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DESIGN-TO-COST MONITORING
SYSTEM FOR CRUISE MISSILE PROJECT

July 1975

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Prepared for

U.S. NAVAL AIR SYSTEMS COMMAND
CRUISE MISSILE PROJECT (PMA 263)
Washington, D.C.

Under Contract N00019-75-C-0381

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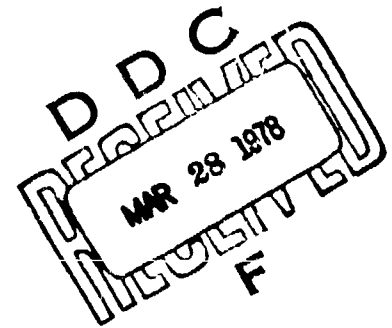
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REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER 1153-01-1-1423	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) DESIGN-TO-COST MONITORING SYSTEM FOR CRUISE MISSILE PROJECT		5. TYPE OF REPORT & PERIOD COVERED
7. AUTHOR(s) H.P. Himpler, Project Engineer		6. PERFORMING ORG. REPORT NUMBER 1153-01-1-1423
		8. CONTRACT OR GRANT NUMBER(s) N00019-75-C-0381
9. PERFORMING ORGANIZATION NAME AND ADDRESS ARINC Research Corp. 2551 Riva Road Annapolis, Maryland 21401		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS U.S. NAVAL AIR SYSTEMS COMMAND CRUISE MISSILE PROJECT (PMA 263) Washington, D. C.		12. REPORT DATE Jul 75
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office) U.S. NAVAL AIR SYSTEMS COMMAND CRUISE MISSILE PROJECT (PMA 263) Washington, D.C.		13. NUMBER OF PAGES 13
		15. SECURITY CLASS. (of this report) UNCLASSIFIED
16. DISTRIBUTION STATEMENT (of this Report) UNCLASSIFIED/UNLIMITED		18a. DECLASSIFICATION/DOWNGRADING SCHEDULE
17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)		
18. SUPPLEMENTARY NOTES		
19. KEY WORDS (Continue on reverse side if necessary and identify by block number)		
20. ABSTRACT (Continue on reverse side if necessary and identify by block number) The design-to-cost program for the Submarine Launched Cruise Missile is evaluated from the perspective of the past two years. A recommended program is outlined for maintaining the project cost baseline in an accurate and up-to-date status.		

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Prepared by
H.P. Himpler, Project Engineer

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Publication 1153-01-1-1423

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ABSTRACT

The design-to-cost program for the Submarine Launched Cruise Missile is evaluated from the perspective of the past two years. A recommended program is outlined for maintaining the project cost baseline in an accurate and up-to-date status.

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SUMMARY

This report documents procedures and techniques for design-to-cost (DTC) monitoring and control for the Cruise Missile Project. A systematic and cost-effective approach to maintaining the DTC baseline in an up-to-date status is outlined.

The report also reviews the development of program cost estimates and suggests procedures for continuing that effort. Contractual sources of DTC data are examined, the content and timeliness of each source is reviewed, and means of increasing the utility of the data are recommended.

Finally, a plan and procedures for tracking DTC goals and identifying and resolving discrepancies are offered for implementation in the Cruise Missile Project.

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Chapter One

INTRODUCTION

1.1 BACKGROUND

Under Contract N00019-75-C-0381, ARINC Research Corporation has been assisting PMA 263, U.S. Naval Air Systems Command, in monitoring and evaluating contractor design-to-cost (DTC) efforts for the Cruise Missile Project. In this project, the Convair Aerospace Division of General Dynamics Corporation and the Vought Systems Division of LTV Aerospace Corporation are competing for the development and production contracts for the air vehicle; while E-Systems, Inc., and McDonnell Douglas Astronautics Company-East are competing for the guidance set award. The Navy is sponsoring further competition by assigning sustainer-engine development to Convair (Williams Research Corporation) and Vought (Teledyne CAE).

Since this project is one of the first in which the design-to-cost concept has been fully applied, the Navy is carefully monitoring and controlling the DTC efforts of the competitors. This report documents these monitoring and control activities; discusses an approach for systematizing DTC monitoring; and outlines procedures that may be used throughout the Cruise Missile Project to assure that costs are controlled consistent with DTC objectives.

