THE DESIGN TO UNIT PRODUCTION COST (DTUPC): RANGE OF APPLICABILITY TO DEVELOPMENT PROCUREMENTS

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Army Procurement Research Office
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FINAL REPORT

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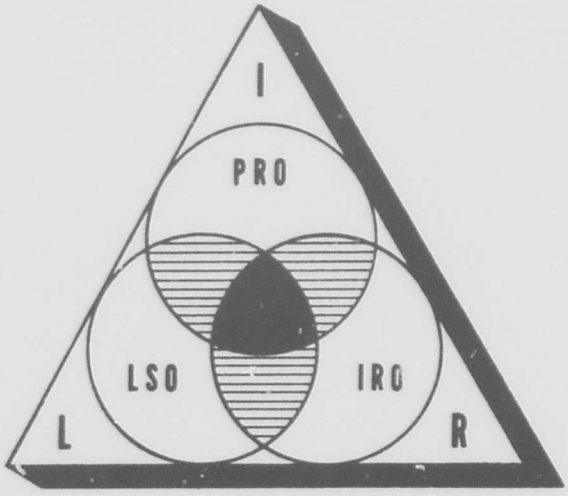

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The merits of Design to Unit Production Cost (DTUPC) as a method of procurement are currently being heralded by the Department of Defense and Army. The goal of lower acquisition costs is very appealing. To date only a few contracts which have incorporated DTUPC have been awarded and only limited experience exists at this point in time. The purpose of this study was to determine the applicability of DTUPC to AMC development procurements. The findings of this study indicate that DTUPC provisions should not be applied to development procurements if contract value does not exceed $1 million or projected production contract values do not exceed $4 million.(U)

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ABSTRACT

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We would also like to express our appreciation to the DTUPC IMPACT action officers at the AMC commodity commands who assisted our research efforts in a spirit of cooperation and efficiency. Our requests were always met with the utmost timeliness and courtesy.

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EXECUTIVE SUMMARY

1. BACKGROUND. In the past, DOD has viewed weapon systems acquisition as a process in which its requirements are paramount and the associated costs are necessary. While repeated efforts to hold down costs have been exerted, the paramountcy of requirements has prevented a viable balance between costs and requirements. This kind of management philosophy has led to cost growth, virtually unaffordable weapons, and program failures. In recognition of this problem DOD has attempted to realign cost and performance emphasis. This new emphasis is embodied in DOD Directive 5000.1, which introduced the concept of "design to cost"; that is, the translation of discrete cost elements into design requirements.

2. PROBLEM. In implementing any new concept, problems both classic and unique arise to confront the implementers. One "new concept" problem that immediately suggested itself to AMC in connection with design to cost was applicability. To what contracts should we apply Design to Unit Production Cost (DTUPC, AMC's term for Design to Cost)? AMC had originally called for its use in only those programs with expected PEMA expenditures exceeding $25 million, but in recent times have required virtual across-the-board application Neither policy has been entirely satisfactory. This study was initiated to find the proper conditions under which DTUPC should be applied in order to maximize the benefits of the concept.

3. SPECIFIC OBJECTIVE. To establish decision criteria that will enable the contracting officer to determine the applicability of DTUPC to a nonmajor development procurement.

4. METHODOLOGY. Simplistically one would apply DTUPC when its benefits exceed its costs. That was the basis of the study approach: estimate the marginal benefits of lower unit price, better system effectiveness, more affordable weapons, etc., and contrast them against the marginal costs of putting DTUPC into the contract, administering the program, contractor's achieving the DTUPC goal, etc. Unfortunately there is no empirical data available on design to cost performance, and most of the cost/benefits could not be quantified. Consequently, it was decided to use a more heuristic, judgmental approach based

upon expert opinion, literature on the subject, present policy, DTUPC contracts, analogous concepts, distributions from summary procurement statistics, and logical synthesis of the diverse bases.

5. FINDINGS AND CONCLUSIONS. Alternatives ranging from keeping the status quo (i.e., per the 13 September 1973 DTUPC guidance letter) to adopting a set of qualitative or quantitative criteria were reviewed to determine to which contracts DTUPC should be applied. The alternative of combined quantitative and qualitative criteria seems to hold the most promise for successful DTUPC applicability decisions: a dollar threshold to indicate those contracts with potential savings and qualitative factors to point out exceptions to the threshold. A $1 million research and development (R&D) threshold is concluded to be the most practicable quantitative criterion. This value is supported by expert opinion, close relationship of the Value Engineering Program Requirements Clause criteria, and a Pareto analogy which showed that 6 percent of the AMC Advanced Development (AD) and Engineering Development (ED) contracts are above $1 million and account for 80 percent of the dollars. Based on historical and recent figures, a $4 million projected supply criterion is felt to be a reasonable basis for DTUPC application by analogy to the $1 million R&D figure.

Application of this dual criterion should result in well over 80 percent of AMC's AD and ED dollar expenditures receiving the benefit of the DTUPC design philosophy, while reducing the required managerial and engineering attention to slightly more than 6 percent of AMC's development contracts.

The evidence failed to support a uniform set of qualitative criteria guiding the application throughout AMC. However, the consensus of expert opinion and a review of the wide range of AMC's procurement needs and their related contexts favor the development of suitable qualitative criteria for field guidance. A tentative set of criteria is proposed.

6. RECOMMENDATION. Apply DTUPC to development procurements of greater than $1 million R&D or with expected supply expenditures of greater than $4 million.

Allow exceptions with written justification and head of procuring activity approval for those procurements above the threshold but with unlikely DTUPC potential. Examples: few production items (compared with past buys), no trade-offs (as shown by the Trade-off Determination or the Trade-off Analysis in the Concept Formulation Package) and situations of DTUPC costs obviously exceeding the benefits.

CHAPTER I

INTRODUCTION

A. Background.

In the past DOD has viewed the weapons system acquisition as a process in which its requirements are paramount and the associated costs are necessary. While repeated efforts to hold down costs have been exerted, the paramountcy of requirements has prevented a viable balance between costs and requirements. This kind of management philosophy has led to cost growth, virtually unaffordable weapons, and program failures.

In recognition of this problem, DOD has attempted to realign the emphasis on performance and cost. The new emphasis is embodied in DOD Directive 5000.1 which introduced the concept of "design to cost" (DTC); that is, the translation of discrete cost elements into design requirements. AMC's term for DTC is "Design to Unit Production Cost" (DTUPC).[1] This concept, while new to DOD, has been used successfully by industry for years.[2]

DOD Directive 5000.1 stated the DTC philosophy:

> Cost parameters shall be established which consider the cost of acquisition and ownership; discrete cost elements (e.g., unit production cost, operating and support cost) shall be translated into "design to" requirements. System development shall be continuously evaluated against these requirements with the same rigor as that applied to technical requirements. Practical trade-offs shall be made between system capability, cost, and schedule. Traceability of estimates and costing factors, including those of economic escalation, shall be maintained.[3]

AR 1000-1[4] and the Letter of Instructions (LOI)[5] further implement DOD Directive 5000.1. In the Policy Guide to AMCRP-S letter, dated 17 October 1972, "Basic Procurement Policies for Design to Cost and Trade-off Provisions in AMC Contract Documents," the applicability of the DTUPC concept was limited to those programs where expected production (PEMA) costs of the program are $25 million or more.[6] Even this policy broadened the application of DTUPC beyond the DOD Directive 5000.1. Subsequently, AMCRP-SC letter, dated 13 September 1973, "Design to Unit Production Cost (DTUPC) Policy," stated that:

> The potential benefit to the Army in using the DTUPC technique warrants its consideration for procurements below the $25 million program threshold. Therefore, effective immediately, it is AMC policy to incorporate DTUPC provisions in all development contracts except those where it is specifically determined that such use would not be in the best interests of the particular program. This determination shall be a part of the procurement record.[7]

Consequently, while there is no question of applicability of DTUPC to major procurements, there is now a definite problem in determining the applicability of DTUPC to individual nonmajor development procurements.[8]

B. Statement of the Design to Unit Production Cost Problem.

Based on the guidance contained in DOD Directive 5000.1, "Acquisition by the Department of the Army," and various AMC policy letters on Design to Unit Production Cost, the major subordinate commands (MSC's) were instructed to include the DTUPC concept in major and nonmajor weapons systems development procurements, as appropriate, to insure that the system or item being developed will have a production cost which the Army can afford. The Directorate for Requirements and Procurement, HQ, AMC realizes there is still wide latitude as to how MSC's will implement this new concept. There

is a need for guidance as to which nonmajor development procurements DTUPC should be applied in order to successfully carry out the program. This is the concern of this report.

C. Purpose and Objective.

The purpose of the study is to improve the understanding of design to cost concepts as applied to AMC acquisition management, and to identify procurement managerial action needed to insure the efficient application of DTUPC techniques to AMC procurements.

The specific objective of the study is to establish decision criteria that will enable the contracting officer to determine the applicability of DTUPC to a nonmajor development procurement with defensible justification for his actions for the procurement record.

D. Study Approach and Research Methods Employed

In attacking the problem of which development contracts are appropriate for DTUPC, the initial consideration was an economic one. Logically, DTUPC should be incorporated into all development contracts that offer a reasonable likelihood for significant cost savings in acquisition and operation That is, if the benefits of using DTUPC exceed the costs of using it, then it is cost beneficial to put DTUPC into the development contract.

In order to ascertain this relationship, a marginal benefit/cost (B/C) model[9] was employed to determine the break point of when DTUPC should be applied to a nonmajor AMC development procurement. Mathematically, the model would be expressed as follows:

$$\sum_{i=1}^{n} MB_i \geq \sum_{j=1}^{n} MC_j$$

Where:

MB = Marginal benefit to be derived from applying DTUPC and

MC = Marginal cost to be incurred as a result of applying DTUPC to this contract.

