or conversely operational need, must be documented in the Statement of Operational Need (SON). The key feature of the SON is that it states the operational performance capabilities that are required to meet the threat. The Requirements Correlation Matrix (RCM), which is a required attachment to the SON, provides a means for documenting the required operational performance features (parameters) as the "user's requirements." Like the SON, the RCM must state the user's requirements in operational terms. These requirements are then translated into system specifications and IOT&E evaluation criteria. The RCM identifies these three items in one document and thus provides a means for highlighting any disconnects that may occur between them. As was documented in the literature review, the interview with Major General Powell, and the lessons learned, the selection of user requirements plays a critical role in the success of the acquisition program. The RCM provides an excellent tool for focusing on the true requirements of the weapon system being procured.

Research Objective Two

Determine who selects the RCM/BCM parameters and the associated values which should identify the user's requirements, the contractual specifications, and the IOT&E criteria for the weapon system.

As directed by AFR 57-1, the RCM is written by the user and is included as an attachment to the SON. The using commands examined in this research effort (MAC, SAC, and TAC) each have an organization which is responsible for the identification of the operational requirements for new/modified weapon systems. They are:

1. HQ MAC/XR, Scott AFB, Illinois;
2. HQ SAC/XR, Offutt AFB, Nebraska; and
3. HQ TAC/XR, Langley AFB, Virginia.

The personnel from these organizations are responsible for the selection of parameters and the user's requirements for them. The personnel from the developing command (ASD) are responsible for translating the user's requirements into specifications to serve as guidelines for the manufacture of the solution by the contractor. Finally, the personnel from the operational test agency (AFOTEC) are responsible for developing IOT&E criteria which are used to determine if the solution meets the user's needs.

The personnel at these organizations tended to be higher ranking officers or non-commissioned officers. An implication of this is that these personnel have at least 10 years of Air Force experience. On the other hand, 50% of the respondents had less than two years of experience in their current organization. This disparity was especially noticeable when looking solely at the using command personnel, where 64.5% of the respondents had less than two years of experience in their current organization. The requirements personnel appear to be highly experienced in the broad sense, while only being moderately experienced in their current positions.

Additionally, slightly less than half of the respondents indicated that they had an aeronautical rating. One might expect that the personnel responsible for identifying operational requirements would have experience as an operator; however, that was not the case. Moreover, it may not need to be the case. This research found that rated officers did not categorize the parameters and values significantly different than non-rated personnel.

Research Objective Three

Determine if requirements personnel at using commands, the developing command, and the operational test agency have differing interpretations of both operational requirements and specifications.

The requirements personnel had different interpretations of an operational requirement and a specification, regardless of their organizational affiliation. There was no consensus in the categorizations of the parameters or the values in the second part of the questionnaire. For example, the parameters were more often categorized as neither a requirement nor a specification, than as either a requirement or a specification or both. All of the parameters should have been identified as requirements because, by definition, they are "user requirements." However, in general they were categorized as a requirement 35% of the time, and in no case was it by more than 54% of the respondents.

The definitions of a requirement provided by the respondents varied greatly but could be classified into a hierarchy of three distinct levels:

1. an operational characteristic of a system;
2. a system that will meet an operational deficiency;
3. a mission capability.

AFOTEC respondents identified a requirement primarily on the most specific level, as an operational characteristic of a system. The ASD and using command responses varied among the three levels. In the context of systems acquisition, none of these definitions are wrong; however, in the context of the RCM/BCM, the first level seems to be the most appropriate.

The definitions of a specification were much more consistent. Most of the definitions tended to include design, functional, and performance characteristics as essential elements of a specification.

The selection of parameters has a tremendous impact on the rest of the matrix. The values (either requirements, specifications, or IOT&E criteria) in the RCM/BCM are only criteria associated with a parameter. Because of the different interpretations of a requirement and a specification, and the lack of clear and consistent definitions, the validity of the parameters and the utility of the values in the RCM/BCM need to be questioned.

The specific question of this research was "What improvements can be made to better define and document the operational performance requirements associated with the acquisition of weapon systems?" The discussion of the three research objectives indicate that there are problems in the process and that improvements can be made. Based on the findings of this research, three implications for managers have been identified.

Implications for Managers

1. The organizations responsible for the development of requirements for RCMs and BCMs must have personnel who understand the implications of the selection of parameters for the weapon system. The parameters should encompass the essential characteristics of the system and must accurately reflect the user's requirements.

2. More acquisition training is required for the requirements personnel, especially for those in the using commands. The majority of the respondents (67.1%) identified that they formed their definitions of a requirement and a specification primarily from personal experience. PCE classes, from which Air Force personnel receive most of their formal Air Force education in acquisition, was cited by approximately 19 percent of the respondents as the source. The final category, "other," which included regulations and directives, was identified by approximately 14 percent of the respondents. The low

response for PCE classes had two possible explanations. The first explanation might be that PCE classes were not available to the personnel and therefore they learned their duties through "on-the-job training." This is a distinct possibility given the relatively limited availability of the classes. The second explanation could be that PCE classes were available but an in-depth discussion of RCMs, requirements, and specifications was not included. A formal course should be developed which includes material on the requirements process beginning with the identification of an operational need to the fielding of the system. The course should focus on the importance of the user's role in the systems acquisition lifecycle.

3. A formal review of the requirements at the general officer level should be conducted for major systems. General Powell believes that the failure of senior officers to prioritize requirements has been one of the greatest past weaknesses of the requirements process. This review is essential to ensuring that the system requirements are truly mission essential and do not include "nice-to-have" items.

Further Study

This research effort has addressed only a small portion of the requirements process, specifically the RCM and BCM. The following suggestions are presented in the hope that future research will be accomplished in this area.

1. The acquisition process was undergoing significant revisions while this research was being conducted. The governing directive for the acquisition process, DODD 5000.1, was undergoing a complete rewrite, the purpose of which was to consolidate the vast number of acquisition regulations that had existed and incorporate changes to the acquisition process. An examination of these changes to the acquisition process that result from this revision should be conducted to analyze the impacts to the requirements process.

2. A study involving a larger sample from AFOTEC and ASD would help guard against a bias towards the using commands. Individuals from the AFOTEC Test and Evaluation directorate and the ASD SPOs would be appropriate inclusions.

3. Part II of the questionnaire consisted of a list of fifteen parameters and one of their associated values (requirement or specification). These parameters and values were randomly selected from actual RCMs and/or BCMs; no criteria were used to select the items. As a result, inappropriate examples may have been included in the questionnaire. A questionnaire, similar to Part II, using carefully selected parameters and values might provide clearer insight into the categorizations.

Collectively, the knowledge gained from these efforts could go a long way to improve the identification and documentation of requirements in the RCM/BCM. Improvements in the RCM/BCM process will have a direct effect on the military utility of weapon systems acquired by the DOD.

