ARMY DEVELOPMENT AND READINESS COMMAND PAMPHLET — DARCOM-P700-6
NAVAL MATERIAL COMMAND PAMPHLET — NAVMAT P5242
AIR FORCE LOGISTICS COMMAND PAMPHLET
AIR FORCE SYSTEMS COMMAND PAMPHLET — AFLCP/AFSCP 800-19

JOINT DESIGN-TO-COST GUIDE

LIFE CYCLE COST AS A DESIGN PARAMETER

15 OCT 1977

DEPARTMENT OF THE ARMY, THE NAVY, AND THE AIR FORCE

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FOREWORD

approve this revised "Guide on Design to Cost" for use within our commands. It provides information and guidance for application of the Design to Cost concept.

Since the first edition of this Guide in October 1973, there have been numerous applications of Design to Cost in both major and non-major system, sub-system and component developments. The great majority of these applications have been limited to "unit production cost". Although no Design to Cost program has yet matured to the point at which "lessons learned" can be garnered from factual cost data, we are convinced from evidence in hand that the concept works and will be of great benefit.

However, the concept can and must be expanded beyond unit production cost to include operating and support costs. Approaches which concentrate on those operating and support costs which are design sensitive are currently available even in the absence of a uniform, useable and historical data base for all operating and support costs.

We seek a favorable balance among the elements of life cycle cost, (development production, operating and support costs) and the performance of every system.

There are no easy steps in designing a complex weapon system to established cost goals. The DOD and contractors must be committed, effectively communicate and maintain essential effort toward achieving the established Design to Cost goals.

Supplemental instructions may be issued by the individual commands.

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Date: 9 January 1976

THE DEPUTY SECRETARY OF DEFENSE
WASHINGTON, D. C. 20301

JUN 11 1976

MEMORANDUM FOR SECRETARIES OF THE MILITARY DEPARTMENTS

SUBJECT: Joint Logistics Commanders Guide on Design to Cost

I am in receipt of a copy of the Joint Logistics Commanders Guide on Design to Cost which was approved by the Commanders on 9 January 1976 and revises the original Guide issued 3 October 1973.

The revised Guide has been reviewed by cognizant members of my staff and found to provide an excellent expansion of the conceptual approaches to the application of the Design to Cost concept. It is consistent with existing DoD policy and is recommended for use on both major and less than major defense systems acquisition programs throughout the Department of Defense. Instructions as necessary should be issued by individual components to provide detailed guidance on the pecularities of Service implementation of the Design to Cost concept. These instructions should supplement the Joint Guide and be subordinate to the information contained therein.

The first tentative step toward requiring the use of life cycle cost elements as design parameters is in consonance with our ultimate objective of Design to Life Cycle Cost. Continued care must be exercised, however, to insure that a balanced approach consistent with our technical knowledge, data base, and contracting abilities is maintained.

I request that the Guide continue to be updated to reflect the latest policy and techniques of the Design to Cost concept. My staff will continue to support you in this area.

W. P. Clements Jr.

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*This pamphlet supersedes DARCOM-P 700-6, NAVMAT P5242, and AFLCP/AFSCP 800-19, 11 June 1976

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1.0 INTRODUCTION

1.1 PURPOSE OF THE GUIDE: The Design to Cost (DTC) concept establishes life cycle cost (life cycle cost to the maximum extent feasible) as a design parameter during a system's design and development phase and provides a cost discipline to be used throughout the acquisition of a system.

This Guide provides information and guidance for application of the Design to Cost concepts contained in DOD Directive 5000.28, Design to Cost, dated 23 May 1975 which has been included as Appendix A. The effectiveness of Design to Cost in meeting weapon systems needs within budget constraints greatly depends upon the manner in which it is implemented. This Guide makes no attempt to develop a standardized approach to implement Design to Cost other than to outline certain policies and basic guidelines. Design to Cost must be tailored to fit the individual program based on stated objectives and risks involved.

The Guide expounds upon the following questions on Design to Cost: Why Design to Cost? What is it? To which programs should Design to Cost be applied and when? Further, it also provides guidance for a Design to Cost effort and describes what Design to Cost goals should be established, incorporated into contracts, managed and tracked.

1.2 BACKGROUND

Projected defense budget levels and rising costs of acquiring, operating and supporting defense systems and equipment have created the need to make cost a principal design parameter.

Several cost effective weapon systems have recently been developed which, because of their cost, were not affordable in adequate numbers to satisfy mission requirements, necessitating additional lower cost developments.

Design to Cost is not a new concept. It has been used successfully by many manufacturers of commercial products. DOD has initiated a number of specific design to cost development programs from which we are learning how to structure and manage such efforts.

Emphasis in the past has been placed primarily on "unit production cost" with "consideration" of life cycle cost impacts. The reason was the inability to predict, or in fact measure, total operating and support costs. This has provided little motivation to the responsible Program Manager and subsequently to the development contractors to trade-off lower predicted savings in operating and support cost in the future for near term "known" higher unit production cost.

Recent acquisition strategies, however, have made inroads to addressing the operating and support cost portion of life cycle cost. The approach has been to look at that portion of the operating and support costs which are design dependent, reasonably predictable, and verifiable during the initial period of system operation. While only a part of the total operating and support cost meets this criteria it is the most important part - the part that the DOD Program Manager and the contractors can effect and control during the acquisition cycle.

1.3 CONCEPT

The concept of Design to Cost is basically a simple one. Cost is established as a design parameter in the same sense and for the same purpose as performance parameters such as speed, range and kill probability and schedule parameters such as initial operational capability. (The word cost, when used alone in the guide and in DOD Dir 5000.28, means the sum of development, production, operating and support costs.)

Every system has many parameters which must be considered in design. Life Cycle Cost has now been added. Because of this multiplicity of considerations, there are a great number of possible combinations of values for each. At the outset of an acquisition, the optimum combination cannot be identified. However, certain limits must be identified. Given a threat environment, level of technology and mission scenario, there are dictated certain minimum essential performance parameters, the values of which must be attained or the system is not mission capable. There also results a certain cost which must be achieved or bettered or the system is not affordable. The solution can be visualized as follows:

COST CEILING

RANGE OF ACCEPTABLE SOLUTIONS

PERFORMANCE/FLOOR

These limits fix the area in which the optimum combination of performance, cost, and schedule values must fall. In this area, it may be found that performance and schedule values above the minimum established requirement are useful and can be obtained within the affordable cost. Performance and schedule values above minimum will also be found for which the added cost, although within the limits of affordability, are unjustifiable in view of the utility of the added performance.

Herein can be defined the basic difference between "cost effectiveness" and "Design to Cost." There can be many solutions above the performance floor and even above the cost ceiling which can be justified as being cost effective. In today's dynamic environment, the "optimum cost effective solutions" may result in designs which are above an affordable cost ceiling. The Design to Cost process has therefore been introduced to identify the optimum cost effective solution <u>within the above limits</u>, and develop a design which can be successfully produced to the established cost goal.

Whenever feasible, Design to Cost goals should be established for all elements of future Life Cycle Cost which are design controllable. Acquisition strategies must then be structured to achieve these goals. Where appropriate, contractual commitments should be used to hold the contractors to cost goals that are consistant with the total system DTC goal. An acquisition strategy tailored to achieve DTC goals and a compatible contractual structure and tracking system plus a clear line of communication and understanding between the PM and the contractor are the keys to a successful Design to Cost Program.

1.4 OBJECTIVES

To establish cost as a parameter equal in importance with technical requirements and schedules throughout the design, development, production, and operation of weapon systems, subsystems and components.

To establish cost elements as management goals for acquisition managers and contractors to achieve the best balance between life cycle cost, acceptable performance and schedule.

Establishment of cost as an active rather than a resultant parameter is the key to the first objective. This requires cost becoming as much as technical challenge to the people involved with design and development as performance and capability have been in the past. Acquisition managers must be aware of and control cost in all phases of the program and be prepared to consider the effects on cost before making each program decision.

The second part of the objective involves the identification and establishment of cost elements as management goal to accomplish the desired balance between performance cost and schedule. Accomplishment here requires the integration of projected cost into the management of systems, subsystems and component design. Finite funding realities must be considered, the program DTC goal must be established and management methodology developed to provide necessary visibility for cost and design control.

1.5 DEFINITIONS

1.5.1 Design to Cost Goal. At this stage of the DTC concept development, DODD 5000.28 requires that a program have only a single monetary DTC goal. This DTC goal is an average unit flyaway cost goal (a production cost element) established by the Secretary of Defense for major programs and by higher designated authority within each

Service for less than major programs, as soon as possible but not later than entry into Engineering Development (Milestone II). The process by which this goal is established is discussed in considerable detail in Section 4.0, however, it is to be stressed here, that this goal is an in-house government goal, almost contractual in nature, between the PM (Service) and the Secretary of Defense.