Contracts awarded to this point in the project, which is about to enter the Full-Scale Development Phase, have been the cost-plus-fixed-fee type with a cost ceiling. It is interesting to note that, thus far in the program, the contractor cost estimates have been substantially lower than those of the government. This variance is attributed to the fact that government estimates are predicated on historical data, including data from systems that did not prove particularly cost effective; and do not fully reflect the advantages to be gained from competitive purchases. The philosophy of PMA 263 has been to manage to the contractor cost estimates, but anticipate those higher costs predicted by the government. When the competitive phase is completed, however, the DTC control effort might not be so favorably disposed.

1.2 CRUISE MISSILE DESIGN-TO-COST APPROACH

The DTC concept is defined in Department of Defense Directive 5000.1, Acquisition of Major Weapons Systems. The directive requires that production cost be a controlled factor in the design of new weapon systems. Traceable elements of recurring costs are to be established early in the design phase to provide designers with cost as well as performance goals. System development must be continuously evaluated against these cost goals with the same vigor as is applied to meeting technical requirements. Practical tradeoffs can then be made between cost and performance.

The DTC concept was implemented for the Cruise Missile acquisition when that project entered the Validation Phase with cost estimates established for both the development and production of the missile subsystem. PMA 263, with Defense Systems Acquisition Review Council (DSARC) approval, specified cost goals and thresholds for the average unit production cost of the air vehicle and guidance subsystems. This "flyaway" cost included the recurring costs associated with missile subsystem hardware, system engineering and project management, and data engineering and management. Excluded were GFE and some other government costs. Associated with these cost goals was a set of specified conditions, including performance parameters and a production schedule. PMA 263 continuously reviews these cost/performance targets for updating as required.

The competing contractors were then directed to specify their own system on the basis of cost/performance tradeoff studies within the boundary conditions imposed. The contractor-specified goals were substantiated by the Navy, and the competitors are thus managed by PMA 263 to a set of self-imposed conditions. Single contractors for the air vehicle and guidance subsystems will eventually be selected following competitive demonstrations against the same criteria.

This approach has resulted in the production of prototype subsystems that are well within the cost thresholds. In addition, contractor estimates indicate that the equipments meet or exceed some performance goals, and come reasonably close to the established cost goal. It is incumbent on PMA 263 to monitor and assess progress, and to take actions as necessary to assure that contractors continue to perform in a like manner, to the end of providing a vital but cost-effective addition to the national defense.

Contracts for the system integration stage of the Validation Phase will include options to continue full scale development and to complete two pilot production phases. The options will be exercised at the Navy's discretion with approval from DSARC IIA. Prior to this review, however, the Navy and contractors will implement LCC studies and tradeoffs to determine an acceptable cost of ownership for the Cruise Missile - that is, DTC emphasis will shift from "cost to produce" to "cost to own". It is understood that the latter will be defined to include all of the concepts of design-to-cost-to-produce. PMA 263 will continue to reevaluate these DTC and LCC goals throughout the various program phases.

1.3 ORGANIZATION OF REPORT

Chapter Two of this report reviews the development of LCC and DTC estimates for the Cruise Missile Project, and suggests procedures for continuing these efforts. Chapter Three examines existing contractual sources of DTC data, reviews the content and timeliness of each source, and suggests procedures for increasing the utility of the data. Chapter Four outlines a plan and procedures for tracking DTC goals, and identifying and resolving discrepancies. Chapter Five presents the conclusions and recommendations of this study.

Chapter Two

EVOLUTION OF PROJECT BASELINE ESTIMATES

2.1 SLCM INITIATION REPORT

The Submarine Launched Cruise Missile Program Initiation Report, Volume IV, is a life-cycle-cost summary issued by NAVAIRSYSCOM on May 1, 1973. The report was prepared in response to Decision Coordinating Paper (DCP) No. 125 to provide information for DSARC as to which Cruise Missile option should be pursued. In that document, life cycle costs are estimated for several options of production quantity and launch techniques. The document, followed by an affirmative decision from DSARC I, provided the project cost baseline for a Sea Launched Cruise Missile (SLCM) to be horizontally launched from a torpedo tube. A combined procurement program of both strategic and tactical missiles was approved. With some modifications, as will be discussed in succeeding paragraphs, this is the basic program structure in effect today.

