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ACQUISITION MODEL FOR
THE CAPTURE AND
MANAGEMENT OF
REQUIREMENTS FOR
BATTLEFIELD SOFTWARE
SYSTEMS

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ACQUISITION MODEL FOR THE CAPTURE AND MANAGEMENT OF REQUIREMENTS FOR BATTLEFIELD SOFTWARE SYSTEMS

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CECOM CENTER FOR SOFTWARE ENGINEERING
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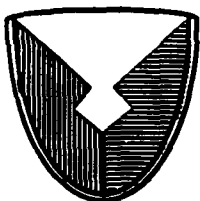
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This report presents an acquisition model that meets the needs of new and unprecedented systems that are software intensive, large, complex, and have extensive man-machine interface requirements. When properly applied, it should reduce the cost, schedule, and quality risks that have been associated with these types of procurements. This model is proposed within the context of DOD-STD-2167A and can be tailored to apply to a wide range of acquisitions.

This model acknowledges that requirements have not and perhaps can not be fully and adequately specified up front, prior to acquisition, especially for large and complex systems. Rather, they evolve throughout the system life cycle. It stresses that requirements must be **engineered** and **managed**, not merely written.

The model proposes six risk reduction strategies, which have been previously recommended by numerous DoD studies. This report provides guidance for the Project Manager on their implementation.

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TABLE OF CONTENTS

APPENDICES

A. TECHNICAL GUIDANCE FOR REQUIREMENTS ENGINEERING CONTRACT RFP PREPARATION AND EVALUATION

B. TECHNICAL CONTENT FOR A STATEMENT OF WORK FOR REQUIREMENTS ENGINEERING SUPPORT

C. REQUIREMENTS ENGINEERING PLAN FORMAT AND CONTENT

D. USER INTERFACE SPECIFICATION

E. GLOSSARY OF TERMS AND ACRONYMS

F. BIBLIOGRAPHY

G. GRAPHICAL OVERVIEW OF THE ACQUISITION MODEL

1.0 EXECUTIVE SUMMARY

This report presents an acquisition model that meets the needs of new and unprecedented systems that are software intensive, large, complex, and have extensive man-machine interface requirements. When applied properly, it should reduce the cost, schedule, and quality risks that have been associated with these types of procurements. This model is proposed within the context of DOD-STD-2167A and can be tailored to apply to a wide range of acquisitions.

Although the immediate audience of this report is the Project Manager, all defense acquisition personnel can benefit from its contents. The intent of this report is to characterize a process model for Requirements Engineering and not to fully specify every detail for its implementation.

The following problems have adversely affected acquisitions: Solicitation and award of a full-scale development contract with incomplete and/or ambiguous requirements; delayed requirements definition and documentation; the appearance of contractual relationships that encourage requirements to increase; and dynamic operational environments where requirements continue to change.

It is acknowledged that requirements have not and perhaps can not be fully and adequately specified up front, prior to acquisition, especially for large and complex systems. Rather, they evolve throughout the system life cycle.

This model stresses that requirements must be **engineered** and **managed**, no merely written. It proposes the following six risk reduction strategies: Designate a Requirements Engineering effort which applies Requirements Engineering techniques from the early project phases and on; contractually decouple requirements definition from the full-scale development effort; establish a functional baseline with an approved System/Segment Specification prior to the solicitation and make the System/Segment Specification a part of the solicitation package; document the user interface and interaction in the System/Segment Specification, together with system testing information; provide structure for the relationship and interaction between the user and the full-scale development contractor for all requirements related matters; and plan to develop systems in an evolutionary manner.

These strategies have been previously recommended by numerous DoD studies. This report consolidates many of their recommendations. It also provides general guidance for the Project Manager on their implementation, from 'Milestone Zero' through the fielding of the last incremental release, presenting the responsibilities and relationships of the primary participants. Appendices provide additional detail, providing information for the acquisition of a Requirements Engineering effort, a proposed format and content of a Requirements Engineering Plan for a typical project, guidelines for the specification of the user interface, a glossary, a bibliography, and a graphical overview of this model, suitable for presentation.

2.0 INTRODUCTION AND BACKGROUND - "WHY"

2.1 Introduction

This document presents a model for the acquisition of software intensive battlefield systems. The model is intended to reduce software life cycle cost, schedule and risks by concentrating on improving the capturing and managing of requirements.

This section contains background information on the need for a new acquisition model.

Section 3 describes the model and provides general guidelines.

Section 4 provides criteria for determining if and when to apply this model.

Section 5 presents specific guidelines for the Project Manager to implement the model.

Section 6 delineates our efforts to insert the model.

The appendices provide additional information for acquisition personnel to implement this model.

2.2 Background

Modern weapon systems are software intensive. That is, they rely heavily on software to provide functionality. These systems are characterized by having extensive user interfaces and interdependence with other systems. They are typically large and complex and they operate in a dynamic environment.

