TECHNICAL PERFORMANCE MEASUREMENT HANDBOOK

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TPM is defined as: "the continuing prediction and demonstration of the degree of anticipated or actual achievement of selected technical objectives."

Technical Performance Measurement (TPM) is an integral function of system engineering. For maximum utility, TPM must be compatible with other related program management activities (cost/schedule control system criteria, contract administration, production management, readiness functions).

The function of this handbook is to provide program management personnel with insight into how technical performance is measured by the contractor, reported to the government and how this information can be effectively integrated with cost and schedule performance data.

Chapters 2 and 3 provide overviews of TPM and C/SCSC taken from published documentation. Chapter 4 was developed using extensive interviews with engineering management personnel within government program offices and DoD contractors. It illustrates how technical, (cont)

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cost and schedule performance are actually being monitored and used to provide program control today. The differences between the government program office and the contractor viewpoints are highlighted. Chapter 5 identifies the issues which must be considered in PMO implementation and execution of a TPM program.

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Chapter 1

GENERAL

1.1 PREFACE

The primary measure of success for a weapon system is that it worked well when it was fielded.[1/] However, the keys to successful program management are control of cost, schedule, technical performance including supportability and the coordination of the new systems into the structure of the sponsoring military service. The ability to effectively and efficiently trade-off between these elements is crucial in today's complex program acquisition management environment. To make these required trade-offs (less the coordination into the service structure which will not be addressed here), the Program Manager must know the status of each of the keys as well as the impact that a change in any one has on the others. A series of Department of Defense (DoD) criteria has been developed to ensure that contractors' management information systems will provide valid cost and schedule performance data. The measurement of the contractor's technical performance progress toward the accomplishment of the required performance specifications is monitored through a combination of methods. It is the intent of this handbook to illuminate these methods for the Government Program Office thereby assisting in the difficult task of fielding weapon systems that are affordable and work well.

1.2 HISTORY

The use of Cost/Schedule Control Systems Criteria (C/SCSC) is now well instituted within the DoD and is also being applied by a number of other Federal agencies. The criteria have evolved over the years and are still subject to various inter-

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1/ "Managing for Success in Defense Systems Acquisition" Baumgartner, Brown, & Kelley (DSMC).

pretations. The development of C/SCSC goes back to the late 1950's and early 1960's and the Polaris Missile Program. The Polaris Program Management Office developed a management information system that could be used to measure contractor performance throughout the course of the program. This system subsequently became the Program Evaluation and Review Technique (PERT). It is a network scheduling technique that graphically displays the interrelationships of specific program activities and establishes the critical paths or path through the network on which management should focus its attention. A capability to budget and report costs by PERT was developed and named PERTCOST. By the mid 1960's several variations of PERTCOST existed in DoD, and monthly cost reports were required. PERTCOST requirements were negotiated into contracts even when, in some cases, contractors had equally effective alternate systems in place. This required operation of separate systems: one used for government reporting and one used by the contractor for actual management.

The PERTCOST system in some cases called for the reporting of costs by the lowest level network activities. This resulted in the collection of large amounts of very expensive detailed cost information which was not consistently utilized.

At the same time, the Air Force Minuteman Missile Program Office, with contractor support, developed a contractor Performance Measurement System based on the lessons learned from PERTCOST. It utilized the work breakdown structure and work packages of PERTCOST. Work accomplished was measured in relation to the budget planned for the work; thus, the name Earned Value.

A second Air Force effort was established in the Office of the Secretary of the Air Force. This effort developed a set of simplified standards by which to measure a contractor's internal management system. The standards contained the key elements of PERTCOST and the Earned Value system and eliminated the detailed cost reporting from PERT networks. This system was published by Air Force System Command in 1966 as Cost/Schedule and Control Specification (C Spec).

In December 1967, DoD Instruction 7000.2, Performance Measurement of Selected Acquisitions, was published by the Assistant Secretary of Defense (Comptroller) and authorized the publishing of a Tri-Service C/SCSC Joint Implementation Guide. The guide provides the formal material for implementation of the criteria. It was published in August 1970 and has had three updates thru October 1980.

Throughout the early development of C/SCSC, technical performance was envisioned as a part of the criteria; however, in 1967 a Technical Performance Measurement (TPM) system began emerging as a separate requirement within DoD. Engineering was within the domain of the Director of Defense Research and Engineering (DDR&E), at the Office of the Secretary of Defense (OSD) level, and the responsibility of the Ass't Secretary (R&D), within the services. This split in functions between the Comptroller (C/SCSC) and DDR&E (TPM) at the OSD level appears to have been the prime reason for the development of entirely separate guidance documents for TPM and C/SCSC. TPM was formally introduced by MIL-STD-499 (USAF) in July 1967 (superseded in May 1974 by MIL-STD-499A[USAF], Engineering Management). This document was developed to assist government and contractor personnel in defining the system engineering effort required in support of defense acquisition programs, and includes a list of specific Statement of Work (SOW) clauses that can be selected for contract inclusion.

1.3 PURPOSE

The function of this handbook is to provide program management personnel with insight into how technical performance is measured by the contractor, reported to the government and how this information can be effectively integrated with cost and schedule performance data. Separate systems have been developed which, when properly linked, provide the keys to good management. Understanding how contractors utilize their cost schedule and TPM data to evaluate their own progress will provide government Program Managers insight into how to monitor their contractors overall progress.

1.4 ORGANIZATION

Chapters 2 and 3 provide overviews of TPM and C/SCSC taken from published documentation. Chapter 4 was developed using extensive interviews with engineering management personnel within government program offices and DoD contractors. It illustrates how technical, cost and schedule performance are actually being monitored and used to provide program control today. The differences between the government program office and the contractor viewpoints are highlighted. Chapter 5 identifies the issues which must be considered in PMO implementation and execution of a TPM program.

Chapter 2

TECHNICAL PERFORMANCE MEASUREMENT

2.1 INTRODUCTION

Technical Performance Measurement (TPM) is an integral function of system engineering. For maximum utility, TPM must be compatible with other related program management activities (cost/schedule control system criteria, contract administration, production management, readiness functions).

The means of measuring technical performance vary with the program phase from engineering analysis of design in the early stage of Full Scale Development (FSD) to system qualification test in the latter stage of FSD. TPM is not a substitute for a risk management program, rather it is a critical function of such a program. TPM along with C/SCSC provide the measurement function of a risk management program. It is the measurement of progress of cost, schedule and technical performance against key parameters that provides management progress information and problem identification. Further, TPM is not a process by which to evaluate the productivity of a single or group of design engineers, but rather a process used to evaluate the progress of an organizational entity against established performance goals for the weapon system's elements.

2.2 DEFINITION

TPM is defined as: "the continuing prediction and demonstration of the degree of anticipated or actual achievement of selected technical objectives. It includes an analysis of any differences between the achievement to date, current estimate, and the specific requirement. Achievement to date is the value of a technical parameter estimated or measured in a particular test or analysis. Current estimate is the value of a technical parameter predicted to be achieved at the end of the contract within existing resources."(1)

TPM is; "...the design assessment that predicts, through engineering analysis or test measurements, the values of essential system performance parameters."(2)

Dr. Norman Waks, formerly of DDR&E, defines TPM as; "...the regular demonstration through test or prediction, extrapolation, or other forecasting technique, of the degree of actual or anticipated achievement of selected technical goals or objectives of a system, component, or equipment project/program and an accounting, in the causal sense, for the difference between the result of this status reading and that which was planned, in a fashion which permits appropriate managers to take timely action on indicated problems."(3)

These definitions lead to two conclusions, the first is that the definitions tend to address a TPM program rather than TPM; and the second is that TPM lends itself to being structured into the following four key elements:

- Status against a plan.
- Estimate of future attainment.
- Variance analysis.
- Problem identification analysis.

Performance measurement and forecast of key parameters must be performed on a regular basis to determine future courses of action in time to be effective. The frequency of this measurement and forecast cycle is related to the complexity of the program. As a minimum, the major established milestones such as Preliminary Design Review (PDR), Critical Design Review (CDR),

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(1) MIL-STD 499A Engineering Management (USAF) May 1974
(2) System Engineering Management Guide, Defense Systems Management College, 3 October 1983
(3) Waks, Norman: Technical Performance Measurement - A Defense Department View, December 1968

etc., provide normal transitions in engineering activities which require total assessment of technical status. For most complex developments it is necessary to identify meaningful sub-milestones that will force the aggregation of technical information and the conduct of meaningful measurement and forecast.

2.3 TPM PROCESS

2.3.1 General

Design and development is an iterative process that allows the engineer to move from the unknown to the known in an effort to define a product that will satisfy stated requirements. Integral to any contractor design activity is a continuous effort to evaluate proposed and revised designs so as to project their expected performance. The head of the design activity is continually faced with assessing progress and making design alternative decisions. The expected results of these decisions are increments in the optimization of the system design. This process continues until either an optimum design is obtained (as defined in the contract), the originally allocated resources of time and funds are expended, a revised level of resources is established and expended, or the originally specified design constraints are modified to coincide with predicted achievable levels.

From the senior OSD management viewpoint, the systems acquisition life cycle is primarily a process in risk management, not design selection. Under this philosophy, a key management principle is the establishment of goals and thresholds for cost, schedule, and performance, readiness and supportability. This is stated in Defense Circular #76-43, pg. 14 dated 22 March 1983. Goals are values that will enable the new system to fully satisfy mission needs. Thresholds are values that describe a minimum performance level or a maximum expenditure of resources for a new system. Variances between goals and thresholds reasonably reflect the degree of risk in an acquisition program at each milestone. Threshold breaches require a reassessment of the program in terms of mission need and prioritization among other acquisition programs. Program managers must report actual or projected threshold breaches to the Defense Acquisition Executive providing an assessment of the problem and recommendations. An example of a goal versus a threshold would be:

Parameter	Goal	Threshold
Weapon System reliability	70%	65%
Fuel consumption (Gal/Hr)	650	700
Maintenance Man-hours/Flying Hour	35	40

In theory, a properly structured, formal TPM program provides the government Program Manager with the bridge between the contractor's engineering design activity and the government's management objectives. The TPM program should identify problem areas and the probable impact on the acquisition program by means of assessment of the contractor's technical achievement trends. Solutions to potentially unacceptable impacts identified by TPM are considered a management function and not a part of the basic TPM process. Also, for the formal TPM program to be efficient, credible and affordable, it should be an integral part of the contractor's engineering management system and not an additional management reporting structure.

The following sections discuss the attributes of a formalized TPM program and the interrelationship with the engineering process.

2.3.2 Period of Formalized TPM

A weapon system "life cycle" extends from concept exploration to production and through operation to disposal. TPM assesses the system design progress toward meeting stated mission requirements. Therefore, the development of basic performance requirements and the accumulation of deployment experience data are not included in TPM. TPM is applicable from the start of subsystem detail design until release of the production baseline specifications.

Specifically, TPM planning should normally be accomplished in Demonstration/Validation with a detailed implementation plan available for review at the time of the Systems Design Review (SDR). The allocated performance requirements approved during the Preliminary Design Review (PDR) at the start of FSD are the baselines from which the TPM program should assess progress. The program is complete when attainment of all performance specifications have been demonstrated by the successful completion of the Functional Configuration Audit (FCA).

2.3.3 TPM Planning

Within the Systems Engineering Management Plan (SEMP) the contractor should address the planning for TPM. The TPM plan should identify parameters to be tracked, the parameter profiles with time or standards, reporting mechanisms, analysis and forecast techniques, key test events, TPM report dates, implementation procedures, and information flow. The plan should also identify organizational and individual responsibility. Section 2.4 will discuss the SEMP format.

The degree of visibility into technical progress will be determined by the care used in selecting the key parameters, and the frequency and completeness of the evaluation and forecast effort. A properly structured systems engineering plan inherently provides a capability to measure performance without the need for special additional reporting tasks being added with their associated cost increases, since it must address the key parameters and their balance in order to perform the system engineering function of specialty integration.

Figure 1 displays the Acquisition Phases with the normally scheduled reviews and audits, and the associated resultant specifications. A generalized schedule of available evaluation techniques is also implied by the schedule of engineering analysis efforts and test events. In major acquisition programs, the design reviews and audits may not be single scheduled events but rather a series of events, for each major configuration item (CI).

As an example, the CDR for a new tactical fighter aircraft may be a series of separate CDRs on the CIs such as the engine, airframe, and avionics; while for a tactical missile, the CIs may be the propulsion system, guidance section, armament section and the control section. In addition to these normal program events, there are other identifiable events, sub-milestones, subsystem status reviews, and critical item analysis and performance tests that provide suitable points in the program where technical progress can be assessed. Therefore, the key to adequate visibility is tied to the ability to identify meaningful measurement points within the overall program schedule between major milestones.

2.3.4 Parameter Selection

The Mission Area Analysis process identifies the system level technical performance requirements and documents them in the System Specifications. The System Engineering process reduces these to Contract Items allocated or design to Specifications. Figure 2 illustrates these influences on the TPM parameter selection process. The selection of parameters to be tracked and reported is a function of TPM and must start in the Demonstration/Validation phase to permit initiation with FSD. The TPM parameters are normally selected because they are:

- Mission Critical
- State-of-the-Art Critical

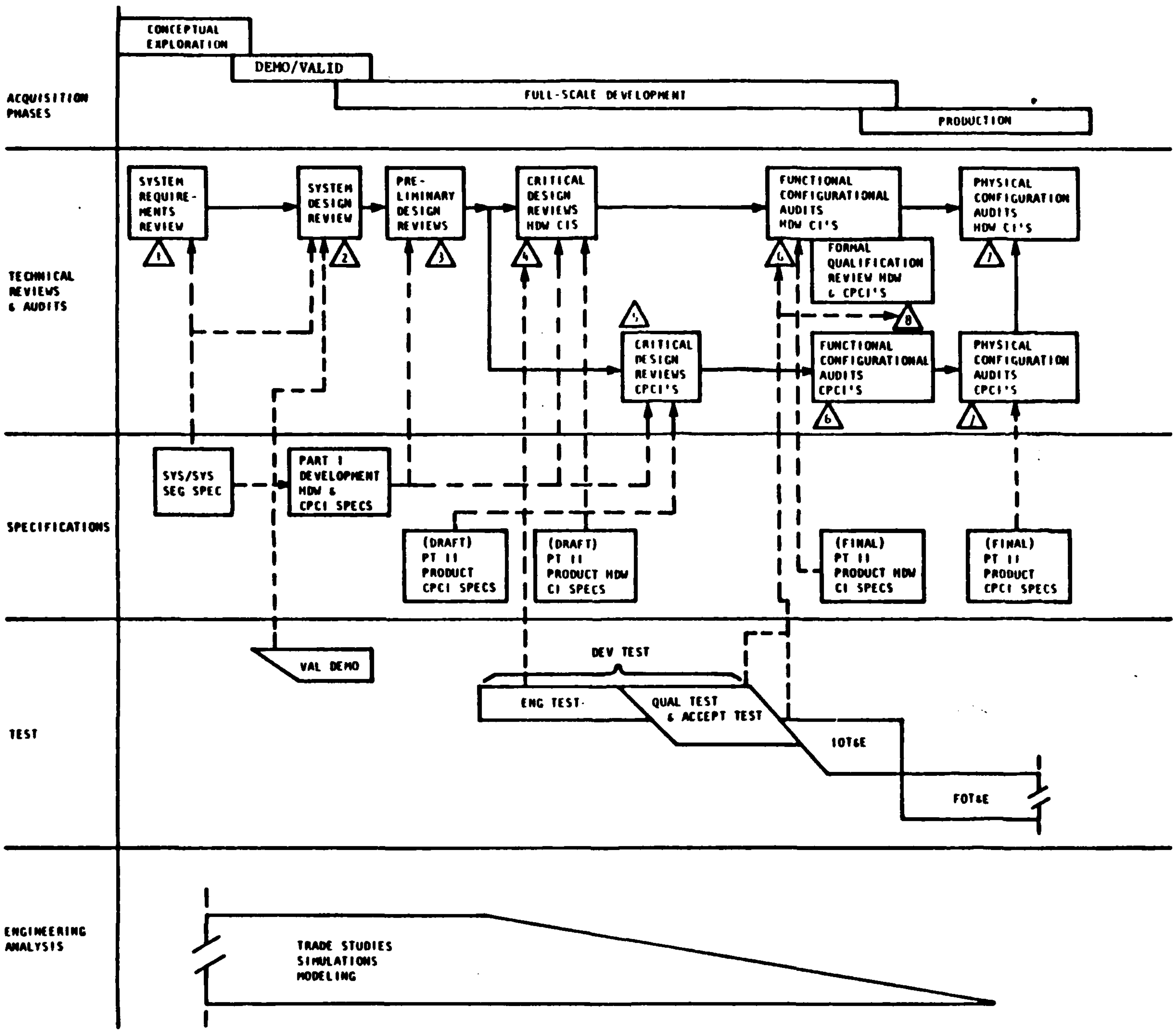

Figure 1. PROGRAM REVIEWS, AUDITS, SPECIFICATIONS TESTS, AND ENGINEERING ANALYSIS BY PHASE

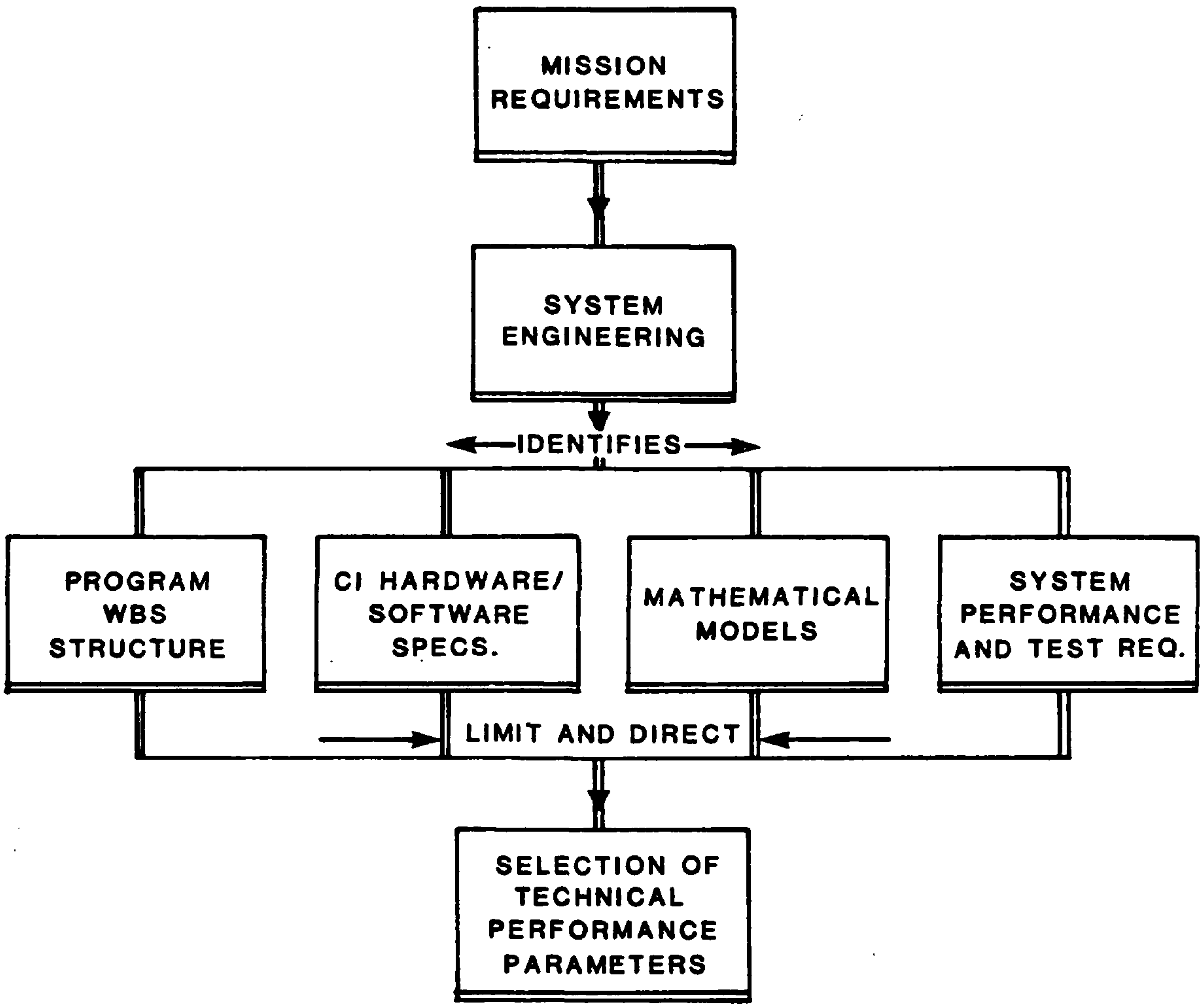

Figure 2. Selection of TPM Parameters

A mission critical parameter, may be ship speed, range or endurance, or it may be the performance reliability or detection range of a subsystem such as radar. State-of-the-Art Critical may be the development of a new graphite nozzle on a space booster engine required to increase performance. Figure 3 provides a sample list of parameters for a number of weapon systems. Parameters selected must be measurable if they are expected to provide technical progress.