Appendix A: Interview, Major General Cecil W. Powell, AFOTEC/CC, 18 January 1990

1. What have been the greatest past weaknesses of the requirements process?

Basically, there have been two weaknesses in the past that have driven the results of our requirements process.

The first, although it recently is changing, has been the failure of senior officers to take appropriate action on requirements generated by their subordinate levels of command. That is, they failed to review those requirements to establish either their feasibility or priority. The problem was that the requirements process was not very disciplined. Action officers were asked to assemble lists of requirements without any type of restrictions levied on them. So, they've been listing every possible item they thought somebody might want as part of a new system. The "nice-to-have" articles were intermingled with mission essential elements and there was never any discrimination of what was most important to what was least impc :tant. As I mentioned earlier, this particular aspect of the requirements process has radically changed recently because of the Chief of Staff's concern that this failure to prioritize results in a tremendous price tag. For example, we could be buying a solid gold Cadillac, when what we really need is a very efficient Ford Escort. Hopefully, that's behind us. But unless the four-star level continues to oversee the results of the initial requirements process to ensure this prioritization occurs, I believe we'll slip right back into the quagmire we were in before.

The second aspect of the requirements process that continually requires attention is the need to ensure that what is stated as an operational requirement is not just a direct quotation from a specification. Too frequently, specifications are only piece-part statements. Dictating that a subcomponent meets a certain mean time between critical failures rate as a "requirement" , is micromanaging and doesn't adequately address the mission requirements. Requirements should be stated in macro terms and be more mission oriented.

These deficiencies that I've talked about have been around for a long time, partly because it's difficult to do what I've suggested. You know it's easy to say what's wrong with a process, but successfully changing it is a tremendous challenge. And, I'm not sure if we'll be able to meet that kind of a challenge.

2. How has AFOTEC and the OT&E community responded to inadequate or questionable user requirements in the past?

They've done two things sequentially. First, they filled the void. If a requirement was missing in an area in which AFOTEC felt there should be one, they created the requirement and then tested to it. This was common until about two years ago when at that time, AFOTEC decided it was inappropriate for them to do that. While AFOTEC's practice of filling in the blanks may have improved the requirements development of the system, it went against the process of developing a system's requirements because AFOTEC isn't in the business of setting requirements. AFOTEC then took a new approach and decided they wouldn't test to anything if a requirement wasn't stated. Our objective was to force the user to come to grips with the fact that his requirements process was deficient. Some good examples include the B-2, C-17 and MARK XV. These programs had to revise their requirements because AFOTEC refused to accept holes where requirements should have been and requirements that were expressed inappropriately.

3. What impact have the BCM and RCM had on the definition of user requirements?

Although the BCM focused on the fact that frequently there were no requirements identified in areas that were critical to mission accomplishment, its initial impact was that it drove the users into becoming more micro in stating subcomponent capabilities as requirements. They simply looked at the specifications in the contract and used them to fill in the blanks in the BCM. Even though the BCM focused on the problem, the user responded from the wrong perspective. However, I think the RCM is headed in the right direction. It focuses on the fact that there were inadequacies in the requirements process and provides for more aggregation of the pertinent operational aspects of the system. The RCM is a tool that can help the user look at requirements from the right perspective. But the jury's still out because we haven't had that many programs work through the RCM process and come out with anything that looks different from the BCM. So right now, the RCM is the BCM renamed, and it'll take some time to see if anyone takes advantage of this new tool.

4. Is OSD's Systems Maturity Matrix a useful tool?

In a non-politicized world it would be a useful tool. But in a politicized world where OSD works, it has the potential to be more destructive rather than constructive.

Specifically, the maturity matrix was envisioned as a kind of PERT process that indicated the amount of testing that should be accomplished by a certain point in time, based on how many test articles were available and the planned test rate. It measures the progress of the testing. The problem, however, is that people also want it to measure how well the system is meeting the user's requirements. They also want it to predict how the system will ultimately perform, based on its present performance. That wasn't the intent; and, the SMM won't give you that type of information. It's just an inventory of test accomplishments. AFOTEC has not yet been forced to use the SMM because it hasn't been formalized. I'd like to see the demise of the SMM as a tool because it won't meet people's expectations.

5. Did the revision of AFR 57-1 in 1987-88 lead to any other improvements?

I don't know. The process is still working through its first cycle and I'm not sure if there will be any side benefits other than those envisioned to result from the revision.

6. Has the change in operational test reporting (meets or does not meet user requirements) had an impact on the definition of requirements?

Yes, it's had an impact on what things are now called "requirements". It helps us delineate between what information is actually required and what is information I would like to know. For years, users have asked us, as part of our test process, to accumulate information that will allow us to make a statement about such things as the adequacy of the training syllabus. That type of information, until recently, has been listed as a "requirement", because we've been very loose in our use of the word. Now, although we tell the user whether we think the syllabus is adequate to meet their needs, we don't formally address whether the training capability associated with the system meets or does not meet user requirements because we don't list training as a contractual "requirement" anymore. That way, it doesn't show up in Washington as a failure to meet requirements, although it essentially is.

The other aspect, which is perhaps the single most important thing we've learned, concerns the reporting process. When someone uses terms that are subjective rather than qualitative, he injects his own biases in the evaluation and his position becomes indefensible. Your position is much more defensible when you use a yardstick called "user requirements", and those user requirements fall someplace on that scale when measured by that yardstick. It's very difficult to argue with specifics. Additionally, it's best to avoid using terminology with a subjective component like "unsatisfactory", because these types of requirements being evaluated are generally not immutable absolutes. Then, when someone says that falling this far below meeting the requirement is unsatisfactory, he's made a preemptive statement and made defacto the decision. Especially, if he's in Washington, where people fasten on to words like that and stop all thought processes after hearing "unsatisfactory". Perhaps that measurement was not really unsatisfactory, but just didn't meet the requirement originally established. But, by using inappropriate evaluation terminology, he preempted the decision process. Someone outside of AFOTEC should determine if the lower measurement is a good enough requirement. That is what we're striving toward.

7. What other AFOTEC initiatives have helped improve the process?

We do much more extensive early planning so that we have carefully matched our test scenarios with the operational concept and associated requirements to be tested. This prevents us from using too many TBDs right up until execution time and winging the test activities.

8. What changes in requirements policy have come out of the recent "summit meetings" on major programs such as the B-1, B-2 and C-17?

I don't think there's been any change in policy published and I don't know if there will be. I suspect that if there is a policy change, it'll be an institutionalization of the four-star review of these programs. As of yet, however, there hasn't been a specific, formalized policy change.