Details of the cost baseline are described in the subject volume (which will be referred to herein as the Initiation Report), along with cost estimates for all other options. These options include vertically launched missiles, varying procurement quantities, strategic-only or tactical-only programs, a mix of strategic and tactical missiles, and a program comprising only a Validation Phase. The cost estimates cover research and development, production, operations and support, and disposition.

Changes to this cost baseline became necessary because of succeeding developments in the program, including the fact that the design concept itself fit a more versatile missile capable of not only submarine launch but air and surface-platform launch as well. Cost estimates were prepared in accordance with a preliminary work breakdown structure (WBS) for the project, which is very similar to the present WBS. The need for further updating this baseline became apparent as more details of the design and project planning were defined.

2.2 SOURCE SELECTION REVISIONS

Source selection activities for both the air vehicle (December 1973) and guidance set (June 1974) further altered the cost baseline established in the Initiation Report. An independent government estimate was prepared for source selection of each of these subsystems. These estimates were based on updated assumptions and a greater amount of factual data than were available for preparation of the Initiation Report. Present program cost estimates and budget preparation figures are based on these updated estimates. Changes impacting the cost baseline occurred primarily in the areas of hardware procurement and government management.

Neither source selection effort addressed costs beyond the Production Phase of the program. The air vehicle version addressed production costs only, while both the Full Scale Development and Production Phase costs were estimated for the guidance set. Most of the R&D costs and all of the operations and support (O&S) costs were still predicated on the Initiation Report baseline after these source selections, but production costs were updated.

2.3 GOVERNMENT COST STUDY

The Cruise Missile cost baseline is being updated in a joint study directed by PMA 263 and conducted by NAVAIR 50114, ARINC Research, and Bird Engineering Associates. This study, aimed toward a closer look at R&D and production costs in view of two years of accumulated experience and program progress, will be completed on about 1 August 1975. It is expected that the O&S phase costs will remain as the only data totally consistent with the Initiation Report. O&S costs will be addressed in detail following the next source selection, in which single contractors to produce the air vehicle and guidance set equipments will be chosen.

2.4 UPDATING COST BASELINE

The cost baseline must continue to be updated since it is, by definition, the criterion against which all current project costs are measured. It is also important that the user be fully aware of the underlying assumptions from which the cost estimates are drawn. These assumptions relate to such yet-unspecified factors as:

- a. System/subsystem configuration(s)
- b. Deployment schedule

- c. Production quantities
- d. Type of launch platform(s)
- e. Materials and processes
- f. Funding constraints

Small changes in any of the above baseline data (or assumptions) may lead to large changes in cost data. Of most frequent interest to senior DoD, NAVMAT, and NAVAIR officials are the impact of adding or deleting launch platforms, procuring different quantities, or accelerating or decelerating the schedule. Projections of such impacts must be sufficiently accurate that no financial misinformation is promulgated. Estimates are frequently needed in both actual and constant dollars, which also necessitates careful tracking and application of current economic indices. For all of the foregoing reasons, it is mandatory that the cost baseline be maintained in a current and accurate status.

The baseline can be updated according to a flexible schedule, but as a minimum at each program major milestone and for each lot procurement. A recommended list of update times is as follows:

- a. Prior to DSARC IIA
- b. At conclusion of Full Scale Development (DSARC IIB)
- c. Prior to DSARC IIIA
- d. Periodically during the production program
- e. At any major changes to program plans.

The recommended method for updating the baseline is a "plug-in" of new data as appropriate by a cost-study team, preferably the same team responsible for maintaining the current baseline.

Chapter Three

DATA SOURCES AND UTILITY FOR DTC CONTROL

This chapter discusses the sources of data available for DTC monitoring and control; indicates how the data may be assessed for effective utilization in a DTC monitoring plan; and suggests, where appropriate, means by which the usefulness of these sources may be increased.