The selection of technical parameters begins in the demonstration/validation phase with the recommendations of the participating contractor(s) system engineers. The final selection of the parameters must be made by the PM. The selected and contractually implemented technical parameters will be the product of detailed negotiations between the prime FSD contractor(s) and the government PM. The PM's decision will be based on the operating commands needs, engineering analysis of risk, OSD desires and the contractor's guidance.

The PMO cost of TPM is proportional to the total number of parameters which must be tracked. To report technical variance at the system level requires the contractor to track and report at the subsystem level and aggregate the data. The tracking of 10 or 20 key system level parameters may result in the contractor being required to track several hundred lower level component parameters. Figure 4 displays the flow-down used by an engine manufacturer to track system reliability (Mean Time Between Failure [MTBF]). To permit determination of the cause of unfavorable variance predictions, the contractor tracked performance on 11 subsystems and 13 unique components as well as the total engine.

The parameters ultimately selected for tracking and reporting should satisfy the following criteria:

- o Each parameter tracked or reported should be correlated with a specific CWBS element.

AIRCRAFT	SHIP
WEIGHT - MAX TAXI, EMPTY, MAX FLT	CRUISING RANGE
PAYLOAD - INTERNAL, EXTERNAL	MAX SPEED
RANGE	DIMENSIONS - LENGTH, BEAM
SPEED - HIGH, LOW, PENETRATION	DRAFT
LANDING DISTANCE	DISPLACEMENT
RADAR CROSS SECTION*	TARGET ACQUISITION RANGE
TURNAROUND TIME	RELOAD TIME*
MAINTAINABILITY	NO. TARGETS ENGAGED SIMULTANEOUSLY
MISSION RELIABILITY	

TANK	SATELLITE
DIMENSIONS - HEIGHT, WEIGHT, WIDTH	DIMENSIONS - WEIGHT, SIZE
SPEED - MAX, GRADE, ACCELERATION	POWER*
CRUISING RANGE	RELIABILITY
SURVIVABILITY*	DRIFT*
MAINTAINABILITY	COMPUTER LOADING
MOBILITY	TELEMETRY ALLOCATION
FORDABILITY	

*Could be state of the art critical if new technology required.

Figure 3. TPM Parameters.

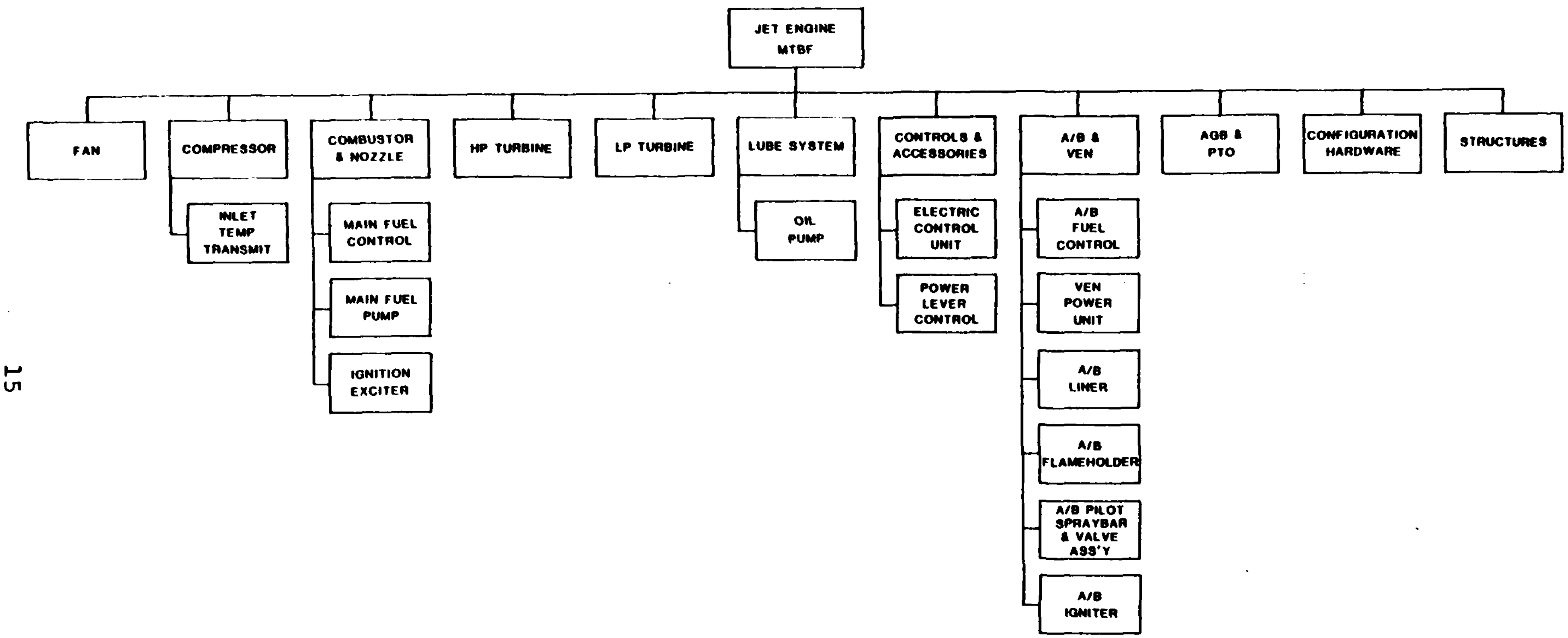

Figure 4. **Parameter Flow Down**

- o A parameter time-phased profile with tolerance bands can be predicted and substantiated during design, development and test.

- o A direct measure of value can be derived from results of functional analysis or tests.

- o Will have a significant effect on system ability to meet specified performance requirements.

Subjective items such as improved quality, management responsiveness and timeliness are not appropriate for TPM.

2.3.5 Parameter Profile Determination

In the May 1982 issue of Research Management, Mr. Alfred H. Schainblatt concluded that the "idea of measuring R&D productivity makes sense only if there are reasonable comparisons." Similarly, the measurement of technical progress makes sense only if reasonable schedules can be established. Realistic performance profiles for evaluating current progress and forecasting levels of attainment must be carefully set to prevent early/late or unnecessary management intervention; any of which would mean that the cost of TPM would have been wasted at best and counter productive at worst.

A profile can be defined as a graphic depiction of a process or relationship which serves the following functions:

- o provides a visual presentation of present status and expected accomplishment
- o provides a means of presenting predictions and planned corrective action effects
- o relates time, performance and significant events both past and present

The shape of this profile will determine the overall effectiveness of a TPM program. A profile that is too optimistic (e.g., early attainment,) will increase the probability of performance variances even though actual progress may satisfy the overall program schedules. Conversely, a conservative profile may not identify problems until it is too late to effectively accomplish corrective actions. Therefore, the parameter profiles must represent the reasonable expectations of technical progress based on the experience of prior similar design activities and current program design completion, prototype assembly, and component test schedules.

Some performance characteristic predictions may tend upward or downward with time, such as engine reliability (MTBF), whereas others may appear as a horizontal line if it is reasonable to forecast that the parameter will be constant (electrical power consumption). Figure 5 provides planned parameter profiles. Figure 6 displays a planned profile with an upper and lower tolerance band. The intent is that performance outside the tolerance band (both positive and negative) would result in variance reporting. In this case the demonstrated performance is outside the tolerance band and variance reporting to include planned corrective action would be required. Performance profiles may also be developed in a tabular form, comparing demonstrated and forecast values to planned value and providing variance. Figure 7 is a tabular TPM comparison.

2.3.6 Parameter Measurement

The methods used to measure technical progress must be tailored to the particular phase of the development program. In the initial phases of design, only engineering analysis is available. As the design matures, the analysis is augmented with engineering hardware test data. Finally, component and full-system-test hardware allows for performance verification. TPM parameter measurements are basically the specialized docu-

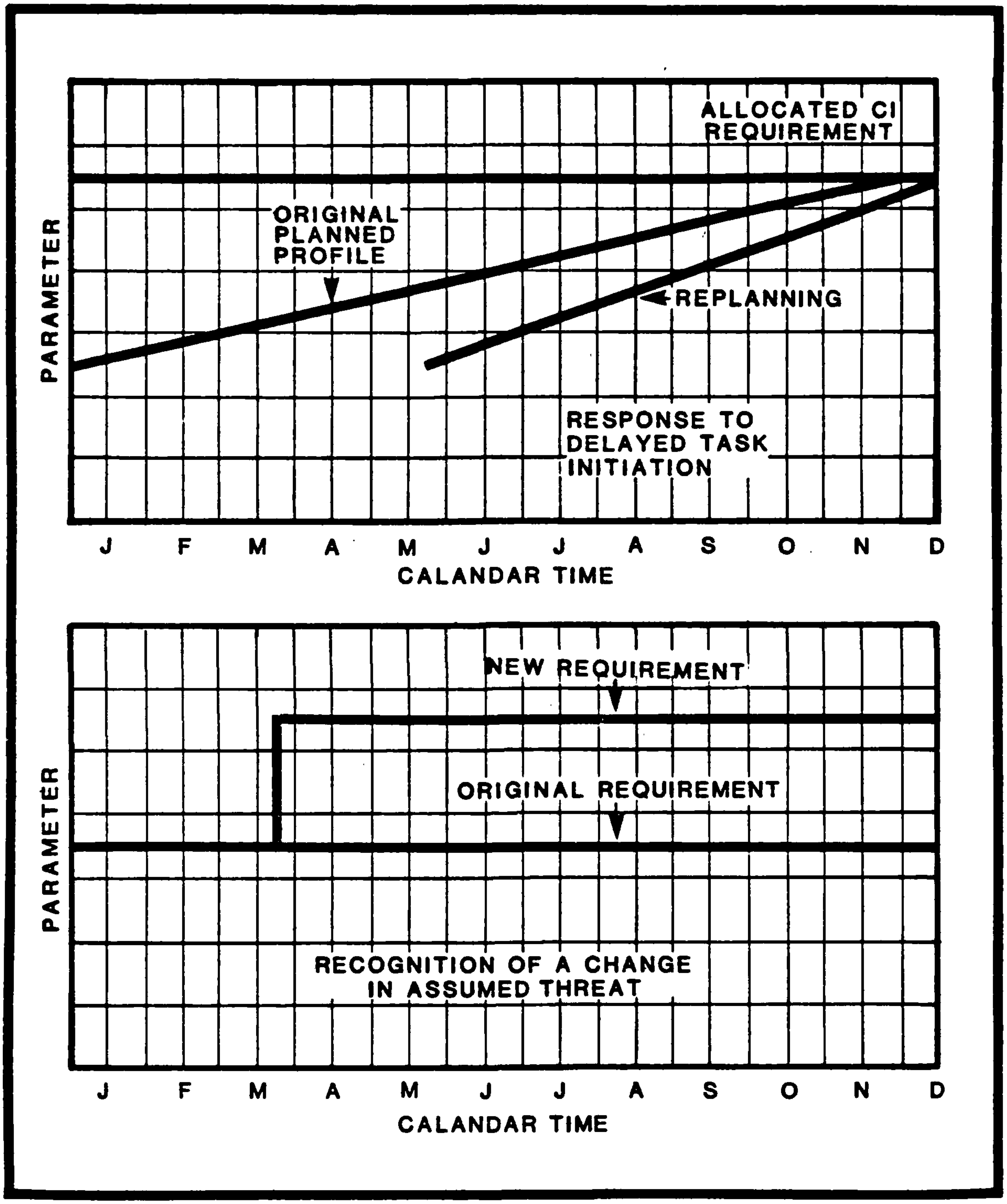

Figure 5. Planned Parameter Profile

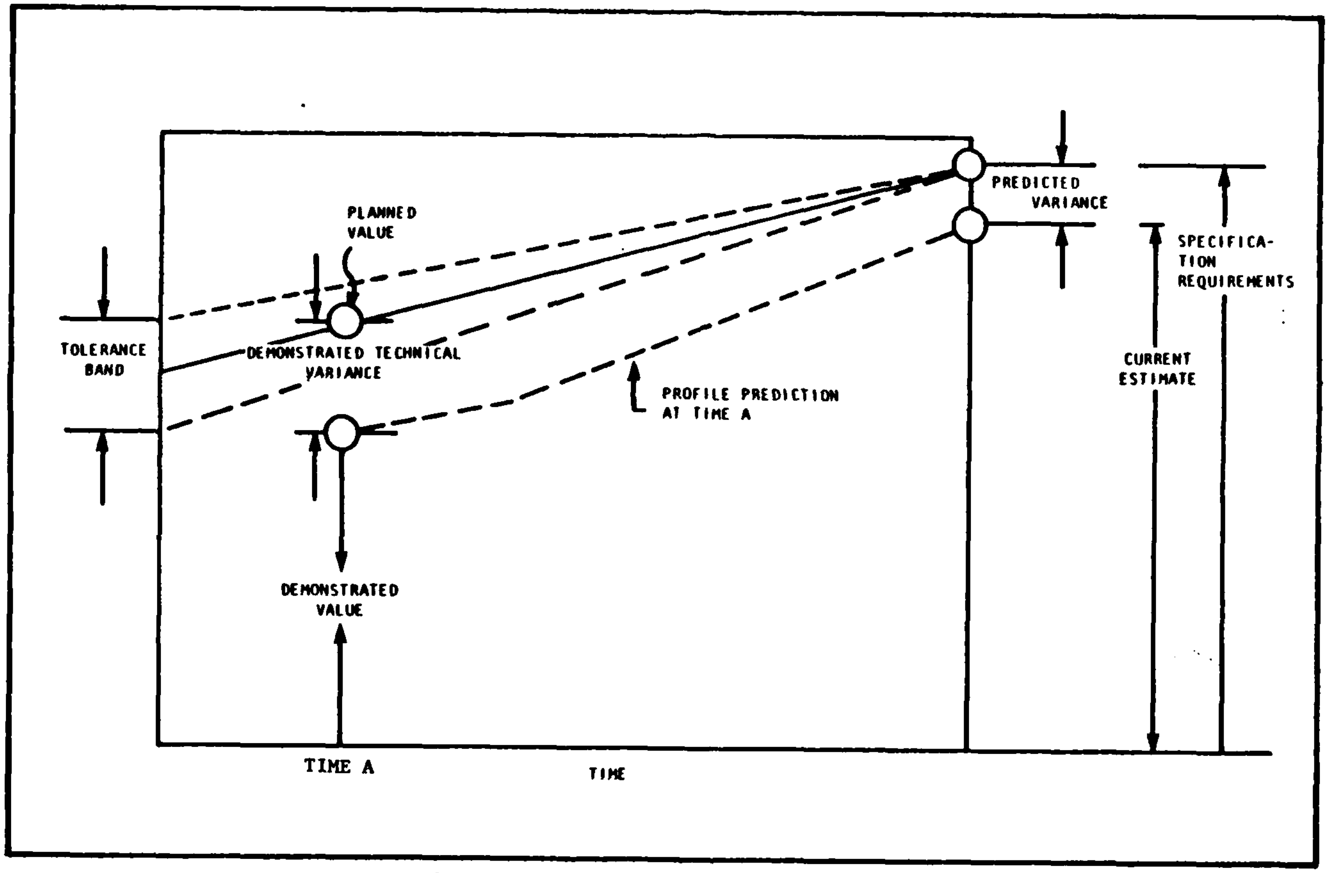

Figure 6. TPM PARAMETER PROFILE

System Element	Parameter	This TPM (Date or Milestone) Demonstrated Value	Planned Value	Demonstrated Variance	End Product Current Estimate	Specification Requirements Original	Specification Requirements Current	Predicted Variances
ENGINE (WBS CODE) (Note: In this case, the Cl/ Subsystem is the "System Element")	SLS Thrust, lbs	26000	28000	-2000	29000	30000	30000	-1000
	Weight, lbs.	5400	5500	-100	4900	5000	5000	-100
	SFC, lbs/ Hr-lb	.045	.05	+0.005	.04	.04	.04	-0-
THRUST	Compressor Pressure Ratio	7.8:1	7.5:1	+0.3	8:1	8:1	8:1	-0-
	Turbine Efficiency (%)	87	85	+2	88	87	87	+1

Figure 7. TPM Comparison

mentation of the natural outputs from the ongoing development activities involving engineering analysis and testing (Figure 1). TPM should not routinely have to introduce testing or analysis events not otherwise required in every design project. The system engineering plan should structure the technical design effort so that it naturally provides the events and measurement activities which TPM reporting will require.

2.3.6.1 Engineering Analysis

Throughout the development activity many techniques are used to identify and evaluate design options. This evaluation is termed Engineering Analysis, and incorporates activities such as modeling, comparisons/similarity/experience determinations, and formal trade studies.

MODELING (Mathematical):

Static math modeling provides equations which duplicate the known relationships between characteristics when a system/subsystem/component is in equilibrium. This technique can be used in establishing quantitative performance requirements for the development of candidate designs. Structural loads analysis of a design is an example of static math modeling with widely demonstrated validity and ready adaptation to automation. Dynamic math models describe conditions that vary with time. Simple dynamic relationships can be solved manually and the results plotted. However, in modern weapon systems, the degree of system complexity requires computer simulation, which also provides increased designer productivity, more rapid response times, and reduced test hardware needs.

MODELING (Physical):

Physical models include both scale models and full size mock-ups. Scale models may be used to establish specific characteristics for subsequent use in computer simulations and model tests. As examples, scale models of aircraft are used in wind tunnels to establish lift and drag characteristics, while scale models of ship hulls are used in water tanks to determine drag resistance and acceleration characteristics. Full size models are usually constructed to support human engineering functions, and those for which a three dimensional presentation will aid in the design of tubbing/cable routings, component placement, and the subsequent accessibility analysis. The implementation of Computer Aided Design (CAD) Mock-Ups will reduce the need for physical modeling.

Dynamic models are primarily engineering hardware models used to provide proof of functional operation or to establish critical performance characteristics. Breadboard/brassboard of an electronic circuit is an example of a dynamic model. The model did not physically look like the anticipated operational configuration, but functionally it was intended to be very representative. In some cases CAD can now accomplish the basic circuit design and functional tests without the need for physical breadboards. Data obtained from this type of engineering model or hardware, which functionally approximates the desired design, allows for confirmation of approach and degree of design optimization.

<u>COMPARISON/SIMILARITY/EXPERIENCE</u>

These techniques are predominant in the early phases of the engineering process. First order design approximations will draw heavily on relationships developed in previous similar programs. As an example, in making an initial estimate of aircraft weight, the engineer would evaluate earlier aircraft designs for a similar mission and develop a weight relationship. Using this relationship and the geometry of the new aircraft, an estimate of total weight is developed. This estimate may then be adjusted based on an assessment of the evolving technology in aircraft structures. In developing the electrical power requirement for a new ship, design engineers would evaluate similarly equipped ships and develop a power relationship based on the power requirements for similar equipment.