It is the intent that, within the constraints of this official DTC goal, the PM be given the authority to divide this goal into cost elements, controlled by him, to suit the structure of his individual program and to make trade-offs between these cost elements as decided by him without need for approval from the OSD. A further breakdown of these elements or subgoals will form contractual DTC targets for the various contractors supporting the program.

1.5.2 Operation and Support Cost Goals. DODD 5000.28 also requires as a part of the DTC concept, goals for O&S cost factors. Until the data base concerning O&S cost by program is sufficiently strengthened, monetary cost goals are not required at this time to be part of the official DTC goal, although they are in no way prohibited if considered feasible by the PM. Major O&S cost factors are required to have goals established in the form of some measureable number which can be monitored during test and evaluation as well as operation. Some of these elements are currently required by service regulations and MIL Specs and others will be established by the PM, subject to review for adequacy, to influence the design and to control O&S cost. See Section 4.3 for additional discussion of O&S goals.

1.5.3 Average Unit Flyaway Cost. This is the cost element defined by DODD 5000.28 that will be used for establishing the Design to Cost goal for a program by the Secretary of Defense. It is based on guidance in DOD Budget Manual 7110.1M of flyaway cost to be used with missiles and aircraft in the budget process. For programs involving hardware other than aircraft and missiles, it will be necessary for the PM to define his average unit production cost using this guidance as a model, e.g. rollaway cost for vehicles, sailaway cost for ships or average unit production cost for other hardware items.

1.5.4 Contractual DTC Targets. A contractual DTC target is that portion of the program goal over which the contractor has control. Contractual DTC targets for the production phase should address only the system elements which are supplied by the contractor. For these elements it should include those elements of cost which are included in the program average unit flyaway cost goal at the program level. DTC targets for design controllable operating and support costs should be structured to fit only the system elements covered by the contract and will be expressed in meaningful terms which can be measured during operational testing or by an early point in the operational life of the system. Where appropriate (normally for subsystems), operating and support DTC targets may also be defined in the form of warranties, particularly operational Reliability Improvement Warranty (RIW) commitments.

1.5.5 <u>Operating and Support Cost</u>. O&S costs are those resources required to operate, and support a system, subsystem, or a major component during its useful life in the operational inventory.

1.5.6 <u>Life Cycle Cost (LCC)</u>. The LCC of a system is the total cost to the Government of that system over its full life. It includes the cost of development, production, operation, support, and where applicable, disposal.

2.0 APPLICABILITY OF DESIGN TO COST CONCEPTS

2.1 WHAT DEVELOPMENTS?

2.1.1 Design to Cost is applicable, and must be applied, to every development and product improvement or modification of systems, subsystems and components. Major Systems meeting the criteria of DODD 5000.1 will have their DTC program reviewed by the DCP/DSARC process and will have DTC goals established by the Secretary of Defense. Programs not meeting the DCP/DSARC criteria will be reviewed by an appropriate authority within each Service in accordance with individual service directives. DTC criteria and goals for subsystems and components will flow down from programs within which they will be used or established directly by sponsoring commands. Applications will vary from one program to another as to which costs are managed, the way the management is accomplished and other specifics. However, the one principle element which is, and must be, common to all: cost must be a consideration in design.

2.1.2 DOD Directive 5000.28 recognizes only one exemption to application of DTC for major systems; those very few programs, which for reasons of national security, have performance or schedule goals that take priority over cost goals. This exemption can only be authorized by the Secretary of Defense. Authorization for this exemption in the cases of non-major systems, subsystems and components will be made at a management level above the Program Manager as dictated by Departmental instructions.

2.1.3 For very low dollar efforts, such as the development of low value components, the effectiveness of the application of Design to Cost must be evaluated in terms of the uncertainty and design sensitivity of production costs and the degree to which the component's design sensitive contribution to operating and support costs can be identified. Also a significant factor is the extent to which component configuration and specifications are dictated by requirements to interface with higher level subsystems and systems. Where there is little room for design flexibility and little cost uncertainty, the application of DTC may not be economical.

However, in most cases, the application of Design to Cost requirements to the development of components and subsystems is necessary and makes an effective contribution to the overall objective of controlling defense costs. Systems are made up of subsystems and components. If the costs of these building blocks are not controlled, systems costs cannot be controlled. Particular emphasis should be placed on controlling the costs of subsystems and components which are used in more than one system.

2.1.4 Government Furnished Equipment (GFE). Control and accountability of DTC goals and design criteria for GFE, particularly GFE used as standard items in several programs is important to Program Managers. These components make up a cost element of the Program Managers DTC goal and, more often than not, are acquired by procurement activities not under the control of the PM. As stated above, control of these cost is absolutely essential and the procurement management systems established by commodity commands for acquisition of GFE must be responsive to the DTC goals of the using programs.

2.1.5 System Modifications

Product improvement or modification of existing systems can be a highly economical way of obtaining increased utility in many cases; however, it presents a special set of circumstances for the application of Design to Cost. The design effort usually involves only specific portions of the system with the objective of achieving limited but significant improvements in system utility. In some cases these utility improvements may specifically be significant reductions in production and/or operating and support costs. In most instances, the objective will be to upgrade performance to meet a new or increased threat. In many cases, the likely product of the design effort will be a set of changes introduced, perhaps not concurrently, into on-going production. Both design flexibility and production cost measurability are likely to be more limited than in the development of a new system. However, these are partially compensated for by lower risk and less uncertainty regarding production, operating and support costs.

Major modifications to completed systems; e.g., wing re-design or fuselage stretch of an existing transport aircraft, upgrading and modernization of a tank, are appropriate for application of DTC. Although there may be relatively low levels of design flexibility, the high level of investment in major rework modifications and the increased ability to project costs based on past experience with the system, justify the effort to identify valid cost trade-offs.

In general, the application of DTC to system modifications should be restricted to those parts of the system which are being redesigned or added to increase performance. If the planned changes in configuration are minor, the application of DTC/goals may not be justified. For major revisions to the system, DTC is mandatory. Between the two extremes, judgment is required. Factors which should be considered in applying DTC to design modification programs include: (1) the extent of the modification; (2) the potential to reduce future costs of the systems; (3) the measurability of production, operating and support cost changes to the system which may result from design changes; (4) the potential of design changes beyond the absolute minimum essential to meet performance needs to be sufficiently cost effective to compensate for increased development costs, cost of tooling, loss of production learning, and loss of commonality (for support purposes) with earlier versions of the system and (5) affordability and/or funds available for the modification. The selection of which parts of a system are to be replaced or improved, as well as the design of replacements or improvements are all subject to cost considerations. The existence of baseline data for current system costs and performance normally allows the generation of relatively precise estimates of future cost and performance to facilitate this selection.

2.2 WHEN TO APPLY?

For major systems, DOD Directive 5000.28 requires the establishment of Design to Cost goals not later than entry into Full

Scale Development and encourages its application as early as possible prior to that milestone. For any development program, Design to Cost concepts must be applied prior to the establishment of firm designs. Later introduction will be less effective because the design cannot be changed to accommodate costs or because the change would be uneconomical because of the cost or schedule impact. In addition, the visibility of costs provided by tracking the estimated production and operating and support costs is valuable to management in controlling cost growth during this phase.

2.2.1 <u>Conceptual Phase</u>

In every review of Design to Cost applications to date, the need for the earliest introduction of cost as a design parameter has been verified. Although not strictly within the purview of this Guide, the requirements generation phase is that in which cost consideration can have the greatest impact. In analyzing the possible ways of countering a threat or of supplying a needed capability, the cost of each of the possible ways must be balanced against the effectiveness and affordability of each. Uncertainty surrounding cost estimates at this stage is very large and point estimates may be grossly in error. Thus cost considerations should be in terms of relative cost differentials between competing concepts at this stage of development.

As the conceptual phase continues, the objective should be to identify viable system alternatives. The major differences in development, production, operating and support costs for the system alternatives under study should be analyzed and evaluated. As part of this process the performance and configuration characteristics having the greatest influence on costs should be identified. Where relevant, the incremental costs associated with various levels of performance should be determined. This approach introduces cost considerations and discipline into the design process and provides the necessary background for the establishment of realistic performance thresholds and cost ceilings at the entrance into the validation phase. (Milestone I)

For high technology programs, in which the state-of-the-art is fluid, or where maximum performance to meet the threat is more important than cost, the use of firm cost goals may be self-defeating in concept formulation and the earlier stages of advanced development. Rapidly advancing technology may either make firm goals too high or too low, driving decisions to less than the best balance between performance schedule and costs. In these situations cost should be allowed to vary with the advancing technology by estimates made and confirmed with each major concept or design event.

As stated previously, these thresholds and ceilings are generally not refined to the point of establishing firm goals at this point, but represent objectives which are to be validated during Advanced Development. An analysis of the affordability of these objectives should have been completed and reported by this Milestone.

Life cycle cost estimates are required in the Decision Coordinating Paper (DCP) at Milestone I (and at comparable points for non-major systems and subsystems). These will be based on the preferred system alternatives from the concept formulation phase.