The basic incremental benefits to be derived from applying DTUPC are lower unit prices, lower operation and maintenance costs, better system effectiveness, etc.

The basic incremental costs to be incurred from applying DTUPC in development contracts are the Government's costs of writing DTUPC provisions into a contract, the increased cost of contract administration, the contractor's cost of achieving the DTUPC threshold, etc.

Field data collection revealed no empirical data available on design to cost performance, and most of the cost/benefits could not be quantified. Consequently, it was decided to use a more heuristic, judgmental approach based upon present DTUPC policy, literature on DTUPC, DTUPC contracts, expert opinion, analogous concepts, distributions from summary procurement statistics, life cycle cost (LCC) implications, and a logical synthesis of these different figures of merit.[10]

The study methods and associated data bases employed in the research consist of the following:

1. A review and analysis of all pertinent policy guidance on DTUPC.

2. A review of all current literature and conference documents on DTUPC that were obtained from the field, Defense Logistics Studies Information Exchange, Defense Documentation Center, etc.

3. An examination of all current DTUPC contracts containing DTUPC provisions.

4. An in-depth analysis of a survey of a select group of professionals at three AMC major subordinate commands[1] and a study of the responses provided by other key personnel at the MSC's and HQ, AMC who are familiar with the DTUPC concept.

5 An analytical comparison of programs, clauses, concepts that are analogous to or are subsets of DTUPC analyzed as a basis for determining when it is appropriate to apply DTUPC to a development contract.

6. Application of the Pareto analogy to empirical data related to AMC Advanced Development (AD) and Engineering Development (ED) contracts as a basis of determining to which AMC development contracts DTUPC should be applied.

7. Examination of the interrelationships between the life cycle cost concept and the DTUPC concept.

Five alternatives were formulated to guide the research study toward its objectives. These alternatives are:

A. Go back as per 17 October 1972 letter, AMCRP-S—apply DTUPC to all developments whose expected production (PEMA) costs of the program are $25 million or more.

B. Remain as now; strict interpretation of 13 September 1973 letter, AMCRP-SC—apply DTUPC to all AMC development contracts in Advanced Development or Engineering Development.

C. Develop a set of defensible qualitative criteria of when not to apply DTUPC (e.g., no trade-offs, few production items, Σ MC's $\geq$ ΣMB's, urgency, and performance characteristics are more important than cost).

D. Develop a set of defensible quantitative criteria of when to apply DTUPC (e.g., R&D $, PEMA $, and number of items to be produced).

E. Develop a combination from Alternatives C and D.

In summary, the overall research strategy is to select the alternative which fully meets the study objective in the most effective and economical manner. The selection is guided by a full consideration of the result of all of the methods employed, taken together, to make an expert value judgment based on experience and understanding of the problem.

NOTES

CHAPTER I

[1]A multitude of terms have been used synonymously with DTUPC. Rear Admiral P. G. Freeman stated that he has some serious concerns that DTUPC would become "more of a buzz word than a viable concept I consider it to be—its real purpose may get lost in the noise level. The words 'design to' are rapidly becoming a standard prefix to almost every element of the acquisition process. The wordsmiths are busily defining and inventing a vast array of 'design to' terms." DTUPC has been called many different names and this has led to confusion. AMC has decided to use only one term, DTUPC, to be consistent.

Rear Admiral R. G. Freeman, USN, "Future Trends in System Procurement," NCMA News Letter, Vol. 13, No. 4, December 1973, pp. 6–8.

[2]"DOD Officials Cite Overmanagement, Cost Problems," Commanders Digest, Volume 12, No. 15, 17 August 1972, p. 6.

[3]Department of Defense Directive (DOD Dir) 5000.1, Title: Acquisition of Major Defense Systems (Washington: U.S. Government Printing Office, 13 July 1971).

[4]Army Regulation (AR) 1000-1, Title: Basic Policies for Systems Acquisition by the Department of the Army (Washington, D.C.: U.S. Government Printing Office, 30 June 1972).

[5]Department of the Army, Letter of Instructions (LOI) for Implementing the New Materiel Acquisition Guidelines, Letter, DAFD-SDY, 23 August 1972.

[6]U.S. Army Materiel Command, Basic Procurement Policies for Design-to-Cost and Trade-off Provisions in AMC Contract Documents, Letter, AMCRP-S, 17 October 1972.

[7]U.S. Army Materiel Command, Design to Unit Production Cost (DTUPC) Policy, Letter, AMCRP-SC, 13 September 1973.

[8]For purposes of this study a nonmajor development procurement is defined as one where expected PEMA expenditures are less than $25 million.

[9]The standard technique of economic marginal analysis under conditions of a constraint can be used to indicate the nature of the most cost-effective choice. Under this analysis the marginal benefit and marginal costs are developed for each alternative.

[10]This involves personal insight, inspiration, and subjective estimates. Such decision rationale as "intuitive feel" on the part of an "expert" can have a very firm foundation in the expert's synthesis of experience even though these experiences or personal histories are not quantifiable. Olaf Helmer of RAND put it this way: "when we talk about systems analysis, we tend to think of an orderly analytical process, usually involving a mathematical model, by which the available alternatives in a decision-making situation are systematically compared with regard to their costs and benefits. There are many cases, however, where decisions have to be based, not on the results of theoretical analysis, but on the intuitive judgment of whatever experts on the particular issue are at hand. This may be so simply because no satisfactory theory has yet been devised; it may also be because judgment must be sought as a matter of principle, because the issue under consideration may involve moral in addition to factual aspects, and thus preferences in addition to data."

Olaf Helmer, Systematic Use of Expert Opinions, P-3721 (Santa Monica, California: The Rand Corporation, November 1967), p. 1.

[11]The types of professionals interviewed at the MSC's included the DTUPC IMPACT coordinators, contract specialists, procurement analysts, contracting officers, legal personnel, and value engineers who had been working closely with DTUPC on current contracts.

CHAPTER II

ANALYSIS OF DATA AND FINDINGS

This chapter first groups the analyses and associated findings on the basis of the research methods employed. It then presents a summary of the findings in terms of each of the alternatives specified in Chapter I and describes the basis for the selection of an alternative.

A. Review of Current Policy Guidance on Applicability of DTUPC.

Basically DOD Directive 5000.1 dated 13 July 1971 states that DTUPC should be applied to all major programs whose dollar values (see Table I) exceed $50 million research, development, test, and evaluation (RDTE) or an estimate production cost of $200 million.[1]

AR 1000-1 dated 30 June 1972 and the LOI dated 23 August 1972 basically concurred with this definition (see Table I) but expanded the policy slightly beyond 5000.1 by including Department of the Army designated and other systems, when practicable. The LOI and AR 1000-1 gave flexibility to include DTUPC provisions in other than major contracts, if practicable, but failed to define what practicable meant. The policy writers of AR 1000-1 and LOI recognized that DTUPC might not be appropriate for application to all developments. Table I summarizes the policy showing to which systems DTUPC should be applied and any exceptions.

AMCRP-S letter dated 17 October 1972 stated that DTUPC provisions would be included in all AMC major or nonmajor (PEMA $25 million (+)) items which are a system, subsystem, or component on a case-by-case basis with approval by the Director or Deputy Director of Procurement and Production of a major subordinate command.[2]

Table I. Summary of Policy Showing Which Systems DTUPC Should Be Applied

POLICY	Systems to Which DTUPC Should Be Applied
DOD Directive 5000.1 (13 Jul 1971)	All major – RDTE $50 million (+) or PEMA $200 million
AR 1000-1 and LOI (30 Jun 1972 and 23 Aug 1972)	All major, DA designated, and other systems when practicable
AMCRP-S letter (17 Oct 1972)	All AMC major or nonmajor (PEMA $25 million (+)) items which are a system, subsystem, or component on case-by-case basis with approval by Director or Deputy Director of P&P of MSC
Deputy Secretary of Defense Memo (18 Jun 1973)	All major except those assessed to be inappropriate or not feasible with approval by DSARC
AMCRP-SC letters (13 Sep 1973 and 17 Sep 1973)	All development solicitations including those below $25 million PEMA except those specifically determined that such use would not be in the best interest of a particular program or those that the command specifically determines are to be excluded.
AMCP 700-6, DTC Guide (3 Oct 1973)	Basically concurred with reviews AMC* guidance except may change as further experience is gained

*Excluded major systems not recommended by DSARC for DTUPC coverage.

Even when AMCRPS issued this letter it recognized that DTUPC would require better definition as time passed and experience was gained. Until definitive guidelines are issued, field personnel must use keen judgment as to whether the DTUPC policy applied to an individual procurement or not.

On 18 June 1973, the Deputy Secretary of Defense issued a memorandum[3] stating that DTUPC should be applied by 31 August 1973 to all major programs not reaching Milestone III (Defense Systems Acquisition Review Council (DSARC) III), except for those assessed to be inappropriate or not feasible. These would then be forwarded to DSARC with a justification for the exemption for approval.

On 13 September 1973, an AMCRP-SC letter[4] issued further DTUPC policy which was then clarified by a 17 September 1973 letter.[5] These policy documents basically stated that the use of DTUPC provisions should be expanded to include development solicitations below $25 million PEMA except for those specifically determined that such use would not be in the best interests of a particular program or those that the command specifically determined are to be excluded. Although this guidance was clear as to the expansion intent of the DTUPC concept in AMC, it gave no definite guidance as to when DTUPC should not be used. In fact, it even could be construed and misused to prevent inclusion of DTUPC in any developments under $25 million expected PEMA expenditures.