These techniques are useful in developing the resource requirement estimates for the engineering effort. The establishment of development schedules, program person loading, and parameter time profiles are highly dependent on prior engineering experience in similar activities. Although these techniques are useful in the concept exploration and early demonstration/validation phases, they are the least preferred activities for measuring technical progress because of their subjectivity and the difficulty in independently verifying and validating these results. While some TPM estimates may initially depend on these methods, their refinement by other methods should be a primary goal of the TPM program at start up.

TRADE STUDIES:

Trade studies formally apply elements of decision theory and multi-attribute utility functions to select a design-alternative that best satisfies a selected set of decision criteria. During Full Scale Development (FSD), when formal TPM is in effect, trade studies are used in detailed design analysis to identify the most desirable design alternatives considering design criteria selected by the system engineering manager such as reliability, weight, cost, speed, size, etc. For the M1E1 tank system, the SEMP required that each trade study consider the following factors, as appropriate, and their respective impacts:

- Performance
- Reliability
- Maintainability
- Durability
- Human Factors/Safety
- Integrated Logistics Support
- Development Cost
- Production Cost
- Life Cycle Cost
- Schedule

The structured trade-off analysis procedure, when made mandatory, prevents the premature commitment to a single design prior to evaluating all viable alternatives. It requires close management attention since it costs time and money to implement and operate such a disciplined system.

The process consists of evaluating all feasible solutions against selected criteria which have been prioritized by weighting. Specific measured/predicted performance information is developed by the use of previously mentioned engineering analysis techniques. The performance of each alternative against the criteria is scored based on the predicted level of attainment. To provide consistency in scoring, utility function curves are developed, prior to performance determination which represents the score for varying levels of performance of each attribute. The candidates are then ranked based on the weighted scores developed from the summation of the individual raw scores multiplied by the weighting factors which have been separately designed to reflect desired criteria priority (Figure 8).

Although this process yields a quantitative rating of candidate systems/solutions, major segments of the process are subjective in nature. The rank ordering and

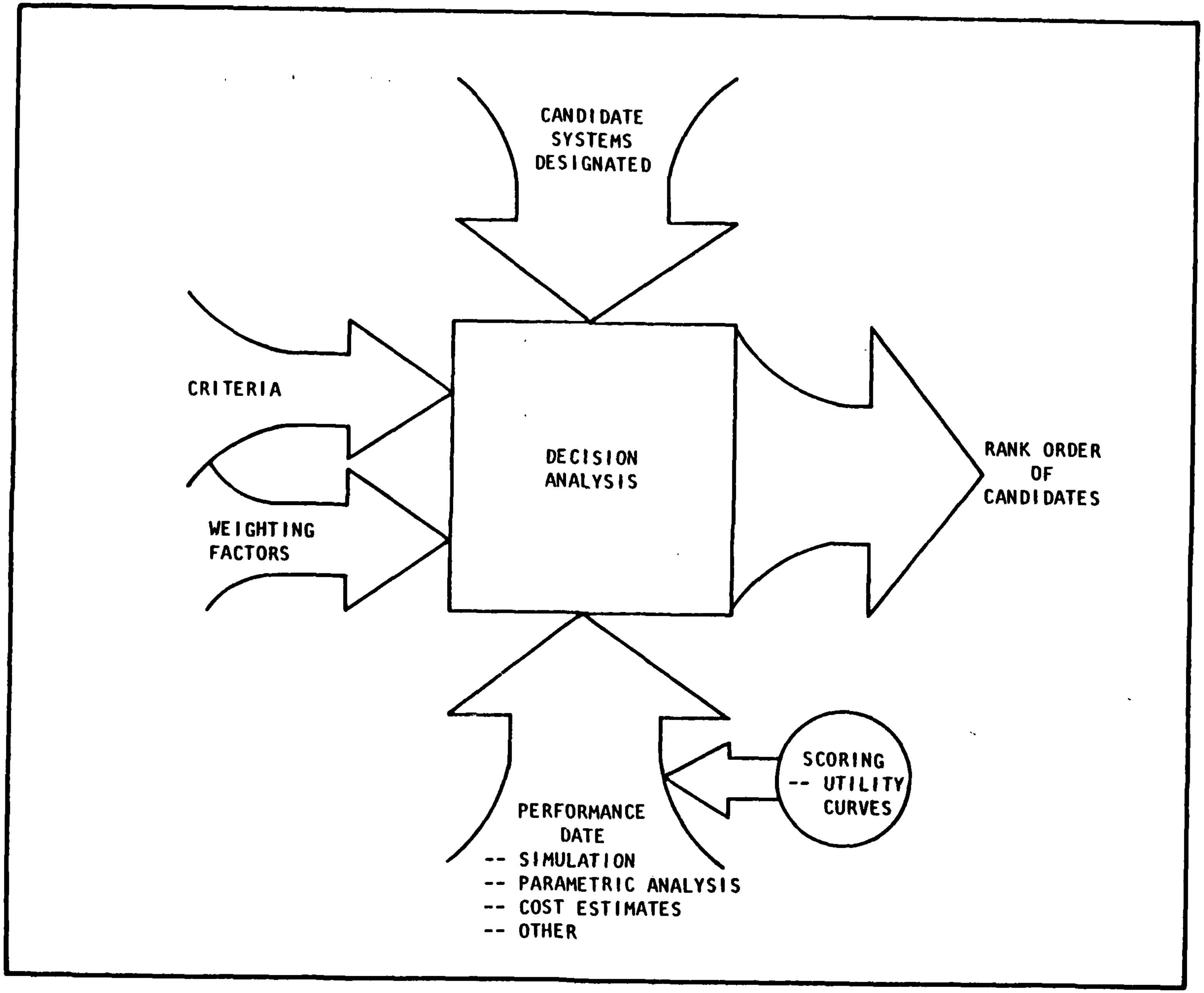

Figure 8. TRADE STUDY

relative weighting of the criteria is a function of management's perception of the importance of these factors. Depending on the particular program, the acceptability of risk, the fiscal or political consideration, or the personnel ceilings may take precedence at any given time. Trade study outputs should always be subjected to sensitivity analysis to determine the range of conditions which would still yield the same results. If the range of conditions for which the outcome remains unchanged is relatively broad and encompasses the perceivable/predictable conditions for the system, the trade study results should be utilized. If the range of conditions is very narrow and there is a probability of result reversal - additional analysis should be conducted, time, personnel and funds permitting, or the options should remain open until additional, more definitive information can be obtained. Figure 9 provides the results of a typical trade study.

2.3.6.2 Testing

It is DoD Policy (DoDD 5000.3) that Test and Evaluation (T&E) begin as early as possible and be conducted throughout the system acquisition process. Planned T&E activity should assess and reduce acquisition risks and, as soon as possible, allow for the estimation of operational effectiveness and suitability of the system under development. DoD further requires that meaningful test objectives and evaluation criteria, related to the satisfaction of mission need, be established before testing begins. Successful accomplishment of these T&E objectives will be instrumental in obtaining decisions to commit additional resources to a program or to advance it from one acquisition phase to another.

Maximum test activity occurs during the FSC phase of the acquisition cycle, the same period for which TPM is formally instituted. Testing is a major function of TPM. It provides the validation of the engineering analysis previously completed.

PRESENT DESIGN: S1451 Cooling System		
XM61462 Electro-Mechanical Clutch (Right auxiliary cooling fan) XM69078 Mechanical Clutch (Left primary cooling fan)		
PROPOSED DESIGN:		
XM69078 Two Mechanical Clutch Designs (Identical right and left cooling fan slip clutches)		
PARAMETER	IMPACTS	
	Present Design	Proposed Design
Performance	Speed 107 Slope - 20.17 MPH Acceleration (0 to MPH) - 6.49 sec	19.63 MPH (-2.77 Change) 6.69 sec (-2.97 Change)
Reliability	15 x 10^{-6} Failures/Mile i.e. 105.97 Vehicles Failures/Year	Same
Maintainability	2.29M-HRS (Remove Replace)	Same
Durability	Usage rate 6000 miles Overhauls 3 times over 20 years	Same
Human Factors	Installation and Maintenance as specified in MIL-STD-1472A	Same
ILS	Provision Requirements for Electro-Mechanical and Mechanical Clutches	Improved Logistics Identical Right and Left
Weight	- - -	-30 lbs.
Overall Assessment - Technical Impacts: Minor degradation in tank performance and a minor degradation in Fuel Economy. Electrical Clutch - 0.58 mpg, Mechanical Clutch - 0.57 mpg (-1.57)		
DTC	$731.81 per unit	$468.00 per unit
Development Cost	$93,348	$5,075
Non-recurring Cost	$18,854	$10,497
LCC	$3,467 system cost	$2,428 system cost
Schedule Considerations: PC-3 Production, Retrofit FV-2 and FV-3		
SEM Analysis and recommendations: Advantages of using the slip clutch outweigh minor degradation in tank performance. An LCC fleet saving of $7.3 million is achieved for 20 years vehicles operating period.		
Trade/Risk Board disposition: Change approved by GDLS Submitted to the Government for implementation through ECP.		

Figure 9. **Trade Study Summary - Example**

There are two types of tests, functional and environmental. Functional tests are used to determine if the performance of the item meets its functional performance requirements. These tests are either electrical or mechanical. An electrical functional test is the measurement of output power from a radar power unit while a mechanical functional test could be torque measurement of the antenna rotation.

Environmental tests are those tests which subject the item to the environmental conditions in which its functional performance will occur. They include the environments of shock, vibration, acceleration, radiation, temperature, electromagnetic compatibility, etc.

Because of the multitude of agencies involved in the various phases of testing and the many applications for the resultant data, it is imperative that careful planning of all phases (including data distribution) be accomplished. The Test and Evaluation Master Plan (TEMP) should document this planning by clearly showing that the various phases of Development, Test and Evaluation (DT&E) and Operational Test and Evaluation (OT&E) are structured to ensure that critical management issues, at each decision point, can be satisfied with verified performance data. The TEMP is prepared by the government PM's test organization and serves as the basis for all contractor test plans. The TEMP should contain six parts. They are as follows:

o Part I Description

  - Mission - brief summary of operational need, mission and planned operational need
  - System - key functions, interfaces and unique characteristics.
  - Required Operational Characteristics
  - Required Technical Characteristics
  - Critical T&E Issues

- Part II Program Summary

  - Management - how the tests will be managed
  - Integrated Schedule

- Part III DT&E Outline

  - Relate test objectives to system operational concept
  - DT&E to date
  - Future DT&E to include equipment, objectives, events and critical items

- Part IV OT&E Outline

  - Relate the test conditions and results to operational effectiveness and suitability
  - test representative of operational environment

- Part V Production Acceptance Test and Evaluation (PAT&E)

  - Plan to demonstrate that items fulfill requirements and specifications

- Part VI Special Resource Summary

  - Key resources for DT&E, OT&E and PAT&E
  - Test articles
  - Special support requirements

<u>DEVELOPMENT TEST and EVALUATION</u>

DT&E is conducted to assist the engineering design and development process and to verify attainment of technical performance specifications and objectives. It encompasses the

T&E of components, subsystems, hardware/software integration, and prototype or full scale development models of the system. It should ensure that:

- o engineering design and development are reasonably complete
- o all significant design problems have been identified
- o solutions to identified problems have been developed
- o design risks have been minimized
- o the system/item will meet its specifications.

DT&E for the M-1 tank program culminated with the competition of prototypes developed by General Motors and Chrysler, designed to prove the above noted functions, but began with bench tests of single bearing and switch designs.

The management of the DT&E activities is usually shared between the contractor and the government. The contractor normally conducts the tests at his own facilities. The government may support some tests by providing specialized test facilities, equipment and personnel, such as wind tunnels and flight test ranges.

OPERATIONAL TEST and EVALUATION

This is the T&E activity conducted to estimate a system's operational effectiveness and suitability, and to provide information on tactics, doctrine, organization, and personnel requirements. It is DoD policy that an initial phase of this testing (IOT&E) be conducted prior to the production decision.

Public Law 98-94, dated 1 NOV 83, established a separate organization, the Directorate of Operational Test and Evaluation, which reports directly to the Secretary of Defense to oversee OT&E on major system acquisitions. Based on the reports of the independent testing organizations and personal visits and analysis, the Director reports to Congress on the operational effectiveness and suitability of major system acquisitions. The reports are forwarded without change to Congress through the Secretary of Defense.

OT&E testing differs from DT&E in that it is accomplished in an environment "as operationally realistic as possible". Government operational and support personnel are used in lieu of contractor personnel to obtain valid estimates of the users' capability to operate and maintain the system. Contractor personnel might be used to assist in data gathering, reduction and evaluation.

OT&E is conducted to:

- o estimate the system's/item's military utility, operational effectiveness and suitability
- o assess the compatibility, interoperability, safety, reliability, maintainability, and supportability
- o provide data to support or assess the validity of operational instructions, publications and handbooks
- o assess the procedures and equipment planned for the support of the fully fielded material.

2.4 DOCUMENTATION

A major effort in any development program is the production and delivery of documentation. The Data Item deliveries as required by the Contract Data Requirements List (CDRL) can account for three to five percent of the total cost associated with the development program. Engineering plans, test plans, analysis reports, test reports, cost and management status reports, plus many other types of specialized functional data comprise the program details of what is to be done and how well it is being accomplished. Within this myriad of standard data items there are several that are key to cost effective TPM. The following subsections discuss the requirements of the Data Item Descriptions (DID) which may be placed on contract to implement the TPM program.

2.4.1 System Engineering Management Plan (SEMP) DI-S-3618/ S-152) (USAF)

The SEMP sets forth the contractor's proposed plan for conduct and management of a fully integrated engineering effort (including internal procedures) necessary to satisfy the general and specific requirements of MIL-STD-499A as implemented by the contract schedule or Statement Of Work (SOW). A contractor's SEMP is usually submitted as part of a response to a request for proposal in which system engineering is specified in the SOW. The SEMP is divided into three parts:

Part 1, System Engineering contains a description of the contractors system engineering process as proposed for application to the definition of system design and test requirements. It will contain the contractor's proposed plans, processes and procedures for:

- Functional analysis
- Requirements allocation
- Trade studies
- Design optimization/effectiveness analysis
- Synthesis
- Technical interface compatibility
- Logistics support analysis
- Productibility analysis
- Generation of specifications

Part 2, Technical Program Integration contains the contractor's proposed technical program planning and control of his engineering efforts for design, development, test and evaluation functions. It shall provide the plan for:

- Risk analysis
- Engineering integration
- Contract Work Breakdown Structure

- o Assignment of responsibility and authority
- o Program reviews
- o Technical Performance Measurement
- o Interface control
- o Documentation control

Part 3, Engineering Integration contains the engineering specialty programs proposed in accordance with applicable military standards. It will include methods by which the contractor proposes to integrate these specialty programs. In addition, this part will include a summary of each specialty program such as reliability, maintainability, safety, survivability, vulnerability, electromagnetic compatibility, etc Figure 10.

2.4.2 Technical Performance Measurement Report (DI-S-3619/ S-153) (USAF)

The Technical Performance Measurement Report is designed to provide visibility to the program manager on the state of engineering accomplishment toward the contract requirements compared to planned and required values." The reportable CI elements and parameters to be included in this report will be those listed in the SEMP. For each parameter selected for TPM reporting, reports shall include:

- o "The demonstrated value, planned value, and demonstrated variance for the design at the time of TPM, plus the current estimate, the current specification requirement and the predicted variance for the end product."
- o "Configuration design status and discussion of design and engineering investigations and analyses which support the demonstrated value, and discussion of the technical effort which supports the predicted profile leading to the current estimate."
- o "Variance Analysis to include discussion of design, development, and/or fabrication problems encountered which cause demonstrated or predicated performance

DATA ITEM DESCRIPTION	2. IDENTIFICATION NO(S)	
	AGENCY	NUMBER
1. TITLE System Engineering Management Plan (SEMP)		DI-S-3618/ S-152
3. DESCRIPTION/PURPOSE To set forth the contractor's proposed plan for the conduct and management of the fully integrated engineering effort necessary to satisfy the general and specific requirements of MIL-STD-499 as implemented by the contract schedule or statement of work.	4. APPROVAL DATE 9 Feb 1970	
	5. OFFICE OF PRIMARY RESPONSIBILITY AFSC	
	6. DDC REQUIRED	
	8. APPROVAL LIMITATION	
7. APPLICATION/INTERRELATIONSHIP Acquired as a product of the Contract Definition Phase IB (or equivalent), this plan is used in the evaluation of a contractor's proposal. This plan will be maintained current and may become a part of the acquisition contract statement of work.	9. REFERENCES (Mandatory as cited in block 10) MIL-STD-499	
	MCSL NUMBER(S)	

10. PREPARATION INSTRUCTIONS

The SEMP will be prepared in accordance with the applicable paragraphs of the requirements section of MIL-STD-499, System Engineering Management. This plan shall set forth a description of the contractor's proposed efforts for the planning, control, and conduct of a fully integrated engineering effort to satisfy general and specific requirements of MIL-STD-499 as tailored by the contract statement of work. The SEMP shall contain sufficient detail to establish that the contractor's proposed process (including internal procedures), his management, and the extent of the planned application of the process, will satisfy the requirements of the Standard as tailored by the statement of work. The SEMP shall include any contractor recommendations for further tailoring of the standard to the particular contractual effort. Those portions of the SEMP proposed by the contractor to become contractual requirements shall be denoted. This plan shall be divided into three parts:

Part 1 - System Engineering.

Part 2 - Technical Program Planning and Control.

Part 3 - Engineering Specialty Integration.

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Figure 10. SYSTEM ENGINEERING MANAGEMENT PLAN

outside the planned tolerance band. When this occurs, a revised planned value profile will be presented. The contractor will report impacts on higher level parameters, on interface requirements and on system cost effectiveness if appropriate. For performance deficiencies alternate and proposed recovery plans and associated configuration changes will be reported with the performance, cost, and schedule implications of each."

- o Appropriate graphical documentation of results (Figure 11).

2.4.3 Engineering Management Report (DI-M-30417)(USAF)

This report provides the PMO with current status information and an alert to significant program problems. Section One provides a summary of overall progress, either favorable or unfavorable. Section Two requires a report of each major technical area under current analysis, its technical progress, technical problems, alternative plans and significant meetings (Figure 12).

2.4.4 Subsystem/Engineering Development Report (DI-S-3582/S-102-1) (USAF)

This report provides "... visibility to the program/project manager on the state of engineering development of CI/subsystem, as well as providing a basis for projecting needed supporting efforts such as verification testing and production scheduling... These data are related to the design requirements for the CI/subsystem and to the design analyses conducted on the item during the design process... This report is ... applicable to other efforts where information on design evolution is necessary to support program decisions and related developmental efforts. This report will describe ... such information as: predicted performance compared to and based upon the design requirements characteristics, discussion of design and development investigations, and design/development and/or fabrication problems encountered, with proposed solutions and probable impact" (Figure 13).

DATA ITEM DESCRIPTION	2. IDENTIFICATION NO(S)	
	AGENCY	NUMBER
1. TITLE Technical Performance Measurement Report	USAF	DI-S-3619/ S-153
3. DESCRIPTION/PURPOSE To provide visibility to the program/project manager on the state of engineering accomplishment toward the contract requirements as compared with planned and required values. Provides a basis for projecting needed supporting efforts.	4. APPROVAL DATE 9 Feb 1970	
	5. OFFICE OF PRIMARY RESPONSIBILITY AFSC	
	6. DDC REQUIRED	
	8. APPROVAL LIMITATION	
7. APPLICATION/INTERRELATIONSHIP These data are related to the design requirements (Part I of the specification) for the Configuration Item (CI) and to its critical elements and design parameters. The reportable CI elements and parameters to be included in this report will be those listed in the System Engineering Management Plan incorporated as a contract requirement and will be identified on the DD Form 1423 either by attachment or reference to the SEMP. This DID will normally be used only when MIL-STD-499 is a contractual requirement; otherwise, DD Form 1664, DI-S-3582 or S-102, should be used. Should this DID be preferred to DI-S-3582 or S-102, when MIL-STD-499 is not a contractual requirement, the task effort for generating this data must be included in the contract work statement.	9. REFERENCES (Mandatory as cited in block 10) MIL-STD-499 AFR 375-7 AFSCM/AFLCM 310-1	
	MCSL NUMBER(S)	

10. PREPARATION INSTRUCTIONS

1. The contractor shall prepare a TPM report(s) on designated parameters. The DD Form 1423 will specify whether a particular report will cover all parameters of a system element, an individual parameter, or selected groupings of parameters.