2.2.2 Validation Phase

The result of Design to Cost application in validation should not be completely limited to coming within the established point cost goals. The specific cost goals established for this phase should be viewed as targets about which visibility into the cost consequences of differing alternate or incremental performance or design features can be measured and assessed for effectiveness. Appropriate elements are the base for and/or must reconcile with the Design to Cost goals for the validation phase whether they be interim or firm goals. Throughout the validation phase the cost effectiveness of performance characteristics and levels and other design characteristics should be assessed in terms of their effects on DTC goals and the LCC estimate in order to arrive at the best affordable mix of system performance and costs.

The ultimate purpose of the Design to Cost effort during the Validation Phase of a program is to provide the information to recommend and justify a firm Design to Cost goal for the alternatives, both preferred and backup, as soon as possible but not later than the presentation for the decision to enter Full Scale Development (DSARC Milestone II).

2.2.3 Full Scale Development

The Milestone II decision to enter Full Scale Development normally includes selecting the one system to be developed from among the competing concepts and design or performance characteristics. As such, it freezes the design approach. Initial application of

Design to Cost at this point in the development cycle, while mandatory, cannot be expected to yield results in the magnitude that earlier application would produce. Because the overall performance characteristics, basic design configuration and unit cost goal have been established, flexibility to trade these elements for cost considerations is significantly lessened. However, even with many of the design decisions made, cost can continue to be used as a design parameter to control the manner in which the chosen design is executed.

With a prior application in Advanced Development, application of Design to Cost in Full Scale Development is greatly enhanced. Cost discipline is already present in the selected concept and in the minds of the designer and decision maker. Much more is known of the cost impact of selection among alternate designs. There is a better indication, as a result of test experience in advance development, of the operating and support costs of the design.

While producibility must be considered even in the earliest phases of development, it is a key ingredient of Full Scale Development. Producibility and maintenance engineering of the selected design are basic and necessary methodologies of designing to cost.

2.2.4 Summarizing, Design to Cost should be applied early in the development cycle. Its largest impact, in terms of alternative expenditures comes first in requirements generation, the conceptual phase, then the validation phase and last in the Full Scale Development phase. Prior to Full Scale Development, one of the principal roles of cost as a design parameter is to yield information upon which to base decisions as to alternative concepts and designs and as to incremental performance features. Without full implementation of the Design to Cost concepts, these decisions may be made without regard to downstream cost impacts. Application in Full Scale Development is mandatory. Since it is the last point at which design can be readily influenced by cost.

3.0 GENERAL REQUIREMENTS

There are certain basic considerations which must be addressed if designing to cost is to be successful. The most important of these are discussed in this section. Variances in these basic conditions are the drivers in the type and extent of application of Design to Cost in each program.

3.1 FLEXIBILITY

Flexibility is the degree of freedom of choice and decision given to the designer by the way in which the system is described in its specifications and the way in which our time needs are expressed. If the specifications are very detailed and rigid, they dictate the design choice. If the specifications contain design rather than performance requirements, there is no design choice at all. If schedules are sufficient for only one cycle of design and test, or if they are detailed as to in-process milestones, there is little opportunity to take advantage of any flexibility in the specifications.

There are certain guidelines which should be followed in order to achieve the flexibility which is necessary for effective application of Design to Cost.

1. Specify the result needed, not the way to obtain the result.

2. Specify performance, not design.

3. Specify performance and cost for the system, not for subsystems or components.

4. Initially specify the end date of the schedule, not interim milestones.

5. Schedule programs with time for several iterations, not on a 100% success basis.

There may be valid reasons for departing from these guidelines in every program. When a departure is proposed, the reasons for it should be carefully examined. This is particularly true of the use of Federal or Military Specifications and Standards. There is no need to use these simply because they exist. Their use depends upon the reason for their existence and the degree to which full or partial use will satisfy that reason. Mandatory application of these specifications and standards should be avoided in advance development and contractors should be required to address the extent of application in writing the specification for use in Full Scale Development.

Flexibility of another type is necessary in the way in which production, operating and support costs are interrelated. The structure of these goals, their tracking and management, must not preclude the identification of significant opportunities for trade-offs among the different elements of life cycle cost.

The PM and each competing contractor must have maximum freedom to provide their version of the best possible design to perform the mission at the established cost goal. As an example, the unit production cost goal should be related to only the minimum number of essential performance and schedule requirements. This will allow the PM and contractor the flexibility needed to make trade-offs among life cycle cost elements, schedule and performance requirements are met. If redesign cannot achieve the cost goal, there must be a willingness to trade-off desired performance to achieve the cost goals while assuring a viable weapon system design is obtained. To this end, both contractor and Service project manager must have early visibility of the expected costs associated with the emerging design.

A Design to Cost program requires control of design changes which are beyond the scope of the initial contract design/performance requirements. Changes may be proposed for many reasons: to improve performance, to solve design problems, or to lower production, and/or operating/support costs. Effect of the change on life cycle cost and an analysis of the effect on system performance is needed. The proposed change should be reviewed on the basis of its cost effectiveness. Only those changes offering benefits which outweigh their costs and which are compatible with the achievement of the Design to Cost goal should be authorized. For example, contractor introduction of new low-cost piece parts to achieve a lower production cost may actually prove more expensive if more reliable and standard piece parts are used for replacement after the hardware enters the operational inventory.

3.2 STANDARDIZATION

In many applications of Design to Cost the question arises whether to use a part already in the inventory or to create a new design or select another part not in the inventory.

This question must be a consideration in design decisions, particularly from the standpoint of support costs. Relative costs must be weighed for each alternative. While lower priced nonstandard parts may be available, lower reliability, the cost of introduction of a new part into the system and the cost of maintaining multiple parts of corresponding function may offset the lower initial cost.

3.3 BASELINE DATA

3.3.1 Whatever cost is to be made a design parameter, (production, operating and/or support,) there should be a set of underlying assumptions, facts or other bases which lead to the stated estimate or goal. The most significant of these are:

1. Definition of the unit production cost goal in accordance with the DOD Budget Guidance Manual (DOD 7110.1 M).

2. Definition of the elements of operating and support costs which will be program cost goals.

3. Identification of the elements of the Work Breakdown Structure to which the costs are associated.

4. Cost elements to be considered such as recurring, non-recurring, labor, overhead, subcontracts, G&A, profit, etc.

5. Anticipated production quantity, rate of production, time of production, and increments of production and learning curve, and provisions for accommodating changes to these factors.

6. Provision for accommodation of changing economic conditions including constant dollar base year, indices to be used to deflate out year dollars, etc.

7. Deployment concepts such as how, where and when the system is planned for use.

8. Operational mission(s) and environment.

9. Maintenance concepts such as how, where, when and by whom will the system be maintained.

10. Models for estimating, tracking and assessing life cycle costs.

11. Inputs to cost models which are Government generated or controlled such as labor and overhead costs of Government maintenance, cost of POL, cost of inventory, introduction and maintenance, costs of training, etc.

3.3.2 Certain of these baseline data are generally specified by the Government. The remaining data are arrived at by evolution during the development cycle as the design matures. Much of these data will be generated in advance development and will form part of the baseline for full scale development.

4.0 GOALS

4.1 Design to Cost goals are single point estimates of various elements of Life Cycle Cost which are made a part of Decision Coordinating Papers (DCP) for major systems. Goals established for non-major systems, subsystems and components are similarly documented in appropriate Service approvals.

4.2 DOD Directive 5000.28 requires the establishment of a Design to Cost goal for production as defined in 1.5.3 as flyaway cost per DOD 7110.1M. The Directive recognizes rare instances in which flyaway cost would not be the most appropriate goal and permits the proposed use of weapon system cost, procurement cost, program acquisition cost, or other category defined in DOD 7110.1M.

4.3 A program can have one or more design to cost goals. Not all goals are appropriate to all programs and care must be taken in application of suitable design to cost goals.

Where operating and support costs are a significant factor, it would be appropriate to propose operating and support cost goals which look at that portion which is design dependent, predictable and verifiable. This would include such things as direct crew cost, spares, direct maintenance manhours, material, training, support equipment, inventory management, technical data and maintenance associated records and transactions, facilities and POL. As a minimum, goals for reliability and maintainability should be specified. However, in order to balance all the elements of production, operating and support costs, with performance and schedule, particularly in order to choose among alternative designs, it is necessary to convert the measures of reliability and maintainability, such as MTBF and MTTR, into expressions of cost.

Pending the development of a suitable data base for use in creating Cost Estimating Relationships, the conversion of design characteristics such as reliability and maintainability into cost is possible through the use of cost models. (A bibliography of cost models is available through DLSIE.) However, they have not demonstrated high degrees of precision in reflecting or predicting absolute costs. These cost models are, however, useful in assessing cost differentials between competing or alternate designs and thus are useful for Design to Cost purposes.

4.4 Design to cost goals for operating and support costs are essential to the management and control of these costs which have been escalating at alarming rates.