The delineation of requirements for such systems is often incomplete, inconsistent, and specified at varying degrees of detail, all of which significantly contribute to the risk of the development. Some full-Scale Development (FSD) contracts for such systems are awarded with incomplete and ambiguous requirements, as the time and effort needed to improve upon requirements definition is frequently underestimated. Requirement errors are frequently not being discovered until much later in the development and acquisition process, resulting in cost and schedule growth. In addition there have been systems for which the specification of user interface and interaction detail was delayed until the critical design review, making changes and improvements very costly in dollars and schedule.

Currently, FSD contractors, in their role of requirements capture, keep the government apprised of new capabilities that can enhance the system being developed. The identification of these capabilities may arise either from new technology or from knowledge of the limitations and potential of the system as it matures. Users and their representatives are typically receptive and supportive of additional requirements which they perceive as providing them with more options and functionality. There have been cases where the FSD contractor was in the awkward position of appearing to drive up the system requirements as a result of this relationship.

Finally, some acquisitions plan to develop and field the system in a single step, not allowing new and unforeseen requirements that materialize as the system matures to be easily incorporated, or uncertainties of risks in implementation to be timely dealt with.

3.0 DESCRIPTION OF THE ACQUISITION MODEL - "WHAT"

This acquisition model stresses Requirements Engineering, emphasizing techniques for requirements definition and change management.

The model recommends the following six strategies for risk reduction:

- Designate a Requirements Engineering effort which applies Requirements Engineering techniques from the early project phases and on.

- Contractually decouple requirements definition from the FSD effort.

- Establish a Functional Baseline (FBL) with an approved System/Segment Specification (SSS) prior to the solicitation and make the SSS a part of the solicitation package.

- Document the user interface and interaction in the SSS, together with system testing information.

- Provide structure for the relationship and interaction between the user and the full-scale development contractor for all requirements related matters.

- Plan to develop systems in an incremental, evolutionary manner.

These strategies have been recommended by numerous studies and workshops (refer to [1]through [4]). This model consolidates those recommendations that are most applicable to our software intensive battlefield systems.

While this model should reduce the quantity and severity of requirements related problems, it is not envisioned that they will or can be eliminated. We will always have valid needs to change requirements, from such reasons as advances in technology, changes in enemy tactics and capabilities, changes to external systems which must be interfaced with, and insight gained during the system implementation.

The following subsections present these strategies.

3.1 Designate a Requirements Engineering Effort Which Applies Requirements Engineering Techniques from the Early Project Phases and On.

Requirements Engineering is the process of applying engineering disciplines to requirements definition and management.

It is not sufficient to write requirements. Requirements must be **engineered** and **managed**. This model strongly suggests the early designation of a team or effort that is responsible for engineering the system's requirements, the Requirements Engineer (RE).

RE must wear many hats. To the user, the RE is a developer, exploring the feasibility and impact of their requirements and then validating them. To the Project Manager (PM), the RE is a

consultant on requirements and their impact. To the FSD contractor, the RE is the user, who seeks clarification for requirements related questions. The latter is bound to occur, as a significant amount of requirements refinement and clarification occurs during the software design phase.

As this function is highly technical and system oriented, it may be appropriate for the project's system engineer to be assigned the lead responsibility.

Staffing the RE team will be a non-trivial and critical task. It is most advantageous for the Government to have its own personnel perform this function directly, and not through a contractor. The Government, itself, must be the one who is the most aware of what it needs, the system requirements. However, this may not always be feasible, due to personnel constraints, and it may therefore require contractual support.

One can view the RE as having a role that is similar to an architect of a building project [5].When constructing a building, we prefer to consult with the expert and independent architect regarding our needs and desires, not construction contractors, who may have expertise, but who also benefit from the new work that requirements generate.

The RE should be under the control and direction of the PM and the effort should be initiated prior to the FSD solicitation with the immediate goal of enhancing the FSD procurement package.

From the earliest acquisition planning phases, adequate time must be allocated for the RE effort. The effort, itself, must begin no later than the initial drafts of the Operational and Organizational Plan and Required Operational Concept documents, early on in the project and before commitments by Government and contractors are made.

Although this report is not a tutorial on Requirements Engineering, it should be noted that the RE has a host of tools and techniques at his disposal to symbolically construct aspects of a system and effectively derive and validate the requirements. Technology provides the capability to quickly generate sample screens, interactions, and representative usage of a proposed system. We refer to this technique as prototyping. We also include simulation and modelling in our definition of prototyping.