3.1 DATA SOURCES

Five principal sources of data are available to PMA 263 for utilization in a DTC monitoring plan. These are:

- a. Monthly program reviews (MPRs) of PMA 263
- b. Contractor progress reports
- c. Design-to-cost reports
- d. Contract performance reports (CPRs)
- e. Contractor cost data reports (CCDRs)

Each of these sources is discussed in detail in the following paragraphs.

3.1.1 Monthly Program Reviews

Monthly program reviews are undoubtedly the best source of data available to PMA 263 because they provide the forum for direct interchange of information. Design-to-cost should be a regular agenda item (quarterly as a minimum) to provide for reasonable reviews of contractor progress/problems. In addition, DTC should be an agenda item for each known or suspected cost/performance problem detected by any method.

It is customary to assign action items at the MPR whenever an issue remains unresolved at the conclusion of the meeting. A follow-up file of open action items should be established by PMA 2632, and reviewed weekly until the actions are

resolved. Open actions should be automatic agenda items for subsequent MPRs. Every effort should be made, however, to resolve DTC problems during the period of the review itself.

3.1.2 Contractor Progress Reports

Contractor (and subcontractor) progress reports are furnished or required by the Contract Data Requirement List (CDRL), form DD-1423, in a number of specific areas, such as:

- a. System safety
- b. Reliability and maintainability
- c. Test and evaluation

This type of report provides no DTC data directly; however, judicious review by the PMA 2632 analyst could disclose areas in which DTC problems might be forthcoming. The analyst should use these reports on a monthly basis to indicate areas of further inquiry. As an example, a computer-reliability problem could lead to engineering changes or redesign efforts, with a direct impact on the DTC baseline. By reviewing these reports, the DTC analyst is kept current on the total program status and is not left unaware and unprepared in the event of a future cost problem.

3.1.3 DTC Reports

The DTC report is a CDRL item. At this phase of the Cruise Missile Project it is submitted quarterly by air vehicle contractors and monthly by guidance set contractors. The frequency of the report may be varied as the program progresses, but should be maintained at present levels through the Full Scale Development Phase.

The object of the report is to provide results of cost/performance tradeoff studies and an update as appropriate to the average unit production (flyaway) cost. This report is a most timely and significant input to the PMA 2632 analyst since it is the only one that yields projected cost changes directly. Trends in DTC reports indicating little tradeoff activity may be the first indicators of potential cost problems in future procurements. In reviewing these reports, the analyst may be able to determine changes to Data Item Descriptions that would aid in improving the reports.

DTC reports should be reviewed immediately upon receipt and again just prior to an MPR. Significant cost deviations from baseline should be added to the MPR agenda for detailed discussion and analysis.

3.1.4 Contract Performance Reports (CPR)

CPRs are issued in accordance with DoD Instruction 7000.1, Cost/Schedule Control Systems Criteria. These reports include planned and actual expenditures on current contracts, both graphically and by functional work element (engineering, manufacturing material, etc.). The CPR is directly traceable to the contract WBS, and summaries are detailed by WBS code. In addition, a narrative explanation of deviations from the plan is also required.

Since the CPR is limited to current operations only, its value in design-to-cost monitoring is as an indication of potential future problems. It may be analyzed to determine if cost/schedule deviations have a nonrecurring or recurring impact on costs. Whenever recurring cost escalations are encountered, there will definitely be an adverse effect on DTC goals. The narrative and other portions of the CPR can also provide some insight into the contractor's expense and overhead positions according to the source of any deviations from plan reported.

The CPR can thus be used to detect DTC-related trends. Trend analysis software may become available to the Navy for use on this program; if not, manual techniques can be employed.

It is necessary to realize the CPRs are useful in DTC analysis, and their distribution should not be restricted to cost/schedule control system specialists.

3.1.5 Contract Cost Data Reporting

The Contract Cost Data Reporting System is described in NAVMAT P-5241, Acquisition Management Contract Cost Data Reporting System. Intended for use as a uniform cost data base for all three services, the CCDR system will probably be implemented in this program during the Full Scale Development Phase. CCDR formats and reporting methods are more time-consuming and detailed than many other cost-accounting techniques now being used by the contractors. When implemented, however, the cost data are separated into detailed categories which facilitate analysis efforts.