The major design characteristics which drive operating and support costs are reliability, maintainability, price for spare parts and support equipment. The most rudimentary goals for operating and support cost would be definitive statements of requirements in these areas.

One of the most basic and fruitful approaches to controlling operating and support cost is the control and reduction of manpower requirements in the operation and support of systems. Manpower has become the most expensive element of the DOD budget. This is reflected in increased systems costs of operating crew, size, skills and training, and maintenance manpower requirements of numbers of maintenance personnel, their skills and training.

Design must address the costs of manpower. Crew size, consistent with operational necessity, can be balanced against hardware sophistication to obtain the lowest overall costs. Normally, improvements in reliability reduce the need for maintenance manpower. Advances in maintainability, by reducing maintenance time, reduce manpower requirements. Generally, both reliability and maintainability can be enhanced through simpler designs, thus contributing to lower production costs. Even when enhanced reliability and maintainability are obtained at increased production cost, the resulting manpower cost savings may be expected to result in overall savings to the DOD.

4.5 Design to Cost goals for major systems are proposed by the Program Manager and the Services and are established by the Secretary of Defense in the DCP.

These goals are drawn from the life cycle cost estimates required in support of the DCP. At each milestone the maturity of the estimates, and thus the goals, increases with the maturity of the concept and design. In this sense, the Design to Cost goals are flexible requirements and are subject to change, as approved by the Secretary of Defense, as performance, quantity and concept changes occur and opportunities for life cycle cost trade-offs arise. Absent such causes, the Design to Cost goals are to be treated as firm and are a basis for assessing the performance of the Service, Program Manager and contractor.

For non-major systems, subsystems and components, all of the above are valid except the level at which the goals are established.

In each case, the authority establishing the goals must be higher than the Program Manager.

4.6 A principle characteristic of a Design to Cost goal is that it should be difficult but achievable. If the goal is too high, there is no motivation toward cost reduction through critical examination of requirements, concepts and designs. This may result in acquiring incremental performance or design features which are not cost effective. Conversely, if the goal is too low, motivation is destroyed because no amount of trade-off could be expected to achieve the goal.

It is also essential that the goals selected be relatable directly to the life cycle cost estimates which support the DCP or budget submissions.

4.6.1 Hardware Elements. The program unit production cost goal should include each element of hardware that will be procured for the flyaway (sailaway, rollaway) unit of the defense system. This includes both GFE and CFE items. In those few instances where it is not practical to estabilish a comprehensive design to unit production cost goal for a system what is and what is not included in the goal should be clearly specified. Likewise when operating and support cost goals are established the hardware elements covered by the goal(s) should be clearly documented.

In some instances it will be necessary to establish individual design to unit production cost goals for the various subsystems within a system acquisition program. This will be primarily in those cases where different and basically unrelated quantities of subsystems are to be procured and/or when a subsystem may be common to two or more programs; e.g., X number of missiles and Y number of fire control systems. In the cases of operating and support costs, it will in many cases be more feasible to establish operating and support goals for the subsystems of major systems, rather than at the total system level.

Where unit production cost goals include GFE, it will be necessary for the manager responsible for the system acquisition to have the appropriate communication and control of the GFE. If a GFE item is being developed for incorporation into only one system, the manager of that system should have effective control of the DTC effort for that GFE item. If GFE is being developed for more than one system, the DTC goal(s) for the GFE should be treated as part of the configuration and performance interface with the systems and controlled accordingly. This latter condition also applies to the unit production cost and other DTC data for a fully developed (production) GFE element which is a part of system being managed in accordance with DTC policy.

It is vitally necessary that prime contract design to unit production cost goals include CFE hardware elements and that the prime contractor take positive action to obtain CFE within the unit production cost goal and which make the proper contribution to the achievement of operating and support goals. This should be done through the application of DTC goals and provisions to subcontracts and/or by other appropriate means.

In all cases, the objective is to have the program unit production cost goal reflect the full procurement costs of the basic system. This should be the principal guideline in determining what will be included in this goal. Items normally included in major system goals are: (1) the basic system unit, (2) the propulsion subsystem including accessories, (3) armament which is normally installed in or procured for the basic system, (4) all communications, navigation and other electronics which are integrated into the system, and (5) all other GFE and CFE which are part of the operating system. Hardware which are not included in the unit production cost goal include system peculiar and special support equipment, special training equipment and initial spares and repair parts (unless normally included in the operating system). However, it is necessary that these items be considered in the life cycle cost management of the system and that appropriate goals be established for this.

4.6.2 Cost Elements. The program unit production cost goal is required to conform to the guidance regarding Average Unit Flyaway Cost for aircraft and missiles contained in DOD Budget Guidance Manual 7110.1M. Programs developing other types of systems should follow this guidance as closely as practical and include all element appropriate to their equipments. Basically the goal should include: (1) the recurring and nonrecurring production costs for all hardware elements of the system, (2) an allowance for fee/profit, (3) an allowance for changes which is normally a percentage of the estimated unit cost of the current configuration based on historical experience, and (4) any management reserve which the program manager is able to retain. It should be understood that only the first element will be reflected in contract design to unit production cost goals and then only for the hardware elements covered by that particular contract.

For DTC goals for operating and support costs the guidance is principally that goals be established for the elements of these costs (or cost-driving factors) which are design controllable and can be measured no later than an early stage of deployment and/or are subject to conversion into reliability improvement warranties.

It is highly desirable that the program unit production cost goal be no more fragmented than necessary to reflect the actual development and procurement structure of the acquisition program. Excessive fragmentation eliminates the management flexibility of the program manager. In the case of operating and support cost goals these should normally be established for elements of the system for which reliability, manning, repair, and spares costs or other quantitative factors can be identified.

It should be understood that there will not necessarily be an obvious direct reconciliation between program design to cost goals and contract goals because some cost elements included in program goals are not appropriate for inclusion in contract goals and, in some cases, not all program hardware elements will be reflected in contract goals. It should also be understood that the reconciliation between program unit design to cost goals and production contracts will be further complicated by economic escalation (program goals are in constant dollars), learning curves and variances of actual from projected production rates and quantities, and the fact that production contract line items will not necessarily align with DTC cost elements or hardware elements. Each Service has its own methods for grouping cost and hardware elements for contract line items and to a lesser extent for FYDP and budget preparation. The use of DTC management principles does not require that these methods be abandoned. However, it does require that contractual and, if necessary, budgetary provisions be made to provide estimates regarding the likely achievement of DTC goals and also the actual cost data necessary to verify accomplishment or the extent of failure.

4.7 Goals Other Than Average Unit Flyaway Cost Design to Cost goals based on average unit flyaway cost are most productive for programs with large production quantities. Provisions have been made in DODD 5000.28 for those programs which do not meet this requirement to use cost goals based on other cost definitions included in the Budget Guidance Manual. The most common is to base the DTC goal on total acquisition cost for programs where production quantities are low. In the past, some programs used total acquisition cost in then year dollars, however, the abnormal escalation of the past few years has generally made this type dollar goal untenable a constant dollar goal is preferred. The primary criteria is to use a cost definition which is convenient and useful for the PM, is defined in the Budget Guidance Manual, and accurately portrays the cost structure of the program.

5.0 TRACKING

5.1 MAJOR REVIEWS

At each significant milestone in the development of a system, subsystem or component, progress toward achievement of Design to Cost goals should be subjected to intensive review by the PM, Service and the authority who established the goal. For major systems these reviews will occur at least at each DSARC and more frequently as the situation warrants.

These major milestone reviews are not, however, sufficient for proper management of a system development. They are too far apart in time and in terms of concept and design maturity.

5.2 MANAGEMENT REVIEWS

There is a whole set of subordinate milestones present within each phase of development which signal the completion of some effort which yields more complete information as a basis for assessing progress.

At the outset of each phase, requirements are established, refined or changed. The Design to Cost goals are likewise established, refined or changed after evaluation.

In each phase, subsequent to the establishment of requirements, the concept or design is frozen at a point which permits assessment prior to completion of hardware for test. There may be several steps to a system design freeze, each of which will yield significant data for Design to Cost review. For the system as a whole, the last of these steps would be upon delivery for Government testing.

It is important to note that whatever the milestone at which Design to Cost is reviewed, it must be related to the maturity of the concept or design. A significant measure of the maturity of a design of a system is the cost weighted percentage of parts, components, subsystems or support equipment which have matured to milestones such as: (1) drawings completed, (2) hardware fabricated, (3) hardware tested, (4) vendor quotes received. This data should be available at every Management Review.

In addition to the foregoing data relating to the maturity of the design, and thus indicating the validity of cost estimates, these management reviews require fairly extensive new estimates of the elements of cost which are included in the DTC goals or contract targets. The following data elements of these new estimates are required for a meaningful review:

1. The Work Breakdown Structure (WBS) used or to be used in production broken down to a reasonable level (usually 3rd or 4th).