Prototyping can be effectively used to test the feasibility of both user requirements and possible implementations. Prototypes can be generated to capture and examine user interface and other external interface requirements, communication protocols, functional operations, conditions, constraints, and performance. Prototyping can be used to perform trade-off studies. Prototyping may also shed light on total system acquisition costs. Finally, symbolic construction typically involves designing the symbolic system, where invaluable insight on the requirements and their allocation for the real system is derived.

There is, however, a major pitfall with rapid prototypes. Although quick, they are also 'dirty.' That is, they are not always engineered in a way that is efficient or easily maintainable (fixable and changeable). The FSD effort is engineered properly, but the user has to wait for it. A common occurrence when a prototype provides or appears to provide needed capabilities is that the user wants to field it immediately. The PM must make it clear to all who have a stake in the

system, the stakeholders, that the use of a poorly engineered prototype in actual fielded applications is not recommended, nor can such a system be supported.

Reference is provided [6] for additional information on prototyping and other Requirements Engineering techniques.

This model recommends that the RE be involved with requirements related issues throughout the lifetime of the project, not just during its early stages. During system development, the RE should interact with the Combat Developer (CD) regarding proposed changes to the baseline. The RE should interact with end users after initial system fielding to gain their feedback. Relevant activities include: prototyping to define or refine requirements for future blocks; risk and feasibility analysis; trade-off studies; requirements change impact analysis; tracing requirements between documents; maintaining the consistency of requirements documents; verification that requirements are being met by the developer; and supporting the PM during reviews and audits.

The PM must carefully assess the requirements for the Requirements Engineering effort and then monitor it carefully. Just as with the FSD effort, the risk of requirements proliferation exists. Unlike the FSD effort though, this effort is on a much smaller scale, reducing risk impact.

3.2 Contractually Decouple Requirements Definition from the Full-Scale Development Effort.

Requirements are a major driving force in acquisition cost and schedule. They should, therefore, be engineered by an independent agent, the RE, and not by the FSD contractor who stands to gain additional work from additional requirements.

A RE contractor should therefore be precluded from the FSD competition and subcontracting.

The FSD contractor should only be responsible for activities beginning with software requirements analysis. This strategy would insure that the design effort commences with a well stated set of requirements.

To minimize the learning curve for the FSD contractor to become familiar with the system's requirements, industry should be kept informed of the acquisition potentials of the system at the earliest possible time. They should also be provided with drafts of all releasable requirements documents, as they become available, as well as prototypes, if appropriate. In the past, comments received from industry during this stage have proven to be invaluable for many projects.

3.3 Establish a Functional Baseline with an Approved System/Segment Specification Prior to Solicitation and Make the Specification a Part of the Solicitation Package.

Solicitation and award of the FSD contract without a firm understanding and agreement with the CD and all stakeholders on the requirements will lead to a contract that lacks firm (or any) cost and schedule commitments.

The recommended strategy is to have the RE write the SSS and conduct the System Requirements Review prior to the solicitation. The approved and validated SSS would then come under Government configuration control and become part of the FBL. The SSS should also become

5

a part of the solicitation package. In doing so, we will know what we are buying and bidders will know what we really want.

This approach does not eliminate the possibility of changing the requirements during the solicitation period and during the development, with controlled revisions of the SSS. However, it does reduce some of the opportunities for changes with serious impact to occur.

3.4 Document the User Interface and Interaction in the System/Segment Specification, together with system testing information.

As mentioned previously, user interface and interaction details are rarely agreed upon in a timely manner. This greatly impacts cost and schedule. Section 3.2.3 of the SSS format describes the interfaces with external systems. This is an ideal place to provide detail on the man-machine interface and interaction from the user-perspective of the system. A detailed breakdown of the information that is needed for this section is provided in Appendix D.

It should be noted that section 4.0 of the SSS deals with provisions for quality assurance. Test case requirement coverage and general system test philosophy should be specified by the RE in this section. Additionally, the RE may be asked to specify the system requirements test plan and cases in separate documents. For some developments, it may be appropriate for the RE to support or actually perform the testing.

3.5 Provide structure for the relationship and interaction between the user and the full-scale development contractor for all requirements related matters.

As mentioned previously, the relationship between the FSD contractor and the user can unknowingly contribute to requirements growth. This model recommends that the user/ FSD interaction be restricted to the point where there is no appearance of a conflict of interest. For example, the contractor should be restricted from picking up the phone and suggesting new requirements directly with the user. Rather, the user and the contractor should interact with the PM and RE.

As the expert on the system requirements, the RE is a competent representative and advocate for user needs to the developer. As an expert on system development, the RE is able to evaluate feasibility and discuss technical concerns with the user.

The CD should be an active participant in the system's formal reviews. These reviews provide a formal and controlled environment for user-developer interaction. Understandably, interactions such as end user evaluation at the contractor site should not be precluded.

3.6 Plan to Develop Systems in an Incremental, Evolutionary Manner.

Our battlefield systems are often too dynamic and/or complex to field successfully in a single release. It is, therefore very difficult to plan for a system's development in one release, or block.