2. For each parameter selected for TPM reporting, reports shall include:

a. The demonstrated value, planned value, and demonstrated variance for the design at the time of the TPM, plus the current estimate, the current specification requirement and the predicted variance for the end product. Determination of the current estimate shall be based on the demonstrated value and the changes to the parameter value which can be attained within the remaining schedule and cost baseline. The format shall be as described in paragraph 3 below.

b. Status of the configuration design and discussion of design and engineering investigations (e.g., experiments and tests performed) and analyses which support the demonstrated value, and discussion of the technical effort which supports the predicted profile leading to the current estimate.

c. Variance Analysis to include discussions of design, development, and/or fabrication problems encountered which cause demonstrated or predicted performance outside the planned tolerance band. When this occurs, a revised planned value profile will be presented as shown in Figure 2. The contractor will report impacts on higher level parameters, on interface requirements and on system cost effectiveness if appropriate. For performance deficiencies, alternate and proposed recovery plans

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Figure 11. TPM REPORT

DATA ITEM DESCRIPTION	2. IDENTIFICATION NO(S) AGENCY	NUMBER
1. TITLE Engineering Management Report	USAF	DI-M-30417
3. DESCRIPTION/PURPOSE The purpose of this report is to keep top program management informed of what is happening, give them warning signals of impending trouble and to direct their attention to significant program problems.	4. APPROVAL DATE 1 Mar 1970	
	5. OFFICE OF PRIMARY RESPONSIBILITY AFSC	
	6. DDC REQUIRED	
	8. APPROVAL LIMITATION	
7. APPLICATION/INTERRELATIONSHIP Broadly speaking, the report should give the answer to the question, "How are we doing?" It is intended that this report will be distributed at levels equal to and above the SPD. Formerly UM-672 (ASD)	9. REFERENCES (Mandatory as cited in block 10)	
	MCSL NUMBER(S)	

10. PREPARATION INSTRUCTIONS

Section I

A. Provide a two page summary pertaining to the overall progress (favorable and unfavorable) of the program.

Section II

A. The outline of the report shall be applied to each major technical area under current analysis. Each area will be discussed separately in terms of:

1. Technical Progress
   (favorable and unfavorable)
2. Technical Problems
   In discussing a specific problem, it is expected that the contractor will identify and discuss the root cause to whatever level is necessary.
3. Plan for
   (Several alternatives and their related advantages and disadvantages should be discussed that lead to the specific course of action decided upon.
4. Significant Meetings

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*U.S. GOVERNMENT PRINTING OFFICE: 1977—703-020/4485

Figure 12. ENGINEERING MANAGEMENT REPORT

DATA ITEM DESCRIPTION	2. IDENTIFICATION NO(S).	
	AGENCY	NUMBER
1. TITLE Subsystem/Engineering Development Report	USAF	DI-S-3582/ S-102-1
3. DESCRIPTION/PURPOSE To provide visibility to the Air Force program/project manager on the state of engineering development of the CI/ subsystem, as well as provide a basis for projecting needed supporting efforts such as verification testing and production scheduling.	4. APPROVAL DATE 1 November 1971	
	5. OFFICE OF PRIMARY RESPONSIBILITY AFSC	
	6. DDC REQUIRED	
	8. APPROVAL LIMITATION	
7. APPLICATION/INTERRELATIONSHIP These data are related to the design requirements (Part I of the special) for the CI/subsystem and to the design analyses conducted on the item during the design process. The report may consist of an initial report, followed by updating reports as the design process finalizes the design configuration of the CI/subsystem by the time of the physical configuration audit (PCA). Although acquired primarily during systems/major equipment asquisition programs, this report is also applicable to other efforts where information on design evolution is necessary to support program decisions and related developmental efforts.	9. REFERENCES *(Mandatory as cited in block 10)*	
	MCSL NUMBER(S)	

10. PREPARATION INSTRUCTIONS

1. The contractor shall prepare an Engineering Development Report for each CI/subsystem as specified on the DD Form 1423.

2. The report shall be structured to separately cover each of the major subtasks of the effort required to develop the CI/subsystem, as defined by the Design Requirements Specification and contract.

3. The report will describe the current design development of the CI/subsystem, to include such information as:

a. Predicted performance compared to and based upon the design requirements characteristics. Where the specific performance parameters required to be compared are not self-evident, they may be further identified in an attachment to the CDRL as a modification to this Data Item Description.

b. Status of the configuration design and changes made thereto to achieve the required performance capability.

c. Discussion of design and development investibations (e.g., experiments and tests performed).

d. Design, development, and/or fabrication problems encountered, with proposed solutions and probable impact.

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Figure 13. SUBSYSTEM/ENGINEERING DEVELOPMENT REPORT

2.4.5 Assessment Technical Performance Measurement Report (DI-R-1754) (U.S. Army)

The TPM report "records the data resulting from the design assessment which estimates and measures the values of essential performance parameters of the current design of the product Work Breakdown Structure (WBS) elements. The data are used as a measure of the effectiveness of actual and planned system performance. The TPMR is initiated during contract definition and continues throughout the development and production phases. It may continue into the operational phase if product improvement takes place" (Figure 14).

2.4.6 Assessment System Performance Record (DI-R-1755) (U.S. Army)

"The System Performance Record (SPR) is the entire collection of data which must be maintained in order to explain the methodology and criteria for system performance assessment, describe the system WBS, identify and determine the status of all system performance parameters, and ensure a complete analysis of the effect of engineering changes on system performance" (Figure 15).

2.4.7 Data Accession List/Internal Data (UDI-A-26486)

The government can obtain data by means other than specific DID inclusion in the CDRL. The contractor will have an internal reporting system for distributing and controlling data it produces. The government can order data from the list provided to the PMO, IAW UDI-A-26486, of these internal reports. The reports will be written in the contractor's format. The advantage to ordering data by this method is that the government pays for only the reproduction costs and not the preparation cost. The disadvantage of this method is the lack of format control and extended time delay in delivery. (Figure 16).

DATA ITEM DESCRIPTION	2. IDENTIFICATION NO'S. AGENCY	NUMBER
1. TITLE Assessment Technical Performance Measurement Report	Army	DI-R-1754

3. DESCRIPTION/PURPOSE The Technical Performance Measurement (TPM) Report records the data resulting from the design assessment which estimates and measures the values of essential performance parameters of the current design of the product Work Breakdown Structure (WBS) elements. The data is used as a measure of the effectiveness of actual and planned system performance.	4. APPROVAL DATE 15 Dec 69 5. OFFICE OF PRIMARY RESPONSIBILITY USAMC 6. DDC REQUIRED 8. APPROVAL LIMITATION
7. APPLICATION/INTERRELATIONSHIP The TPM is initiated during contract definition and continues throughout the development and production phases. It may continue into the operational phase if product improvement takes place. DI-R-1750, Assessment Program Plan DI-R-1753, Assessment System Performance Status Report	9. REFERENCES (Mandatory as cited in block 10) AR 70-32 MIL-STD-881 TM 38-760 MCSL NUMBER(S) 50911 10100 30854

10. PREPARATION INSTRUCTIONS

1. Unless specified otherwise by the procuring activity the TPM Report shall contain the following sections:

   a. Planned Parameter Profiles
   b. Parameter Status Tracking and Forecast
   c. Records of Achieved Parameter Profiles
   d. Problem Analysis and Corrective Action
   e. Input Data for the System Performance Status Report (SPSR).

2. Instructions for the preparation of each of these sections will be as specified by the procuring activity.

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Figure 14. ASSESSMENT TPM REPORT

DATA ITEM DESCRIPTION

1. TITLE: Assessment System Performance Record	2. IDENTIFICATION NO(S) — AGENCY: Army; NUMBER: DI-R-1755
3. DESCRIPTION/PURPOSE: The System Performance Record (SPR) is the entire collection of data which must be maintained in order to explain the methodology and criteria for system performance assessment, describe the system Work Breakdown Structure (WBS), identify and determine the status of all system performance parameters, and ensure a complete analysis of the effect of engineering changes on system performance.	4. APPROVAL DATE: 15 Dec 69 5. OFFICE OF PRIMARY RESPONSIBILITY: USAMC 6. DDC REQUIRED: 8. APPROVAL LIMITATION:
7. APPLICATION/INTERRELATIONSHIP: The SPR represents the data base from which System Performance Status Reports (DI-R-1753) are prepared. DI-R-1750, Assessment Program Plan	9. REFERENCES (Mandatory as cited in block 10): MIL-STD-881 AR 70-32 TM 38-760 AMCR 702-8 MCSL NUMBER(S): 50911 10100 30854

10. PREPARATION INSTRUCTIONS

The SPR shall be structured and maintained as specified by the procuring activity.

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Figure 15. ASSESSMENT SYSTEM PERFORMANCE RECORD

DATA ITEM DESCRIPTION	2. IDENTIFICATION NO(S)	
	AGENCY	NUMBER
1. TITLE DATA ACCESSION LIST/INTERNAL DATA	NAVY-SH	UDI-A-26486

3. DESCRIPTION/PURPOSE

The purpose of the data item description is to provide an accession list which is an index of data that may be available for request. It is a medium for identifying contractor internal data which have been generated by the contractor in compliance with the work effort described in the Statement of Work.

4. APPROVAL DATE: 73 Dec 14

5. OFFICE OF PRIMARY RESPONSIBILITY: SHIPS 0465

6. DDC REQUIRED

8. APPROVAL LIMITATION

7. APPLICATION/INTERRELATIONSHIP

7.1 This Data Item Description is designed for use on contracts to facilitate the identification of internally generated data that is usually not determinable at the outset of a contract. The list may be used to identify data developed by the contractor for his own internal use that may be of value in Government program management.

9. REFERENCES (Mandatory as cited in block 10)

MCSL NUMBER(S)

10. PREPARATION INSTRUCTIONS

10.1 The Data Accession List is a list of contractor internally generated data used by the contractor to develop, test, and manage a program. The format and content of these data shall be as prepared by the contractor to document his compliance with the Statement of Work task requirements.

10.2 The Data Accession List shall be a listing of all data, including drawings, documents, specifications, manuals, plans, reviews, reports, computer program, and vendor-furnished data developed under a program contract, whether technical or managerial, deliverable or non-deliverable.

10.2.1 The list shall include as a minimum: the identification number, title, and in-house release date, forecast/actual.

10.2.2 Data items shall be cross reference to their appropriate Contract Work Breakdown Structure sub-task number. The contractor organizational unit responsible for each data item will be included.

10.2.3 The list shall begin as a listing of the contractual (as negotiated) Authorized Data List and shall develop to include all data generated in the program.

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Figure 16. DATA ACCESSION LIST/INTERNAL DATA

2.4.8 Selection of TPM Reports

The Data Requirements Review board will develop the list of data/reports that the program will put on contract through the CDRL. The PM should make the final decision on data requirements based on cost and need. For TPM, parameters will be selected, identified in the SOW, and reports will be required. As noted in paragraph 2.3.4, parameters will be selected for various reasons; however, requirements levied by higher headquarters must be considered when data requirements are developed. The previous listed DIDs provide the basis for TPM reporting; however, specially tailored reports can be developed. Some contractors have established TPM reporting formats. If these are appropriate, they may be requested through the Data Accession Listing.

As parameters are achieved and no further action planned, reporting requirements should be deleted. Contractor reporting frequency should be based on the expected change in data and the PMO's need for information. Contractor reports have a cost and should only be required or continued when they provide needed information for timely PMO action.

Chapter 3

COST/SCHEDULE CONTROL SYSTEM CRITERIA (C/SCSC)

3.1 INTRODUCTION

A fundamental responsibility in the acquisition and modification of major systems is to ensure that visibility of contractors' progress is sufficient to reliably assess the results being obtained. C/SCSC allows contractors to use the specific management system of their choice. The use of generalized criteria establishes the characteristics and capabilities which should be inherent in an effective cost and schedule control system as an alternative to a single DoD dictated measurement system. The objective is to obtain assurance that the contractor's internal management systems are sound, and to obtain summarized data for cost effective contract management. This chapter is designed to provide basic knowledge of C/SCSC and the reports that are generated from an acceptable contractor system. For further information, the following documents should be reviewed: DoDI 7000.2 Performance Measurement for Selected Acquisitions; AFSCP 173-5, DARCOM-P 715-5, NAVMAT P5240, Cost/Schedule Control Systems Criteria Joint Implementation Guide; and DoDI 7000.10, Contract Cost Performance, Funds Status and Cost/Schedule Status Reports.

3.2 THE CRITERIA

DoD Instruction 7000.2, Enclosure 1, Performance Measurement for Selected Acquisition, and the Tri-Service Cost/Schedule Control Systems Criteria, Joint Implementation Guide, provide the guidance for implementation of C/SCSC.

After considerable turmoil, DoD determined that the development of a universal system for cost and schedule control was not feasible. No single set of management control systems will meet every DoD and contractor need for performance measurement due to variations in organizations, products and methods utilized. DoD has adopted an approach which simply defines the criteria that must be met by contractors' management control systems.

As a minimum, contractors' management control systems are expected to provide a framework for defining work; assigning work responsibility; establishing budgets; controlling costs; and summarizing, with respect to planned versus actual accomplishment, the detailed cost, schedule, and related technical achievement information for appropriate management levels. Such systems must provide for:

- o Realistic budgets for work schedule within responsibility assignments.
- o Accurate accumulation of costs related to progress of the planned work.
- o Comparison between the actual resources applied and the estimated resources planned for specific work assignments.
- o Preparation of reliable estimates of costs to complete remaining work.
- o Support an overall capability for managers to analyze available information to identify problem areas in sufficient time to take remedial action.

The criteria are grouped under five headings: ORGANIZATION; PLANNING & BUDGET; ACCOUNTING; ANALYSIS; and REVISIONS & ACCESS TO DATA. The contractor's management control systems will include policies, procedures and methods designed to ensure that they will accomplish each of the five items.

3.2.1. Organization

- o "Define all authorized work and related resources to meet the requirements of the contract, using the framework of the Contractor Work Breakdown Structure (CWBS).
- o Identify the internal organizational elements and the major subcontractors responsible for accomplishing the authorized work.

- Provide for the integration of the contractor's planning, scheduling, budgeting, work authorization and cost accumulation systems with each other, the CWBS, and the organizational structure.

- Identify the managerial positions responsible for controlling overhead (indirect costs)." (4)

3.2.2 Planning and Budgeting

- "Schedule the authorize work in a manner which describes the sequence of work and identifies the significant task interdependencies required to meet the development, production, and delivery requirements of the contract.

- Identify physical products, milestones, technical performance goals, or other indicators that will be used to measure output.

- Establish and maintain a time-phased budget baseline at the cost account level against which contract performance can be measured. Initial budgets established for this purpose will be based on the negotiated target cost. Any other amount used for performance measurement purposes must be formally recognized by both the contractor and the Government.

- Establish budgets for all authorized work with separate identification of cost elements (labor, material, etc.).

- To the extent that the authorized work can be identified in discrete, short-span work packages, establish budgets for this work in terms of dollars, hours, or other measurable units. Where the entire cost account cannot be subdivided into detailed work packages, identify the far-term effort in larger planning packages for budget and scheduling purposes.

- Provide that the sum of all work package budgets plus planning packages within a cost account equals the cost account budget.

- Identify relationships of budgets or standards in underlying work authorization systems to budgets for work packages.

- Identify and control Level of Effort (LOE) activity by time-phased budgets established for this purpose. Only that effort which cannot be identified as discrete, short-span work packages or as apportioned effort will be classified as level of effort.

(4) DARCOM-P 715-13/NAVMAT P5244/AFLCP 173-2/AFSCP 173-3/ DLAH 8315.3, Cost/Schedule Control System Criteria, Joint Implementation Guide, October 1980.

- Establish overhead budgets for the total costs of each significant organizational component whose expenses will become indirect costs. Reflect in the contract budgets, at the appropriate level, the amounts in overhead pools that will be allocated to the contract as indirect costs.
- Identify management reserves and undistributed budget.
- Provide that the contract target cost plus the estimated cost of authorized but unpriced work is reconciled with the sum of all internal contract budgets and management reserves." (5)

3.2.3 Accounting

- "Record direct costs on an applied or other acceptable basis in a formal system that is controlled by the general books of accounting.
- Summarize direct costs from cost accounts into the WBS without allocation of a single cost account to two or more WBS elements.
- Summarize direct costs from the cost accounts into the contractor's functional organizational elements without allocation of a single cost account to two or more organizational elements.
- Record all indirect costs which will be allocated to the contract.
- Identify the basis for allocating the cost of apportioned effort.
- Identify unit costs, equivalent unit costs, or lot costs, as applicable.
- The contractor's material accounting system will provide for:
  - Accurate cost accumulation and assignment of costs to cost accounts in a manner consistent with the budgets, using recognized, acceptable costing techniques.
  - Determination of price variances by comparing planned versus actual commitments.
  - Cost performance measurement at the point in time most suitable for the category of material involved, but no earlier than the time of actual receipt of material.
  - Determination of cost variances attributable to the excess usage of material.

(5) Ibid

- Determination of unit or lot costs when applicable.

- Full accountability for all material purchased for the contract, including the residual inventory." (6)

3.2.4 Analysis

o "Identify at the cost account level on a monthly basis using data from, or reconcilable with, the accounting system:

- Budgeted cost for work scheduled and budgeted cost for work performed.

- Budgeted cost for work performed and applied (actual where appropriate) direct costs for the same work.

- Variances resulting from the above comparisons classified in terms of labor, material, or other appropriate elements together with the reasons for significant variances.

o Identify on a monthly basis, in the detail needed by management for effective control, budgeted indirect costs, actual indirect costs, and variance along with the reasons.

o Summarize the data elements and associated variances listed above, through the contractor organization and WBS to the reporting level specified in the contract.

o Identify significant differences on a monthly basis between planned and actual schedule accomplishment and the reasons for the discrepancies.

o Based on performance to date and on estimates of future conditions, develop revised estimates of cost at completion for WBS elements identified in the contract, and compare these with the contract budget base and the latest statement of funds requirements reported to the Government." (7)

3.2.5. Revisions and Access to Data

o "Incorporate contractual changes in a timely manner, recording the effects of such changes in budgets and schedules. In the directed effort before negotiation of a change, base such revisions on the amount estimated and budgeted to the functional organizations.

(6) Ibid

(7) Ibid

- Reconcile original budgets for those elements of the WBS identified as priced line items in the contract, and for those elements at the lowest level of the DoD Project Summary WBS, with current performance measurement budgets in terms of (a) changes to the authorized work and (b) internal replanning in the detail needed by management for effective control.

- Prohibit retroactive changes to records pertaining to work performed that will change previously reported amounts for direct costs, indirect costs, or budgets, except for correction of errors and routine accounting adjustments.

- Prevent revisions to the contract budget base except for Government-directed changes to contractual effort.

- Document, internally, changes to the performance measurement baseline and, on a timely basis, notify the procuring activity through prescribed procedures.

- Provide the contracting officer and duly authorized representatives access to all of the foregoing information and supporting documents." [8]

3.3 HOW IS COST AND SCHEDULE PERFORMANCE MEASURED?

The objective of C/SCSC is twofold: first to obtain assurance that contractors' internal management control systems are sound, and second to obtain summarized data for contract management. Contractors' internal systems must be able to provide:

- Budgeted Cost for Work Scheduled (BCWS).
- Budgeted Cost for Work Performed (BCWP).
- Actual Cost of Work Performed (ACWP).
- Estimated cost at completion.
- Budgeted cost at completion.
- Cost and schedule variances.
- Traceability.