2. A current estimate of production, operating and support cost for each of the lowest level elements of the WBS.

3. These estimates displayed by functional cost elements such as labor, overhead, purchased/subcontracted parts, G&A and Profit. (See DOD 7110,1M)

4. A successive summation of these detailed estimates at each level of the WBS.

5. Identification and analysis of deficiencies at each level between the current estimate and prior estimates or the DTC goal or contract target.

6. Proposed or implemented actions to correct over-target variances or to take advantage of under-target conditions.

Reliability, availability and maintainability reports against predicted and allocated growth give some measure of operating and support cost progress. Conversion to comparative cost can be accomplished utilizing cost factors or cost models.

5.3 CONTINUING ATTENTION

5.3.1 In addition to specific, scheduled reviews, there must be constant attention on the part of designers, managers and executives in the Government and Contractor, to what is happening with respect to cost. This requires that some means exist to assess the cost impact of each and every design decision or alternative. These means may vary widely but all must involve a way to provide the designer with cost information which is current and reasonably accurate. At every point in the development cycle, production engineers, logisticians and cost analysts must participate in the design process.

5.3.2 If a continuing feedback of cost and design is established, a continuing check on progress toward DTC goals can be obtained and used by program managers. Most often, this continuing check will consist of a variance analysis conducted at specific intervals (usually quarterly) at significant levels of the Work Breakdown Structure.

These checks should usually display the then current estimate of cost and compare it with the allocated cost goal at each of the lower levels of the WBS derived from the last management review.

A complete new estimate at the quarterly checks is not cost effective and probably not possible. However, the key is the on-going identification of suspected variances.

5.3.3 It is usually possible to achieve some degree of trade-off of costs between elements of the Work Breakdown Structure. Periodic reporting and tracking requirements should not constrain the designer in taking advantage of this possibility. It is, therefore, prudent to require tracking to the highest levels of the Work Breakdown Structure which give good visibility into the trends of cost and design decisions and which correspond to decision making levels in the designing organization. However, there must always be a method and requirement to reveal successively lower levels of the WBS to trace the point at which a variance from allocated performance, maturity or cost goals or specifications has occurred or may occur. Additionally, a very costly item may be positioned at a relatively low level of the WBS and because of large opportunities for cost variances or because the item in question may be used in other systems, tracking of its costs and performance may be necessary.

6.0 MANAGEMENT

6.1 General. Implementation of DTC was not intended to require separate DTC Managers, Teams, Sections, etc. DTC management must be integrated into the existing management systems and procedures and must be the concern of everyone involved with the development. The use of cost as a design criteria and cost goals for control must be introduced and supported by the highest levels of management in each organizational unit and permeate the structure just as any other discipline that is executed by management. No separate DTC unit or team can successfully implement the concept from a staff position.

6.2 DTC Management Functions. DTC management functions are precisely geared to and must become an integral part of detailed program management. The functions generally breakdown into two distinct phases separated by the establishment of a firm program DTC goal by higher authority.

During concept formulation and Advanced Development, the primary management functions are directed toward identification and validation of the system performance, cost and schedule desired. DTC management likewise, must identify and validate the cost elements composing the recommended program DTC goal. Continuing iteration between mission requirements and affordability with the development technical solution and its cost is needed to establish the early technical and cost objectives for the development. The thrust and direction must be continuously aimed at determining the system to enter Full Scale Development and identifying, justifying and supporting its projected average flyaway unit cost and the goals established for O&S cost factors.

Entry into Full Scale Development (DSARC Milestone II, or equivalent milestone for less than major programs) selects and approves the system to be developed and establishes its average flyaway unit cost in the form of a firm DTC goal. If the established DTC goal differs from the Program Managers recommended goal, it will be necessary to review the entire program DTC structure and adjust such as necessary to conform to the firm DTC goal.

The new firm program DTC goal and the adjusted subgoals now become the baseline cost specification for each element of the program and the DTC management functions shift toward control of cost during subsequent development and production efforts.

6.3 Managerial System. Because the DTC goal and process is directed at control of average unit flyaway cost, there must be a system available to account for the subelement goals which comprise the program DTC goal.

6.3.1 Program Managers System. The program DTC goal is based on the program cost elements accounted for at the Program Managers level. It would be rare for any single prime contracter to control all the costs in these elements. It is, therefore, necessary for the Program Manager to have his basic system controlled within his office and accumulate all cost elements included at his level. Some of the more desirable characteristics of such a system would include the following:

1. Because the DTC goal is based on a production cost element, the system must be keyed to the programs' production plan, usually

the Production Work Breakdown Structure.

2. The system must be integral with the cost estimating methods, procedures and process utilized by the PM and able to display both the goal breakdown and comparable current best estimate.

3. The system should be discrete enough to provide goal visibility to all subelement managers and able to portray cost management performance at each level.

4. All cost elements required to be in the DTC goal must be consistent with the supporting criteria for the goal and easily summed to program DTC goal.

5. The system must be able to be adjusted for changes in production quantities, rates and schedules, economic escalation, changes in funding profiles, etc.

6. The system should be structured to utilize all DTC data generated in the development phases including contractor and in-house inputs, refinements, trade-off action, prototype and cost model data, etc.

6.4 Contractor DTC Management. The PM, via the RFP and contract, must insure that contractor's management systems will provide DTC cost projections and information compatible with his own management system. Some contractors will have this ability from their existing normal management system others must make some adjustments. These adjustments are not envisioned to result in the establishment of new and extensive DTC Management Systems; all of the functions required by the DTC concept are now being accomplished in one form or another. Any adjustment necessary would be required in the order, priority, form and use of the generated information. Some training may be necessary, but this should be little more than would be necessary to conduct normal business in the commercial market place.

The key elements of any contractors management system to be examined for DTC operations included (1) the contractors methods for subdividing and distributing the contract DTC goal to his designers; (2) his methods of feeding back production estimates of preliminary designs to the designers (the time lapse for this operation is critical varying by actual industry observation from instantaneously to weeks); (3) the methods for collecting production estimates on final designs and updating the production cost projections; (4) methods for obtaining and integrating sub-contract DTC data.

It should always be stressed that, although the PM will require some DTC data from the contractor, the contractors management systems must produce the above type information for his own internal cost control, if he intends to successfully compete in business in a Design to Cost atmosphere.

7.0 CONTRACTUAL IMPLEMENTATION OF DESIGN TO COST

7.1 OBJECTIVES

7.1.1 Contracting for the Various Program Phases. Most programs which have design to cost goals will go through four distinct contractual phases: (1) the conceptual phase, which will consist of in-house and contractor studies; (2) the validation or advanced development phase, which will normally entail the contractor design, fabrication and test of one or more complete or partial prototypes of the system; (3) the full-scale development phase which will include the complete contractor design, fabrication and test of one or more production-configuration systems, and, finally, (4) the production phase which will include the contract(s) for series production of the required quantity of systems. Where funding is available, the conceptual, validation and the full-scale development phase may involve contractors operating in parallel. Contracts for these phases should be of types consistent with the technical and other risks associated with the program. During the production phase, the Government may exercise options for reliability improvement warranties. Of course, the agreement on contract type is a bilateral contracting decision which will be influenced by the particulars of each individual procurement situation. The production phase may also involve competitive procurement, based principally on price, commencing as early as the first quantity production contract; or a second source production contractor may be developed. Contracting for Design to Cost is discussed in subsequent paragraphs.

7.1.2 Procurement Objectives. The basic objectives in contracting for a Design to Cost program are:

1. To define Design to Cost targets in terms which are auditable, contractually enforceable, and meaningful to both the contractor and the Government. Note that contract provisions normally use "target" and management documents utilize the broader term "goal."

2. To contractually establish the schedule for contract performance and the requirements for contract deliverable end-item performance and configuration in the scope and depth necessary to protect the interests of the Government and provide for an enforceable contract, yet allow the contractor latitude to tailor his design to fit design to cost targets.

3. To define the means by which contractor progress towards design to cost targets will be formally assessed, recorded and reported.

4. To provide incentives which will effectively motivate the contractor to exert himself to achieve the design to cost targets.

7.2 CONCEPTUAL PHASE

7.2.1 Contract Requirements. The contracts in this phase are typically for studies and/or feasibility models. At this stage, often there is no formal requirement for a program design to cost target. However, in some cases the contractor(s) may be provided guidance as to the anticipated acceptable cost level along with other design guidance. Where this is done the guidance should be in sufficient detail to be meaningful, i.e., the included planned elements of cost and the general production quantities and rates and deployment concept.

7.2.2 Outputs. One of the outputs of the conceptual phase should be information sufficient to establish the system design to cost goals and targets with a reasonable level of confidence. Therefore, the requirement to make any guidance regarding costs meaningful to the contracting parties also applies to any estimate of unit production cost and operating and support cost required from the contractor as a product of his study. Estimates should be required to be in as much detail and with as much substantiating data as is consistent with the degree of design definition. One of the objectives of the studies of the conceptual phase should be an appreciation on the part of the procuring activity as to what performance and logistics support levels can be obtained within design to cost goals.