As noted for CPRs (Section 3.1.4), the CCDR reports contain only current information. The data may be evaluated and extrapolated in the same manner as for CPRs.

3.2 PROCEDURES FOR DATA ACQUISITION

Since the reports cited as data sources are all CDRL items, a procedure for timely distribution within the Cruise Missile Project should be sufficient to establish the necessary review efforts. PMA 2632 should provide for copies of each report to be directed to the designated analyst(s) immediately upon receipt. Some adjustments of report delivery schedules may be needed to assure the availability of all reports in the same timeframe.

A file of contractor reports indexed by reporting period should be established for use by the cost analysts. Initial reviews should be accomplished in the same week the reports are received, and this action should be prerequisite for attendance at progress reviews. If the analysis indicates that further investigation is required, a specific agenda item for the next MPR should be established. (If an overall cost review is scheduled at an MPR, then the need for a special agenda item may be alleviated.) In all cases, PMA 263 should determine the need for cost discussions at MPRs based on the best data available.

If DTC is an MPR agenda item, then DTC working group should meet in a separate session to resolve any anomalies detected and to acquire any amplifying data necessary to problem resolution.

Chapter Four
UPDATING COST BASELINE

4.1 ANALYSIS PROCEDURES

A continuing program to monitor and update the cost baseline for the Cruise Missile would generally follow the steps outlined in the decision tree of Figure 1.

The first step of the diagrammed procedure is to review available data for comparison with the latest baseline information. The intent is to identify potential causes of changes to the baseline, e.g.,

- a. Major technological modifications
- b. Cost deviations from the current baseline
- c. Missed project milestones.

Subsequent steps in the analysis are then as indicated in the decision tree, which outlines a complete procedure for the identification, classification, and reporting of DTC-related problems. Decision-tree branches not accounted for in the data sources, such as a missing tradeoff study, should be brought to the attention of PMA 263 immediately.

Both main branches in Figure 1 (A) and (B) lead to the assessment of a cost change or impact. If it is determined that a change in recurring costs has been made (point C), note that a new cost estimate is required. Both current and projected cost changes are addressed in this methodology.

4.2 MEASUREMENT CRITERIA

All measurements or assessments of cost/performance data received are evaluated relative to their baseline values. It is therefore imperative that the analyst have available the latest documentation pertaining to schedules, cost estimates, performance parameters, and subsystem configurations.