9. Do you think the Defense Management Review (DMR) will result in further changes?

Yes, but none of them are relevant to the questions at hand. The DMR is an attempt to cut fat from the management structure and eliminate duplicative activities. Unfortunately, it's so highly publicized that no one knows what the outcome will be. But I don't think it's applicable to the requirements process.

10. Will the shrinking defense budget affect the requirements process?

Not in the context of changing the structure or development of requirements. But in a pragmatic sense, it will probably force people to be very incisive about what they're calling a requirement as opposed to developing a long shopping list. It's just one more pressure that says someone can't just list every possible thing he might want to have in a system and call it a requirement.

11. Will the DMR put even more emphasis on OT&E?

I do not think the size of the budget will have any effect on whether OT&E receives emphasis or not. Sadly enough, what has increased emphasis on OT&E is the fact that the OT&E agencies are independent of the major commands. I think that is an unfortunate reason to focus on OT&E. It implies that everyone in your command, the user commands, or anybody else who is subject to some supervision below the Chief of Staff level, does not have any integrity. It implies that because someone is concerned about being promoted, he will say whatever the program manager instructs him to say. Unfortunately, he is not acting under the pretext of being a good soldier and following orders; he is suppressing information that will make the program look bad. And nobody wants to do that. There is always some of that in any endeavor, but we do not have fifty thousand people in the acquisition process who are a bunch of lying, cheating, spineless, self-aggrandizing individuals. But, because the OT&E agencies are independent of everyone except the CNO and Chiefs of Staff of the Army and Air Force, they are supposed to be more honest. I think it is a damn shame, but that is the way it is. So, the budget size will not impact OT&E.

12. How has congressional interest/oversight most affected OT&E? . quirements?

Congress believes contractors, if left to their own devices, will unduly influence the acquisition process in favor of their product. But the repugnance with which Congress views contractor involvement in the process has been taken to an extreme, because Congress claims any contractor association with operational test automatically provides this unwarranted influence. What this has done to OT&E for Air Force systems, which tend to be much more technically complex than systems for the other services, is force us to violate the letter of the law. Why? Because until you have all the components of a major weapon system, such as the special test equipment which is delivered after the vehicle is developed, all the bombs to be used and validated and verified technical orders, you can't adequately test the system. It is totally unreasonable to expect to have all of those things prior to setting up the full production line. So then, we are caught in a terrible dilemma due to Congressional stricture of contractor involvement. We have handled this by saying we are meeting the spirit of the law because we do not allow the contractors any place at the table during the evaluation process. But sometimes, we use contractor models because it would cost tens of millions of dollars to establish the same model; we use their data collectors on occasion; and, we use some of their data collection systems as well. As a result, we are violating the letter of the law, but as long as we do not allow the contractors to participate in the evaluation process, we maintain that we have kept sacrosanct the spirit of the law.

13. If you were sitting on this side of the table, are there any other questions you would ask the AFOTEC commander?

I would ask, "What is the greatest challenge you face in operational testing." Discounting politics, which we can do fairly easily because we are insulated by the current Chief of Staff, the greatest challenge we face is being able to create and maintain for the duration of the test, a credible facsimile of a realistic, operational environment. The reason is twofold. First, the instrumentation requirements are expensive and must be non-intrusive on the outcome of the test. Second, and more importantly, testing against existing threats, much less against a postulated capability that does not yet exist, is a very expensive proposition. Unless our country can do a better job of obtaining those threats that exist, we will not be able to adequately address operational realism. Building surrogates is horrendously expensive, is very time consuming, and frequently is not effective.

Final thoughts:

If the need expressed for a system dictates a new invention, it, by definition, can not be a requirement for that system. If someone makes so many requirements for a system such that something new must be invented, he's built in automatic failures because no one knows how the system works. Requirements must be technically achievable at the time we embark on the development of the system. Anything beyond that falls into the experimental research category and should not be associated with that particular acquisition. This may seem like a subtle point or a play on words, but it is not. It is a very profound issue. If a particular capability has been specified as a requirement, but cannot be technically accomplished, it is no longer a requirement. There is a difference between what someone says they need and what they're requiring of a particular system. Needs and requirements are not synonymous, even though they're frequently translated that way.

Interview conducted by: Captain David Struck, AFIT/LSG
Mr. Lawrence Benson, AFOTEC/RS

Appendix B: Lessons Learned

USAF Lessons Learned Impact Areas

1. Computer Resources (Support)
2. Energy Management
3. Engineering Data (Technical Data)
4. Facilities
5. Funding (Logistics)
6. Logistics Management Information Support
7. Maintainability
8. Maintenance Concept (Planning)
9. Modification Planning
10. Manpower Requirements
11. Reliability
12. Reliability & Maintainability
13. Safety
14. Supply Support
15. Support Equipment
16. Survivability
17. Technical Orders (Technical Data)
18. Test and Evaluation
19. Transportation Packaging and Handling
20. Training and Training Support
21. Artificial Intelligence
22. Propulsion Systems
23. Systems Integration (Hardware)
24. Systems Integration (Software)
25. Software
26. Software Management
27. Configuration Management
28. Contract Administration
29. Contracting
30. Data Management
31. Engineering
32. Foreign Military Sales
33. Human Factors Engineering
34. Life Cycle Cost
35. Manufacturing
36. Operational Requirements
37. Program Control
38. Quality Assurance
39. Source Selection
40. Program Management Responsibility Transfer
41. Logistics Support Analysis
42. Program Management
43. Environmental Management
44. Warranties
45. Hazardous Materials
46. Automated Information Systems

47. Total Quality Management (TQM)
48. Personnel
49. Operations

USAF Lessons Learned Abstract

CALL NUMBER: 2109 VALIDATOR: AFALC/ERRT/SCHUCK

TOPIC: EFFECTIVE TEST PLANNING (REQUIREMENTS CORRELATION MATRIX)

LESSON LEARNED: Test program objectives must be correlated to either operational or clearly defined developmental requirements. Failure to do so will result in test time devoted towards objectives which serve no useful purpose.

OT&E LESSONS LEARNED REPORT

PROGRAM NAME/TYPE OF TEST: AUTOMATED REMOTE TRACKING STATION (ARTS)/IOT&E

PHASE OF TEST DURING WHICH LESSON WAS LEARNED: TEST EXECUTION

DATE: 16 AUG 1989 AFOTEC-LL-89-319

OFFICIAL/OFFICE SUBMITTING REPORT: AFOTEC - DET 4

FOCUS OF LESSON LEARNED: MANAGEMENT

TOPIC OF LESSON: BASELINE CORRELATION MATRIX (BCM) REQUIREMENTS PROCESS

LESSON: Don't rush the BCM process just to get the test underway; the results are poorly defined and/or inappropriate user requirements and test criteria.