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[8] Ibid

The BCWS represents the value of the work planned to be done at a given point in time. BCWP represents the value of completed work. The comparison of BCWS with BCWP indicates whether more or less work was done than scheduled: the difference is schedule variance. Comparison of BCWP with ACWP indicates whether the actual cost of the work performed was greater or less than the planned cost. Based on performance to date and estimate of future conditions, an estimated cost at completion can be computed and compared to the total budget. At the contract level, total budget is usually equal to the contract value, and the difference will provide a forecast of contract over or under-run.

The WBS, MIL-STD-881A, is a family-tree type subdivision of products, components, work tasks and services required to produce an end product (Figure 17). For performance measurement purposes, it is desirable that the WBS be structured in the same way that the work is actually to be performed. The top three levels of the contract WBS are developed by the government and negotiated with the contractor. These summary level items are included in the contract. The contractor may extend the summary WBS in any manner he chooses to divide the contractual work into manageable portions, before he assigns responsibility. Contract line items are included normally as separate WBS elements and the WBS is aligned with the statement of work as much as possible. Integration of the contractor organizational structure with the WBS is necessary in order to assign functional responsibility (Figure 18). The intersection of the organizational structure and the CWBS is normally referred to as the <u>cost account</u>, and it is at this point that collection and analysis of cost and other information is accomplished prior to summation for higher level management.

The integration of the organizational structure and the CWBS results in a key intersection or management control point (cost account). Integration of the other subsystems (scheduling, budgeting, work authorization, and cost collection) should also

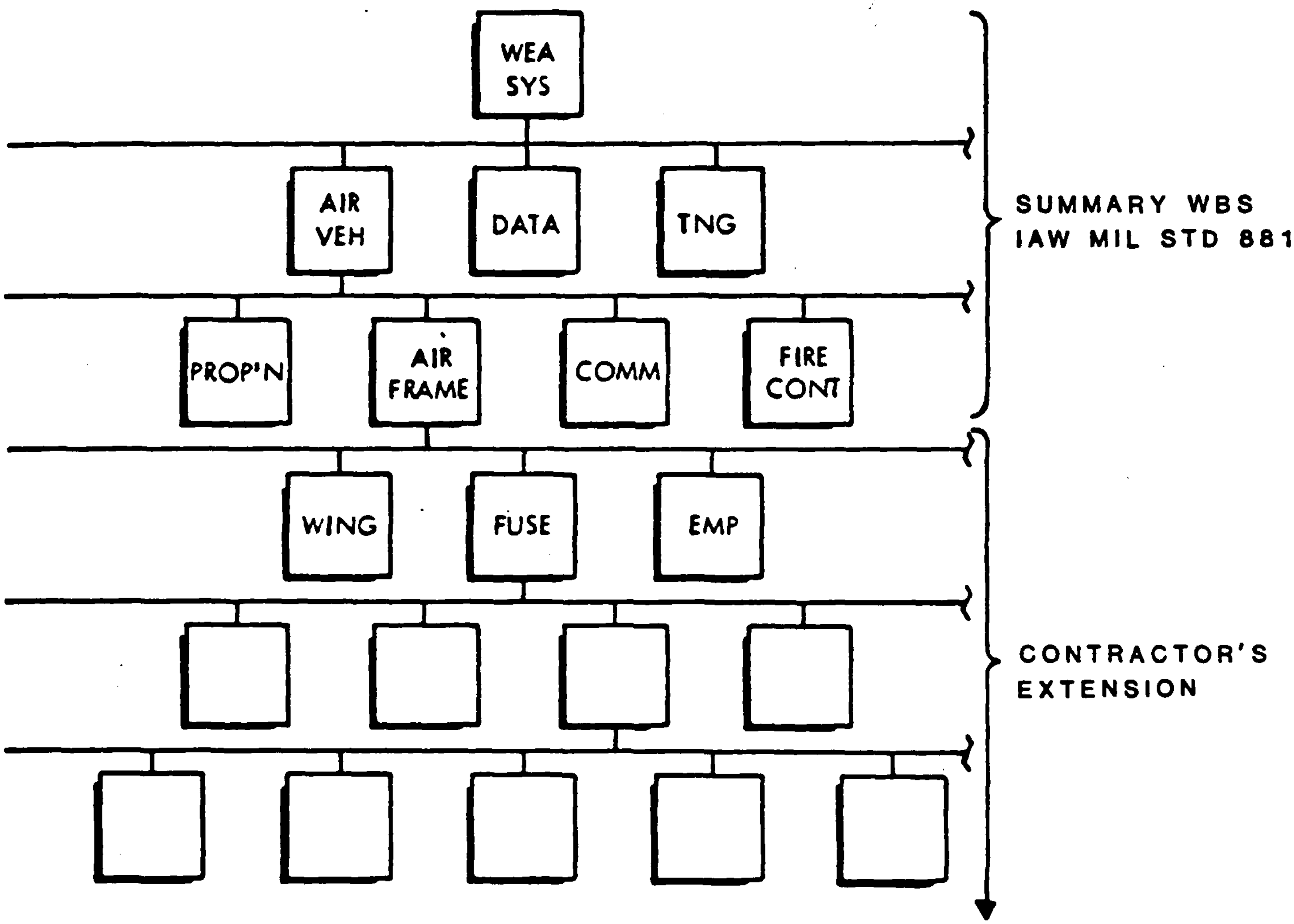

Figure 17. WORK BREAKDOWN STRUCTURE

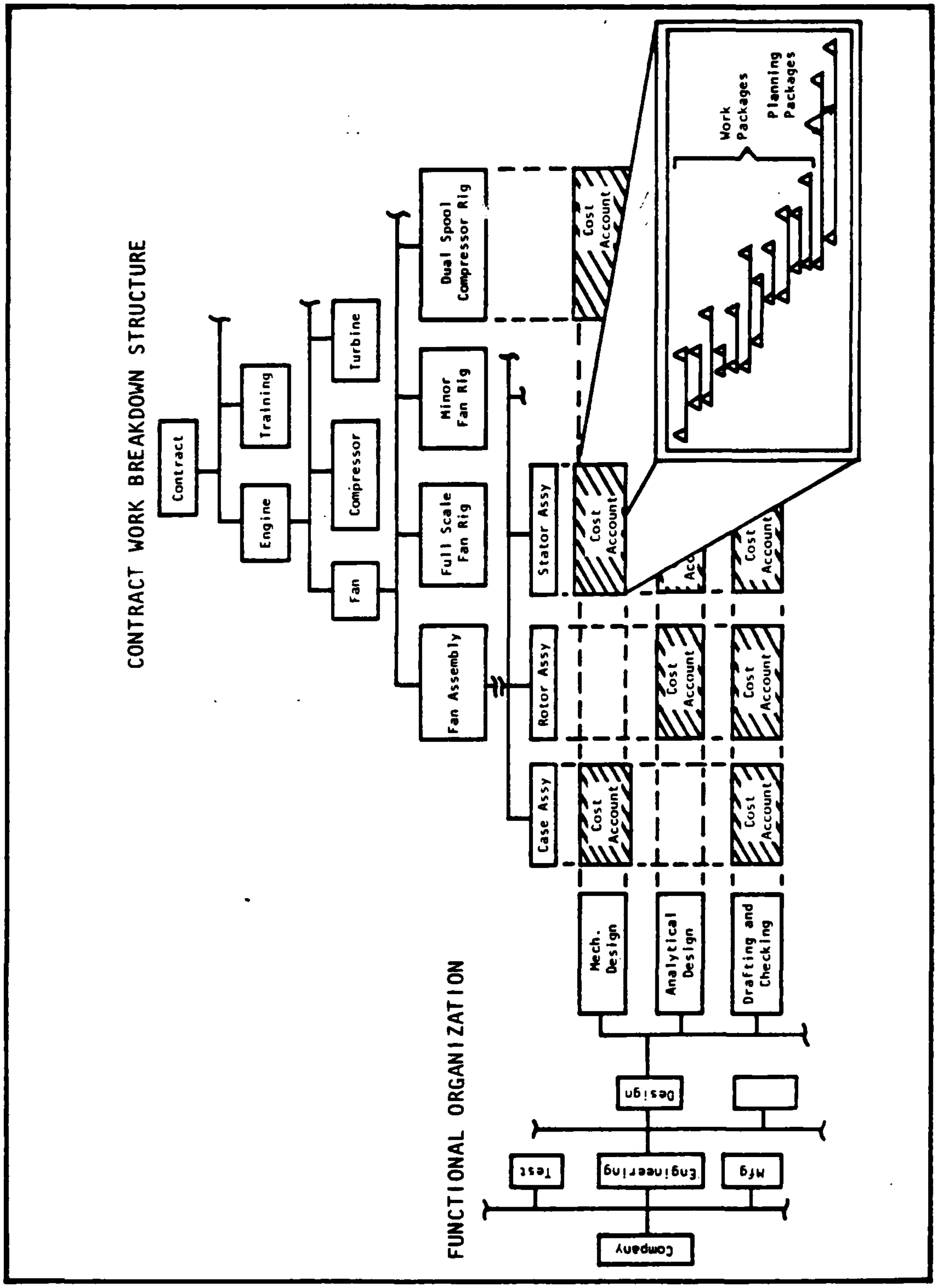

Figure 18. INTEGRATION

DARCOM-P 715-13/NAVMAT P5244/AFLCP 173-2/AFLCP 173-3/ DLAH 8315.3, COST/SCHEDULE CONTROL SYSTEM CRITERIA, JOINT IMPLEMENTATION GUIDE, OCTOBER 1980 exist at the management control point since this is where the planning and management for lower level tasks occurs.

Once functional responsibilities for the work have been established, further subdivision of the effort into <u>work packages</u> can be accomplished and the work can be identified with the performing organization or individuals.

Work packages are the basic building blocks used for detailed planning, assignment and control of contract performance. The task of a work package should be clearly defined, scheduled, budgeted and assigned to a single organization responsible for its completion.

The contractor defines the contractual effort using the WBS as an aid to subdividing and displaying units of work. Scheduling and budgeting the work produces a time-phased baseline which can be used for performance measurement purposes, and effectively integrates the work, schedule and budget. Contract accomplishment is measured by accumulating the budgets applicable to work performed (BCWP) and comparing them to the budgets for work scheduled (BCWS) and to the actual costs of work performed (ACWP). This derives both schedule and cost variances. Performance trends and work yet to be accomplished can be used to develop an estimated cost at completion.

3.4 REPORTING

As noted earlier, C/SCSC provides criteria that contractors' management control systems must meet. C/SCSC is not a reporting system. Department of Defense Instruction 7000.10, Contract Cost Performance, Cost/Schedule Status Reports, provides procedures for collecting summary level cost and schedule performance data from contractors for program management purposes. This instruction encourages contractors to substitute internal reports, provided that the data elements and definitions are compatible with prescribed requirements and in a form suitable for management use. Data Item Description DI-F-6000B identifies the Cost Performance Report (Figure 19).

3.4.1 Cost Performance Report (CPR)

The CPR provides contract cost/schedule status information for use in making and validating management decisions based on problem identification through variance analysis of both cost and schedule. The CPR is provided in five formats:

Format 1 provides data to measure cost and schedule performance by summary level WBS elements (Figure 20).

Format 2 provides similar measurement by organizational or functional categories (Figure 21).

Format 3 provides the budget baseline plan against which performance is measured (Figure 22).

Format 4 provides manpower loading forecasts correlated with the budget plan and cost estimate predictions (Figure 23).

Format 5 is a narrative report used to explain significant cost and schedule variances and other identified contract problems (Figure 24).

Program managers use the CPR to evaluate contract performance, identify the size and impact of actual and potential problem areas causing significant cost and schedule variance, and provide status information to higher headquarters.

3.4.2 Cost/Schedule Status Report (C/SSR)

The C/SSR provides summarized cost and schedule performance information which is limited to level 3 or higher of the contract work breakdown structure. It is normally used on smaller

DATA ITEM DESCRIPTION

1. TITLE	2. IDENTIFICATION NO(S). AGENCY	NUMBER
COST PERFORMANCE REPORT	DOD	DI-F-6000B

3. DESCRIPTION/PURPOSE

3.1 This report is prepared by contractors and consists of five formats containing cost and related data for measuring contractors' cost and schedule performance. Format 1 provides data to measure cost and schedule performance by summary level work breakdown structure elements. Format 2 provides a similar measurement by organizational or functional cost categories. Format 3 provides the budget baseline plan against which performance is measured. Format 4 provides manpower loading forecasts for (Continued on page 2)

4. APPROVAL DATE

1 February 1979

5. OFFICE OF PRIMARY RESPONSIBILITY

OASD(C)MS

6. DDC REQUIRED

8. APPROVAL LIMITATION

7. APPLICATION/INTERRELATIONSHIP

7.1 The CPR will normally be required for selected contracts within those programs designated as major programs in accordance with DoD Directive 5000.1, "Major System Acquisitions," dated 18 January 1977. It will be established as a contractual requirement as set forth in the DD Form 1423 Contract Data Requirements List (CDRL), and DD Form 1660, Management System Summary List.

7.2 If the CPR supports a contractual requirement for contractor compliance with the Cost/Schedule Control Systems Criteria (C/SCSC), the CPR data elements will reflect the contractor's implementation in accordance with Department of Defense Instruction 7000.2. If compliance with the C/SCSC

(Continued on page 2)

9. REFERENCES (Mandatory as cited in block 10)

DoDD 5000.1
DoDD 5000.19
DoDD 5000.32
DoDI 7000.2
DoDI 7000.10
Cost Accounting Standard 414

MCSL NUMBER(S)

00934

10. PREPARATION INSTRUCTIONS

10.1 Unless otherwise stated in the solicitation, the effective issue of the document(s) cited in the referenced document(s) in this block shall be that listed in the issue of the DoD Index of Specifications and Standards (DoDISS) and the supplements thereto specified in the solicitation and will form a part of this data item description to the extent defined within.

10.2 Hard copy printouts from contractors' internal mechanized reporting systems may be substituted for CPR formats provided the printouts contain all the required data elements at the specified reporting levels in a form suitable for DoD management use. Where data are furnished which require mechanized processing, narrative remarks should accompany tapes or cards and identify pertinent items to which they apply, and a listing of the tape or card data should be included to expedite processing. CPR formats will be completed in accordance with the following instructions:

10.2.1 <u>Heading Information - Formats 1 through 4</u>

10.2.1.1 <u>Contractor Name and Location</u>: Enter the name, division, if applicable, plant location and mailing address of the reporting contractor.

10.2.1.2 <u>RDT&E ☐ Production ☐</u>: Check appropriate box. Separate reports are required for each type of contract.

10.2.1.3 <u>Contract Type/Number</u>: Enter the contract type, contract number and the number of the latest contract change or supplemental agreement applicable to the contract.

(Continued on page 3)

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PAGE 1 OF 18 PAGES

Figure 19. COST PERFORMANCE REPORT

CLASSIFICATION

Page ___ of ___

CONTRACTOR: LOCATION: RDT&E ☐ PRODUCTION ☐	COST PERFORMANCE REPORT – WORK BREAKDOWN STRUCTURE			SIGNATURE, TITLE & DATE	FORM APPROVED OMB NUMBER 22R0280
	CONTRACT TYPE / NO.:	PROGRAM NAME/NUMBER	REPORT PERIOD:		

QUANTITY	NEGOTIATED COST	EST COST AUTH. UNPRICED WORK	TGT PROFIT/FEE %	TGT PRICE	EST PRICE	SHARE RATIO	CONTRACT CEILING	EST CONTRACT CEILING

ITEM	CURRENT PERIOD					CUMULATIVE TO DATE					REPROGRAMMING ADJUSTMENTS		AT COMPLETION		
	BUDGETED COST		ACTUAL COST WORK PERFORMED	VARIANCE		BUDGETED COST		ACTUAL COST WORK PERFORMED	VARIANCE		COST VARIANCE	BUDGET	BUDGETED	LATEST REVISED ESTIMATE	VARIANCE
	Work Scheduled	Work Performed		Schedule	Cost	Work Scheduled	Work Performed		Schedule	Cost					
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
WORK BREAKDOWN STRUCTURE															
COST OF MONEY															
GEN AND ADMIN															
UNDISTRIBUTED BUDGET															
SUBTOTAL															
MANAGEMENT RESERVE															
TOTAL															
RECONCILIATION TO CONTRACT BUDGET BASE															
VARIANCE ADJUSTMENT															
TOTAL CONTRACT VARIANCE															
						(ALL ENTRIES IN THOUSANDS OF DOLLARS)									

Format 1

CLASSIFICATION

Figure 20. CPR - WBS

CLASSIFICATION

Page ___ of ___

CONTRACTOR: LOCATION: RDT&E ☐ PRODUCTION ☐	COST PERFORMANCE REPORT - FUNCTIONAL CATEGORIES														FORM APPROVED OMB NUMBER 22R0280
	CONTRACT TYPE/NO.:					PROGRAM NAME/NUMBER:					REPORT PERIOD:				
ORGANIZATIONAL OR FUNCTIONAL CATEGORY	CURRENT PERIOD					CUMULATIVE TO DATE					REPROGRAMMING ADJUSTMENTS		AT COMPLETION		
	BUDGETED COST		ACTUAL COST WORK PERFORMED	VARIANCE		BUDGETED COST		ACTUAL COST WORK PERFORMED	VARIANCE		COST VARIANCE	BUDGET	BUDGETED	LATEST REVISED ESTIMATE	VARIANCE
	Work Scheduled	Work Performed		Schedule	Cost	Work Scheduled	Work Performed		Schedule	Cost					
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
COST OF MONEY															
GEN AND ADMIN															
UNDISTRIBUTED BUDGET															
SUBTOTAL															
MANAGEMENT RESERVE															
TOTAL															

Format 2

CLASSIFICATION

Figure 21. CPR - FUNCTIONAL CATEGORIES

CLASSIFICATION

Page ___ of ___

CONTRACTOR: LOCATION: RDT&E ☐ PRODUCTION ☐	COST PERFORMANCE REPORT - BASELINE			FORM APPROVED OMB NUMBER 22R0280
	CONTRACT TYPE/NO.:	PROGRAM NAME/NUMBER	REPORT PERIOD:	

(1) ORIGINAL CONTRACT TARGET COST	(2) NEGOTIATED CONTRACT CHANGES	(3) CURRENT TARGET COST (1) + (2)	(4) ESTIMATED COST OF AUTHORIZED, UNPRICED WORK	(5) CONTRACT BUDGET BASE (3) + (4)	(6) TOTAL ALLOCATED BUDGET	(7) DIFFERENCE (5) - (6) (SEE PAGE 9)

(8) CONTRACT START DATE	(9) CONTRACT DEFINITIZATION DATE	(10) LAST ITEM DELIVERY DATE	(11) CURRENT COMPLETION DATE	(12) ESTIMATED COMPLETION DATE

ITEM	BCWS CUM TO DATE	BCWS FOR REPORT PERIOD	BUDGETED COST FOR WORK SCHEDULED (NON-CUMULATIVE)											UNDIST BUDGET	TOTAL BUDGET
			SIX MONTH FORECAST						(ENTER SPECIFIED PERIODS)						
			+1	+2	+3	+4	+5	+6							
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
PM BASELINE (BEGINNING OF PERIOD)															
(LIST BASELINE CHANGES AUTHORIZED DURING REPORT PERIOD)															
PM BASELINE (END OF PERIOD)															
MANAGEMENT RESERVE															
TOTAL															

Format 3

CLASSIFICATION

Figure 22. CPR - BASELINE

CLASSIFICATION

Page ___ of ___

CONTRACTOR: LOCATION: RDT&E ☐ PRODUCTION ☐	COST PERFORMANCE REPORT – MANPOWER LOADING CONTRACT TYPE / NO.: / PROGRAM NAME/NUMBER: / REPORT PERIOD:													FORM APPROVED OMB NUMBER 22R0280
ORGANIZATIONAL OR FUNCTIONAL CATEGORY	ACTUAL CURRENT PERIOD	ACTUAL END OF CURRENT PERIOD (CUM)	FORECAST (NON-CUMULATIVE)											AT COMPLETION
			SIX MONTH FORECAST BY MONTH (ENTER NAMES OF MONTHS)							(ENTER SPECIFIED PERIODS)				
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
TOTAL DIRECT														

(ALL FIGURES IN WHOLE NUMBERS)

Format 4

CLASSIFICATION

Figure 23. CPR – MANPOWER LOADING

CLASSIFICATION

Page ___ of ___

CONTRACTOR: LOCATION: RDT&E ☐ PRODUCTION ☐	COST PERFORMANCE REPORT – PROBLEM ANALYSIS			FORM APPROVED OMB NUMBER 22R0280
	CONTRACT TYPE/NO.:	PROGRAM NAME/NUMBER:	REPORT PERIOD:	

EVALUATION

Section 1 - Total Contract: Provide a summary analysis, identifying significant problems affecting performance. Indicate corrective actions required, including Government action where applicable.