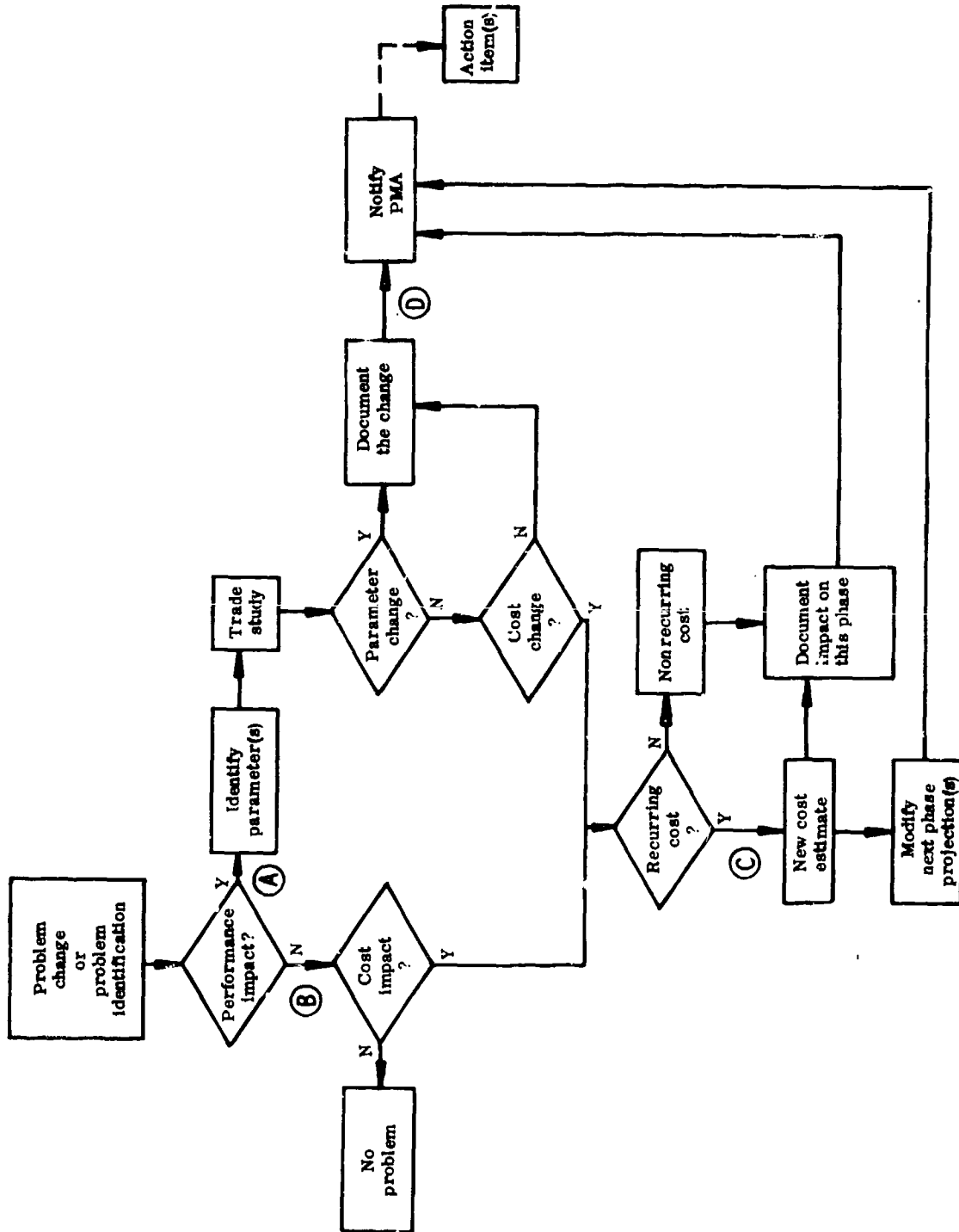


Figure 1. Decision Tree for Analysis and Reporting of Identified Problems

Cost impacts are assessed at the work package level. The analyst must be able to determine if changes are of recurring or nonrecurring type, or both. An understanding of a contractor's work package and its relationship to the contract WBS are therefore prerequisites to cost analysis. Cost-breakdown charts such as illustrated in Figure 2 can assist the analyst by depicting the cost baseline in an organized, understandable format.

In instances where a performance parameter has been modified (for example, a decrease in range), the cost impact may not be determinable without further information. Any such supplementary data required should be obtained at a monthly progress review or through special request of PMA 263.

1.3 REQUIREMENTS FOR REPORTS

As illustrated in Figure 1, point (D), changes in cost vs. performance criteria should be documented by the analyst and immediately referred to program management's attention. By serializing and logging each report, PMA 2632 will assure documentation and control of problems until adequate corrective actions are taken.

The reporting process could be similar to that for reliability failure reporting. A "Design-to-Cost Problem Report" would document the problem (or potential problem), provide details as to its source or cause, and recommend corrective actions. PMA 2632 should maintain a file of these problem reports and provide for attachment of a closeout sheet when problems are resolved. A suitable format for the report could be a one- or two-sheet narrative of the problem and recommended corrective actions.