DISCUSSION: The BCM for the ARTS Acquisition I test program was apparently worked in a hurry to support the IOT&E schedule. Throughout the test program, various members of the ARTS community held different interpretations of the user's requirements and, therefore, the IOT&E test criteria, as well.

For example, the user's requirement for "mission success rate" was identified in the BCM as a mature requirement; however, "mature" was not defined until the Test and Evaluation Master Plan (TEMP) was approved, which was virtually at the end of the test program. The term "mature" was defined as one year after IOT&E, with no threshold provided for IOT&E. Therefore, by definition, we never tested against the user's actual requirement. As a testimony to the validity or importance of this requirement, we were not asked to take advantage of the one opportunity we had to evaluate a "mature" capability.

Also, once the BCM was signed it was as if it were in concrete. Although it was obvious that there were problems with the interpretations of the user's requirements, there was a reluctance to bring up the subject "because changes would have to be staffed back up to the generals, and that took time, and we didn't have the time."

SOLUTION: Either start the BCM process earlier or postpone testing.

Appendix C: Cover Letter for Questionnaires

LSY

Research Questionnaire on Requirements

1. You have been selected to participate in an Air Force research project which is important in the evaluation of Air Force weapon systems. The responses you give to the attached research questions will be used as a data source for determining the effectiveness of the Requirements Correlation Matrix (RCM) and Baseline Correlation Matrix (BCM). Since you are a key player in the identification of the parameters and values contained in these documents, your input is extremely valuable.

2. Please take a few minutes to provide this important information. Please answer each question as accurately and truthfully as possible. All responses will be held confidential, and no attempt will be made to match any specific individual with specific responses. Of course, your participation is strictly voluntary.

3. Please return your completed questionnaire (through distribution) in the envelope provided within one week of receipt. Any questions concerning this questionnaire should be directed to Captain Dave Struck, AFIT/LSG, AUTOVON 785-8989. Your help in this important project is greatly appreciated.

JOHN DUMOND, Lt Col, USAF
Head, Department of System
  Acquisition Management
School of Systems and Logistics

2 Atch
1. Questionnaire
2. Return Envelope

Appendix D: Questionnaire Part I

Part I of AFOTEC Questionnaire

RESEARCH QUESTIONNAIRE ON
AIR FORCE REQUIREMENTS

The following research questionnaire has been developed to solicit information on Air Force requirements as stated in a Requirements Correlation Matrix (RCM) or Baseline Correlation Matrix (BCM). Your inputs will be included in an AFIT thesis which will examine the effectiveness of the RCM and BCM.

Your participation in this research effort is voluntary and anonymous; however, your cooperation is appreciated and will directly impact this research effort.

PART I

INSTRUCTIONS

Please provide answers to the following questions in the space provided. Your answers should be complete but concise; however, feel free to include any additional information that you feel is relevant. If you need more space to answer a question, continue on the reverse side of the page on which the question is found. If you have any additional comments after completing this questionnaire, please write them on the back of the last page of the questionnaire.

1. What is your current AFSC and rank/grade? Are you rated?

2. What is your present position title and what duties (briefly) does this position entail?

3. How long have you been assigned to the AFOTEC Plans and Policy Directorate?

4. What were your previous assignments (identify base, Command, organization, length of tour, and AFSC for each position held) and what type of duties did you perform?

5. How do you define a requirement?

6. How do you define a specification?

7. What do you use as a basis for these definitions (PCE classes, personal experience, etc)? Be specific.

8. Do you provide assistance in the selection of parameters and/or values to the developers of SONs, SORDs, or RCM/BCMs? If yes, what level of involvement do you have?

Part I of Using Command Questionnaire

RESEARCH QUESTIONNAIRE ON AIR FORCE REQUIREMENTS

The following research questionnaire has been developed to solicit information on Air Force requirements as stated in a Requirements Correlation Matrix (RCM) or Baseline Correlation Matrix (BCM). Your inputs will be included in an AFIT thesis which will examine the effectiveness of the RCM and BCM.

Your participation in this research effort is voluntary and anonymous; however, your cooperation is appreciated and will directly impact this research effort.

PART I

INSTRUCTIONS

Please provide answers to the following questions in the space provided. Your answers should be complete but concise; however, feel free to include any additional information that you feel is relevant. If you need more space to answer a question, continue on the reverse side of the page on which the question is found. If you have any additional comments after completing this questionnaire, please write them on the back of the last page of the questionnaire.

1. What is your current AFSC and rank/grade? Are you rated?

2. What is your present position title and what duties (briefly) does this position entail?

3. How long have you been assigned to the DCS/Requirements?

4. What were your previous assignments (identify base, Command, organization, length of tour, and AFSC for each position held) and what type of duties did you perform?

5. How do you define a requirement?

6. How do you define a specification?

7. What do you use as a basis for these definitions (PCE classes, personal experience, etc)? Be specific.

8. Are you currently involved in the development of requirements for SONs, SORDs, or RCM/BCMs?

9. If the answer to the previous question was yes, do you seek assistance from individuals or organizations outside of your office? If so, from whom?

Part I of ASD Questionnaire

RESEARCH QUESTIONNAIRE ON AIR FORCE REQUIREMENTS

The following research questionnaire has been developed to solicit information on Air Force requirements as stated in a Requirements Correlation Matrix (RCM) or Baseline Correlation Matrix (BCM). Your inputs will be included in an AFIT thesis which will examine the effectiveness of the RCM and BCM.

Your participation in this research effort is voluntary and anonymous; however, your cooperation is appreciated and will directly impact this research effort.

PART I

INSTRUCTIONS

Please provide answers to the following questions in the space provided. Your answers should be complete but concise; however, feel free to include any additional information that you feel is relevant. If you need more space to answer a question, continue on the reverse side of the page on which the question is found. If you have any additional comments after completing this questionnaire, please write them on the back of the last page of the questionnaire.

1. What is your current AFSC and rank/grade? Are you rated?

2. What is your present position title and what duties (briefly) does this position entail?

3. How long have you been assigned to the ASD Deputy for Development Planning?

4. What were your previous assignments (identify base, Command, organization, length of tour, and AFSC for each position held) and what type of duties did you perform?

5. How do you define a requirement?

6. How do you define a specification?

7. What do you use as a basis for these definitions (PCE classes, personal experience, etc)? Be specific.

8. Do you provide assistance in the selection of parameters and/or values to the developers of RCM/BCMs? If yes, what level of involvement do you have?

Appendix E: Questionnaire Part II

PART II

INSTRUCTIONS: The following list consists of typical parameters and values found in various published RCMs and BCMs. Please use the following categories to classify **both** the parameter and value of each item on the list:

Requirement (R)
Specification (S)
Both a requirement and a specification (B)
Neither a requirement nor a specification (N)

Any comments pertaining to the parameters or values shown should be written directly beneath the item. If additional space is needed, continue on the back side of the page.