AMCP 700-6, Joint Design to Cost Guide[6] concurred with previous AMC guidance in that DTUPC is generally applicable[7] by a manager to a new end item of military equipment. Even the new AMCP 700-6 dated 30 October 1973 recognized that DTUPC still needs considerable development and that change in DTUPC concepts and practices may occur as experience is gained. AMCP 700-6 recognizes that a modified approach, using DTUPC to a lesser degree because of certain facts such as budget constraints, and making DTUPC a design parameter, is not always appropriate.

One can see from the discussion above that current DTUPC policy (summarized in Table I) acknowledges that unrestricted application of DTUPC may "not be in the best interest of" the Government. But the absence of when not to apply DTUPC tends to favor

an interpretation of either unrestricted application or arbitrary avoidance. In fact, recognition of the potential shortcomings of applying DTUPC to all research and development (R&D) procurements led to the initiation of this study. Based on the above discussion, literal interpretation of current policy statements would not favor unrestricted application of DTUPC to all development contracts, Alternative B. Current guidance, strictly interpreted, would also not favor Alternatives D and E but is compatible with Alternative C.

B. Review of Current Literature and Conference Documents.

1. The American Defense Preparedness Association's (ADPA) report on design to cost[8] recommended that DTUPC be considered for "those development contracts that have an immediate production potential, and where the product, in production, will have an estimated total production cost in excess of $10 million."[9] Also, ADPA's report recommended that:

> There is a minimum value below which it would not be economical to include a design-to-cost incentive in a development contract. This value could vary considerably depending on a number of factors (type of item anticipated, quantity and length of production, state-of-the-art, etc.). The minimum value must be established by the head of the procuring activity (HPA), but a minimum development cost of $500,000 is recommended.[10]

Based on the above recommendations by ADPA, one can see that ADPA seemed to prefer a quantitative threshold in terms either of PEMA expenditures or size of development contract before DTUPC should be applied to a development contract. ADPA went one step further in regarding the size of a development contract by giving some qualitative qualifiers such as type of item, anticipated quantity and length of production, state-of-the-art, etc. But, they failed to clearly define what each qualifier meant and how said

qualifier could be used to determine the correct value. ADPA in the absence of quantifying each qualifier therefore gave the user flexibility to implement DTUPC as he deemed appropriate.

ADPA informed the Army Procurement Research Office (APRO) that the values of $500,000 and $10,000,000 represented a consensus of opinion of the people who prepared the report. After considerable discussion, a key ADPA researcher[11] concluded that "$1 million contract was not much different from their $500,000 recommendation and that a higher value (than $500,000) might be better until further experience was gained in using DTUPC. If at that time it were assessed to be appropriate to use on smaller dollar procurements, then lower the value; but for the present do not apply to all small development contracts." This tends to support Alternative D (quantitative), and in particular the contract value of $1 million or more.

2. Army Management Engineering Training Agency (AMETA) recommended in their report[12] that DTUPC should be used "on selected development contracts which have a high potential, in terms of dollars, for future production."[13] They are recommending a quantitative type of figure but did not give an appropriate value in terms of PEMA expenditures. It readily follows that they prefer a quantitative criteria (Alternative D) over a qualitative approach.

3. MG R. F. Trimble stated in an article in "National Contract Management Association" News[14] that:

> It (DTUPC) isn't a new standard contract clause. It isn't something which can be applied blindly with blanket usage. It must be flexible and specifically tailored to a given procurement.[15]

Based on MG Trimble's comments, one can conclude that Alternative B (use on all development contracts) is inappropriate. There was no preference, however, for other alternatives.

4. In a report on DTC by the National Security Industrial Association (NSIA),[16] appeared the following:

> The bulk of DOD hardware procurements will have to be heavily influenced by the design-to-cost philosophy. Contractors who expect to perform in this environment must develop their capability to design to cost.
>
> Design to cost is applicable to limited classes of Department of Defense procurement programs. It is not for general cost reduction but rather is to be used only when the state of technical risk and other conditions warrant.

The NSIA recognized that the development contracts involving the bulk of expected PEMA expenditures should include DTUPC provisions but the DTUPC concept is not applicable across the board. One can conclude from this that Alternatives A and B are inappropriate and that Alternatives C, D, or E would be favored but no indication of preference is given.

In summary, Alternatives A and B are given practically no support in the literature. Two of the references prefer a quantitative Alternative D, with one quantifying the size of development contract at $1 million, one preferred a qualitative alternative, and three could accept Alternatives C, D, or E but showed no preference among them.

Moreover, other research groups and experts on DTUPC have eliminated Alternative A and B as their choices for the proper alternative. All in some manner gave preference to the universe of alternatives left (C, D, or E). Overall Alternative D is given the most support, with the strongest preference for $1 million threshold

C. Review of Current Contracts/Solicitations Containing DTUPC Contractual Provisions.

Based on our review of contracts and research on this project, a list of Army, Navy, and Air Force contracts were compiled. A list of the contracts can be found in Tables I, II, and III respectively in Appendix A.

Table I gives a list of current contracts/solicitations containing DTUPC contractual provisions and yielded the following information:

1. The Army, as of the fall of 1973, had at least 30 systems/items with 54 contracts awarded or proposed to be awarded by the end of the fourth quarter FY 74.

2. There were 16 major/project managed and 14 nonmajor[17] systems in the group of 30 systems/items.

Table II in Appendix A shows that the Navy[18] during the fall of 1973 had at least 22 systems with 24 requests for proposal (RFP's)/contracts which contained DTUPC provisions.

Table III in Appendix A shows that the Air Force during the fall of 1973 had at least 19 systems[19] with 30 RFP's/contracts which contained DTUPC provisions.

Patterns were sought in dollar value ranges and qualitative characteristics; e.g., type of item, life cycle phase, major/nonmajor system, performance requirements, trade-off provisions, DTUPC goals, etc.

The review of current Army contracts containing DTUPC contractual provisions gave some insight into DTUPC experiences to date. However, the qualitative and quantitative features of the contracts/solicitations were highly heterogeneous and could not be used to determine the applicability of DTUPC to nonmajor procurements.

D. Analysis of the Results from the Field Survey.

This section presents the results from the field survey that drew on expert opinion from a select group of professionals at the MSC's as to when it is cost-effective to apply DTUPC to nonmajor AMC development procurements.

1. Alternative C (Qualitative Criteria). Figure 1 shows the Alternative C statement (Qualitative Criteria) that was used to solicit field responses. Most field personnel agreed with the basic policy statement and the qualitative exceptions as to when not to apply DTUPC provisions to a given procurement that are shown in Figure 1. During the field testing of the basic policy statement and the qualitative criteria of when not to use DTUPC, the field personnel made many comments as to wording, problems, and potential pitfalls in their use. Only those items mentioned that seemed to be relevant will be discussed. Beginning with the policy statement shown in Figure 1, each will be discussed in turn.

a. "Policy statement." Several personnel challenged whether it was too early or too late to apply DTUPC in Validation (6.3) and questioned the degree of coverage intended. As for the degree of DTUPC coverage, basically, current policy guidance provides for only one degree of coverage but does not clearly state that there can be varying degrees of DTUPC coverage based on type of equipment, stage in life cycle, size of contract in dollars, etc.

Figure I. Qualitative Criteria—Alternative C

Policy: Apply DTUPC to all AMC development procurements in Validation (6.3) or at the beginning of Full-Scale Development (6.4), except that it would not normally be applied in PEMA expenditures of less than $25 million if any of the following conditions are present*:

1. There are no trade-offs to be made between performance and cost (e.g., where the specifications tend to be firm, due to the state-of-the-art, etc.).

2. Few production items (of low unit price) are to be made.

3. The estimated Government administrative costs and contract costs are greater than any anticipated dollar savings. This is a critical point since one must be able to show that the sum of the marginal benefits are greater than or equal to the sum of the marginal costs (ΣMB's $\geq$ ΣMC's) in order to justify applying DTUPC; if this cannot be done, then DTUPC would probably not be appropriate anyway.

4. The development is urgent and the necessary procurement planning and administrative implementation preclude the determination and confirmation of the DTUPC provisions (e.g., DTUPC bogie, proposal evaluation and award criteria, award and incentive features, and tracking and monitoring provisions).

5. The performance characteristics of the item are so critical to national security that it does not allow for DTUPC trade-offs.

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*Even when these conditions support the omission of DTUPC, the principles of DTUPC should be used.

It is probable that there can be varying degrees of DTUPC coverage, but it was beyond the scope of this study to investigate this area.

b. "No trade-offs." No trade-offs to be made between performance and cost is the first exception as shown in Figure 1 of when not to apply DTUPC. Several personnel pointed out that they did not agree with the example, "where the specifications tend to be firm," because specifications by definition tend to be firm. It is believed that field personnel associated the term specifications exclusively with Military Specifications.

The most controversial comment over this exception was that, generally, the performance requirements, as specified by the technical/engineering personnel, are normally described as essential (though often overoptimistic) and therefore would seldom allow for any trade-offs. A counter argument to this is that there is always "fat" in a new development for which trade-offs can be made. One can see that the Government has an in-house problem where all personnel need to be reoriented to understand the DTUPC concept. But for the present, if the field, in general, were to insist on this exception, as most did and as was discussed above, then DTUPC would probably not be used on any development procurements.

c. "Few production items." Although the concept was fairly clear to the respondents who basically agreed with it and conceded that it was one of the most valid exceptions, it raised the issue "What does 'few' mean?" "Few" means that one must compare the number of military items that have been purchased in the past of this class of commodity to that of the current projected number to be purchased.