Plans for the development should call for incremental releases of the system. It is recommended that users prioritize their requirements, listing and rating them by need and by certainty. Requirements that are certain, well understood and that are critical to user/system

functionality should be met in the initial release. These requirements should be specified in detail in the body of the SSS. This initial system must be useful to the user, providing essential capabilities, albeit it is not everything that is needed.

Requirements for subsequent releases must also be documented in the SSS. They can be stated in separate appendices and at this point, do not need the great detail of the initial release's requirements.

Requirements for subsequent releases can become separate options on the FSD contract or they can be separate procurements, depending on the system.

As the RE completes work on a block, the RE should continue to interact with the CD and all system stakeholders to refine and document requirements for subsequent blocks. The end user must provide the RE with feedback from his experience with blocks already in the field.

Just as with the initial release, subsequent releases must be completely defined, validated by all stakeholders, and baselined before commitments are made to implement them.

4.0 MODEL APPLICABILITY -"WHEN"

This section presents the characteristics of systems that would most benefit from applying the strategies of this model. Any one of these characteristics can be sufficient to warrant the use of this model. The model can also be tailored, applying some of its six strategies to broaden its relevance.

As an example, a new and complex Command and Control system would benefit significantly from the application of this model to its acquisition.

4.1 Medium to Large Size.

Systems that are expected to exceed 50,000 source lines of code usually require lengthy development schedules, significant investment in resources (funding, management attention, and manpower), extensive design efforts, and prolonged test and evaluation programs. The potential for overruns due to faulty or deficient system requirements in these programs warrants the use of this model to reduce the technical risk and shorten the development schedule through advanced requirements definition techniques prior to FSD.

4.2 Complex Functionality.

When a system has complex functions, there is a very high risk of cost and schedule growth unless the requirements are defined prior to FSD to the fullest possible degree. Complexity can come from having a large number of user options or having a large number of external interfaces. It can also come from the internal complexity of the software needed to satisfy the functional requirements. This model recommends the application of Requirements Engineering technologies to better understand and specify system requirements.

4.3 Intensive Man-Machine Interface.

Without hands-on user involvement, it is difficult to specify and validate the requirements for systems that have complex, user-dependent, man-machine interfaces. This model recommends rapid prototyping and the early documentation of the user interface and interaction.

4.4 Unprecedented Systems.

Systems which are being developed to provide capabilities that have not been previously available would benefit greatly from this model. As the delivery of the system will probably change the operational environment, users need to work with prototypes early on, to understand potential applications and impacts.

5.0 PROJECT LEVEL MODEL IMPLEMENTATION - "HOW"

This section provides the PM with additional guidance on applying the acquisition model. This is divided into four time frames:

- Milestone 0 to Requirements Engineering Task Initiation.

- Requirements Engineering Task Initiation to Release of the FSD Request For Proposal (RFP).

- FSD RFP Release to Contract Award.

- FSD Contract Award to Final Block Deployment.

This model proposes no changes to procurement strategies before Milestone 0.

Each of the following sections identifies the model activities during these phases and presents responsibilities and relationships of the primary participants.

5.1 **Milestone 0 to Requirements Engineering Task Initiation**

After Milestone 0, the PM prepares an Acquisition Plan, based on risk analysis, which addresses the degree that the model will be utilized and the needs for Requirements Engineering. The plan should include:

- The block release approach.

- A scope and strategy for Requirements Engineering.

- A proposed source for the Requirements Engineering expertise, either in-house or contract.

If a Requirements Engineering contractor is needed, a cost reimbursable type contract is recommended because the tasks for this effort are difficult to predict. Appendix A contains guidance for acquiring a Requirements Engineering contractor. Appendix B contains technical content for a Requirements Engineering Statement of Work. The latter can also be used when the Requirements Engineering is being done by Government personnel.

Prospective bidders should be requested to document their approach in a Requirements Engineering Plan. After contract award, the Requirements Engineering Plan should become part of the contract. A proposed format and content of this plan is provided in Appendix C.

Responses to a Requirements Engineering RFP should be evaluated based on the bidder's understanding of the technical and operational characteristics of the objective system, the candidate's expertise in Requirements Engineering, and his relevant experience in system development.

5.2 Requirements Engineering Task Initiation to Full -Scale Development Request for Proposal Release

The goal of this phase is to produce a high quality FSD procurement package, with clearly specified requirements and a FBL, documented by a SSS.

Under the direction and control of the PM, the RE develops the FBL. The PM, together with the RE, must identify the areas of requirements related risk. From this analysis, the Requirements Engineering Plan may need to be revised in order to identify the portions of the system that need to be studied, the techniques that should be used, and who should review the products. The PM must insure a disciplined flow of information between the program participants and that all requirements related information is well documented and transferrable. The PM must evaluate the evolving requirements, providing guidance to the RE through frequent interaction and in-progress reviews.