PARAMETER	CAT.	VALUE	CAT.
1. Missile length		175 inches	
2. Mean time between maintenance actions (MTBMA), Type 1		3.0 hours MTBF	
3. Speed at sea level		600 KTAS	
4. Takeoff distance 450,000 lb GW		9,100 feet	
5. Threat/systems survivability		Highest practical level of protection against 12.7 mm armor piercing incendiary	
6. Sortie generation rate (peacetime)		1.05	

PARAMETER	CAT.	VALUE	CAT.
7. Cruise speed/initial cruise altitude		.87 mach/ 25,500 ft	
8. A/A weapons employment, AIM-9		AIM-9 can be employed to full a/c limits	
9. Conventional weapon delivery--laser guided bomb		60% delivery success rate	
10. Takeoff/landing performance		Takeoff in 75% of available runway	
11. Ferry range		3500 nm	
12. A/A weapons employment, AIM-9		A/C system supports employment of AIM-9	
13. Break rate		Maximum 14.3% of sorties	
14. Useful life		18 years	
15. Radar A/G resolution		13 ft out to 20 NM	

Please return the completed questionnaire in the attached envelope. Thank you for your participation.

Appendix F: Responses to Question 5

How do you define a requirement?

AFOTEC:

1. System-specific operational capability necessary to satisfy an operational mission deficiency.

2. A characteristic or function that must be obtained to accomplish a specific mission.

3. Those elements essential to successfully improving and completing the mission.

4. An outcome which must be accomplished in order to successfully carry out the designated mission.

5. The desired characteristics of a new/improved system.

6. The need that must be met, given a set of conditions.

7. A mission a system must perform or a capability it must have.

MAC:

1. A general statement (qualitative or quantitative) of a needed capability.

2. A need for something new.

3. In the acquisition process, a requirement is usually thought of as expressing a using command's need. That need or requirement could be the result of a deficiency in a current system, a changing threat, or an application of new technology to provide operational requirements.

4. A requirement is usually spelled out in a SON and further defined in a SORD. It states the user's needs and continues throughout the acquisition process. The key word is need.

5. A need, necessity which is indispensable to meeting the mission of the weapon system.

6. A requirement defines a user need that must be met in order for the "thing" being acquired to perform its intended mission. A requirement should be written in operational terms.

7. Contained in SORD/SOC. Tested in IOT&E, QOT&E. What the user needs to go to war broken down into operational effectiveness and suitability issues by critical issues, objectives, MOE, and evaluation criteria.

8. A need.

9. The end user's operational need.

SAC:

1. A need written in operational terms which can be evaluated/confirmed.

2. Widget needed to improve the warfighting capability, maintainability or reliability of a system or new capability.

3. Requirement is a need or a "must have."

4. Requirement is a needed capability (needed to accomplish assigned military mission). It is the result of an identified shortfall which can not be resolved by a change in strategy, tactics, doctrine, or training.

5. A mission capability.

6. A need established by the user and coordinated with an analysis of the threat.

7. Requirement is a definition of a user need (i.e., need is met by satisfaction of requirements). Requirement further defined by a derived requirement (i.e., derived requirement further defines the general requirement) more specific.

8. A need or necessity which must be satisfied in order to fulfill a condition.

9. What is necessary to accomplish stated needs.

10. A statement of what must be done. Should not say how it must be done. May be general or specific. Typically, prepared by a user prior to contracting stage of procurement process. A requirement becomes a goal when it exceeds minimum capability for mission.

11. Formalization and validation of a mission need generated by the operational community.

12. Analysis of changing threat, or change in tactics or mission, technological obsolescence, unsupportability problems, reduced reliability of the system. May be surfaced through material improvement (MIP) from the field or depot, or a recurring problem surfaced from an operator.

13. A requirement is the iterative statement that develops from a basic deficiency in capability. Stated in operational terms, a need is refined through a disciplined process of review and evaluation to state the data on which a solution can be based. Technological opportunity may also generate a requirement.

14. A requirement represents the translation of an operational need into characteristics that the system must have for the intended mission. The operational need is derived from employment, logistic, manpower, and training constraints and opportunities associated with stated operational objectives and can be met through changes in tactics, strategy, doctrine, training, new development, new procurement, or upgrade of an existing system. In my opinion, the term "requirement" is the most abused term in the acquisition process. In AFR 57-1 and throughout the texts for Defense Systems Management College, there are operational, test, design, performance, system, item, input, functional, reporting, intelligence, and mission requirements. This term's overuse to describe the parameters, characteristics, design, plan, outcomes, standards, features, traits, components, elements, attributes, etc. of a system dilutes the significance of the operational need. The only relevant requirements are the operational needs of the warfighting commanders or the commanders supporting the warfighting commanders. These requirements can not always be quantified or measured (i.e., stop the advance of heavy armor, deny the use of forward operating locations, perform deep interdiction of critical transportation nodes, extend the life expectancy of crews in combat). Requirements are seldom precise and do not necessarily describe a particular solution

TAC:

1. Operators' needs to allow them to complete the mission.

2. An approved, recognized need for some capability.

3. What you need to do your mission.

4. A required (necessary) operational capability; major system (e.g. F-15E), sub-system (e.g. APG-70 radar).

5. An Air Force user operational need.

6. A requirement is a generic solution to an operational need, i.e., a night vision device which can detect and identify tanks.

7. When the operations community determines what it needs to do to counter threats; the equipment, software, systems, etc., that can accomplish that mission becomes a requirement.

ASD:

1. A mission capability, need-derived system-level capability.

2. Requirements are defined in terms of operational jobs that need to be accomplished. This needs to be described in means of operational measures (tons in a time period, size of vehicle transported, runway length restrictions).

3. An operational deficiency which can be met with a system solution. A requirement implies that the system solution is affordable, feasible, and can be built within a known schedule.

4. It is an expression of need by a using command for a new capability.

5. A need for a functional capability.

6. A requirement is a need established by the user. A requirement is necessary for the user to accomplish his mission.

7. Need to perform the user's mission and a force multiplier.

8. Requirements are essential needs and objectives to any concept that will yield a product or tangible service. Requirements are simply building blocks and foundations.

9. Something needed to perform a particular function.

10. System operational capability needed to fulfill an operational objective.

11. A military capability that is necessary to accomplish a defined mission.

12. A system that fulfills a user need or deficiency.

13. I have difficulties with the word "requirement." Basically, a requirement for new systems, or mods to existing systems, must be established by the combatant command (SAC, NORAD, USAFE, etc.) to support operational objectives (provide close air support, defeat enemy air attacks, etc.).