"Few," as used, was misinterpreted and could be easily abused, especially if one did not want to use DTUPC provisions on a given nonmajor development procurement.

d. "Marginal costs exceeding marginal benefits." This was understood in theory but drew much criticism and discussion from field personnel. The last part of the sentence, "if this could be done, then DTUPC would probably not be appropriate anyway" drew the most severe criticism because most field personnel thought this could not be shown, unless heuristically, or perhaps by some rule of thumb. In any case, it would require a great deal of effort to ascertain that marginal costs exceeded marginal benefits due to the lack of cost data and experience. Also, many commented that, once established, one could probably show marginal benefits or marginal costs to be larger, depending on whether one wanted to use DTUPC or not. APRO tried to develop a cost model and collect cost data based on subjective estimates so as to determine the point where it is cost-effective to apply DTUPC provisions on a given development, but was not successful. Based on the foregoing discussion and APRO's experience, only one conclusion can be reached: even though the concept is valid in theory, due to the current state-of-the-art of cost estimating capability of field personnel and amount of cost data, this exception could only be used in very special cases. As more experience is gained, a rule of thumb (cost estimating) method could potentially be developed to show at exactly what point application of DTUPC becomes cost-effective

e. "The development is urgent." This drew many varied comments from the field personnel. What does "urgent" mean, especially in a development contract? In production contracts for ammunition during war time an urgency coding is used. This in a development contract is a rare occurrence and would occur only once (when the policy was first issued to include DTUPC contractual provisions on development contracts) and from that point forward should never occur again, since during Advance Procurement Plan (APP) one would normally decide whether to include DTUPC. Let us assume, for example, that AMC is some years down stream and an urgent development comes in with no APP. One could possibly amend the solicitation to state that the contract will be modified at a later date to add DTUPC provisions. But to add DTUPC contractual provisions to a contract after it had been awarded would reopen negotiation for the cost of the increased work in a sole source environment.

Conversely, several field personnel responded that all developments are urgent and, therefore, DTUPC should not be used. One can readily see, then, that "exception 4" concerning "the development is urgent" is subject to much misinterpretation and may not be a valid exception at all.

f. "The performance characteristics are so critical to national security that it does not allow for DTUPC trade-offs." This statement drew few comments from field personnel. Some personnel pointed out that it was potentially a subset of exception 1, "no trade-offs to be made." Some pointed out that, for example, it was valid since the item could be a critical part of a larger system, yet others stated that there was always room for trade-offs, since nothing was that critical to national security. It is felt that this is a rare exception and possibly could be combined with exception 1

g. "Even when the conditions (exceptions 1 through 5 shown in Figure I) support the omission of DTUPC, the principles of DTUPC should be used." This drew much enthusiasm, primarily because it would tend to satisfy the bargain the MSC had made with the U.S. Army Training and Doctrine Command (TRADOC) to develop and produce an item within some specified cost range. The biggest thing they wanted to know was what was meant by "the principles of DTUPC should be used." To try to clarify this, the MSC could still put in a DTUPC threshold into the development contract with possibly a provision to the effect the contract could be canceled if the DTUPC goal was exceeded. This, then, would give the contractor a clear understanding of what the Government expects in the way of cost, exclusive of the rest of the DTUPC provisions, such as tracking, source selection, etc. Another way of looking at principles would be to add on, for example: Value Engineering (VE) Program Requirements Clause, Producibility Engineering Planning, Should Cost (if appropriate), competitive prototyping, etc.

One question that arose here concerning VE was that if only a DTUPC threshold was specified in contract, would this qualify it as a DTUPC contract? If this were the case, the VE Program Requirements Clause could not be used, based on earlier direction from HQ, AMC.

Upon conclusion of analyzing the qualitative criteria, several individuals pointed out that each and every qualitative measure could be used as justification for not using DTUPC. Therefore, by using the qualitative criteria in this context and in light of the foregoing discussion, one can see that all of the nonmajor development procurements probably would not have DTUPC provisions included in them. To justify using or not using DTUPC with a set of qualitative criteria would take more work by field personnel to implement. The one thing that the qualitative criteria implied, but did not clearly spell out, was that there is flexibility to implement or not to implement DTUPC provisions on individual procurements if it could be clearly demonstrated that it would be in the best interests of the program.

Two additional questions were posed to field personnel upon conclusion of discussing Alternative C. "To what type of nonmajor procurements do you think DTUPC should not be applied and why?" All of the respondents interviewed during the field survey responded negatively, in that they were unable to list any other procurements to which they thought DTUPC should not be applied. Also, the field personnel were asked "if there were any qualitative factors other than those shown in Figure 1 that would determine whether DTUPC was applicable or not to a given procurement." They gave a few answers that should be mentioned for sake of clarity; i.e., study and basic research. One, that these two types of development efforts would not have any expected production and two, that they would probably fall in Research (6.1) or Exploratory Development (6.2).

One can see from the above discussion that most field personnel agreed with the qualitative exceptions to the basic policy contained in Figure 1, but pointed out many potential pitfalls in their use in reality. Some of these were that it will take too much time to implement, leaves too much room for interpretation since the qualitative criteria are not definitive and could be misused.

In general, one can see that Alternative C, a qualitative set of alternatives, was not considered to be a viable alternative by field personnel because they generally believed that the criteria which make up Alternative C would be used as a basis for not using DTUPC

provisions on nonmajor development contracts. Since most of the field personnel basically agreed with these qualitative exceptions in theory with some qualifications, as was seen by the earlier discussion, such exceptions might best serve as a set of qualitative examples to demonstrate when DTUPC should not be used.

2. Alternative D (Quantitative Criteria).

Figure II shows the Alternative D statement (Quantitative Criteria) that was used to solicit field responses.

Figure II. Quantitative Criteria—Alternative D

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1. Do not apply Design to Unit Production Cost (DTUPC) to nonmajor AMC development Procurement in Validation (6.3) or at the beginning of Full-Scale Development (6.4) if (Fill in the blank and if no opinion leave blank):

a. The amount or cumulative amount in dollars of this contract does not exceed $_____.

For example, "there is a minimum value below which it would not be economical to include a design-to-cost incentive in a development contract. This value could vary considerably depending on a number of factors (type of item, anticipated quantity and length of production, state-of-the-art, etc.) The minimum value must be established by the head of the procuring activity (HPA), but a minimum development cost of $500,000 is recommended" (DTC Contracting Guidelines by ADPA (AOA) Sept 73).

Do you agree or disagree with this figure? Why or why not?

b. The expected cumulative PEMA funds do not exceed $_____.

c. At least _____ units at $_____ per unit are expected to be procured and programed into the 5-Year Defense Plan.

d. The expected cost to the Government of applying DTUPC exceed _____ percent of the development contract costs.

Let us examine the first criterion (Figure II, 1.a), "Do not apply DTUPC to nonmajor AMC development procurements if in Validation (6.3) or at the beginning of Full-Scale Development (6.4) if the amount or cumulative amount in dollars of this development contract does not exceed $_____ ." A $1 million R&D contract value was chosen by the majority of the managers who felt qualified to estimate a value. Two reasons given for choosing $1 million were that a $1 million development contract is the break point for full-blown application of DTUPC contractual provisions and $1 million is the point where it is cost-effective to apply DTUPC, based on field experience. Even those who had no opinion or could estimate no value stated that some quantitative value or point would be better than none at all. Others did not give a quantitative value since the decision must be based on each individual case. Generally, all tended to agree that a quantitative value would be easier to implement in the field than a qualitative set of criteria.

The ADPA recommendation of $500,000 was used to trigger discussion and to get opinions. The field personnel disagreed, primarily because they thought $500,000 was too low and had already picked $1 million. Questions 1.b, c, and d in Figure II failed to produce a consensus preference upon which to reach quantitative criteria. This was primarily because the greatest percentage of the respondents had no opinion or felt they were not qualified to answer for this type of criterion question.

After the completion of Figure II, the field personnel were asked, "Are there any other quantitative factors that come to mind that you think would be applicable to whether or not DTUPC should be applied?" Only one respondent could think of another quantitative criteria. This respondent stated that a certain percentage of the R&D dollars should be covered by DTUPC. By this it was assumed that he meant that the majority of R&D dollars would account for the majority of the expected PEMA expenditures as was recommended by an AMETA study.[20]

In the same AMETA study they recommended that the DTUPC[21] program be funded as a separate line item in the contract. This would then give a figure similar to the one APRO was looking for in question 1.d which states "do not use DTUPC if the expected cost

to the Government of applying DTUPC exceeds _____ (a certain) percentage of the development contract costs." Most people in the field thought that the value placed on this separate line item would be meaningless and could not be easily evaluated.

The majority of the field personnel preferred a quantitative value over a set of qualitative criteria because of the following reasons: (1) easier to implement, (2) less costly procedure to use to decide whether to use DTUPC or not, (3) better utilization of the time of procurement and other personnel and (4) less chance for misuse. The only reservation they had was that they wanted flexibility to include or exclude DTUPC even with a given quantitative value.

In general, based on expert field opinion, it would then seem that there is some size of development contract below which it would not be economical to apply the full scope of the DTUPC contractual provisions and a $1 million minimum R&D contract would be the appropriate value. But the field personnel expressed a need for qualitative criteria when quantitative criteria were met but DTUPC not otherwise appropriate and flexibility to include DTUPC contractual provisions in contracts under $1 million R&D if otherwise appropriate (e.g., an R&D contract of less than $1 million but with a large production such as ammunition). Consequently, the ultimate preference of the manager appears to be a combination of qualitative and quantitative criteria, Alternative E.