7.3 VALIDATION PHASE

7.3.1 Request for Proposal (RFP). This phase may involve prototype design, fabrication, and test. Often there is competition among two or more contractors when program funding considerations permit. This also likely will be the first phase in which design to cost targets will be contractually specified. In this phase, the RFP should specify design to cost targets or affordability ceilings and the minimum acceptable performance and schedule constraints. In specifying the performance and other design requirements, great care should be exercised to avoid the inclusion of requirements which would have significant cost but make only a marginal contribution to accomplishment of the required mission, or which add to life cycle cost out of proportion to their contribution to system mission effectiveness.

7.3.2 RFP Considerations. The contractor should be asked to propose a design and a program for achieving that design which he considers to be a balance among performance, life cycle cost elements and schedule. When pertinent life cycle cost models are available, consideration should be given to utilizing the RFP to make them available to prospective offerors. The RFP requirements should be structured to encourage the offerors to exercise technological ingenuity and inventiveness in their proposal. Therefore, detail specifications and technical requirements which are not essential to the advance development phase should be excluded. The RFP should concentrate on the system capabilities essential to mission accomplishment and the reliability and maintainability characteristics necessary for efficient deployment and operation. It may be that the advance development models of the system will not be required to demonstrate all of these characteristics; however, to the extent they are known, the RFP for the advance development phase should specify the essential requirements to be met by the fully developed system. Consideration should be given to stating the performance requirements in terms of one or more mission scenarios, with the offerors required to propose a system capable of performing the mission(s) described. The RFP should specify the relative importance for the various items of performance: cost, design characteristics, and schedule. This will facilitate the offerors proposing designs which achieve the desired balance among these features. In validation, particularly where there is competition, this ranking of parameters should be continued in the contract for the purpose of accommodating trade-offs during the development of the design. Even in the absence of such ranking, the RFP and contract must specifically describe what may be traded by the contractor and what trades require Government approval.

Design requirements may be specified in terms of compatibility with equipments and facilities with which the system must operate. The offerors should be encouraged to identify levels or types of performance which they consider to be high risk and/or likely to have a predominant effect on life cycle cost. This can be done directly, or by requiring the offerors to state and rationalize levels of confidence of achieving various levels of performance within design to cost targets, or by other appropriate means.

In this phase, the degree of latitude given the offerors/contractors will be heavily influenced by the degree of competition maintained. Where funding constraints necessitate the selection of only a single advanced development contractor, the proper protection of the Government's interest may require somewhat less flexibility in the RFP and subsequent contract requirements. However, the article developed in this phase, barring significant design changes, will largely determine life cycle cost; therefore, the basic guideline to be followed in all cases is to avoid unnecessary requirements and allow latitude of design to fit the cost. The design to cost requirement must be stated in meaningful and specific terms, based upon quantities, rates and time periods involved and a deployment concept. Also, the cost elements included in design to cost targets must be clearly specified. If ceilings or other limiting goals are to be placed on other elements of cost, this too, must be clearly specified.

7.3.3 Proposal Evaluation. The implementation of a design to cost requirement places an extra burden on the DOD source selection process. In selecting the validation contractor(s) it is necessary to identify the proposal(s) which offer the best potential combination of performance and life cycle cost. To do this, it is necessary to evaluate the proposed technical approaches and to establish the credibility of each offeror's production, operating and support cost estimates. The selection may be complicated by the existence of different designs and technical approaches among the various proposals as a result of the flexibility allowed in this phase.

7.3.4 Proposal Requirements. In order to clarify the Government's objectives, simplify proposal preparation, and ease the proposal evaluation task, the principal source selection criteria should be included in the RFP. These should direct the offerors' efforts to what the procuring activity considers to be the most important areas of performance, design, schedule, risk and cost. The RFP should provide guidance as to the scope and depth of data required to support all claims made in the proposal. In the cost area, each offeror should be required to provide estimates of production, operating and support costs of his design. Each offeror should describe in his proposal, the methodology used to generate the estimate, the assumptions made, the data used and their sources. Estimates of the program costs not included within design to cost targets may also be required if they are a significant part of the estimated total program cost.

7.3.5 Contract Requirements for Design to Cost. The advance development contract(s) should specify the design to cost targets, the cost elements included in them including any escalation factor used, production planning and deployment concept on which the design to cost targets are based, requirements for tracking and reporting status against the targets, and the data required at contract completion to verify design to cost accomplishment. Requirements for any planned DOD reviews of these cost estimates should also be specified.

In the technical area, contract requirements should follow the philosophy expressed regarding those requirements, i.e., contract requirements should concentrate on the kinds and levels of performance essential to mission accomplishment. Nonessential and highlyy detailed requirements should be avoided. The contract(s) should define as system requirements only those necessary for mission capability and compatibility with other DOD equipments and facilities.

7.3.6 Contractor Latitude for Trade-Offs. During advance development, the contractor should be given broad latitude to make tradeoffs between performance and cost in order to achieve the design to cost objective. These trade-offs are of two major types: those which affect design within the specified performance, production plan, deployment concept, cost and schedule, and those which require changes to these specified parameters. As to the first type, the contractor should be allowed complete freedom of decision without Government involvement (except for visibility). While the second type must be a decision of the Government, the contractor should be strongly encouraged to challenge the specified parameters and recommend changes to them wherever there is a valid indication of significant cost savings. This latter effort can be especially productive in examining trade-offs between production, operating and support costs. Any use of Value Engineering contract provisions should be tailored to ensure compatibility with the design to cost requirements.

7.3.7 Contract Incentives and Competition. It is probably unnecessary to utilize incentives to motivate achievement of design to cost targets in advance development contracts when competition is maintained throughout this phase. Competition is likely to be a much more effective spur to achievement of the design to cost targets than any cost incentive. Therefore, contractual incentives are likely to be ineffective when competition is present. However, if there is only a single system contractor during this phase, it may be desirable to use contract incentives. In validation, the most flexible incentive would be an award fee. Award fees can be developed to permit an appraisal (with associated fee awards) of the overall performance of the contractor in balancing performance, cost and schedule.

7.3.8 Subcontractors. Most major defense system developments entail work by one or more major subcontractors as well as the prime contractor. Frequently the subcontractor is responsible for a portion of the system/subsystem which is critical to system performance and constitutes a substantial part of total system costs. under these circumstances, it may be necessary for the primce contract(s) to require the allocation of design to cost targets to such subcontracts. The tracking and reporting of progress toward these targets, and visibility of prime contractor decisions regarding changes (trade-offs) in subcontract design to cost targets and performance requirements should be included.

7.4 FULL-SCALE DEVELOPMENT PHASE

7.4.1 Contractor Selection. By the time the program enters this phase, the design configuration and the system performance requirements should be established except for relatively minor modifications. When parallel full-scale development is not feasible, source selection for this phase involves the selection of the better advance development design in terms of system performance, cost and schedule. Since advance development for all except the most costly systems will entail the testing of prototypes, there will normally be test data upon which to base the evaluation of performance and, to a lesser extent, operating and support cost. The actual costs incurred in prototype fabrication may provide a useful, but not conclusive, indication of the production unit costs. The advance development contractor(s) should be required to provide refined estimates of production, operating and support cost. Methodology, plans, assumptions, data and source information should be made available by the contractor and reviewed by the source selection authority and/or his representatives. The review and evaluation normally will be more intensive than that conducted during advance development because of the greater quantity and accuracy of data available.

7.4.2 Contract Technical Requirements. Because the full-scale development phase will often have a single contractor for the system, the contract requirements will normally be more explicit. This is also consistent with the degree of system definition, since by this phase, design configuration and performance normally should be established and reflected in the contract requirements. However, as with advance development, unessential and overly detailed technical requirements should be avoided.

7.4.3 Trade-Offs. The full-scale development phase normally will not be characterized by major cost and performance trade-offs unless problems arise which invalidate the conclusions of the advance development phase. Trade-off flexibility must still, however, exist between DTC goals and anticipated life cycle costs where significant life cycle cost savings can be demonstrated. Any decision regarding trade-offs which affect system level configuration, performance and life cycle costs are likely to involve significant re-orientation of the development program and should be made by the DOD program manager or higher levels if DCP goals are affected. Contractor decisions in full-scale development are likely to be limited to the selection of detailed design alternatives.

7.4.4 Contract Design to Cost Requirements. The full-scale development contract must include design to cost targets, a definition of the cost elements included, and the assumptions upon which the targets are predicated. The contract should also include the requirements for the tracking, reporting and review of status with respect to these targets. Provisions covering the allocation of targets to the major subcontractor(s) and the tracking, reporting and review of their status should also be included.

The unit production cost target included in the full-scale development contract should be defined in terms that enable the use of contractor's cost accounting system or elements which are directly relatable to those of his system. This establishes a basis for direct comparison of contractor estimates and actuals with the contract target. Since operating and support cost targets or factors may take many forms, the definition of the elements must be accomplished on an individual basis. The definitions, however, must be consistent with the elements of data to be collected during operational test and evaluation.