14. Established by using command to quantify need, often expressed as baseline and goal.

Appendix G: Responses to Question 6

How do you define a specification?

AFOTEC:

1. System specific design criteria specified in a contract which, if satisfied, should contribute to meeting a system's required operational capability.

2. A testable, verifiable characteristic or function contractually agreed to by buyer and contractor and derived from requirements.

3. Those elements that make up the engineering and design of a system to fulfill the developmental requirement.

4. A parameter, derived from operational requirements, delineating required system performance and which is contractually described and binding on both the government and the vendor (usually quantifiable).

5. A quantitative value used to define a contractual requirement.

6. A detailed requirement.

7. A contractual value from which an item can be built; a measure of a physical characteristic.

MAC:

1. A specific statement (qualitative or quantitative) of a needed capability that can be measured.

2. The things an item should conform to or do.

3. A specification is a contract document between the implementing command and contractor that spells out specifically the performance requirements (ops and maint) of the acquired system. It is derived from the using command's requirements documents and PMD.

4. A specification is basically a statement of particulars to identify exactly what/or how an item should look or work in terms of form, fit and function.

5. A spec or series of specs are technical requirements/sub-requirements normally accomplished within

the acquisition communities to meet validated user requirements.

6. A specification is a contractual parameter that the "thing" must meet. If the "thing" meets the specification, then the user's requirements should also be met.

7. Contained in spec/statement of work, tested in DT&E/QT&E; what the contractor must meet to get paid.

8. A description of a need.

9. That which should meet the requirement.

SAC:

1. A detailed task(s) which can be tested/evaluated.

2. The required documentation to ensure the requirement is met.

3. A detailed description of requirements.

4. Specification is a contractually binding performance level identified for various parameters of a solution for a validated requirement.

5. A performance requirement.

6. Supporting criteria within the requirement. The requirement specifies particular support items, e.g., a nuclear hardness criteria is a specification within a requirement for nuclear hardness.

7. Specification quantifies a requirement so that a contractor can build to spec thus fulfilling the requirement.

8. A definite and complete description of requirements in an organized fashion clearly stated.

9. Clear description of a certain item.

10. The translation of a requirement into a contract RFP/finalized contract. Must be specific and verifiable. A proper specification is not overly constrained, i.e., top speed greater than 600 knots vice top speed of 600 knots. Specifications may change during the course of an acquisition.

11. Detailed description of a system's dimensions, capabilities or composition.
12. We do not write specifications. We write requirements that come from field problems or future threats. The SPO or AFLC (ACC) turns our requirements into specifications and statements of work for contractual efforts.

13. Contractual measurement on which a deliverable item can be assessed. Spec is derived from requirement and must ensure that the basic need is met.

14. The distinction between a "requirement" and a "specification" is the degree of precision by which specifications describe a system. The term "requirement" has not been well defined within the acquisition process, however, the term "specification" has been strictly defined. Requirements from need statements are analyzed in the systems engineering process and translated into system and developmental specifications which ensure that requirements are properly stated and traceable within the configuration management process. Specifications are prepared to a standard format (Mil Std 490A) and terminology and establish requirements in terms of complete design details and performance. "General" specifications apply to all programs and incorporate many government standards which define items, approaches, procedures, or testing to be used in development and production processes. "Program-peculiar" are specifications that define unique mission needs.

TAC:

1. Weight, dimensions, capabilities.

2. The exact definition of the guidelines and/or limitations needed to describe/meet a requirement.

3. The parameters of what is needed to do the mission; shape, size, range, speed, etc.

4. An ingredient/s that make up a solution to fulfill the requirement, reliability, supportable, and within cost parameters.

5. System operating parameter which will fulfill the requirement. A quantifiable point which can be evaluated during Test and Evaluation.

6. An engineering definition of a requirement.

7. Specific characteristic of a system which is a solution to the user requirement, i.e., 8-12 mission FLIR with 10 degrees field of view.

8. When a requirement has been established and put on contract, then the requirement has become a specification. Problem: requirements change faster than specifications.

ASD:

1. A system-level capability developed to the level of detail needed to develop, design and manufacture hardware/software.

2. Specifications define a system and how it must look and perform to meet the requirements. Specifications are derived to make the system perform as required.

3. It is a measure of performance which the system must meet.

4. It is a detailed description of an item which describes the actual or required size, performance, quality, terms and other particulars that will provide for its development and production.

5. A specific attempt to address a requirement.

6. System specification is a measurable end item of a hardware contract.

7. Bounds placed on equipment; what it's to do; size, weight, affordability and practibility.

8. Specifications imply that you shall determine the precision of a given article. Specifications describe how items will be built or orders carried out.

9. Detailed explanation of how to meet a requirement.

10. Those attributes of a system required to meet a system level operational capability.

11. An in-depth description with detailed characteristics of a desired physical item.

12. Document that details the configuration and performance aspects of a system.

13. The value of a specific performance parameter; e.g. speed, range detection distance, etc. In other words, factors that can be controlled by the designer.

14. Contract direction; "build to"; must be measurable.

Appendix H: Sources of RCM Assistance

SAC:

HQ SAC/XR/XRF/XRRR/XRRM/DO/LG/XO/XP/IN/DE/DP/IG
HQ USAF/XOORE
HQ SAC/SMOD
Contractor engineers
OC-ALC (engineering and management)
ASD (engineering, management and costing)
SPO
Testers

MAC:

Contractors ("other government agencies often provide more help than I need")
Equipment operators
Using commands
ASD SPO engineering
HQ MAC staff
HQ AFOTEC/TEZ
Previous requirements
Implementing commands

TAC:

HQ TAC staff (/DO and /LG)
Air Staff
Coordination process
AFSC Product Divisions
AFOTEC
AFLC
Senior leadership within commands
Operating units
"Poor response from coordinating agencies"

Appendix I: Categorizations for All Respondents

Parameter Categorizations (%)

QUESTION	R	S	B	N
1	12.2	36.7	20.4	30.6
2	38.8	8.2	24.5	28.6
3	20.4	22.4	22.4	34.7
4	28.6	24.5	20.4	26.5
5	46.9	4.1	12.2	36.7
6	53.1	2.0	10.2	34.7
7	32.7	26.5	12.2	28.6
8	46.9	2.0	12.2	38.8
9	51.0	6.1	10.2	32.7
10	26.5	8.2	20.4	44.9
11	38.8	4.1	16.3	40.8
12	40.8	6.1	10.2	42.9
13	26.5	12.2	16.3	44.9
14	34.7	10.2	12.2	42.9
15	30.6	14.3	20.4	34.7

Value Categorizations (%)