Section 2 - Cost and Schedule Variances: Explain all variances which exceed specified variance thresholds. Explanations of variances must clearly identify the nature of the problem, the reasons for cost or schedule variance, impact on the immediate task, impact on the total program, and the corrective action taken. Explanations of cost variances should identify amounts attributable to rate changes separately from amounts applicable to manhours used; amounts attributable to material price changes separately from amounts applicable to material usage; and amounts attributable to overhead rate changes separately from amounts applicable to overhead base changes and amounts applicable to changes in the overhead allocation basis.

Within this section, the following specific variances must be explained:

a. Schedule variances (Budgeted Cost for Work Scheduled vs Budgeted Cost for Work Performed)
b. Cost variances (Budgeted Cost for Work Performed vs Actual Cost of Work Performed)
c. Cost variances at completion (Budgeted at Completion vs Latest Revised Estimate at Completion)

Section 3 - Other Analysis: In addition to the variance explanations above, the following analyses are mandatory:

a. Identify the effort to which the undistributed budget applies.
b. Identify the amount of management reserve applied during the reporting period, the WBS and organizational elements to which applied, and the reasons for application.
c. Explain reasons for significant shifts in time-phasing of the PM Baseline shown on Format 3.
d. Explain significant changes in total man-months at completion shown on Format 4.
e. Explain reasons for significant shifts in time-phasing of planned or actual manpower usage shown on Format 4.

Section 4 - Over-Target Baseline: If the difference shown in block (7) on Format 3 becomes a negative value or changes in value, provide:

a. Procuring activity authorization for the baseline change which resulted in negative value or change.
b. Reasons for the additional budget in the following terms:
   (1) In-scope engineering changes
   (2) In-scope support effort changes
   (3) In-scope schedule changes
   (4) Economic change
   (5) Other (specify)
c. The amount (by WBS element) for added in-scope effort not previously identified or budgeted.

Format 5

CLASSIFICATION

Figure 24. CPR - PROBLEM ANALYSIS

programs which do not use the CPR and is provided in only a single format, versus the five formats for the CPR. The C/SSR does not have the underlying requirement of a compliant C/SCSC system as does the CPR, therefore knowledge of the contractor system is extremely important to the PM. Data Item Description DI-F-6010A identifies the C/SSR (Figure 25). Figure 26 provides a sample of the C/SSR Report. For further information on the C/SSR refer to the Cost/Schedule Management of Non-Major Contracts (C/SSR Joint Guide) 1 Nov. 78.

DATA ITEM DESCRIPTION	2. IDENTIFICATION NO(S)	
	AGENCY	NUMBER
1. TITLE COST/SCHEDULE STATUS REPORT (C/SSR)	OSD	DI-F-6010A
3. DESCRIPTION/PURPOSE 3.1 This report is prepared by contractors and provides summarized cost and schedule performance information for program management purposes.	4. APPROVAL DATE 1 November 1979 5. OFFICE OF PRIMARY RESPONSIBILITY OASD(C) 6. DDC REQUIRED 8. APPROVAL LIMITATION	
7. APPLICATION/INTERRELATIONSHIP 7.1 The Cost/Schedule Status Report (C/SSR), Figure 1, is applicable to contracts of $2,000,000 or over and 12 months' duration or more which do not use the Cost Performance Report (DI-F-6000). It will be established as a contractual requirement as set forth in the Contract Data Requirements List, DD Form 1423, and Management System Summary List, DD Form 1660. 7.2 Data reported on the C/SSR will pertain to all authorized contract work, including both priced and unpriced effort. Data reported will be limited to level 3 of the contract work breakdown structure or higher. However, if a problem area is indicated at a lower level, more detailed data will be provided on an exception basis until the problem is resolved.	9. REFERENCES (Mandatory as cited in block 10) DoD 4120.3M, Aug 78 MIL STD 881A, 25 Apr 75 DoDI 7000.2, 10 Jun 77 MCSL NUMBER(S) 71559	

10. PREPARATION INSTRUCTIONS

10.1 Unless otherwise stated in the solicitation, the effective issue of the document(s) cited in the referenced document(s) in this block shall be that listed in the issue of the DoD Index of Specifications and Standards (reference DoD 4120.3M) and the supplements thereto specified in the solicitation and will form a part of this data item description to the extent defined within.

10.2 <u>Heading Information</u>

10.2.1 <u>CONTRACTOR</u>: Enter the name and division (if applicable) of the reporting contractor.

10.2.2 <u>LOCATION</u>: Enter the plant location and mailing address.

10.2.3 <u>RDT&E ☐ PRODUCTION ☐</u>: Check appropriate box. Separate reports are required for each type of contract.

10.2.4 <u>CONTRACT TYPE AND NUMBER</u>: Enter the contract type, contract number and the number of the latest contract change order or supplemental agreement applicable to the contract.

10.2.5 <u>PROGRAM NAME/NUMBER</u>: Enter the name, number, acronym and/or the type, model and series, or other designation of the prime items purchased under the contract.

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Figure 25. COST/SCHEDULE STATUS REPORT

DI-F-6010A

CONTRACTOR: LOCATION: RDT&E ☐ PRODUCTION ☐	COST/SCHEDULE STATUS REPORT			SIGNATURE, TITLE & DATE	FORM APPROVED OMB NUMBER 22R0327
	CONTRACT TYPE/NO.	PROGRAM NAME/NUMBER	REPORT PERIOD:		

Contract Data

(1) ORIGINAL CONTRACT TARGET COST	(2) NEGOTIATED CONTRACT CHANGES	(3) CURRENT TARGET COST (1) + (2)	(4) ESTIMATED COST OF AUTHORIZED, UNPRICED WORK	(5) CONTRACT BUDGET BASE (3) + (4)

Performance Data

WORK BREAKDOWN STRUCTURE	CUMULATIVE TO DATE					AT COMPLETION		
	BUDGETED COST		ACTUAL COST WORK PERFORMED	VARIANCE		BUDGETED	LATEST REVISED ESTIMATE	VARIANCE
	Work Scheduled	Work Performed		Schedule	Cost			
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
GENERAL AND ADMINISTRATIVE								
UNDISTRIBUTED BUDGET								
MANAGEMENT RESERVE								
TOTAL								

Figure 26. COST SCHEDULE STATUS REPORT

Chapter 4

TPM CURRENT ACTIVITIES

4.1 INTRODUCTION

An interview survey was completed with the engineering community within the DoD PM community and with Defense Contractors (Appendix C). All organizations interviewed were directly involved with the acquisition or development of products for DoD. The objective was to determine the means by which the goals of TPM are currently being accomplished.

Government engineers were interviewed at all organizational levels within the acquisition community. Position titles varied, among them were; Program Manager, Chief Engineer, Director for Engineering, Deputy for Engineering, Associate Project Leader and functional engineer. Program size and complexity were varied as well, with the number of engineers assigned ranging from several hundred to one or two. Some programs had engineers residing within the Program Office while other programs had engineers remaining within their functional area and providing support to the program office. Engineering support from functional specialty areas ranged from dedication to a single program to multiple program support.

The Defense Contractor engineering interviews were performed with contractors who had at least 50% of their business with the Department of Defense. Again, the interviews were designed to check the view from all engineering levels. In most cases several individuals were interviewed simultaneously, each providing their perspective on TPM and the CPR. Position titles spanned the range from Vice President for Engineering and Technical Support, Program Manager for Engineering, Laboratory Manager, Associate Engineering Director, Deputy Director for Engineering, to Avionics Design Manager and Weight Manager. Organizational positions ranged from program office to functional area specialists.

Questions were developed for each of the two groups - government and contractor engineers. The interviews with the government engineers concentrated on their methods of monitoring their contractors' technical performance while the interviews with the contractors concentrated on their methods of measuring their technical progress and providing government required information. Although responses varied, patterns developed which established the prevalent practices and perceptions within the two communities.

This chapter details the survey results, provides some observations, and forms the basis for Chapter 5 which offers the PM guidelines for an effective/affordable TPM program which reflects current practice and experience.

4.2 SERVICE PROGRAM OFFICE POINT OF VIEW

4.2.1 Monitoring Technical Performance

The key question asked of the government acquisition engineers was how they monitor their contractors' technical performance. Once a program has hardware to test the answer naturally becomes the monitoring of test results. The more difficult challenge was the monitoring during D/V and the early stages of FSD when the design is still being iterated and trade-offs are being accomplished. The interviewees consistently stated that technical progress is monitored through daily interface or technical interchange meetings held at the contractors plant, where a one on one engineering exchange takes place. This occurs at all organizational levels and is generally held at the contractor's plant due to the reduced cost involved in bringing government engineers to the plant rather than bringing the numerous contractor engineers to the PMO; and because the government engineers need to see the results of the design and test activity as it progresses. In some cases, based on the PM's management style, government engineers will be assigned to the contractor's plant during critical periods to maintain vigilance over the activity. The PM may feel that he needs his representative(s) on site full time to ensure that he stays adequately informed of the contractor's progress due to the inherent time delay in any formal reporting system.

Based on the significance that the government engineers placed on face to face meetings with the contractor's engineers to evaluate technical progress, the next question involved utilization of the existing Plant Representative Office (PRO). The Naval Plant Representative Office (NAVPRO), Air Force Plant Representative Office (AFPRO), and the Defense Contract Administrative Service (DCAS), are the PM's agent in the plant and appear to be a logical means of monitoring technical performance. All PMO's interviewed had PRO organizations supporting their programs and their role was defined within regulations. The PRO monitored the contractor's compliance with the contract and the quality of the product being produced. They were not involved in the monitoring of technical progress in the development (design) of the product. The PRO organization had limited resources and TPM was not in their charter. In some cases, Memorandums Of Agreement (MOAs) had been developed between the PMO and the PRO to perform other functions, but in no case was TPM monitoring identified as an agreed-to requirement.

The function of the SEMP was addressed. Normally the FSED RFP issued by the PMO requires an engineering management plan, which may or may not be specifically called a SEMP. It will, however, require the contractor to detail in his proposal how he will perform the systems engineering functions. Although this plan is reviewed by the government, during the source selection process it is not consistently incorporated into the contract and updates are not generally required. Although it seems logical that the engineering plan be kept updated, (since it lays out how the contractor proposes to control his engineering, design effort) this was not found to be the case. The degree of formality of the SEMP and the updating requirements seemed to be associated with the specific procuring activity and differed even within each DoD agency.

There was general agreement that a comprehensive engineering management plan was important for FSED. The consensus was that the contractors proposed SEMP should not become a part of the FSED contract. This approach allows for flexibility to react to unanticipated needs without requiring a formal contractual change. It was also felt that formal update of the engineering plan should only be accomplished when there are major changes in the program; such as a significant modification program or major schedule changes due to budget considerations which will impact the design time period, number of test articles available, or time available for test.

Some concern was raised over insufficient evaluation emphasis being placed on system engineering during the source selection process. Specifically, it was felt that the engineering management process is not adequately analyzed to ensure existence of an appropriate task allocation system; that the contractor's process of defining and measuring technical progress was cost effective, and identified unambiguous, measurable tasks. Although there is policy guidance on engineering management, there are a lack of definitive guides to aid evaluation boards. The perception is that each program has been unique in terms of TPM definition and implementation plans.

4.2.2 Parameter Selection and Required Reporting

While the system specifications form the logical basis for the parameters that are selected for monitoring, the actual selection process varied considerably from program to program. However, some consistent factors were clear. If the program does not push the technological state of the art, little concern was evident in parameter monitoring. Primary management emphasis was placed on cost and schedule. Conversely, if a specific requirement pushed the technological state of the art, this was flagged for monitoring and normally was called out as a specific parameter.

When government engineers were asked how they selected the parameters that they monitored to determine technical progress, the answers were:

- o operational command need - threat change
- o areas of risk - new technology, tight schedule
- o cost drivers - high cost components
- o negotiations with contractor - contractor recommendations
- o contract with higher headquarters - higher headquarters desires

In general, government engineers attempt to select parameters at high levels that cut across subsystems and are the primary risk areas based on analysis of the operational need.

In the reporting area, standard DIDs based on the applicable MIL-STDS were required by the functional managers for technical monitoring. The requirement was based on the particular discipline, experience, and judgment of the engineer and the expected cost of the data. Several innovative PMO's were receiving contractor in-house reports which monitored TPM rather than requiring specially formatted reports. This was contracted through the Engineering Management Report (D1-M-30417). In one case, the contractor's report monitored a particular parameter down to the component level (Ref 2.3.4, Figure 4). Another contractor was monitoring 14 specific parameters, developing 27 separate charts and providing them to the government on a monthly basis. Figure 27 provides an example of how a contractor was tracking and reporting the weight parameter at the system level. The chart clearly indicates that the specification allocation was increased in April 1983 due to the addition of a function to the system. The written status report that accompanied the chart stated that current weight was 367 pounds below

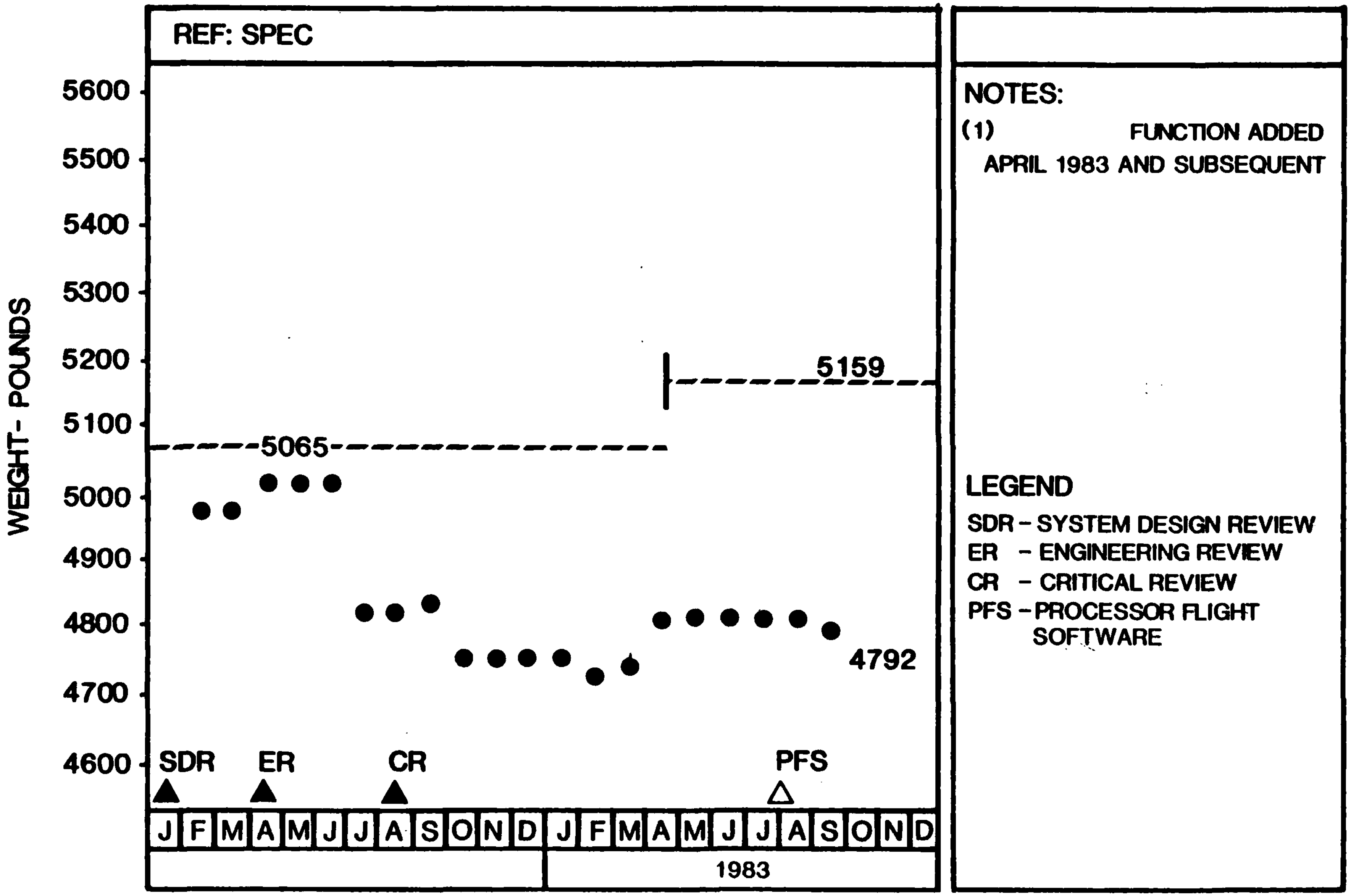


Figure 27. TPM, System Weight

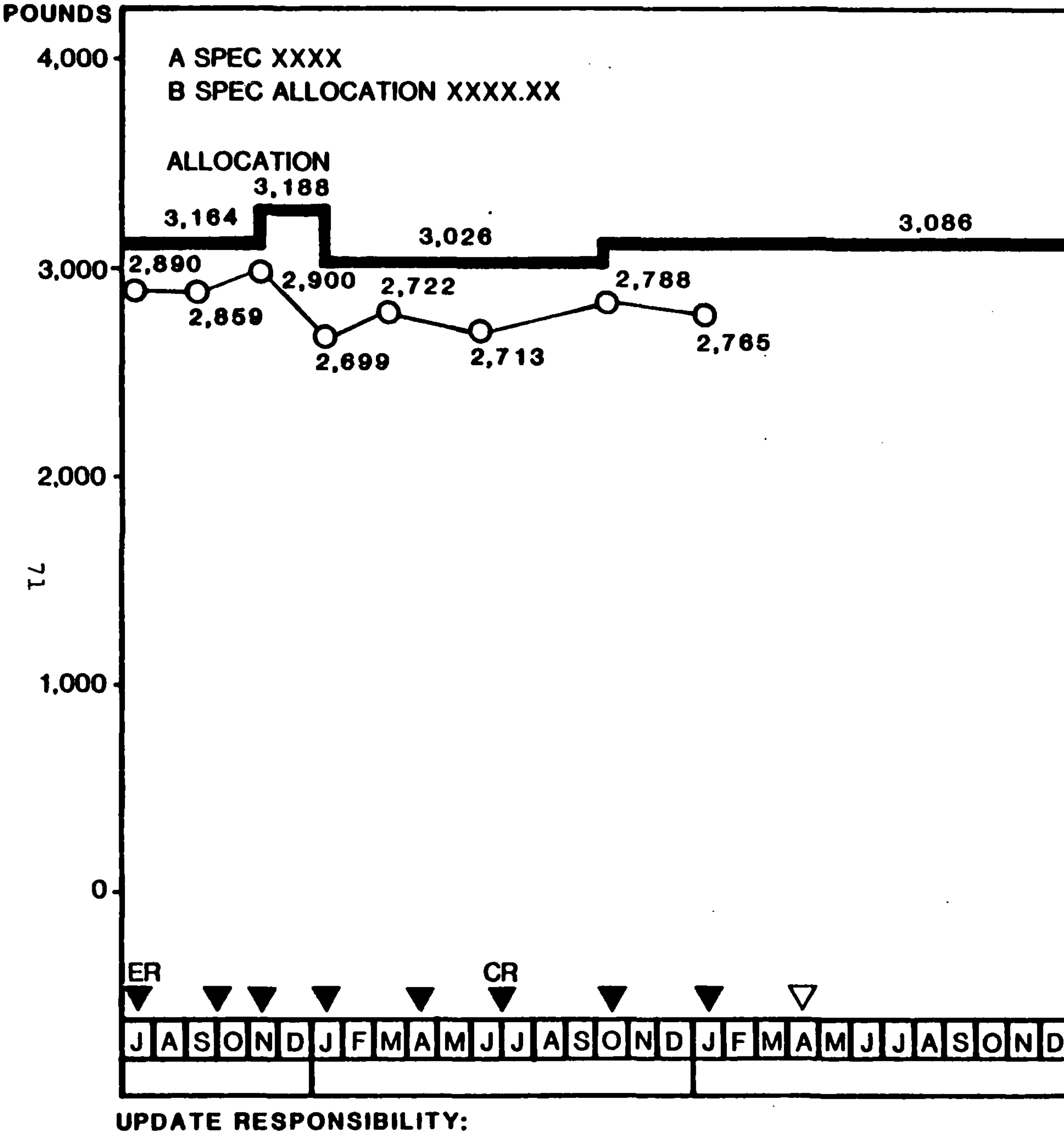
specification allocation and that the actual weightings of Line Replaceable Units (LRUs) represented 56% of the total weight with the remainder based on analysis. Figure 28 provides another sample of the monitoring of weight. The Interface Control Document (ICD) provides a not-to-exceed weight.