7.4.5 Design to Cost Contract Incentives. The contract should be structured to require and motivate the contractor to introduce producibility and supportability considerations into his design, suggest configuration changes which can reduce cost without seriously reducing mission performance capabilities, and to recommend the elimination of performance requirements or specifications which he considers to be unproductively costly; i.e., do not provide system capabilities commensurate with their costs. Since the full-scale development phase usually does not involve parallel contracts, it is in this phase that maximum consideration should be given to contractual means of motivating achievements of DTC targets. The success or failure in the achievement of the targets will be largely determined by the basic design configuration defined in advance development. In full-scale development, the significant challenges are avoidance of cost increases through introduction of changes and proper consideration of producibility and supportability. Where competition does not exist, additional incentives may be the appropriate means to motivate the contractor to apply the kind of effort needed to do the complex job necessary in designing to life cycle cost.

7.4.6 Types of Incentives. The nature of the incentive arrangement and the size of the incentive should be determined on the basis of its purpose in the overall acquisition strategy. If the strategy is to rely primarily upon competition and trade-offs in the advanced and full-scale development phase to achieve the DTC targets, then the use of DTC incentives will normally be unwarranted. If competition does not exist, then the contract should contain some type of incentive to properly motivate the contractor to achieve the design to cost target. One such arrangement would be an award fee (as an additional incentive in the development contract, (for example, CPIF/AF)). Because of the complexity inherent in the nature of operating and support (O&S) targets and their measurement, the flexibility of an award fee arrangement is particularly useful for O&S cost incentives. However, an award fee is not a fee to which the contractor is automatically entitled by achievement to a single objective. Determining and awarding the amount or amounts of fee rests with the Government alone. If the amount or amounts were specific entitlements to the contractor upon achievement of the specified target alone, these sums would be included within the incentive pattern of a firmer type contract, e.g., CPIF. The Government may, under an award fee contract, properly not award any sums specified as award fee, if the contractor has achieved the single objective while performing at unacceptable levels under other key elements of the contract. Predetermined milestones should be established where increments of award fees may be paid. Increments to be paid should be a smaller percentage of the total award fee at the initial milestones and become larger towards the end of the contractual effort. These interim evaluation features will instill a discipline periodic examination of progress against the desing to cost targets. Incentive arrangements providing for penalties for missed targets also should be used whenever appropriate.

A second alternative, particularly for production cost targets, is a variation of the fixed price incentive formula (FPI) type of contract. Under this arrangement, development could be performed under cost-type contracts, but with an agreed upon formula for establishing the profit of at least the initial major production contract. This formula would base the target profit of the production contract on the achievements in regard to the design to cost target and the required performance in the development contract. The formula would reward the contractor with a substantial incentive payment if he were able to achieve or beat the design to cost target contained in the full-scale development contract (and in the subsequent production contract) without degrading system performance below required levels. In this situation, the formula should relate the cumulative average unit production cost employed as the overall design to cost target to the cumulative average cost for the number of units to be procured under the production contract(s) to which it is to be applied. This approach also could provide for penalties if the contractor did not meet the design to cost target.

In those instances where a substantial fee may be paid by the Government, the basis of an estimate or projection should be developed in accordance with an agreed formula. The formula should provide for such matters as application of progress (learning) curves, the effects of hard tooling, rate tooling, labor mix changes, forward pricing rates, and adjustments for inflation. Any other factors of significance to the program should also be addressed. A formula treatment of this type is best suited to programs with a low-rate production phase.

Powerful motivation for the control of unit production costs in full-scale development can be achieved through the use of a priced option for initial production quantities in the development contract. This approach is strictly limited by DOD Directive 5000.1 to those cases in which risks have been reduced to manageable levels.

7.4.7 Reliability Improvement Warranties (RIW). The use of reliability improvement warranties (RIW) on selected hardware can provide additional motivation to the contractor(s) to consider operational supportability factors during the design and development process. Decisions for RIW application should be made as early as possible in the acquisition cycle. The contractor should be informed early in the design phase that there will be warranty requirements so that reliability and maintainability are given appropriate attention at the time the equipment is initially designed.

It should be emphasized that the terms and commitments required of the contractor should result in a reasonable balance between his risk and the degree of incentive needed to achieve the primary goal of system availability. The size and scope of the initial commitment should be determined in consideration of the uncertainties and future support cost and the risk involved to both contractor and Government.

7.4.8 Cost Reduction Contract Changes. In design to cost, it is DOD policy to encourage contractor-generated contract cost reduction change proposals which identify unnecessary or marginally cost-effective specifications and requirements. Historically development contracts have generally been silent in this regard.

There are several ways to treat this problem contractually. One is to treat such proposals individually, consistent with design to cost objectives. Another is to use special contractual language addressing this issue. This could include incentives, since unless specifically addressed, DTC production unit cost or O&S cost incentives do not address contract changes. Value Engineering Incentive clauses provide a full range of contractor incentives to suggest such changes and should receive serious consideration for this purpose. Several methods are available to insure that VE and DTC unit production cost or O&S cost incentives interface properly.

7.5 PRODUCTION PHASE

7.5.1 Contract Requirements. If the production contracts are structured to reward the contractor for actual cost performance against the unit production design to cost target, provisions should be included (a) to provide for measurement of actual costs against a target established in accordance with an agreed set of cost elements and progress (learning) curves and (b) to prevent assignment of production related costs to elements of cost not covered by the design to cost target. An approach to achievement of the first objective is to express the design to cost in terms of the appropriate elements of the contractor's cost accounting system, as mentioned above, and, using agreed to progress (learning) curves and escalation factors, translate the design to cost goal into numbers against which the actual costs incurred can be directly measured. To achieve the second objective, production contract activities on deliverable items which are not a part of the unit production tasks covered by the unit production cost goal should be separately priced contract line items with the contractor required to segregate the actual return costs against these tasks. These line items may also be covered by cost incentive arrangements. The contractor should be required to collect and periodically report the actual costs incurred in the elements of cost included in the cumulative average unit production cost goal. This will enable measurement of the extent to which the design to cost target is being achieved.

When the RIW commitment approach has been used in the development contract, the warranty will apply to production items. Therefore, the production contract must provide quantities, rates and schedules consistent with the terms of the warranty.

7.5.2 Production Competition. If follow-on production contracts are awarded on the basis of price competition or if a second production source is established, the development and initial production contractor(s) cannot be penalized for failure of other contractors to achieve the cumulative average unit production cost goal. In this situation there are too many factors for which the design contractor cannot be held responsible, such as labor and overhead rates and efficiency of the subsequent producers.

7.5.3 Design to Cost and Cost Reduction During Production. DOD Directive 5000.28 requires that production cost be rigorously controlled to the DTC production unit cost goals. A number of factors such as engineering fixes, mission changes, and performance increases may increase costs during production. There are a number of techniques available to counter such increases. These include VE Incentive clauses and cost reduction oriented contractual Product Improvement Programs. Funding set-asides to finance such efforts must be made if these opportunities are to be properly exploited.

APPENDIX A

GUIDELINES FOR UNIFORM DESIGN TO COST STATUS REPORTING DURING DEVELOPMENT

This appendix to the JLC Design to Cost Guide is designed to provide guidance and standardization, where practicable, for tracking DTC goals during the development phase of a major weapons system acquisition. Guidance provided is to assist the Project/ Program Manager to establish a method of tracking contractor progress in the achievement of the DTC goal for the system being developed and produced. Inclus . of this information as an appendix is considered appropriate since there is no intent to establish a new report.

An essential element in the management of a DTC acquisition program is a system to facilitate DOD tracking and monitoring of the contractor's progress in developing a hardware system which will meet the contractually required DTC goals. The system must deliver data at a level of detail which provides the Government acquisition management with meaningful DTC status, identifying those critical areas and problems which might cause DTC goals to be exceeded.

It is emphasized that the reporting from the contractor to the DOD acquisition manager is only one element of the information system necessary to effectively execute a DTC development program. The contractor must provide for the assignment or allocation of contract DTC goals to appropriate elements of the defense system on a rational basis consistent with system complexity, performance requirements, schedules, and anticipated costs. Design responsibility for these elements must include all design requirements including DTC goals. As design development proceeds the contractor must estimate the production costs and other relevant costs of each projected design configuration, compare it with the applicable DTC goals and, whenever necessary and possible, adjust the design, to achieve the cost (and performance) goals.

The DTC reporting guidelines are separate from but compatible with the cost, schedule, and performance controls associated with the on-going development contract and provide the DOD project/program manager with data he needs to, (a) assess how effectively the contractor is implementing the DTC program; (b) evaluate DTC goals and monitor their projected achievement; (c) perform analysis needed to formulate management decisions concerning design and cost, schedule, and performance tradeoffs; and (d) use as an input into required cost reporting to higher management levels.