QUESTION	R	S	B	N
1	4.1	65.3	22.4	8.2
2	20.4	36.7	32.7	10.2
3	18.4	36.7	36.7	8.2
4	16.3	49.0	26.5	8.2
5	42.9	18.4	18.4	20.4
6	42.9	14.3	30.6	12.2
7	14.3	49.0	26.5	10.2
8	49.0	20.4	12.2	18.4
9	40.8	22.4	20.4	16.3
10	32.7	14.3	18.4	34.7
11	34.7	30.6	26.5	8.2
12	51.0	10.2	18.4	20.4
13	28.6	28.6	20.4	22.4
14	36.7	26.5	24.5	12.2
15	12.2	55.1	22.4	10.2

Appendix J: Categorizations by Aeronautical Rating

Rated Parameter Categorizations (%)

QUESTION	R	S	B	N
1	10.0	40.0	20.0	30.0
2	35.0	5.0	30.0	30.0
3	15.0	30.0	20.0	35.0
4	25.0	35.0	10.0	30.0
5	35.0	5.0	15.0	45.0
6	45.0	5.0	10.0	40.0
7	20.0	25.0	20.0	35.0
8	50.0	5.0	10.0	35.0
9	45.0	10.0	15.0	30.0
10	25.0	15.0	15.0	45.0
11	30.0	15.0	5.0	50.0
12	35.0	10.0	10.0	45.0
13	20.0	10.0	25.0	45.0
14	20.0	10.0	15.0	55.0
15	25.0	30.0	20.0	25.0

Non-Rated Parameter Categorizations (%)

QUESTION	R	S	B	N
1	13.8	34.5	20.7	31.0
2	41.4	10.3	20.7	27.6
3	24.1	17.2	24.1	34.5
4	31.0	17.2	27.6	24.1
5	55.2	3.4	10.3	31.0
6	58.6	0.0	10.3	31.0
7	37.9	27.6	10.3	24.1
8	44.8	0.0	13.8	41.4
9	55.2	3.4	6.9	34.5
10	27.6	3.4	24.1	44.8
11	41.4	3.4	20.7	34.5
12	44.8	3.4	10.3	41.4
13	31.0	13.8	10.3	44.8
14	44.8	10.3	10.3	34.5
15	34.5	3.4	20.7	41.4

Rated Value Categorizations (%)

QUESTION	R	S	B	N
1	0.0	75.0	20.0	5.0
2	30.0	30.0	35.0	5.0
3	20.0	45.0	30.0	5.0
4	20.0	50.0	25.0	5.0
5	30.0	25.0	20.0	25.0
6	55.0	15.0	25.0	5.0
7	10.0	55.0	25.0	10.0
8	60.0	20.0	10.0	10.0
9	40.0	20.0	25.0	15.0
10	30.0	15.0	20.0	35.0
11	35.0	35.0	25.0	5.0
12	65.0	10.0	15.0	10.0
13	30.0	25.0	30.0	15.0
14	25.0	35.0	30.0	10.0
15	15.0	70.0	15.0	0.0

Non-Rated Value Categorizations (%)

QUESTION	R	S	B	N
1	6.9	58.6	24.1	10.3
2	13.8	41.4	31.0	13.8
3	17.2	31.0	41.4	10.3
4	13.8	48.3	27.6	10.3
5	51.7	10.3	20.7	17.2
6	37.9	10.3	34.5	17.2
7	13.8	48.3	27.6	10.3
8	41.4	20.7	13.8	24.1
9	41.4	24.1	17.2	17.2
10	34.5	13.8	17.2	34.5
11	31.0	27.6	31.0	10.3
12	41.4	10.3	20.7	27.6
13	27.6	31.0	13.8	27.6
14	44.8	20.7	20.7	13.8
15	10.3	48.3	24.1	17.2

Appendix K: Categorizations by Organization

Using Command Parameters

QUESTION	R	S	B	N
1	17.9	28.6	25.0	28.6
2	35.7	10.7	17.9	35.7
3	21.4	10.7	32.1	35.7
4	25.0	21.4	25.0	28.6
5	46.4	3.6	10.7	39.3
6	39.3	0.0	14.3	46.4
7	32.1	17.9	17.9	32.1
8	42.9	0.0	3.6	53.6
9	53.6	0.0	7.1	39.3
10	25.0	7.1	17.9	50.0
11	42.9	3.6	10.7	42.9
12	39.3	3.6	3.6	53.6
13	25.0	7.1	14.3	53.6
14	39.3	3.6	10.7	46.4
15	32.1	7.1	17.9	42.9

Using Command Values

QUESTION	R	S	B	N
1	7.1	64.3	25.0	3.6
2	21.4	39.3	32.1	7.1
3	21.4	28.6	46.4	3.6
4	17.9	39.3	39.3	3.6
5	46.4	14.3	25.0	14.3
6	42.9	7.1	39.3	10.7
7	21.4	39.3	35.7	3.6
8	50.0	17.9	14.3	17.9
9	50.0	21.4	21.4	7.1
10	39.3	10.7	25.0	25.0
11	46.4	17.9	35.7	0.0
12	53.6	7.1	17.9	21.4
13	32.1	25.0	25.0	17.9
14	42.9	21.4	28.6	7.1
15	17.9	50.0	25.0	7.1

ASD/XR Parameters

QUESTION	R	S	B	N
1	7.1	42.9	7.1	42.9
2	50.0	7.1	21.4	21.4
3	28.6	14.3	14.3	42.9
4	42.9	14.3	14.3	28.6
5	42.9	7.1	7.1	42.9
6	64.3	7.1	7.1	21.4
7	42.9	28.6	0.0	28.6
8	50.0	7.1	21.4	21.4
9	42.9	21.4	7.1	28.6
10	28.6	14.3	14.3	42.9
11	28.6	7.1	21.4	42.9
12	50.0	14.3	14.3	21.4
13	21.4	21.4	14.3	42.9
14	28.6	28.6	7.1	35.7
15	21.4	28.6	21.4	28.6

ASD/XR Values

QUESTION	R	S	B	N
1	0.0	64.3	21.4	14.3
2	21.4	35.7	28.6	14.3
3	21.4	42.9	21.4	14.3
4	21.4	57.1	7.1	14.3
5	50.0	14.3	7.1	28.6
6	35.7	28.6	21.4	14.3
7	7.1	57.1	14.3	21.4
8	50.0	28.6	0.0	21.4
9	35.7	28.6	7.1	28.6
10	28.6	21.4	0.0	50.0
11	21.4	42.9	14.3	21.4
12	50.0	21.4	14.3	14.3
13	28.6	28.6	14.3	28.6
14	35.7	28.6	14.3	21.4
15	7.1	57.1	21.4	14.3