3. Requisites of a Break-Even Marginal Cost Analysis.

The original break-even marginal cost analysis model, Σ marginal benefits (MB's) $\geq$ Σ marginal costs (MC's), was expanded in order to derive subjective estimates of the Government resources required to implement DTUPC as it should be. It was hoped that these data could be used to determine when it would be cost-effective to apply DTUPC to a given procurement.

As for the break-even marginal cost analysis model, insufficient cost data were obtained from the field with which to do a valid "break-even" analysis.

Even though field data could not be obtained to show the appropriate size of R&D contract such that the Expected [Σ MB's] $\geq$ Expected [Σ MC's], the field personnel interviewed were able to improve the MC model which listed the various tasks that would be required to implement DTUPC into a development solicitation/contract as shown in Table II.

Table II. Checklist of Areas That Must be Addressed During and After APP in Order to Implement DTUPC Provisions into a Development Procurement

ADVANCE PROCUREMENT PLAN

- Determine applicability of DTUPC
- Other Procurement Actions in accordance with ASPR 1-2100

PRE-SOLICITATION ACTIONS

- Establish DTUPC threshold . . .
- Establish DTUPC methods, procedures, and contract provisions for:
  - DTUPC trade-off constraints . . .
  - DTUPC incentives . . .
  - DTUPC tracking and control . . .
  - DTUPC alternatives if threshold exceeded . . .
  - DTUPC modification . . .
  - DTUPC flow down to subcontractors . . .
  - DTUPC as a factor in proposal evaluation and source selection . . .
- Prepare RFP incorporating the above and normal procurement actions . . .
- Normal procurement review actions . . .
- Presolicitation Conference (optional) . . .
- Issue RFP

PRE-PROPOSAL ACTIONS

- Pre-proposal Conference . . .
- Amend RFP as appropriate

FORMAL PROPOSAL EVALUATION AND SOURCE SELECTION

- Competitive Range Decision
- Pre-award survey . . .
- Negotiation . . .
- Source Selection . . .

DTUPC ADMINISTRATION

- Educate personnel administering DTUPC . . .
- DTUPC threshold modification . . .
- Tracking DTUPC achievement . . .
- Enforcing DTUPC provisions . . .
- Evaluate DTUPC achievement (incentives) . . .

Table II shows that many things are required as a part of the total effort in order to implement the DTUPC provisions into a nonmajor development procurement. Anyone familiar with procurement can look at the areas in Table II which make up the total additional effort to implement DTUPC into a nonmajor procurement and see that it would take quite an amount of Government resources. This is especially true for the Award Fee (AF) and tracking features of the DTUPC when applied to a smaller development procurement.

For example, several of the field personnel, when envisioning the DTUPC concept, believed that it would take quite an additional amount of Government resources to implement DTUPC. They could not estimate how much additional Government resources it would take however. One of the field personnel did say that it would take four people full time to properly implement DTUPC into an R&D contract, or $100,000 per year.

One can see that a considerable amount of resources will be expended to implement DTUPC provisions into a smaller R&D contract (i.e., less than $1 million– that would most likely have a smaller production planned to go with it. Thus, the marginal benefits to be gained from DTUPC application would soon be outweighed by the marginal cost of applying DTUPC. Through this heuristic logic one can but conclude that it is not generally cost-effective to apply DTUPC on smaller development contracts. Therefore, it stands to reason that DTUPC should not be applied below some dollar threshold.

4. Additional Problems Encountered and Areas that the MSC's Need Answered to Better Implement the DTUPC Concept.

From the results of the review of the contract files, field interviews and other secondary research, a list of the most relevant problems encountered was compiled. Initially, it was thought that the problem areas would give an indication as to whether or not to use DTUPC on a nonmajor development contract. Although list of problems was unable to aid in establishing criteria, the magnitude of the problem areas argues against unrestricted application of DTUPC provisions. Until some of the critical problems are resolved, DTUPC should not be applied to all development contracts (i.e., Alternative B is inappropriate).

5. Local Policy.

One of the questions asked was, "Has your MSC written or is it in the process of writing any local policies, guidance, or regulations on DTUPC?" The purpose was to see if they had; and if so, to get copies to see if there was any guidance on when DTUPC should be applied to nonmajor developments. None were found other than the U.S. Army Missile Command (MICOM) who had issued a DF on the responsibilities of various elements within the command to implement DTUPC.

Since no guidance has been issued by the MSC's, no information was ascertained by this method of when to use DTUPC on a nonmajor procurement.

6. Protests/Armed Services Board of Contract Appeals (ASBCA) Cases on DTUPC.

It was felt that one should look at the on-going development contracts containing DTUPC provision to see if there were any protests/ASBCA cases over the DTUPC provisions and if so why. If there were, then these facts might give APRO some insight into when and when not to apply DTUPC to a nonmajor system. From the field survey it was learned that there have been no protests or ASBCA cases on DTUPC to date. Although this approach, used in an attempt to establish criteria, was unsuccessful, it was encouraging to see that there have been no protests or ASBCA cases over DTUPC in AMC.

7. Industry's Acceptance of the DTUPC Concept.

The basic hypothesis was that industry has accepted the DTUPC concept. If the contractors had not accepted the DTUPC concept, then the reasons why would possibly give APRO insight as to when to apply DTUPC concept to nonmajor weapons systems and how to improve the DTUPC concept.

Mr. T. A. Wilson, Chairman of the Board of the Boeing Company, reiterated how emphasis in the past was placed on operational capability and readiness (weapon system acquisition, reliability, and development of logistics support systems) which overshadowed

the cost of the item. Also, he reemphasized what may be industry's fears that ". . . over-correcting for operational deficiencies of the 50's caused many of the woes of the 60's" and that the DTC concept would head down this same path of overkill (use upon across-the-board with in-depth applications) that would create another cult before evolving into what could be a powerful and useful management technique.[22]

General C. McKeen in his speech at the AMC Seminar on Weapons System Acquisition, "The Little Four" Memoranda held 5 December 1973, stated:

> In our discussions with industry concerning the above programs, as well as various seminars, serious reservations have surfaced relative to the application of the design-to-cost concept. Some industry representatives express the feeling that the tight cost ceilings combined with trade-off freedom will produce new weapons systems with inferior battlefield capabilities. This will require our project managers and test and evaluation agencies to exercise unusual vigilance to insure that this does not happen [23]

Thus, these findings tend to imply that until the DTUPC concept has been further proven on major weapons systems acquisitions with all the bugs ironed out and has been accepted by industry, the DTUPC provisions probably should not be applied across-the-board on AMC development procurements (Alternative B).

E. Analysis of Programs, Clauses, and Concepts that are Analogous to or Subsets of the DTUPC Concept.

This section will present an analysis of the applicability of DTUPC and programs, clauses, and concepts that are analogous to, or are subsets of, the DTUPC concept as another basis for when it is appropriate to apply DTUPC to nonmajor systems developments.

Of all the established concepts reviewed, the only useful one relating to DTUPC is the Value Engineering Program. MIL-V-38352 defines the Value Engineering Program as "contractually required value engineering directed toward design and delivery of supplies and material with essential characteristics at lowest overall cost."[24] This definition at face has a distinct similarity to the DTUPC concept.

The relationship of DTUPC to VE is, indeed, close, as was shown by Vice Admiral Eli T. Reich in his recent article in the Defense Management Journal entitled "Value Engineering and Design to a Cost: Kissin Cousins?"

In this article Vice Admiral Reich states that:

> . . . VE methodology is one of many means which can be employed to attack areas of high cost or areas exceeding target cost [DTUPC goal] during development.
>
> . . . Somehow VE must gain acceptance in the engineering community as a real contributor to the achievement of design to a cost objectives.
>
> . . . History shows that, properly applied, VE has produced and could produce more reductions in costs of defense systems. VE can contribute to the application of the design to a cost concept.[25]

Many other authors of articles and speeches which include Barry Schillito, Dr. John Foster, General Henry Miley, and General C. McKeen, reiterate the same basic philosophy shown in Vice Admiral Reich's article; that is, the close relationship between DTUPC and VE.[26]

An AMETA study in April of 1972 recommended that the Value Engineering Program Requirements Clause should not be used in the same contract containing DTUPC Provisions.[27]

On 31 August 1973, AMCQA-V issued a letter with the subject: "Value Engineering (VE) and Design to Cost," which stated that:

> Normally, the VE Program Requirement (VEPRC) will not be incorporated in development contracts containing design to cost [DTUPC] provisions.[28]

These facts further support the similarity of DTUPC to VE and tend to indicate that both should not be used in the same contract in order to avoid paying twice for the same thing, since one would be reduntant/duplicative.

Since ASPR 1-1702.3(b)(1)[29] states that the Value Engineering Program Requirements Clause shall be included in development contracts if they are in excess of $1 million, and based on the foregoing discussion which shows how the VE and DTUPC have similar programs, objectives, and methodology, one would conclude that it would seem to be cost-effective to apply DTUPC only to development contracts in excess of $1 million. This value also gives greater support to the expert field opinion which reached the same $1 million R&D contract threshold independently. These findings then favor a quantitative alternative, Alternative D.

F. Pareto Analogy.

The economist Vilfredo Pareto has shown that certain things in nature which are often in the minority account for the majority of a related phenomenon. The Pareto distribution for example has been proven to be true in DOD for procurement actions versus dollars expended and has been used as one justification by the Commission on Government Procurement to recommend that the dollar limit of small purchases be raised from $2,500 to $10,000: the minority (2 percent) of the procurement actions above $10,000 account for 99.3 percent of the dollars spent.[30]

Table III shows that AMC had 522 Advanced Development and Engineering Development contracts in FY 71 and 807 AD and ED contracts ir FY 72 to which DTUPC contractual provisions could be applied.