Information contained on page 63 establishes DTC reporting guidelines that should be applied to all projects/programs requiring contractor DTC data. Each project/program manager must review the requirements of his specific program and determine what data he may require. The level(s) of system breakdown and cost element detail should be limited to those necessary to provide practical and useful data to the project/program management office.

It is important that a consistent framework be used throughout the development and production phases for DTC tracking and reporting. The contract work breakdown structure (CWBS) normally provides the necessary hardware identification uniformity; and the cost elements as identified in Format A on page 64 are intended to provide consistency within a given program and also among all DOD components. Contractual DTC goals are normally established by the project/program manager at a summary level. The contractor then extends this to lower levels of hardware elements which are assigned to engineering managers or design groups. The DTC goals are allocated to these elements as part of the design requirements. Normally, it will be at this level that the contractor manages the development of the system and tracks and controls the achievement of the DTC goals. Estimated costs of the designs for the hardware elements will be generated and fed back to the responsible contractor design managers as the system is developed. Comparison of these estimates with the allocated goals will identify the cost status of the design for the various hardware elements. In any development program, it is normal to expect some deviations from original DTC goals as allocated to elements in these lower levels of the CWBS. Some of these deviations may be higher and some lower. It is not the primary intent of DOD to require contractor efforts to be directed toward maintaining these original lower level estimates across the board. Rather, what is important is that the contractor management strive to balance these lower level costs in a manner such that the aggregate or end-product costs of the overall defense system conform to contract DTC goals and that the necessary performance is achieved. The key question is whether projected program costs are within planned limits.

In compiling DTC status information for DOD, therefore, the essential element which must be presented clearly and prominently is a comparison between DTC goals and current estimates of costs for the overall end-product defense system and major components thereof. Major component (sub-system) estimates must be supported by summaries of DTC estimates for key elements in the next level or so of the CWBS. Any DTC estimate tracking system must clearly list and define all the assumptions that were used to establish the DTC goal. For establishing design to unit production cost goals, this would include quantity, production rate, learning curves, escalation indices used, production start dates, and first unit costs. Any changes in assumptions must be documented and reflected in both goals and estimates.

If the overall estimates exceed DTC goals, the management information system must provide an assessment of the cause and significance thereof and a discussion of measures in process, or possible, for bringing them back within limits. Any associated performance penalties must be identified.

In the sense just discussed, contractor DTC status reporting to the project/program manager should normally be at contract WBS level 3. Lower levels of reporting may be required by the Program Manager as necessary to track the status of critical system elements. Summarization from the CWBS into the project summary WBS will allow project/program managers to relate the current contract DTC estimates to the DTC goals for the total program.

Formats A and B have been developed to be used primarily as guidelines for tracking unit production cost goal achievement. Formats specifically for tracking operating and support cost goals are not provided because of the very limited experience and present wide variation in the application of the DTC concept to the operation and support (O&S) area. It is, however, the responsibility of the project/program manager to apply and track operating and support cost goals to the extent practicable on his particular project/program. It is envisioned that a format similar to that of Format B would be used to track and report achievement of operating and support goals (i.e., operating crew requirements, reliability, or maintainability requirements, spares cost, direct manpower costs, etc.). If the CWBS does not provide appropriate breakout for tracking operating and support goals, other identification such as work unit code may be used instead.

Format A, shown on page 64, illustrates the DTC breakdown of recurring/ nonrecurring costs to provide a unit production cost goal for each significant cost element contributing to the total cost of a WBS element. Project/program managers may identify and use cost elements tailored to the specific contract at a level of detail consistent with the dollar magnitude and cost uncertainty (risk) of the program. Reporting by CWBS may be limited or expanded to provide visibility to those defense system elements considered critical to DTC goal achievement. Use of Format A provides the project/program manager a summary report of the current DTC estimates reported by the contractor (for the particular reporting period) as compared to the allocated DTC goals, and any variance therefrom, be it favorable or unfavorable. While the Format A sample includes many of the inclusive costs, only those that apply to the individual contract goals would be shown; for example, some contract DTC goals may not include nonrecurring costs.

Format B on page 65 provides a framework for the contractor to list those WBS elements from Format A for which a DTC variance exists and, in a narrative analysis, provide an explanation of the variance from the established DTC goal, as well as changes in DTC goal allocation, and differences between current and previous DTC estimates. The project/program manager may establish a threshold dollar value or a percentage of the DTC baseline which, when exceeded requires an analysis of variance. Further, the contractor should state the impact on other characteristics/requirements (i.e., technical, performance, schedule, etc.) and describe any corrective action taken or planned.

Design to Cost information will be forwarded to the Government at the contractually agreed to dates and/or milestones. Interim reporting should be required whenever an individual threshold is exceeded or if the sum of the system estimated costs exceed the total DTC goal.

As stated above, DTC information is only one element of effective DTC project/program management. Information requirements should be determined in conjunction with the other elements of the plan for execution of a DTC program and all of these elements should be appropriately reflected in contract requirements. The following factors should be considered in determining DTC information requirements:

- Government and contractor management responsibilities for DTC including those for review and control of DTC status
- The CWBS elements to be tracked and reported
- The reporting schedule
- Requirements for contractor generation and use of DTC projections
- Requirements for DOD access to contractor DTC data and for on-site evaluation and verification of contractor DTC estimates
- Any specific thresholds for DTC reporting and variance analysis
- Cost/schedule/performance tradeoff reporting requirements and procedures
- Potential impact of contractor overhead costs on DTC goal achievement
- Responsibilities for tracking subcontractor DTC status
- Monitoring and control of costs that may not be included in contract DTC goals (e.g., engineering change proposals, cost of peculiar support equipment, cost of Government-furnished equipment)
- Procedures for adjustment of DTC goals for major contract changes
- Treatment of economic escalation in adjusting contract DTC goal and/or formulating cost estimates

DTC Guidelines for a Management Information System

1. Guidelines for a DTC reporting system consist of two formats containing DTC and related data for measuring performance toward achieving DTC goals. These data will be used by Government and contractor managers to, (a) assess how effectively the contractor is implementing the DTC program; (b) evaluate DTC goals and monitor their achievement; and (c) provide the projections and analysis needed to develop timely management decisions concerning design changes and/or tradeoffs.

2. A DTC status report is normally required for contracts having DTC goals. Reporting by the Contract Work Breakdown Structure (CWBS) may be limited or expanded to provide visibility to those CWBS elements considered critical to DTC goal achievement. Identification and use of cost elements may be tailored to the specific contract consistent with the dollar magnitude of the program.

3. Formats A and B represent sample reports that can be used by Project/ Program Managers to track DTC performance against goals:

Cost Element/CWBS Data - cost goals in accordance with Format A for identified cost elements and contract work breakdown structure elements.

Cost Variance Analysis - prepared in accordance with Format B to agreed to contract work breakdown structure level. Variance analysis will be required for all elements which exceed the Government established threshold.

NOTE: Formats also may be modified as necessary to adapt them for tracking operating and support costs or factors identified as Design to Cost goals.

FORMAT A

CONTRACTOR ____________

ADDRESS ____________

CONTRACT # ____________

FY DOLLARS ____________

DE ~GN TO COST

COST ELEMENT/CWBS DATA

____________ PERIOD

____________ DATE

Contract Work Breakdown Structure / Cost Elements												TOTAL
Production Nonrecurring (inclu... ll those non-recurr... production costs, i.e., tooling, necessary to acquire a production capability)												
Production Recurring 2/												
• Production (includes all engineering, tooling, manufacturing, quality control, G&A, and profit associated with the cost of production capability)												
• Engineering Changes												
Current DTC Estimates												
DTC Goal												1/
Variance												

NOTE: 1/ Should be ... ...able to total specified contract Design to Cost goal. Other CWBS columns represent contra... ...ed cost goals.

2/ Appropr... elements will include cost by: direct labor, material, overhead, other direct charges.

FORMAT B

CONTRACTOR ______________

ADDRESS ______________

CONTRACT # ______________

FY DOLLARS ______________

______________ PERIOD

______________ DATE

DESIGN TO COST

VARIANCE ANALYSIS

Contract DTC Work Breakdown Structure (Note a)	Allocated DTC Goal	DTC Estimate Previous Report	DTC Estimate Current Report	Variance (Note b)		Analysis of Variance/Reallocation (Note c)
				from alloc. DTC Goal	fm prev. DTC Est.	

Notes:

(a) List each WBS element indicated on Format A having a DTC goal variance beyond threshold.

(b) Variance is difference between current DTC estimate and allocated DTC goal and between current DTC estimate and that included in the prior DTC report.

(c) In a narrative analysis, provide rationale for variance from established DTC goal, changes in DTC goal allocation, and difference between current estimate and previous estimate. State impact on other elements (i.e., Technical, Cost, Performance, Schedule, etc.) and provide a schedule for corrective action or specify corrective action accomplished.

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