It is recommended that the PM keep industry apprised of the developing RFP, providing them drafts of requirements related documents and products, as appropriate, as well as a draft RFP. Care must be taken to give equal access and opportunities to all prospective bidders.

The RE must engineer the requirements, refining and transforming the requirements from a broad Mission Needs Statement to a validated FBL. In addition, the RE must insure that the requirements are feasible, consistent and testable. Using the best available Requirements Engineering technology, the RE interacts with the CD and/or end user in an iterative fashion, until the requirements are clarified, validated, and refined for a quality SSS.

In all likelihood, the first release will have some, but not all, of the functionality that the end users requested. The PM must work carefully with the RE and all stakeholders as they prioritize requirements for the initial release. The following factors relating to a requirement should be considered:

- Criticality.

- Desirability to the user.

- Implementation risk.

The block release strategy must be reflected in the SSS. The body of the SSS should focus on the initial release. All subsequent block releases must be planned, specified in as detailed a manner as is possible, and incorporated into appendices of the SSS. All requirements in the SSS, as well as proposed incremental versions, must be documented and clearly traceable to source documents.

The SSS is formally validated through the Systems Requirements Review, per DOD-STD-2167A. This review should be hosted by the RE, who authored the SSS. Once accepted, the SSS is placed under configuration control.

The validated SSS becomes part of the FSD RFP, enhancing the procurement package and providing confidence for the commitment of resources needed to build the system.

The CD supports both the PM and the RE by providing expertise or actual end users to meet the Requirements Engineering needs. The CD must review the FSD RFP.

5.3 **Full-Scale Development Request for Proposal to Contract Award**

To maintain procurement integrity, the SSS must be frozen before the FSD RFP is issued. In a dynamically changing world, this is not always possible and user needs may dictate a pre-award revision. Also, the Government may receive valuable insight from comments from the bidders. If possible, changes should be relegated for inclusion in later incremental blocks. If changes are mandated, all bidders must be given sufficient time after receipt of the updated specification to submit their 'Best and Final Offer.'

Once Block One requirements have been baselined, the RE can begin defining and refining requirements for subsequent incremental blocks, repeating the process used in the identification of the Block One requirements.

5.4 **Contract Award to Final Block Deployment**

During this phase, the RE tasks during this period include interacting with system stakeholders and the FSD contractor, supporting the initial block's development, and supporting the development of future blocks.

When discussing requirements with a stakeholder, the RE must play the role of the FSD contractor and evaluate requirements feasibility and impact, consulting and/or involving the FSD contractor as necessary. The RE should then provide the PM with a recommendation and an implementation approach. If this new or changed requirement is approved, the RE should document it as an Engineering Change Proposal.

To the developing contractor, the RE is the surrogate user, answering requirements related questions and seeking clarification from the CD when necessary.

If the FSD contractor differs with the RE, then the PM will make the final decision.

The RE can support the PM in the same areas that were suggested for Block One. Because the RE has an in-depth understanding of the system specifications and the development rationale, the PM can use this knowledge to aid in overseeing the FSD effort. The PM can use the RE to assist in ensuring that the system's requirements are being met. The RE may provide support during reviews and may review draft contract data requirements list items. The RE can also be tasked to trace the evolving requirements to source documents. The RE may provide technical support to the project's Configuration Control Board to review proposed changes. The RE may prepare the plans and test cases for acceptance testing and perform the tests.

Future releases incorporate specific requirements which have been identified in the initial SSS and deferred to a later release. They also include requirements that are changes to the initial baseline, resulting from lessons learned from fielded releases. The RE should, therefore, solicit and record user feedback on their experience with the fielded releases.

Engineering, specification, and validation of the requirements for later block releases

proceeds in the same fashion as the first release. However, later blocks have the added constraint that the change must be compatible with fielded blocks.

When a proposed block FBL has been sufficiently defined, the RE should host a new SRR for it. This review should address new requirements, changes to old requirements, and compatibility issues between blocks.

The RE should be responsible for reflecting the evolution of the system by revising the SSS, using Engineering Change Proposals, providing additions and modifications to the sections that refer to the future blocks.

The PM must decide how new incremental blocks should be acquired. The existing FSD contract may make provisions for a block approach. Or, the contract may be modified, based upon new costs and/or schedules. Alternatively, a new contract could be awarded competitively. The existence of a RE gives the PM a resource to help him proceed with any of these strategies. Further, the RE can assist in the development of the necessary procurement documents.

6.0 EFFORTS TO PROMOTE THE MODEL AND GAIN ITS ACCEPTANCE

The acquisition model presented in this report proposes a small change to the current acquisition process. Current policies, regulations, and standards do not preclude the implementation of this model, but they do not encourage it, either.