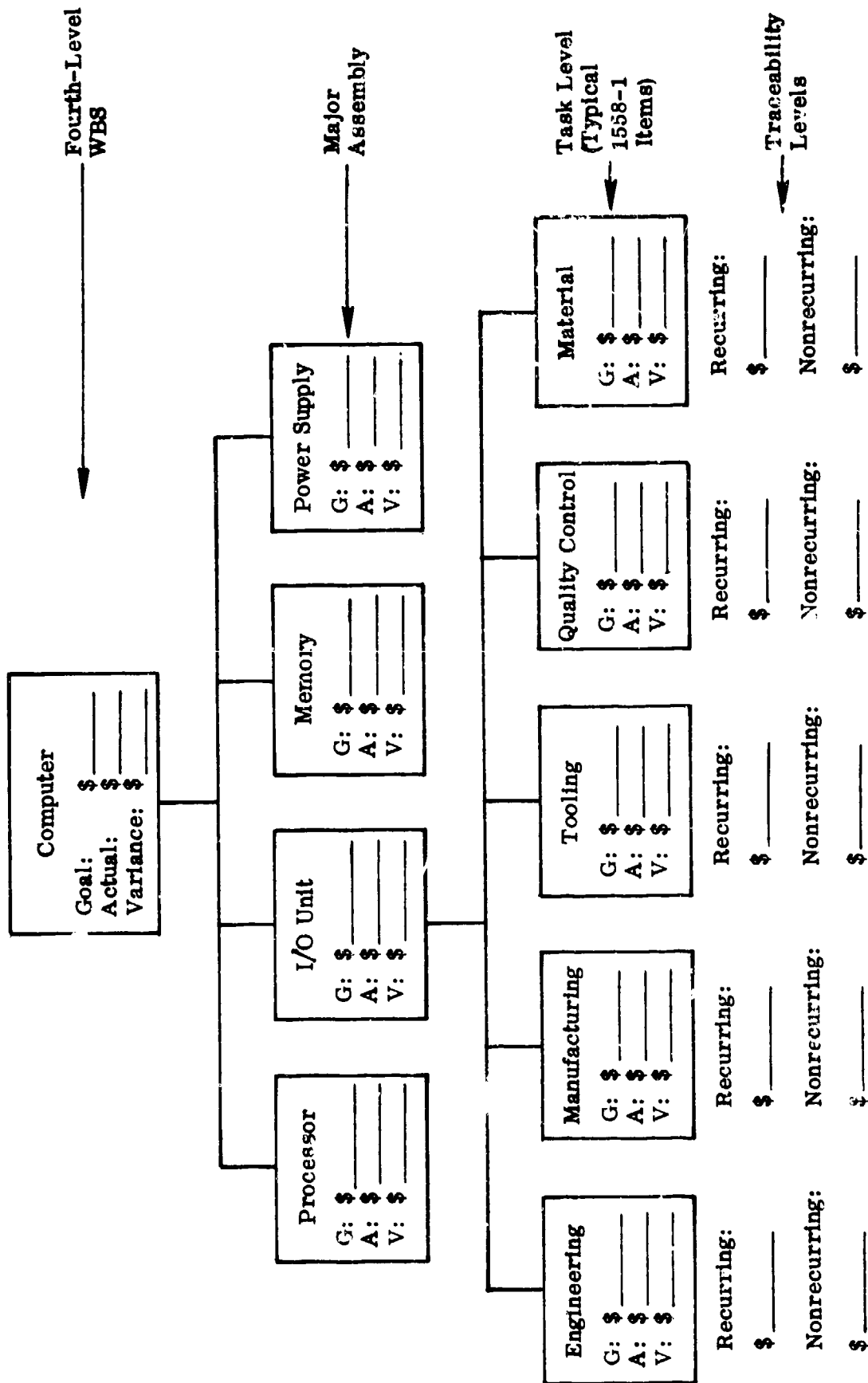


Figure 2. Typical Configuration/Cost Breakdown Charts

Chapter Five

CONCLUSIONS AND RECOMMENDATIONS

5.1 CONCLUSIONS

Based on ARINC Research Corporation's participation in the Cruise Missile Project, including the analysis developed in this report, it is concluded that:

- a. The project has developed DTC goals early and has made several significant updates.
- b. The present method of monitoring and updating the DTC baseline is too informal to achieve the results that PMA 263 would prefer.
- c. The existing CDRL and MPR requirements are sufficient to maintain DTC estimating, with some possible modifications in contractor delivery schedules and formats.

5.2 RECOMMENDATIONS

To implement an effective DTC monitoring plan with a minimum of expense and formal procedures, it is recommended that:

- a. PMA 2632A be designated as the DTC monitoring system coordinator.
- b. PMA 2632 designate cost analysts for receipt of specific CDRL items.
- c. The designated analysts prepare and submit recommended report formats.
- d. Logging, recording, and routine follow-up procedures be implemented, both for 1) MPR action items affecting cost and design-to-cost, and 2) problem reports generated by designated DTC analysts.
- e. Regular project reviews of DTC problem reports prior to each MPR be instituted.