Note in Table III that the contracts are arrayed above and below $1 million, the threshold suggested earlier. As expected, a Pareto-type condition was found. Those development contracts above $1 million account for 80 percent of the AD and ED dollars and are only 6 percent of the contracts.

Based on these findings, the $1 million figure would seem to be a reasonable threshold which would cover the majority of the dollars by putting DTUPC provisions in a relatively small number of contracts.

Historically, when guidance is issued with respect to R&D dollar thresholds there has often been an associated PEMA value. The most prominent example has been the one to four ratio as was shown in DOD Directive 5000.1 which is applicable to $50 million R&D or $200 million PEMA[31] and prior to DOD Directive 5000.1 issuance, DA Pam 11-25 used $25 million R&D or $100 million PEMA.[32]

Table III. Distribution of Definitized Advanced Development (6.3) and Engineering Development (6.4) Contracts by $ Size and $ Involved Above $10,000 by $ Size of Contract for AVC for the Time Period FY's 71–72.

$ Size of Contract (in thousands)	No. of AD & ED K's for FY's 71–72				Total $ (in thousands) for this class interval			
	No.			% of Total	$			% of Total
	71	72	Total		71	72	Total	
10-999.9	501	757	1,258	93.8	43,595	89,236	132,831	19.4
1,000	26	50	76	6.2	135,176	371,636	506,812	80.6
Total	527	807	1,334	100	178,771	460,872	639,643	100

Table IV shows that amount of dollars (in thousands) spent in DA for R&D and supply for FY's 70–73.

Table IV. Dollar Value in Thousands Spent in the Department of the Army for R&D and Supply for FY's 70–73*

FY	R&D	Supply
70	$1,124,613	$4,501,681
71	1,089,852	3,749,372
72	1,429,210	3,585,485
73	1,396,827	3,936,794

*For Contracts above $10,000

Source: Department of the Army, Procurement Statistics. Washington, D.C. Procurement Statistics Office, FY 70–73.

A rule of thumb for projecting expected supply expenditures[33] would be represented as a ratio of supply expenditures to R&D expenditures. Table V shows the percentage of R&D dollars spent above $10,000 for FY's 69–73 by research category: 6.1 was 7.4 percent, in 6.2 was 23.6 percent, in 6.3 was 40 percent, and in 6.4 was 29 percent. The table also shows the total dollars spent by DA in R&D and that most clearly reflects later PEMA expenditures in 6.3 and 6.4. Therefore

$$\text{recent average } \frac{\text{Supply}}{\text{R\&D (.69)}} = \frac{15,733,332}{5,040,502(.69)} = 4.5/1 \text{ or Supply} = 4.5 \text{ R\&D (6.3 \& 6.4).}$$

Table V. Dollars spent in the Department of the Army Above $10,000 by Research Category for FY's 69–73* (in thousands).

FY	Research Category			
	Research 6.1	Exploratory Development 6.2	Advance Development 6.3	Engineering Development 6.4
69	$ 79,559	$ 199,537	$ 260,604	$ 508,059
70	66,485	182,370	236,069	153,788
71	51,791	179,950	262,348	152,339
72	61,520	214,985	452,510	251,828
73	58,719	234,364	506,378	180,962
TOTAL	$318,074	$1,011,206	$1,717,909	$1,246,976
%	7.4	23.6	40.0	29.0

*Excludes operational system and management and support dollars for each FY.

Source: Department of the Army, Procurement Statistics. Washington, D.C.: Procurement Statistics Office, FY's 69–73.

Therefore, in general, a $1 million R&D expenditure would account for $4 million in supply expenditures. Since this is a direct relationship and since the earlier facts showed that 6 percent of the AD and ED actions are above $1 million, then at least 80 percent of the later expected supply expenditures would also be covered by DTUPC. This criteria then will also meet the findings of two earlier studies[34] in that it will cover the majority of the expected supply expenditures.

In this section devoted to the Pareto analogy, the universe of AD and ED contracts in AMC has been shown. It was found that the 80 percent of R&D dollars expended are above $1 million which shows a Pareto type distribution. The Pareto analogy thus supports the earlier preference for Alternative D (apply DTUPC to development contracts above $1 million) which was reached by expert field opinion and by the VE analogy. Also, it was shown that for $1 million spent in R&D (6.3 and 6.4), about $4 million would be spent in supply. Therefore, Alternative D could be changed to read, "apply DTUPC to all development contracts above $1 million or development contracts which have an expected supply expenditure of $4 million," in the absence of marginal cost data to the contrary.

G. LCC Implications.

Several of the policy documents recognized that the current emphasis on DTUPC may result in meeting the DTUPC goal at the expense of essential performance requirements for mission accomplishment and at the expense of increased operation and maintenance (O&M) costs. Therefore, caution must be exercised.[35] Additionally, several other authors have shared our concern over what effect DTUPC will have on O&M cost.[36]

There were several people in the field who believed that the DTUPC goal will be met at the sacrifice of performance which could eventually have an adverse impact on O&M costs. In other words, the degraded performance would cause O&M costs to rise in a greater proportion than the dollar savings in initial acquisition cost.

Therefore, based on these comments DTUPC should probably not be used on all R&D contracts until proven that it will not adversely affect performance and O&M cost. This again suggests that Alternative B is inappropriate.

H. Summary of Findings as to the Proper Alternative.

This section will be used to summarize the findings in Chapter II as a means of reaching a decision as to the proper alternative that will answer the primary objective of this investigation. The primary objective was to establish decision criteria to enable the

contracting officer to determine the applicability of DTUPC to a nonmajor development procurement with defensible justification for his actions for the procurement record.

It is felt that rather than fully discuss the facts for and against each alternative, it would be proper to briefly recap the findings of Chapter II as shown in Figure III to enable the reader to see how the final conclusion was reached.

Figure III. Summary of the Figures of Merit to be Used as a Short Term Basis for Selecting the Proper Alternative

SUMMARY OF:	ALTERNATIVES				
	A $25 MILLION PEMA	B ALL K's	C QUALITATIVE	D QUANTITATIVE	E C&D
FINDINGS FOR	INSURES SOME PRODUCTION SAVINGS LIMITS IMPLEMENTATION COSTS	CURRENT GUIDANCE (STRICTLY INTERPRETED) PROVIDES MAXIMUM OPPORTUNITY PRODUCTION COST SAVINGS	CURRENT GUIDANCE THEORETICALLY & INTUTTIVELY APPEALING BUT . . .	FIELD SURVEY: $1 (+) MIL R&D OTHER EXPERT OPINION PARETO ANALOGY VE ANALOGY $1 (+) MIL $4 (+) MIL SUPPLY EASIER TO IMPLEMENT	COMBINATION OF C&D
FINDINGS AGAINST	NSIA REPORT 13 SEP 73 LTR	HEURISTIC B/C ANALYSIS LACK OF INDUSTRY'S ACCEPTANCE LCC IMPLICATIONS VOLUME OF PROBLEMS	NOT HELD FEASIBLE BY FIELD PERSONNEL	NEED FOR FLEXIBILITY CURRENT GUIDANCE (STRICTLY INTERPRETED)	CURRENT GUIDANCE (STRICTLY INTERPRETED)

One can see from Figure III that findings were marginal for Alternative A, which would be to apply DTUPC on all development contracts greater than or equal to $25 million PEMA.

The National Security Industrial Association report and AMETA reports would be against this Alternative A because their recommendations of covering the majority of production dollars would never be realized by this dollar threshold. Additionally, the 13 Sep 1973 letter from AMCRP-SC would be against Alternative A.

The basic findings for Alternative B, which was defined to apply DTUPC to all development contracts, were current guidance (strictly interpreted) and that this alternative provides maximum opportunity for production cost savings. The basic findings against Alternative B were that (1) even current guidance on when to use DTUPC recognizes that DTUPC should not be applied to a development contract if not appropriate but fails to give definitive criteria of what is meant by "not appropriate;" (2) the heuristic benefit/cost analysis showed that it would take many Government resources (dollars, time, and manpower) to implement DTUPC on a development contract and, therefore, would be non cost-effective on smaller development contracts; (3) industry has not yet accepted the DTUPC concept fully; (4) the DTUPC concept has not been fully proven to work on DOD development contracts; (5) many problems exist in the implementation of DTUPC and it probably should not be applied to all development contracts until all the "bugs" in DTUPC are "ironed out;" and (6) it has been shown that DTUPC will not have a potentially bad effect on life cycle cost. The other comment relating to Alternative B was that the field survey showed that on smaller development contracts the field would like flexibility to include DTUPC and/or principles if they deemed it appropriate.

Figure III shows that current guidance alone could favor Alternative C, a set of definitive qualitative criteria as to when to use DTUPC. Also, Alternative C based on the results of the field survey, is not a viable alternative because the field personnel in general

believed that the criteria in Figure I would be used as a basis for not using DTUPC on any nonmajor development contracts. One might conclude, though, that part of the Alternative C criteria, slightly modified per field comments, could serve as a set of qualitative examples in Alternative E as to where it would be inappropriate to use DTUPC above some R&D dollar threshold.