A step-by-step approach is planned to gain recognition and acceptance of the strategies in this model. Our near term goal is for the model to be implemented and validated on a pilot project at the US Army Communications/Electronics Command (CECOM), monitoring and reporting the technical and financial benefits provided by it on the program.

In addition, we have prepared a Requirements Engineering tutorial to brief CECOM and PEO/PM organizations on the advantages and features of this model.

We also plan to use existing Defense Industry associations and trade journals to disseminate the model and its effect on the system development process. These associations provide an effective medium for educating industry and also provide a forum to obtain industry review and comment on this model.

Finally, CECOM Center for Software Engineering (CSE) is serving as CECOM's focal point for Requirements Engineering related research, development, and implementation. As such, the CECOM CSE would provide the necessary support in implementing this model.

Appendix A

CONSIDERATIONS FOR PREPARING A REQUIREMENTS ENGINEERING CONTRACT PROCUREMENT DATA PACKAGE

This appendix provides information to aid a Project Manager for the preparation of a Requirements Engineering contract's Procurement Data Package. It provides guidance for requesting relevant proposal data from bidders. It also provides considerations for evaluation approach. This appendix is not intended to be a sample Procurement Data Package, as contractual guidance, content, formats, and legal interpretation vary between acquisition agencies.

A.1 Relevant Proposal Data

A.1.1 General Considerations

In their technical proposal, bidders must be asked to demonstrate competence and a detailed understanding of the mission environment of the objective system, Requirements Engineering, and software engineering.

The contractors must identify their experience in working with other systems in the same general mission area as the objective system. This experience need not specifically involve requirements derivation. The purpose of the mission area experience is to guarantee a familiarity with the environment, terminology, and philosophy of the intended system.

Prospective contractors should be asked to cite specific experience in using Requirements Engineering tools, techniques, and methodologies for the development of the requirements of tactical software systems. They must identify specific projects in which this experience was used. They must identify those tools with which they have specific experience and that are available to support the Requirements Engineering process.

They should demonstrate their understanding of Requirements Engineering techniques by discussing perceived advantages and trade-offs associated with different Requirements Engineering approaches and techniques, as related to the objective system.

The contractors should outline, categorize, and discuss potential aspects of risk of the objective system development and present their approach to deal with them.

Bidders should be asked to provide a plan for staffing the Requirements Engineering effort. This plan should identify key technical and management personnel. Key individuals should be committed to participation in the effort more than 50 percent of their time and should not be replaced before 90 days after award. Resumes should be included for all key personnel. These resumes should fully document the individual's education and specific experience which is relevant to the effort. This staffing plan must include the bidder's approach for obtaining and assigning non-key personnel for the project.

The bidder's management proposal should cover the corporate and project management structure that will be in effect during the effort, including responsibilities, access to resources, quality assurance procedures and subcontract management.

A.1.2 Possible Draft Deliverables

Each respondent may be asked to submit draft CDRL items with their proposal. These sample deliverables provide insight into the contractor's understanding of the requirements of this effort. They also provide an insight regarding the contractor's capabilities as a RE. As the Government does not compensate prospective bidders for proposal preparation costs, the Government must keep this requirements to a minimum.

A.1.2.1 Requirements Engineering Plan.

The Requirements Engineering Plan documents the approach that the contractor will take to identify, document, and validate the requirements of the objective system, identifying all activities, schedules, tools, and resources that will be used in the requirements engineering process.

The format and content of a Requirements Engineering Plan is provided in Appendix C of this report. This document should become a part of the Requirements Engineering contract upon its award.

A.1.2.2 Requirements Engineering Notebook Format.

Requirements Engineering Notebooks document the underlying source and rationale of the system requirements, providing the PM with an audit trail from the requirements sources to the Requirements Engineering products and activities. The contractors would propose a structure and format for these notebooks.

A.1.2.3 Configuration Management Plan.

The Configuration Management Plan specifies how the contractor will maintain his developmental baseline control of requirements and prototypes until such time as the specifications are turned over to the Army for formal configuration control. The contractors would provide a draft of this plan.

A.2 **Proposal Evaluation**

A.2.1 Government Evaluation Team

The Government must ensure that a qualified team is available to support the evaluation of the Requirements Engineering proposals. Individuals on this team should have experience in the mission area of the objective system, Requirements Engineering, and software engineering. If such individuals are not available within the PM's organization, then the PM must draw support from other organizations for the procurement process.

A.2.2 Selected Evaluation Considerations

The following should be considered, at a minimum, when planning for the evaluation:

Technical:

- Demonstration of the contractor's understanding and experience in the mission area of the objective system. This should include a demonstration of the contractor's understanding of the risk areas associated with the objective system and an appropriate plan for mitigating those risks.