AFOTEC Parameters

QUESTION	R	S	B	N
1	0.0	57.1	28.6	14.3
2	28.6	0.0	57.1	14.3
3	0.0	85.7	0.0	14.3
4	14.3	57.1	14.3	14.3
5	57.1	0.0	28.6	14.3
6	85.7	0.0	0.0	14.3
7	14.3	57.1	14.3	14.3
8	57.1	0.0	28.6	14.3
9	57.1	0.0	28.6	14.3
10	28.6	0.0	42.9	28.6
11	42.9	0.0	28.6	28.6
12	28.6	0.0	28.6	42.9
13	42.9	14.3	28.6	14.3
14	28.6	0.0	28.6	42.9
15	42.9	14.3	28.6	14.3

AFOTEC Values

QUESTION	R	S	B	N
1	0.0	71.4	14.3	14.3
2	14.3	28.6	42.9	14.3
3	0.0	57.1	28.6	14.3
4	0.0	71.4	14.3	14.3
5	14.3	42.9	14.3	28.6
6	57.1	14.3	14.3	14.3
7	0.0	71.4	14.3	14.3
8	42.9	14.3	28.6	14.3
9	14.3	14.3	42.9	28.6
10	14.3	14.3	28.6	42.9
11	14.3	57.1	14.3	14.3
12	42.9	0.0	28.6	28.6
13	14.3	42.9	14.3	28.6
14	14.3	42.9	28.6	14.3
15	0.0	71.4	14.3	14.3

Appendix L: Categorizations by Experience Level

Parameters
Less Than 2 Years Experience

QUESTION	R	S	B	N
1	11.5	46.2	23.1	19.2
2	42.3	11.5	19.2	26.9
3	15.4	26.9	26.9	30.8
4	38.5	23.1	19.2	19.2
5	46.2	7.7	15.4	30.8
6	50.0	3.8	7.7	38.5
7	30.8	30.8	15.4	23.1
8	42.3	3.8	11.5	42.3
9	53.8	3.8	15.4	26.9
10	23.1	11.5	26.9	38.5
11	42.3	3.8	19.2	34.6
12	34.6	7.7	11.5	46.2
13	26.9	15.4	15.4	42.3
14	42.3	7.7	11.5	38.5
15	34.6	15.4	15.4	34.6

Values
Less Than 2 Years Experience

QUESTION	R	S	B	N
1	3.8	76.9	15.4	3.8
2	23.1	53.8	15.4	7.7
3	23.1	38.5	34.6	3.8
4	15.4	57.7	23.1	3.8
5	50.0	23.1	15.4	11.5
6	42.3	19.2	6.9	11.5
7	15.4	53.8	26.9	3.8
8	46.2	26.9	7.7	19.2
9	42.3	26.9	19.2	11.5
10	38.5	19.2	15.4	26.9
11	46.2	34.6	19.2	0.0
12	53.8	11.5	11.5	23.1
13	34.6	34.6	19.2	11.5
14	50.0	30.8	11.5	7.7
15	11.5	65.4	15.4	7.7

Parameters
More than 2 but Less than 4 Years Experience

QUESTION	R	S	B	N
1	14.3	21.4	28.6	35.7
2	35.7	7.1	28.6	28.6
3	21.4	21.4	21.4	35.7
4	14.3	28.6	28.6	28.6
5	50.0	0.0	7.1	42.9
6	57.1	0.0	14.3	28.6
7	35.7	21.4	14.3	28.6
8	50.0	0.0	14.3	35.7
9	42.9	7.1	7.1	42.9
10	35.7	7.1	7.1	50.0
11	28.6	7.1	14.3	50.0
12	42.9	0.0	14.3	42.9
13	28.6	0.0	21.4	50.0
14	21.4	7.1	21.4	50.0
15	28.6	14.3	28.6	28.6

Values
More than 2 but Less than 4 Years Experience

QUESTION	R	S	B	N
1	7.1	57.1	35.7	0.0
2	28.6	14.3	57.1	0.0
3	21.4	35.7	42.9	0.0
4	21.4	42.9	35.7	0.0
5	35.7	21.4	21.4	21.4
6	64.3	7.1	28.6	0.0
7	14.3	57.1	21.4	7.1
8	64.3	14.3	21.4	0.0
9	50.0	21.4	21.4	7.1
10	21.4	21.4	28.6	28.6
11	14.3	28.6	50.0	7.1
12	50.0	7.1	35.7	7.1
13	28.6	28.6	21.4	21.4
14	21.4	28.6	42.9	7.1
15	21.4	57.1	21.4	0.0

Parameters
More than 4 Years Experience

QUESTION	R	S	B	N
1	11.1	33.3	0.0	55.6
2	33.3	0.0	33.3	33.3
3	33.3	11.1	11.1	44.4
4	22.2	22.2	11.1	44.4
5	44.4	0.0	11.1	44.4
6	55.6	0.0	11.1	33.3
7	22.2	22.2	11.1	44.4
8	55.6	0.0	11.1	33.3
9	66.7	11.1	0.0	22.2
10	22.2	0.0	22.2	55.6
11	33.3	0.0	22.2	44.4
12	55.6	11.1	0.0	33.3
13	22.2	22.2	11.1	44.4
14	33.3	22.2	0.0	44.4
15	22.2	11.1	22.2	44.4

Values
More than 4 Years Experience

QUESTION	R	S	B	N
1	0.0	44.4	22.2	33.3
2	0.0	22.2	44.4	33.3
3	0.0	33.3	33.3	33.3
4	11.1	33.3	22.2	33.3
5	33.3	0.0	22.2	44.4
6	22.2	11.1	33.3	33.3
7	0.0	33.3	33.3	33.3
8	33.3	11.1	11.1	44.4
9	22.2	11.1	22.2	44.4
10	22.2	0.0	11.1	66.7
11	11.1	22.2	33.3	33.3
12	44.4	11.1	11.1	33.3
13	11.1	11.1	22.2	55.6
14	22.2	11.1	33.3	33.3
15	0.0	22.2	44.4	33.3

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13. ABSTRACT *(Maximum 200 words)* This purpose of this research was to analyze the Requirements Correlation Matrix (RCM) and Baseline Correlation Matrix (BCM). The specific question addressed by the research was "What improvements can be made to better define and document the operational performance requirements during the acquisition of aeronautical weapon systems?" Requirements personnel at using commands, ASD and AFOTEC were surveyed to determine who selects the parameters and values in RCMs and BCMs, and whether these personnel had differing interpretations of both requirements and specifications. The results indicated there was not a clear understanding of parameters and values as requirements or specifications by all requirements personnel, and a lack of acquisition education opportunities existed for requirements personnel at the using commands. The recommendations included ensuring requirements personnel understand the implications of the selection of parameters, more requirements oriented training for using command personnel, and a formal general officer review of requirements should be conducted for major weapon systems.

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