One can see from Figure III that Alternative D, a set of quantitative criteria would be favored because (1) other experts in the field who have published papers, done research and made speeches lean toward a quantitative criteria and a $1 million R&D threshold. This was also supported by a researcher on the ADPA study, (2) the field survey results of expert opinion showed that DTUPC should be applied to development procurements if they exceed $1 million R&D, (3) the VE analogy showed that since VE was similar in many aspects to DTUPC and that VE Program Requirements Clause should not be used in a contract containing DTUPC then the $1 million criteria for applying VE Program Requirements Clause per ASPR would also be the break point where DTUPC should be applied, (4) the Pareto argument supported the choice of $1 million R&D by showing the universe of AMC Advanced and Engineering Development contracts and that 6 percent of the development contracts should account for 80 percent of the later supply expenditures associated with these development programs. It also shows that we have a Pareto type distribution and that it is not necessary to cover all development contracts in order to have DTUPC provisions cover the majority of later defense expenditures for hardware; (5) easier to implement; (6) that associated with a $1 million R&D expenditure in 6.3 and 6.4 would be on the average about a $4 million R&D supply expenditure. The basic findings against Alternative D were that the people need flexibility to implement DTUPC above or below any dollar threshold that would be recommended.

Based on the facts shown in Figure III, experience, analysis, and discussions in Chapter II, and the understanding of the primary objective of this study, it was determined by the researchers through expert value judgment that Alternative E, a combined quantitative and qualitative criteria, seems to hold the most promise for successful DTUPC applicability decisions: a dollar threshold to indicate those contracts with potential savings and qualitative factors to point out exceptions to the threshold.

NOTES

CHAPTER II

[1]DOD Dir 5000.1, loc. cit.

[2]AMCRP-S ltr. dtd 17 October 1972, loc. cit.

[3]Deputy Secretary of Defense, Design to a Cost Objective on DSARC Programs, Memorandum, 18 June 1973

[4]AMCRP-SC ltr, dtd. 13 September 1973, loc. cit.

[5]U.S. Army Materiel Command, Impact Task–Design to Unit Production Cost (DTUPC), Letter, AMCRP-SC, 17 September 1973.

[6]Army Materiel Command Pamphlet (AMCP) 700-6, Title: Joint Design-to-Cost Guide (Washington, D.C.: U.S. Government Printing Office, 3 October 1973).

[7]Except excluded major systems not recommended by DSARC for DTUPC coverage.

[8]Design-to-Cost (DTC) Contracting Guidelines, Technical Report (Washington, D.C.: American Defense Preparedness Association, September 1973).

[9]Ibid., p. 4.

[10]Ibid., p. 19.

[11]Telephone interview with Salvatore J. Castiglioni, DCASA, NY, November 1973.

[12]U.S. Army Management Engineering Training Agency, Producibility and Producibility Cost Control Considerations During Weapon System Development (August 1971).

[13]Ibid., p. VI-3.

[14]MG Robert F. Trimble, USAF, "Procurement Work Force Management and the Economic Environment," NCMA News Letter, Volume 13, No. 13, November 1973, p. 6.

[15]Ibid., p. 6.

[16]National Security Industrial Association, Research and Engineering Advisory Committee, Report of the Design-to-Cost Panel, How to Motivate Design Teams to Design-to-Cost (Washington, D.C.: National Security Industrial Association, February 1973).

[17]One of these is a product managed system.

[18]These RFP's/contracts covered systems and subsystems both which included some competitive prototyping.

[19]These RFP's/contracts covered systems and subsystems both which included some competitive prototyping.

[20]AMETA Study, April 12, op. cit., p. VI-4.

[21]They called DTUPC a producibility and producibility cost control program.

[22]"Comment . . . The New Pentagon Imperative: Design to Cost," Performance, Vol. 3, No. 1 (Brea, California: American Society for Performance Improvement, Society of American Value Engineers and National Association of Suggestion Systems, January–February 1973), p. 9.

[23]U.S. Army Materiel Command, "AMC Seminar on Weapons Systems Acquisition, The Little Four Memoranda," 5 December 1973.

[24]MIL-V-38352, Value Engineering Program Requirements (Washington, D.C.: U.S. Air Force, 20 January 1965), p. 4.

[25]Vice Admiral Eli T. Reich, USN, "Value Engineering and Design to a Cost," Defense Management Journal, Vol. 9, No. 4, October 1973, pp. 54–55.

[26]Performance, Vol. 3, No. 1, op. cit., p. 10.

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"The Little Four" Memoranda, loc. cit.

[27]AMETA Study, April 1972, op. cit., p. VI-2.

[28]U.S. Army Materiel Command, Value Engineering (VE) and Design to Cost, letter, AMCQA, 31 August 1973.

[29]Department of Defense, Armed Services Procurement Regulation , 1973 edition, ASPR 1-1702.3(b)(1).

[30]Summary of the Report of the Commission on Government Procurement, Stock No. 5255-00005 (Washington, D.C.: U.S. Government Printing Office, December 1972), p. 12.

[31]DOD Dir 5000.1, op. cit., p. 1.

[32]Department of the Army Pamphlet 11-25, Title: Life Cycle Management Model for Army Systems, October, 1968, p. 1–3.

[33]Supply equal PEMA plus Stock Fund and PEMA and Stock Fund estimates can be made.

[34]NSIA Report, February 1973, loc. cit.

AMETA Study, April 1972, loc. cit.

[35]Army Materiel Command Guide, Title: Design to Unit Production Cost–AMC Guide (Preliminary Draft) (Alexandria, VA: Comptroller, HQ AMC, November 1973), p. VI-3.

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[36]The Little Four Memoranda, loc. cit.

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AMETA Study, April 1972, op. cit., pp. 8–9.

CHAPTER III

CONCLUSIONS AND RECOMMENDATIONS

A. Conclusions.

The objective of the study was to establish decision criteria to enable the contracting officer to determine the applicability of DTUPC to a nonmajor development procurement with defensible justification for his actions for the procurement record. Alternatives ranging from the present criteria, to a set of qualitative or quantitative criteria were reviewed to determine to which contracts DTUPC should be applied.

Based on the facts shown in Figure III, experience, analysis, and discussions in Chapter II, and the understanding of the primary objective of this study, it was determined by the researchers through expert value judgment that Alternative E, a combined quantitative and qualitative criteria seems to hold the most promise for successful DTUPC applicability decisions: a dollar threshold to indicate those contracts with potential savings and qualitative factors to point out exceptions to the threshold. A $1 million R&D threshold is concluded to be the most practicable quantitative criterion. This value is supported by expert opinion, close relationship of the VE Program Requirements Clause criteria, and a Pareto analogy which showed that 6 percent of the AMC Advanced Development and Engineering Development contracts are above $1 million and account for 80 percent of the dollars. Based on historical and recent figures, a $4 million projected supply criterion is felt to be a reasonable basis for DTUPC application by analogy to the $4 million R&D figure.

Application of this dual criterion should result in well over 80 percent of AMC's AD and ED dollar expenditures receiving the benefit of the DTUPC design philosophy, while reducing the required managerial and engineering attention to slightly more than 6 percent of AMC's development contracts.

The evidence failed to support a uniform set of qualitative criteria guiding the application throughout AMC. However, the consensus of expert opinion and a review of the wide range of AMC's procurement needs and their related contexts favor the development of suitable qualitative criteria for field guidance. A tentative set of criteria is proposed.

B. Recommendation.

It is recommended that AMC adopt the conclusion of when DTUPC should be applied to a nonmajor weapons system and recommend it to the field. The basic policy AMC should adopt would be to apply Design to Unit Production Cost to AMC development procurements of greater than $1 million R&D or with expected supply (PEMA and Stock Fund) expenditures of greater than $4 million. There may be some valid reasons why DTUPC may not be applicable: (1) few (compared with past buys) or no production items (of low unit price) are to be made, (2) it can be demonstrated that there are no trade offs to be made between performance and costs as shown by the Trade-off Determination (TOD) or the Trade-off Analysis (TOA) in the Concept Formulation Package (CFP), (3) it can be demonstrated that the sum of the marginal benefits to be gained from applying DTUPC would be outweighed by the sum of the marginal costs of applying it (Σ MB's $\leq$ ΣMC's), or (4) it can be clearly demonstrated that the use of the DTUPC principle on an individual procurement would not be in the best interests of the program. Exceptions require a written justification and approval by the head of the procuring activity. Such justification will be made part of the procurement file. If there is clear justification for including DTUPC provisions in development contracts below $1 million or with less than $4 million expected supply expenditures, then DTUPC should be included or can be included to some lesser degree than envisioned in current policy guidance on development contracts over $1 million or at least cost reduction principles can be emphasized in the contract. Whenever this occurs, a written justification by the contracting officer is all that is needed. As further experience is gained in application of DTUPC, the above values on R&D and PEMA may be lowered or conversely, increased.

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APPENDIXES

APPENDIX A

LIST OF ARMY, NAVY, AND AIR FORCE CONTRACTS

CONTAINING DTUPC PROVISIONS

Table I. Army Systems/Items Containing DTUPC Contractual Provisions*

System/Item	MSC	PM	Major System	Kr(s) or Status
1. Absolute Altimeter, AN/APN-209( )(V)	ECOM	NO	NO	Proposal evaluation—forecast award of 2 K's
2. Advanced Attack Helicopter (AAH)	AVSCOM	YES	YES	Bell Helicopter Co., Hughes
3. Armored Reconnaissance Scout Vehicle (ARSV), XM800	TACOM	YES	YES	Lockheed, FMC
4. Cannon Artillery Weapons Systems—CLGP (Cannon Launched Guided Projectile)	ARMCOM	YES	YES	RFP being prepared—forecast award of 2 K's
5 Communications Central Office, Automatic, AN/TTC-39 (subsystem of TRI-TAC) Validation Phase	ECOM	YES	YES	GTE Sylvania ITT Defense Communications Div
Engineer Development (ED)				Proposal evaluation—forecast award of 2 K's.
6. Family of Military Engineering Construction Equip (FAMECE)	TACOM	NO	NO	RFO—forecast award of 2 K's
7 Heavy Lift Helicopter (HLH) Air Frame Engine	AVSCOM	YES	YES	Boeing Vertol Detroit Diesel Allison of GMC

*As of Fall 1973.