- Demonstration of the contractor's understanding and experience in Requirements Engineering. This should include the adequacy and appropriateness of the proposed Requirements Engineering methodology for the objective system.

- Demonstration of the contractor's understanding and experience in software engineering.

- Adequacy of the requested sample deliverables.

- Hardware and software resource availability to perform the work.

- Demonstration of the contractor's capability to write clearly, unambiguously, and concisely.

Personnel:

- Key and supporting personnel availability who are qualified in the objective system mission area, Requirements Engineering, and software engineering.

- Realism and adequacy of staffing plan for non-key personnel.

Management:

- Effectiveness of project organizational structure and management approach in controlling cost and schedule, and insuring quality.

- Adequacy and feasibility of plan for acquiring supplementary resources, such as subcontractors, if subcontractors are proposed

- Adequacy of the quality assurance approach.

Appendix B

TECHNICAL CONTENT FOR A STATEMENT OF WORK FOR REQUIREMENTS ENGINEERING SUPPORT

This appendix provides technical content for a Statement of Work for a Requirements Engineering contractual effort. This appendix was not written to be a sample RFP, as contractual guidance, content, formats, and legal interpretation vary between acquisition agencies.

The developing agency is referred to as [Agency]. The name of the objective system is referred to as [System].

This appendix was written as broadly as possible, including as many Requirements Engineering functions as possible. It may be tailored to apply to a wide range of acquisitions.

B.1 General Requirements

The RE shall be responsible for the development, refinement, validation, documentation, traceability, and management support of the [System] system requirements and their evolution. He shall interact with the Program Manager (PM), the Combat Developer (CD), the Full-Scale Development Contractor (FSDC), and all system stakeholders. The RE shall be responsible for the preparation of the Systems/Segment Specification (SSS) and the System Requirements Review. The SSS shall fully describe the user interface and interaction needs of [System]. This effort shall continue through the fielding of the final version of the last block release.

The above shall be accomplished in three distinct phases:

* Phase 1 -- Requirements Engineering task initiation through FSD RFP release

* Phase 2 -- FSD RFP release through contract award

* Phase 3 -- Contract award through final fielding

B.1.1 Phase 1 -- Requirements Engineering Task Initiation Through FSD RFP Release

During this phase, the RE shall establish a Requirements Engineering facility and environment. The RE shall structure/revise a cohesive plan for the Requirements Engineering needs for the acquisition and ultimate fielding of [System], performing whatever risk assessments that are necessary. The RE shall implement this plan. The RE shall verify that all requirements are feasible, consistent, testable, and complete. The RE shall interact with the PM, CD and system stakeholders to establish a feasible and acceptable system Functional Baseline (FBL) of [System], documenting it in the SSS. The RE shall host the [System] System Requirements Review (SRR). The RE shall prepare and submit technical reports and construct prototypes as required. A Requirements Engineering Notebook shall be developed and maintained, documenting the development and evolution of the system requirements. The RE shall support the incremental block release strategy for [System] that is approved by the PM and CD.

B.1.2 Phase 2 -- FSD RFP Release Through Contract Award

Throughout this phase, the RE shall maintain the SSS, effecting necessary minor revisions, prior to the receipt of best-and-final offers for contract award for the initial block of [System]. The RE shall also begin refining and documenting system requirements for subsequent blocks, utilizing the procedures employed and interfaces defined for Block 1 requirements.

B.1.3 Phase 3 -- FSD Contract Award Through Final Fielding

Throughout this phase, the RE shall assist the PM in monitoring the FSD of the [System] for requirements compliance. The RE shall identify discrepancies and anomalies between the system requirements and the system in development, recommending appropriate resolution when possible. The RE shall trace the evolving requirements to source documents. The RE shall create the requirements testing plan and cases and he shall perform the actual testing. The RE shall provide the PM with insight on the cost, schedule, and quality impacts of requirements changes and evolution. The RE shall be responsible for the documentation of new or changed requirements through Engineering Change Proposals (ECPs) to the FBL.

The RE shall maintain close liaison with the CD and available end users to identify any new or potential changes to the system requirements. He shall provide them with insight on the feasibility and impact of new requirements or requirements changes.

The RE shall provide technical support to the project's Configuration Control Board to review proposed changes. He shall support the CD in preparation of plans for field testing.

The RE shall answer the requirements related questions of the FSDC.

B.2 Detailed Requirements

The RE shall devise and implement processes for managing and performing all Requirements Engineering activities. Required engineering processes shall include, but may not be limited to the following:

- Develop/ purchase and maintain a Requirements Engineering environment.
- Assess and manage risk.
- Perform system requirements analysis and studies.
- Develop System/Segment Specification.
- Perform System Requirement Review.
- Trace requirements.
- Assess requirement changes and evolution.
- Create the requirements test plan, cases, and perform the testing.
- Monitor FSDC compliance with requirements.
- Interact with the FSDC.