The PMO's surveyed were developing technical performance reports for higher headquarters that met specific format requirements levied upon them. They were not requiring the contractor to comply with a prescribed format, but were abstracting the data from the contractor reports. Figure 29 provides an example of an Air Force PMO-required TPM chart for reporting at Secretarial reviews.

4.2.3 Relationship Between TPM and the CPR

In responding to the question, "what is the relationship between TPM and CPR?" government engineers stated that they were not involved in CPR analysis. In only one case did government engineers analyze CPR data. CPR data was analyzed by the business office, program control, cost analysis or the procurement function and one of these offices was responsible for informing the PM on the results. Engineering's perception of the CPR was that it was received too late to be a useful tool in the daily management of technical progress since it identified problems after the fact and was not predictive. They did state that the PM reviewed data at monthly program status briefings, but that the other functional areas were responsible for the content, not engineering.

When asked if there was a link between TPM and the CPR, government engineers agreed that a link did exist. The link was the PM who received technical performance data from the engineers and CPR (cost and schedule) data from other functional areas at program status reviews. Generally, the PM would ask questions concerning either TPM or the CPR and would expect to receive verification of a problem noted in one system by the other.



LEGEND:
▽ ASSESSMENT MILESTONE
◯ STATUS

DATA SOURCE	TOTAL	ACTUAL	CALC	EST
LB	2,765	2,128	405	232
%	100	77	15	8

NOTES: ALLOCATION INCLUDES:
ECP
ECP
ECP

NO. LRUs CURRENTLY EXCEEDING LRU ICD NTE	
CFE	GFE
1	0
WITHIN 5% OF LRU ICD NTE	
5	0

ICD – INTERFACE CONTROL DOCUMENT
NTE – NOT TO EXCEED
LRU – LINE REPLACEMENT UNIT
ER – ENGINEERING REVIEW
CR – CRITICAL REVIEW

RESPONSIBLE MANAGER:

Figure 28. Technical Performance Measurement – Subsystem Weight

CHARACTERISTICS	APPROVE PROGRAM	CURRENT EST	DIFFERENCES FAVOR	DIFFERENCES UNFAVOR
MAX SPEED/SEA LEVEL, SUST, (MACH)	1.2	1.2	-	-
MAX SPEED/ALT, SUSTAINED (MACH)	2.3	2.3	-	-
MAX SPEED/BURST (MACH)	2.5	2.5	-	-
SYSTEM SERIAL MTBF (HR)	3.5	3.8	0.3	-
SYSTEM OPERATIONALLY READY RATE (%)	80.0	80.0	-	-
MAINTAINABILITY (MMH/FH)	20.0	15.0	5.0	-

AS OF ______________ SOURCE ______________

Figure 29. Technical Status Report PMO to HQ.

4.2.4 Contractual Implications

The service engineers were asked questions concerning the exchange of technical information under various contract types and the importance of incentives/award fees to a TPM effort.

Contract type was not viewed as an inhibitor to the flow of technical information between engineering communities. The relationship is open and does not change based on contract type, although this is not necessarily true for cost data. Under a fixed price contract, the contractor may become less responsive to cost exercises if a benefit is not evident, while on a cost plus contract, the contractor will normally respond to any type of request.

Some confusion existed when discussing incentives and award fees for technical performance. Incentives are used to reward technical performance, they require measurement and technical performance is measurable. Award fees are a subjective reward for contract performance, but not specifically technical performance. In discussing incentives, the major positive aspect is that it clearly identifies to the contractor what the PM considers important. An example of an incentive on technical performance is the added fee for satellite operation beyond a specified time. If the contractual agreement is for 12 months of operation, a negative incentive can be employed for less than 12 months of operation, while a positive incentive for operation beyond 12 months up to some specified time provides an added fee to the contractor. Government engineers generally stated that engineers are incentivized by the design challenge to successfully complete a task rather than contract incentives. The reason was that when an incentive is applied to a specific parameter, the outcome or impact upon other parameters is not necessarily known. Emphasis on one area may cause the contractor to deemphasize something else. This was viewed as the major negative effect of incentive type contracts for technical performance. If incentives are used for technical performance, a strong system engineering program is required.

4.3 CONTRACTOR POINT OF VIEW

4.3.1 Measurement of Technical Performance

In an effort to understand how contractors measure their technical performance three areas were investigated: how they planned their engineering, how tasks were assigned, and finally how they measured their progress. On any individual contract the entire process starts with the RFP. Upon receipt of an RFP a proposal manager is selected and a team established. The establishment of the proposal team is the most common practice; however, in companies that are projectized the RFP is assigned to an existing project group and no special proposal team is established. This occurs frequently with on going programs where the company has been working the specific project for sometime and must prepare a proposal for a follow-on contract (FSD after completion of D/V).

In response to the RFP, contractors vary considerably in the level of detail planning that is completed during proposal preparation. Once a corporate decision is made to propose, whatever effort is viewed as required to win the contract will be expended. The level of detail planning completed for the proposal will determine how quickly a contractor can start after contract award. Generally, contractors will take the tasks from the SOW and break them down functionally in their proposal preparation; however, they may or may not expand the WBS and develop cost accounts. After contract award a CWBS is developed to some level well below that provided by the government in the RFP. A cost account plan is developed and task oriented work packages are established which have measurable milestones. The schedule is reviewed and adjusted as appropriate. A negotiation process occurs between the contractor PM and the functional managers based on labor-hours and need dates. The cost account managers allocate budget and time to the work packages based on the results of the negotiations.

In the early phase of design, before there are testable components, technical progress is measured by two means: work package milestone completion and technical in-house meetings. Completion of measurable work package milestones provided a ready means of identifying progress. The completion was verified by the supervisor and, in some cases, by a system engineering group. A series of internal meetings -- design reviews, peer reviews, interface meetings, configuration meetings and management reviews provide a status on technical progress. These meetings occur at a frequency that ranges from daily to monthly and at locations varying from the design room to the General Manager's Conference Room. The attendees of these meetings are predicated on the problem and the level of review. Frequently, there are daily meetings between both specialty area and system engineering group supervisors and design teams to discuss specific progress, plans and alternatives.

4.3.2 Parameter Selection, Problem Identification and Corrective Action

Contractors consistently stated that the government established the key high level parameters and these were identified in the SOW. Their functional engineers review the SOW and system specifications during their proposal preparation and make sure that the specifications make sense and that in their judgement, the key parameters the government plans to monitor are the right ones. Recommended changes may be included in the proposal package or negotiated after contract award. This SOW and specification analysis forms the basis of the contract negotiations.

Problems impacting system technical performance are identified by various tracking systems. At the completion of each component design iteration, various design and design support disciplines review the design based on their understanding of the allocated requirements and the impact upon their function. Weight engineers estimate the weight to verify the expected weight; thermal engineers evaluate the design based on the rated temperature range; electronic engineers evaluate the susceptibility to electromagnetic interference (EMI) either from itself, nearby components, or other systems. Structural, guidance, aerodynamic, reliability, producibility, maintainability, human engineering all evaluate the proposed design based on their requirements and in accordance with the SEMP procedures.

For example, in a recent design iteration of an Auxiliary Power Unit (APU) for an advanced fighter, it was discovered that the hot exhaust from the APU would blow into the avionics bay and on the maintenance person servicing the avionic, equipment. Since the APU had to be on during maintenance of the avionics equipment, a redesign of the APU exhaust system was required. This problem could have been identified by any number of specialties, i.e., safety, maintenance, avionics engineering, or human engineering but became clear only when the component was viewed from the systems perspective. Each system engineering discipline views the design or test based on their experience and the requirement.

Monitoring of the completion of work package milestones may also flag problems. When a work package is running behind schedule, several situations can exist. It may be that the estimate to complete the effort was wrong and no problem exists other than determining what impact the late completion will have on other activities, or a real problem may exist and more resources must be expended or an alternative design must be developed.

In most cases, no matter who identifies the problem, some form of in-house report is developed to document it. This report is provided to various levels of management to keep them informed and to ensure that the appropriate resources are applied in developing the fix. These reports are called by various names, such as trouble reports, red darters, investigation reports, technical performance reports, or daily interest items. In some cases, contractors have provided these in-house reports to the government as a part of their TPM program.

Managers of the various disciplines evaluate these reports and develop impact statements, workarounds and corrective actions based upon the impact on their specific schedule. A problem which causes a delay on the critical path will have a ripple effect upon the entire program. For this reason, corrective action is usually attempted at the lowest level possible so as to have minimum effect upon the next higher level; i.e., correct at component level rather than subsystem level. Daily meetings between various groups, matrix engineers and functional departments, subsystem managers, and design engineers are held to determine system status and address problems. The makeup, frequency, and decision authority at these meetings is the result of the company's system engineering process.

As problems occur which impact key parameters, formal trade-off studies are developed and reviewed by the system engineer and project manager. This is part of the design iteration process. Initial requirements allocation to subsystems or components may have to be changed and reallocation made. This is the challenging part of system engineering, keeping all phases of the design open so that trade-offs can be made. As the design freezes in various subsystems, the ability to reallocate decreases, yet design progress schedules are based on the timely freezing of each component design.

4.3.3 Relationship Between TPM and CPR

The contractor engineering community was totally conversant with the concept of C/SCSC and the CPR report. The earned value method of measuring performance was completely ingrained within the companies.

The CPR is the foundation of the contractor Management Information System (MIS) which provides management program status. Cost and schedule data is reviewed at the cost account level anywhere from weekly to monthly. The availability of CPR data is not considered a problem by the contractors. Labor hour data is available very quickly, and is used as a status indicator. Excessive hours frequently correlates with a technical problem.

When responding to the question; "if C/SCSC and the CPR were no longer required, how would you manage?" The answer in almost every case was by some form of earned value system. The contractors indicated they would still develop cost accounts, have task-oriented work packages, and develop milestone schedules. "We would still negotiate budget to the cost account level and allocate to work packages". These answers were fortified by the fact that CPR's were developed for firm fixed priced (FFP) contracts even though not required by the government. One contractor, which has 80% of its business FFP, creates an in-house cost performance report on all contracts.

The consensus of the industry engineering community was that C/SCSC and the SEMP require a degree of advanced planning that is essential to good program and engineering management.

In responding to the question: "Is there a link between the CPR and TPM;" the engineering community identified their PM or chief engineer as the link. It is these individuals who evaluate the CPR and TPM variance at formal in-house status reviews. These reviews, much like the governmental program review, provide the PM a review of technical progress, cost and schedule status. Also identified as a link between the CPR and TPM was the accomplishment of measurable milestones established by the contractor. The milestone schedule is an integral part of both systems and therefore forms a link between the two systems.

4.3.4 Contractual Implications

The area of contractual relations and technical performance was evaluated in terms of data availability, incentives and award fees.

The type of contract did not, in the contractor's view, inhibit the flow of technical data between the contractor and the service program office. When the government program office put an engineer in the plant, he was invited to the in-house program meetings and could report what he wanted back to the program manager. These in-house meetings were in many cases the place where problems were addressed and solutions freely debated.

An element of contradiction existed in the area of effectiveness of award fees and incentives for technical performance. Several contractors stated that award fees had been used for technical performance in the past. They further stated that the subjectiveness of the award fee required the government to accomplish considerable planning which was not always done thoroughly. Award fees are not generally appropriate devices for assuring superior technical performance.

Contractually specified incentives did identify to the contractor what the government PM considers most important. Concern was raised over their use for technical performance parameters because it is difficult to predict the system level effect. For example, the designer of an ordnance system may be provided an incentive to reduce weapon reload time. His solution might be the incorporation of an unobstructed trunk between the weapon launcher and the magazine. This may reduce weapon reload time; however, it could degrade system water-tight integrity and combat survivability or maintainability. In addition, the contractors stated that the inflexible nature of incentives tended to hamper their ability to make objective system level trade-offs.

Information on incentives and award fees does not appear to flow down into the contractor organization. The design engineer does not necessarily know if there is an incentive on the contract or of progress toward its achievement. A tightening of allocated specifications is generally how management ensures that the incentive is earned. Some publicity and verbal exchange occurs on incentives and award fees especially in the area of design to cost; however, little is done to publicize incentives associated with technical performance design features.

4.4 SURVEY SUMMARY

The government engineer's function is to develop the system specifications and the statement of work, select the contractors and monitor their technical progress, all based on the mission requirement. The contractor engineer must utilize the system specification and statement of work, develop a proposal, win the contract, and develop the weapon system based on the specifications.

The survey revealed agreement between the two engineering communities in the areas of contract incentive/award fee effectiveness, information flow, and linkage between the CPR and TPM.

Some confusion existed about the appropriateness of award fees for technical performance. Since, by its nature, technical performance should be measurable, subjective award fees do not appear to be the appropriate vehicle to incentivize technical performance. All agreed the incentives for technical performance need to be carefully structured because they can cause unexpected results. Contract type does not inhibit the flow of technical information. Both engineering communities identified the PM as the only existing effective link between the CPR and TPM. The contractors elaborated by also listing the accomplishment of common measurable milestones as a link.

Several survey questions identified different perceptions among the engineering communities in the areas of SEMP, CPR and involvement in program management. DoD PMO engineers appeared to be ambivalent about the SEMP, some placing little value on it as a requirement and having little concern over whether it was updated. On the other hand, contractor engineers stated that this document was their engineering management baseline by which they established their plan for accomplishing the essential system engineering functions of design.

The CPR forms the basis for the contractor's MIS, and is monitored by the engineering community. TPM and the CPR are briefed by the contractor system engineers to the PM and are tracked together. Work package completion is utilized to monitor design group technical progress. The government engineers monitor technical progress, but have little involvement with the CPR. The CPR is monitored by a totally separate organization.

Micro management by the service engineer was not listed as a concern by the contractors; however, when DoD engineers were asked the question, "What is your decision organizations process when variance occurs in cost, schedule or technical performance?" the answers covered the entire spectrum of involvement. One answer was -- "It's the contractor's problem, not ours" -- total non-involvement. Another responded with -- "set up a tiger team, go to the contractor's plant and work the problem" -- possible over-involvement. Neither of these respondents stated that they would first make an effort to fully understand the problem and the contractor's corrective action plan. Monitoring requires thorough evaluation of the corrective action plans and the availability of sufficiently detailed timely information. When the contractors planned solution will impact other functions, the service engineer must become involved. If the problem is such that only the PMO can solve it through a change in specification, relief on schedule, or a change in the budget, then the PMO must take the initiative to implement appropriate contract change proposal action.

One of the most significant results of the survey was the determination that an adversarial relationship does not exist between the engineering communities. Contractor engineers tend to be open with their customers and provide technical information regardless of contract type. In addition, the use of the CPR by the contractor as the foundation of the program Management Information System (MIS) validates that it is an established system accepted by the engineering community. This is not the case for the government engineering community.

CHAPTER 5

IMPLEMENTATION OF A TPM PROGRAM

5.1 INTRODUCTION

This chapter is designed to review the actions the Program Office can take prior to and after the first FSD contract award in order to have a viable cost effective TPM Program. The chapter concludes with some impacts technology is having on TPM implementation.

TPM is a means of keeping the government PM informed on the status of his contractor's technical progress. It is the aggregation of technical information in a manner suited to prompt decision making. The PM cannot be expected to be an expert in all engineering disciplines; TPM should be an integral part of the management review process, allowing management by exception. This approach enables the PM to establish control limits for the value of each significant parameter and to concentrate attention on those parameters that presently or eventually will fall outside the control limits. It allows the PM to direct efforts toward the design aspects that have a major influence on the outcome of the program. Complex programs involving the interactions of many parameters can be effectively managed by the prompt selective application of management resources where the benefit is the greatest, if through TPM these areas can be readily identified.

Implementation of a TPM program and the application of C/SCSC both require careful front end planning by the contractor. The contractors SEMP will provide information on how he plans to conduct system engineering. The on-site review of the system will provide confidence and understanding which will aid in evaluating problems in the future. The PM's review of TPM reports and the CPR will be the primary link between the two systems.

5.2 UPFRONT ACTIVITIES

The successful Program Manager must carefully direct the development of the FSD RFP. The RFP is the need document to which the contractors will respond, therefore it is perhaps the most important document the PM will issue in his tenure. The SOW and system specifications must unambiguously state the program objectives. The SOW should identify a carefully tailored TPM Directive as a requirement or a guide (Air Force MIL-STD-499A, Army FM770-78). A formal TPM process, tailored to the particular program needs, should be required in the RFP, allowing for incremental assessment of design attainment during the periods between the MIL-STD-1521A reviews (PDR, CDR, etc). The PM should, in the RFP, define the schedule, depth and documentation of program status reviews desired. This will depend on a number of factors, among these are: program visi- bility, risk and management complexity. As an example, there may be three levels of status meetings: First, monthly techni- cal interchange meetings between the government senior engineer- ing staff and their counterparts; second, bimonthly/quarterly program manager meetings between the PM and senior staff with the contractor's counterparts; and finally, quarterly/semiannual senior management reviews between the PM's commander and the CEO. Each of these reviews should be structured to assess the status of the program at different detail levels, therefore the agenda should be so structured. The frequency and formats of reports required from the contractor for TPM monitoring should be carefully structured.

5.2.1 Parameter Selection

Increasing complexity of programs demand the tracking of multiple TPM parameters. Experience suggests that specific parameters, and the number of parameters to be tracked will depend on the characteristics of the program, the selected acquisition strategy, and recognized risk areas. Clearly, the level of new technology embedded in the program vice off-the-shelf or existing technology is a critical factor in the process in order to logically select TPM parameters.

The number of parameters appropriate for a program may vary widely. Some programs have selected five to ten critical system level parameters. In certain cases, additional parameters have been specified for subsystems or lower level components. In any event, it is increasingly apparent that parameters selected to be worth the cost should be relatively independent of each other, and significant indicators of system capability relative to overall objectives. Where parameters are dependent, there may be cases where contradictory indications are provided to program management. The ability to use these parameters to guide management decisions and develop trade-offs is degraded, and prompt management response inhibited.

As an example, if three parameters are recognized as being critical, and two of these parameters are related to, or aggregate to provide the third, it is possible that the top level parameter will be satisfied while one of the other factors is not satisfied. To further amplify this case, if in the development of a guided artillery round, single shot kill probability, single round reliability and accuracy are selected as three parameters, the following situation could occur. The probability of a single shot kill (PSSK) is a function of reliability and accuracy. Accuracy could be specified as X meters, Reliability specified as R, and the resultant probability of a single shot kill as Y. In testing, system accuracy is measured as 1/2 X meters or better than the specified parameter, reliability is R' which is less than the specified level of R. The calculated single shot kill probability is, therefore, Y' which may be greater than the specified Y. The program could encounter delays in entering rate production because it has not met its stated reliability objective.