Table I. Army Systems/Items Containing DTI PC Contractual Provisions—Continued

System/Item	MSC	PM	Major System	Kr(s) or Status
8. Heliborne Laser Fire and Forget Missile System (HELLFIRE) 3 subsystems:	MICOM	YES	YES	
a. Airborne Laser Locator Designator				RFP being prepared
b. Ground Laser Locator Designator				RFP being prepared
c. Tri Service Seeker				RFP being prepared
9 Howitzer Howitzer, Towed, 155MM, XM198 Howitzer, Towed, 105MM, XM204	ARMCOM	NO	NO	In-house
10. Hybird Engine for use in 1/4 ton truck	TACOM	NO	NO	White Engines
11 Laser Range Finder, Hand Held, AN/GVS-5	ECOM	NO	NO	Proposal Evaluation
12. MANPAC UHF Satellite Line-of-Sight Transceiver	ECOM	NO	NO	Proposal Evaluation
13. Mechanized Infantry Combat Vehicle (MICV), XM723	TACOM	YES	YES	FMC
14. Mobile Electric Power (MEP), 30KW Generator	TROSCOM	YES	YES	Solicitation on the street
15. Mortar/Artillery Locating Radar (MALOR), AN/TPQ-37	ECOM	Product Manager	NO	Hughes Aircraft Sperry RAND Corp.

Table I. Army Systems/Items Containing DTI PC Contractual Provisions—Continued:

System/Item	MSC	PM	Major System	Kr(s) or Status
16. Miniature Radar Illuminator Detector (MIRID), AN/PSS-10	ECOM	NO	NO	General Instruments Corp.
17 XM1 TANK	TACOM	YES	YES	GM, Chrysler
18. NAVCOM, LORAN C/D Airborne Navigation System	ECOM	YES	YES	TRACOR, INC. Teledyne, INC.
19 Night Vision	TROSCOM	NO	NO	Under Negotiation
20. Optical Character Recognition Equipment (OCRE)	ECOM	NO	NO	Resolicitation-forecast award of 3 K's
21 Pershing II	MICOM	YES	YES	Planned
22. Platoon Early Warning System (PEWS)	ECOM	NO	NO	Pre-award protest
23. Radio Data Link for Ground Ranging Set, AN/GRA-114	ECOM	NO	NO	DELCO (GMC)
24. 2.75 Rocket System	MICOM	YES	YES	Planned

Table I. Army Systems/Items Containing DTUPC Contractual Provisions—Continued:

System/Item	MSC	PM	Major System	Kr(s) or Status
25. SAM D Missile (Surface-to-Air Missile)	MICOM	YES	YES	Raytheon
26 S/M/S Sensor	ECOM	NO	NO	RFQ on the street
27. Switched Network Automatic Routing System (SNARS)	ECOM	NO	NO	Proposal evaluation-forecast award of 3 K's
28. STINGER (Man Portable Air Defense System (MANPAD))	MICOM	YES	YES	General Dynamics
29. Utility Tactical Transport Aircraft (UTTAS)	AVSCOM	YES	YES	Boeing Vertal Sikorsky
30 Vehicle Rapid Fire Weapons System (VRFWS), Bushmaster	ARMCOM	YES	YES	
Validation Phase				GE, AAI, Philco
Engr. Dev. (ED)				RFP being prepared-forecast award of 2 K's

Table H. Navy Systems Containing DTUPC Contractual Provisions (RFP's and Contracts)

AGILE Missile

AIM 7F Missile (PMA-262)

AN/BQQ-5 Submarine Sonar (PMS-302)

ANTI-Ship Weapon Systems Project Office (PMA-258)

CH-53E Aircraft System Project (PMA-261)

Electronic Warefare Suite

Emergency Escape Breathing Devices

HARPOON Missile

Modified Operations Summary Console (MOSC)

Moving Target Detector Processor Multi-Mission Helicopter (PMA-256)

Nuclear Powered Aircraft Carrier (CVAN) Ship Acquisition Project (PMS-399)

Patrol Frigate (PF) Escort Ship Acquisition

Project (PMS-399)

Patrol Frigate Sonar

Patrol Hydrofoil Ship (PMS-303)

Phalanx Missile (PMO-403)

Poseidon and Harm Missiles

S3A Weapon System Project (PMA-244)

SPS-49 Radar

10 KW Static Inverters (2 K's to be awarded)

40KW Static Inverters (2 K's to be awarded)

VISTOL Technology Prototype

Table III. Air Force Systems Containing DTUPC Contractual Provisions (RFP's and Contracts)

Advanced Ballistic Reentry System

Advanced Medium STOL (Short Take-off and Landing) Transport

AGM-65, Maverick System Program Office

AGM-69, Short Range Attack Missile (SRAM)

AGM-86A, Subsonic Cruise Armed Decoy (SCAD) Missile (4 subsystems—Airframe and air vehicle, decoy, guidance and control, and propulsion)

AIMS/TRACALS

Airborne Warning and Control System (AWACS)

A-10 (Formally the AX) System Program (Close Air Support Aircraft)

B-1 Bomber Program (Advanced Manned Strategic Bomber) (4 subsystems—airframe, engine, avionics, and radio frequency surveillance/electronic countermeasures (RFS/ECM))

Base and Installation Security System Program Office (BISSPO)

Defense Navigation Satellite Demonstration Program Drone/RPV System Program Office

F-15 Eagle Advanced Tactical Fighter

Fleet Satellite Communications System (Joint venture with the Navy)

Lightweight Fighter

Low Altitude Supersonic Target Drone

TACAN (Tactical Air Navigation System)

Tactical Information Processing and Interpretation (TIPI)

WX 200 Radar

APPENDIX B

STUDY TEAM COMPOSITION

Study Team Composition

This study was conducted under the direction of Mr. Robert F. Williams, Chief of Test and Evaluation Group, U.S. Army Procurement Research Office, Institute of Logistics Research, U.S. Army Logistics Management Center (ALMC). Members of the study team were:

Kimrey D. Newlin, Project Officer, B.S. in Physics, Gilford College 1966; M.S. in Agricultural Economics, Clemson University, 1969; and M.E. in Industrial Engineering, Texas A&M University, 1970. Economist, U.S. Army Procurement Research Office, Institute of Logistics Research, ALMC. Mr. Newlin has published several papers. Prior to joining the U.S. Army Procurement Research Office, Mr. Newlin was a General Engineer (Instructor) specializing in RAM and ILS in the Logistics Support Design Management Course with ALMC.

Shirley H. Carter, B.S. in Agricultural Economics, VPI, 1953; M.S. in Agricultural Economics, VPI, 1957; and advanced work towards a Ph.D. in Agricultural Economics at N.C. State University, 1958–1960. Computer Programer, U.S. Army Procurement Research Office, Institute of Logistics Research, ALMC. Mr. Carter has worked on numerous published research reports by the U.S. Army Procurement Research Office. Prior to joining the U.S. Army Procurement Research Office, Mr. Carter served in various operations and analysis positions in the U.S. Air Force.

APPENDIX C

LETTER (AMCRP-SP, HQ, AMC, 17 MAY 1974) WHICH IMPLEMENTS THE RECOMMENDATIONS OF PRO TASK 304

DEPARTMENT OF THE ARMY
HEADQUARTERS UNITED STATES ARMY MATERIEL COMMAND
5001 EISENHOWER AVE., ALEXANDRIA, VA. 22304

AMCRP-SP

17 May 1974

SUBJECT: Design to Unit Production Cost (DTUPC)

SEE DISTRIBUTION

1. References:

a. Letter, AMCRP-SC, HQ, US Army Materiel Command, 13 September 1973, subject: Design to Unit Production Cost Policy.

b. Message, AMCRP-SC, 281312 September 1973, subject: Impact Task - Design to Unit Production Cost (DTUPC).

c. AMC Guide, Design to Unit Production Cost, Preliminary Draft, November 1973.

2. References a and b extended the application of the DTUPC provisions to all development contracts in Advanced and Engineering Development except those where it is specifically determined that such use would not be in the best interests of the particular program.

3. An extensive study of the administrative effort at the major subordinate commands and the opportunities for trade-offs associated with the implementation of this policy has indicated that a more definitive expression of the policy is appropriate.

4. The criteria for application of design to unit production cost ceilings to contracts recommended by the study are as follows:

a. Hardware development contracts for items/systems in advanced/engineering/operational systems development as defined in ASPR 4-101, estimated to be $1,000,000 or more.

b. Development of items/systems whose production is expected to be $4,000,000 or more regardless of the estimated amount of the development contract.

5. These criteria are effective upon receipt of this letter.

AMCRP-SP
SUBJECT: Deisgn to Unit Production Cost (DTUPC)

17 May 1974

6. In addition to the foregoing, each such contract containing a DTUPC ceiling should contain an award fee applied to the achievement and/or betterment of the ceiling when such can be expected to generate significant rewards and/or penalties.

7. DTUPC ceilings shall be fully defined and structured in accordance with guidelines provided by reference 1c above. Where precise planning data on production quantities and rates of production are not available, nominal value estimates shall be used during contract performance.

FOR THE COMMANDER:

C. M. McKEEN, JR.
Major General, USA
Director of Requirements
and Procurement

DISTRIBUTION:
A and B