Presuming that the calculation is correct, fewer shots will be required per target, thereby reflecting an increase in targeting effectiveness, and other benefits that could include reduction of exposure of the launch crew to enemy targeting, and also more kills per crew in unit time. On the other hand, the reduced reliability can equate to increased maintenance and support requirements, in the case of a maintainable round and in the possibility of round "jams."

A simple answer is not always the right answer. The question is, what is important about an artillery round? Possibly, the key parameter, in this case of a "wooden" or nonmaintainable round, should have been the single shot kill probability rather than three interrelated parameters. The net effect would have been no program delay and reduced development cost. The contractor, therefore, would have had the ability to take the single parameter of a probability of a single shot kill and trade off between the various levels of reliability and accuracy. Specifically, calling out all three interrelated parameters as specification values without providing additional guidance as to priority, could have degraded the contractor's ability to trade-off design and program alternatives.

For Example:

PSSK = Probability of a single shot kill

X = Accuracy - measured by the number of fired rounds impacting within lethal distance

R = Reliability - measured by the number of delivered rounds that fire

PSSK = X x R

If a PSSK of .76 is required then .76 = .90 x .85
and R can be varied to produce the same PSSK
.76 = .95 x .80 or .88 x .87

Although it is usually desirable to keep TPM parameters at the system level it will not always be practical. If a program is organized into separate segments and the Program Office rather than a prime contractor has responsibility for integration, lower level parameters may have to be defined that are significant for each segment. For example, on an aircraft program where speed is a key parameter, the Program Office may have to allocate weight to the various system contractors, and thrust/weight factors to an engine contractor.

State-of-the-Art technology may be the key to criteria guiding the selection of parameters. The risk implicit in development of a system and the impact on the mission of "missed" objectives will drive the specified level for a parameter to a high level, and possibly, more importantly, to a level that cannot be reduced without degrading the capability of the system to perform its mission. A radar detection range that degrades below a certain level may reduce the pilot's response time to launch a missile to achieve a kill at an acceptable or safe range. However, a reliability degradation in the radar from a "high" level to a slightly lower level may not significantly degrade mission effectiveness, and may only slightly increase its support cost. The net impact on Life Cycle Cost (LCC) may be nominal, unless the attempt to capture the specified reliability forces the program into a complex "fix" or a technology enhancement effort that could significantly increase development cost and, therefore, LCC. Where the possible impact on program schedule is considered, logic may drive this program to accept the "fact of life".

The government PM, chief engineer and system engineering chiefs from the key functional disciplines should meet and make the final decision on what parameters form the foundation of the program and will be monitored in the TPM program.

5.2.2 System Engineering Management Requirements

The FSD RFP should require delivery of a comprehensive engineering management plan. The SEMP is one format, however, contractors have engineering management procedures and internal plans which they should be encouraged to propose if they satisfy the requirement. This plan must explain how the contractor will manage his integrated engineering effort and must become his engineering management baseline. The documentation provided by the contractor in the form of TPM reports is equally important. The data call during RFP preparation is a very important function which frequently does not get the visibility needed within the PMO. The Data Requirements Review Board (DRRB) will determine what information the Program Office should receive from the contractor. How this is managed will impact the Program Office's ability to effectively monitor performance. The Program Manager should chair this board. The SOW should clearly identify the TPM parameters and data required from the contractor. Some contractors have established specific formats for TPM management and have been using them for years. If they provide the needed data, they can be requested through use of the Data Accession List. The requirement for a specific DID merely establishes the format vehicle. Keep in mind a piece of paper never solved a technical problem -- you need current, clear information and this intent should be specified in the SOW. Once attainment of a TPM parameter has been reached and design frozen, then discontinuance of reporting should be automatic if no further activity can be expected.

5.2.3 Source Selection Criteria/Procedures

The RFP has required the contractor to develop a proposal which states as clearly as possible how the development system engineering process including TPM will be managed. The source selection is the next critical step to a contract award. This step can be an extremely important function for engineering. In evaluating the contractor response to the SOW, special attention must be placed on the contractor's engineering management process, including TPM, and appropriate selection factor weighting should be developed by the PMO. The system engineering TPM proposal evaluation should consider:

- o Have the SOW tasks all been clearly allocated and are they readily traceable to the system specifications?
- o What procedures or capabilities exist for conducting analysis and data aggregation to the specification level?
- o Is the engineering milestone chart presented in sufficient detail to show the interrelation of design activities, technical reviews, analysis group reports, simulation, and tests?
- o Does system engineering control bring all functional areas into a balanced integrated effort using clear firm rules and procedures?
- o Has a TPM plan been developed which will be both responsive to the government PM needs and avoid duplicated efforts and special test/analysis requirements?

Concern was raised during the survey reported in Chapter 4 that in the past, insufficient attention has been paid to engineering management capability during source selection. Proposed cost and schedule may have been the driving factors in source selection. What is required is a balance between cost, schedule and technical performance capabilities enforced thru source selection criteria weights.

5.2.4 Negotiation

A program that was carefully laid out in the RFP and responsed to in the Proposal can become disjointed during negotiation if the balance between cost, schedule and technical performance is disrupted. The two-step procurement practice which first evaluates technical capability, placing all contractors who qualify above some level to equal and then evaluates cost, may impact system engineering management and the desired TPM program. A contractor who barely qualifies technically and has a weak TPM program may have the lowest cost and win the contract. This may not be the best value for the dollar to the government.

Data reduction, schedule changes, deliverable adjustments, etc., should be evaluated by the appropriate functional discipline before a decision is made. The effect of incentives, both positive and negative, on key technical parameters, for improved performance, should be evaluated by the PMO due to the possible unexpected outcomes.

5.3 AFTER CONTRACT AWARD

Since the SEMP is the way the contractor is going to manage the engineering, it is necessary that it be updated to reflect the results of the negotiations. An update 60 days after contract award should be contained in the negotiated contract. This provides the engineering management baseline which will be tracked by both the government Program Office and the contractor. The baseline is important for the contractor's allocation and subsequent measurement of performance.

With the negotiated contract, SEMP update, and TPM plan in hand, the important PMO task is for the PM and staff to learn the contractors engineering process as it is actually executed. The PM and staff must visit the contractors facilities for a reasonable time (not just a day or two) to understand exactly how the contractor accomplishes the engineering activity if D/V has not provided the familiarity. This will provide the PM and staff the understanding of the underlying organizational structure and individuals behind the technical information provided by the contractor at future meetings and in TPM reports. Without the PM's personal commitment to understanding the process, the credibility of the contractor's reports will always be suspect. This visit will enhance the PM's ability to evaluate future reports and not engage in micro-management every time a problem surfaces.

The technical staff of the PMO, who monitor technical progress through TPM, must also familiarize themselves with how the contractors will be working particular functional areas. The technical staff must normally monitor progress at several levels lower than that monitored by the PM and need a greater degree of familiarity with the sources of information they will receive.

As FSD begins review of contractor TPM status reports, schedules and CPR reports will be the primary PMO means of monitoring contractor technical progress toward parameter achievement. Meetings between the government PM and his staff and the contractor should provide the greatest insight into technical progress during the design phase. Meetings specified in the contract will be organized by the contractor. Design status in relation to the selected TPM parameters should be the agenda framework. The CPR should be reviewed at the CWBS level that best relates to the TPM parameters being monitored. The two reporting systems should be used to evaluate progress; CPR for cost and schedule and TPM reports for technical performance. For example, in a vehicle program status review, technical problems were briefed concerning the development of the transmission. The review of the CPR at the CWBS, level 4, drive train, indicated a schedule variance. The Problem Analysis of the CPR, Format 5, provided an analysis of the schedule variance, identification of the problem and planned corrective action. The TPM report identified the problem and the CPR confirmed it. The system impact and planned corrective actions were reviewed in terms of the key parameter, reliability. The transmission problem, if not corrected, will impact the entire program and will prevent the mean time between repair parameter from reaching its required level. This provided a cross-check against the technical problem and the time extent of slippage being experienced.

Over-involvement and its prevention will be a problem throughout the PM's relationship with the contractor. The majority of TPM data being provided by the contractor is designed to keep the government PM informed. Meetings held with the contractor will either be for information or approval of a specific action. The government PM and staff should be evaluating contractor design decisions based on time and dollars. In a properly managed program design decisions are made by the contractor, however there will be information that indicates the problem cannot be resolved within the contractors area of responsibility or might be resolved more efficiently by others. That is the time for the PMO to take action to optimize the problem resolution.

5.4 CAPITALIZING ON AVAILABLE MANAGEMENT/TECHNOLOGY

Computer aided design, engineering and manufacturing as well as networking, (linking of computers, terminals etc.) are becoming factors in the cost and utility of a TM program. Automation technology should facilitate TPM. Accounting type functions are automated and can be accomplished rapidly. The CPR is automated by almost all contractors. The PMO's ability to monitor schedules and keep track of dollars can be almost on a real time basis. The CPR is available to the contractor within two weeks after close-out and labor hour data is available daily. The CPR should be provided to the government PMO within a maximum of four weeks after close-out.

Computer aided design, engineering and manufacture (CAD, CAE, CAM) are in use throughout industry and the use is growing. The degree of automation varies considerably by contractor. This year one contractor interviewed is installing 700 engineering stations. Figure 30 provides a projection of CAD and CAM use. As this area develops, the product definition data base will improve in timeliness and assessibility, this is fundamental for a credible assessment of technical performance progress at any point in time. With development of added simulations and algorithms the system design data base will provide real time performance analysis capability. Information is now feeding the contractors data base, but it was not apparent that

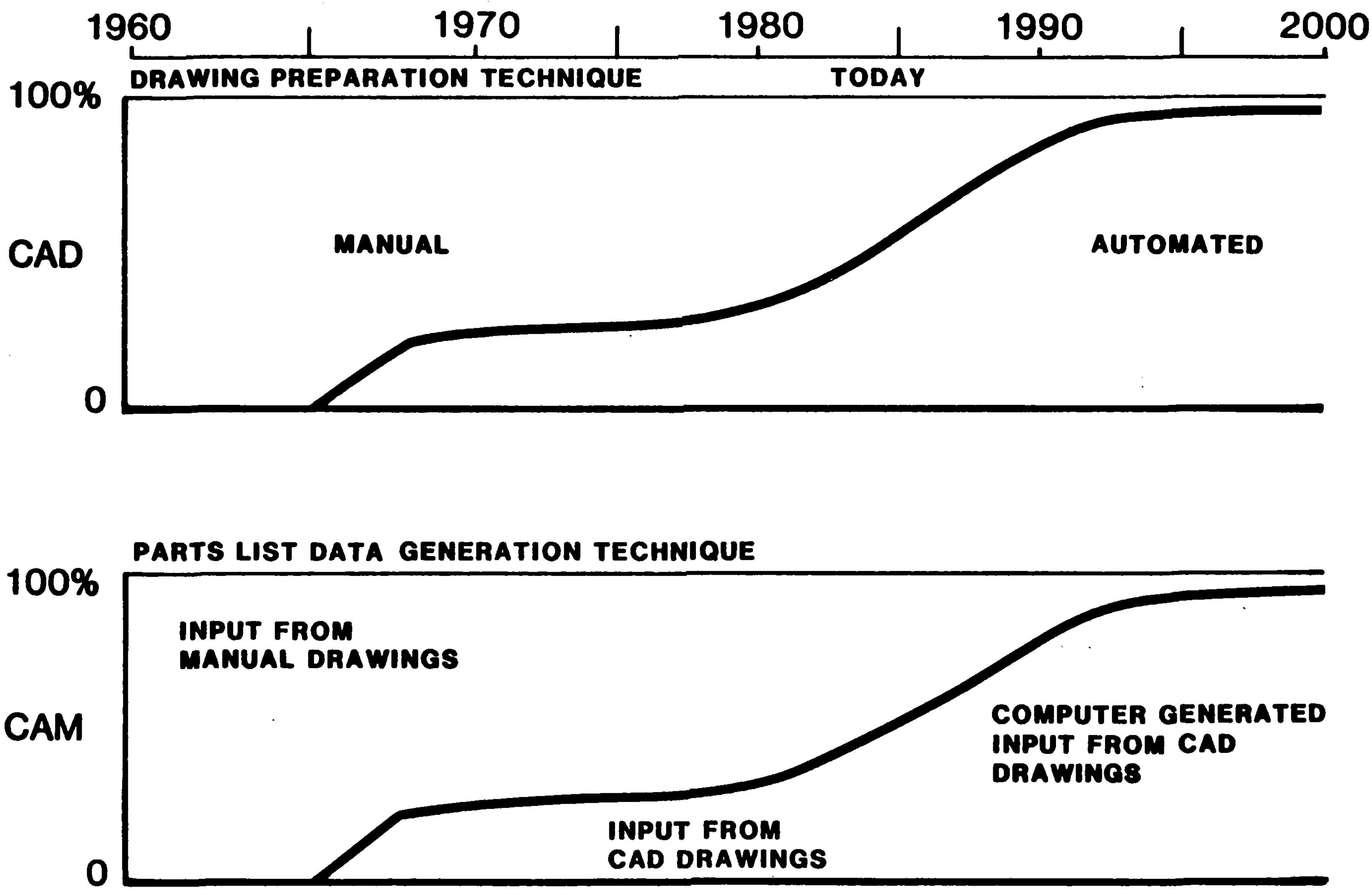


Figure 30. CAD/CAM Usage

this is helping the government PMO. There appears to be no existing attempts to directly extract key technical parameter information for PMO use, and real time PMO analysis of the design process relative to TPM is still awaiting implementation.

So where does industry now stand? We have an automated CPR system and CAD, CAE, CAM systems in various stages of implementation. An overall consolidated contractor integrated MIS which captures technical progress seems to be missing. The computer power is available for such a system; however, the contractor as well as government personnel have not determined their specific needs for information. In almost every survey case contractors are reviewing their MIS. As the program manager, you need to know your contractor's status. You will not have an easy task in developing automated delivery of management information to the PMO because there is not yet a single point to tap into the contractors systems for all PMO needs. This is another reason why the government PM must understand how the contractor is managing the engineering effort. Consideration might logically be given to the degree of automation compatibility and potential efficiency the contractor MIS has with the PMO during CEM or DV source selection.

The next technological area is electronic networking. It is not uncommon for the government program office to have electronic links with their contractors for selected information. There are no technological barriers to receiving information directly from the contractors system through networking. For example, contractors located around the country are using central computers through networking to perform many functions. However, there are management barriers that must be overcome. A perception of micro management can occur when the Government PM has access to data at the same time or before contractor senior management.

Management problems are not all on the contractor side. The Government engineer may be creating problems through the requirement for written documentation in a prescribed DID format rather than accepting contractor data directly. An example of this is in the area of ECP tracking. Contractors have an automated ECP system which contains cost, schedule and technical information. The PMO requires conversion of this data into a typed format which is mailed to the PMO. The PMO then converts the typed data into their automated system.

For cost effective program management in an environment of expanding technological opportunity, the government PMO must tailor a program with the contractor that is open and free of management inhibitors, such as required formats or over involvement. Networking should allow the PMO to receive essential data from the contractor at nearly the same time as it is being reviewed within their management structure. This is especially true for the CPR data. At least for the near future the PM will be the primary link between the CPR and TPM.

5.5 PROPOSED STEPS TO STRUCTURE A TPM PROGRAM

The following steps in development of a TPM program are designed in the form of a checklist to encourage distribution and regular review by government and contractor PM's. Space has been provided for additions, and as you have the opportunity to utilize and evaluate their effectiveness please take the time to send your tailored and improved revisions to: Defense Systems College, Dept SE-T, TPM Handbook Project Monitor, Ft. Belvoir VA 22060.

TPM PROGRAM

FSD/RFP Development

- o System Engineering Management Plan required
- o Formal TPM process required
- o Key parameters selected
  - mission critical
  - state-of-the-art critical
- o TPM reporting requirements identified by DRRB
  - format
  - frequency
- o Schedule, depth and documentation of program status reviews defined - MIL-STD 1521A tailored as a minimum

Source Selection Plan/Conduct

- o Evaluation of SEMP
  - TPM planning addressed
  - TPM parameters identified
  - Analysis and forecasting techniques identified
  - Reporting of TPM
  - Key events and TPM milestones identified
  - TPM implementation procedures/schedules
  - Information flow/release authority
  - Integration of functional areas
- o System engineering control of trade-off studies
- o SOW tasks allocated and traceable to specifications
- o Extent of automation compatibility

Negotiation

- o Proposed changes (data reduction, schedule changes, specification changes) reviewed and the impacts determined by the appropriate functional area managers before a decision is made.

- SEMP required to be updated 60 days after contract award
- Incentives for improved technical performance evaluated for system level effects

After Contract Award

- Updated SEMP reviewed by PMO
- PM and key staff visit contractors facility to review contractors engineering system and management
- PMO TPM monitoring procedures established
  - Tracking of delivery dates/response times establish
- CPR provided to engineering for analysis as well as the business office
  - Timely response required
- Program status review agendas structured with contractor concurrence

APPENDIX A

ACRONYMS AND ABBREVIATIONS

ACRONYMS AND ABBREVIATIONS

A/B	After Burner
ACWP	Actual Cost of Work Performed
AFPRO	Air Force Plant Representative Office
AFSCP	Air Force Systems Command Pamphlet
AGB	Accessory Gear Box
BCWP	Budgeted Cost for Work Performed
BCWS	Budgeted Cost for Work Scheduled
CAD	Computer Aided Design
CAE	Computer Aided Engineering
CAM	Computer Aided Manufacturing
CDR	Critical Design Review
CDRL	Contract Data Requirements List
CEO	Chief Executive Office
CI	Configuration Item
CPR	Cost Performance Report
C/SCSC	Cost/Schedule Control System Criteria
C/SSR	Cost/Schedule Status Report
CWBS	Contractor Work Breakdown Structure
DARCOM	Army Material Development and Readiness Command
DCAS	Defense Contract Administrative Service
DDR&E	Director of Defense Research and Engineering
DID	Data Item Description
DoD	Department of Defense
DoDD	Department of Defense Directive
DoDI	Department of Defense Instruction
DRRB	Data Requirements Review Board
DT&E	Development Test and Evaluation
D/V	Demonstration and Validation
ECP	Engineering Change Proposal
FCA	Functional Configuration Audit
FQR	Formal Qualification Review
FSD	Full Scale Development
HP	High Pressure
IOT&E	Initial Operational Test and Evaluation
LCC	Life Cycle Cost
LOE	Level of Effort
LP	Low Pressure
LRU	Line Replaceable Unit
MIL-STD	Military Standard
MIS	Management Information System
MOA	Memorandum of Agreement
MTBF	Mean Time Between Failure
NAVMAT	Naval Material Command
NAVPRO	Naval Plant Representative Office
OT&E	Operational Test and Evaluation
PCA	Physical Configuration Audit
PDR	Preliminary Design Review
PERT	Program Evaluation and Review Technique
PM	Program Manager
PMO	Program Management Office
PRO	Plant Representative Office
PRR	Production Readiness Review
PTO	Powered Take Off

R&D	Research and Development
RFP	Request for Proposal
SDDM	Secretary of Defense Decision Memorandum
SDR	System Design Review
SEMP	System Engineering Management Plan
SOW	Statement of Work
SRR	System Requirements Review
T&E	Test and Evaluation
TEMP	Test and Evaluation Master Plan
TPM	Technical Performance Measurement
VEN	Variable Exit Nozzle
WBS	Work Breakdown Structure

APPENDIX B

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APPENDIX C

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	Mr. Tom Banks	Director of Mechanical Engineering
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	Mr. Robert Slevin	Deputy for Engineering
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GTE Products Corp. Northboro, MA	Mr. Tom Curran	Director of Contracts
	Mr. Vicent Costaldo	Line Engineer
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	Mr. Roger Kendall	Engineering Resources
	Mr. Robert Ohrtman	Engineering Administration
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	Mr. Guy Northcutt	Valve Engineering
	Mr. Larry Webb	Chief Design Administration
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