- Perform system requirements analyses for block releases.

(Note: These processes may overlap and/or be applied iteratively/recursively.)

B.2.1 Develop and/or Purchase and Maintain an Automated Requirements Engineering Environment

With [Agency] approval, the RE shall develop or purchase Requirements Engineering software and hardware as required to identify and elicit requirements; evaluate requirements feasibility and alternatives; document requirements; trace requirements to source documents; and communicate with the CD and PM in requirements refinement and validation. The RE shall maintain the software and hardware associated with the Requirements Engineering environment throughout the life of the contract and they shall be delivered to the [Agency] at contract completion.

B.2.1.1 Configuration Management

The RE shall perform configuration management of the Requirements Engineering environment in compliance with the guidance found in MIL-STD-483 and supplements thereto.

B.2.2 Assess and Manage Risk

The RE shall establish and implement procedures for risk assessment that effectively identify, analyze, monitor, and mitigate areas of the [System] procurement that involve potential requirements related cost, schedule, or quality risks. They shall be documented in technical reports.

The RE shall establish and implement procedures for controlling risk to include:

a. Identifying the risk areas of the procurement and the risk factors in each area.

b. Assessing the risk factors identified, including the probability of occurrence and the potential impact to cost, schedule, and quality.

c. Identifying and analyzing the alternatives available for reducing the risk factors.

d. Proposing the most promising alternative for each risk factor.

e. Obtaining feedback to determine the success of the risk reducing action for each risk factor.

B.2.3 Perform Systems Requirements Analysis and Studies

B.2.3.1 Requirements Engineering Planning

The RE shall develop/revise and maintain plans for the conduct of all activities required by this SOW in a document entitled the Requirements Engineering Plan (REP). The format and content of this plan is provided. (See Appendix C.)

B.2.3.2 Apply Requirements Engineering Techniques to the Development of System Requirements

The RE shall perform and document trade-off analyses of alternatives for optional requirements.

The RE shall apply Requirements Engineering techniques and technology to develop the FBL, from mission needs statements and other high level requirements documents to its validation. The RE shall elicit and confirm the system requirements with all system stakeholders. The RE shall insure that all requirements are feasible, consistent, and testable.

The RE shall propose and develop a block release strategy for the system. The block release strategy shall ensure that the initial block release provides a set of capabilities that is approved by the PM and CD.

B.2.3.3 Requirements Engineering Notebooks

The RE shall document all Requirements Engineering efforts, participants, information, and sources of information in the Requirements Engineering Notebook which shall be in a format proposed by the RE and subject to [Agency] approval. The RE shall utilize this notebook to provide an audit trail of his activities.

B.2.4 Develop System/Segment Specification

B.2.4.1 System/Segment Specification

The RE shall prepare and maintain the SSS for the [System] which shall document all planned block releases. The initial SSS shall completely specify the requirements for the block 1 release and it shall be adequate for the solicitation and subsequent development of the first block of [System]. This SSS shall identify each subsequent block release to the level of detail possible at this time. The RE shall subsequently maintain the SSS to reflect the evolving requirements of this system.

B.2.4.2 User Interface and Interaction Specification

The RE shall identify and document the user system interface and interaction requirements at the same level as interfaces to external systems. Proposed content for this section is provided. (See Appendix D.)

B.2.4.3 Test Architecture

Section 4 of the SSS shall propose a test architecture for the system quality assurance provisions. The architecture shall be developed in concert with the designated test organization and shall address the system test philosophy. The architecture shall identify the resources that shall be required for system testing, including operational and test hardware and software. The architecture shall include the test evaluation criteria below:

• Traceability

- Consistency with requirements.

- Adequacy of test cases/test procedures.

B.2.5 Perform System Requirements Review (SRR)

The RE shall conduct the SRR in accordance with MIL-STD-1521. The RE shall present the SSS at the SRR for validation. The RE shall ensure that all changes approved at the SRR are incorporated in the revised SSS.

When incremental block FBL's are sufficiently defined and ready for implementation, the RE should host the SRR for it. This review shall address new requirements, changes to old requirements, and compatibility issues between blocks.

The RE shall provide the PM with minutes for all SRR's.

B.2.6 Trace Requirements

The RE shall trace all requirements from the high level source documents initially provided to the SSS. This tracing shall be implemented in an automated database and shall be expandable to include design related detail. (The RE shall trace the requirements to the following FSD deliverables: ...)

The RE shall provide traceability of requirements changes.

B.2.7 Assess Requirements Changes and Evolution

The RE shall evaluate all proposed changes identified by the PM/CD as to their completeness, accuracy, consistency, and testability and shall apply Requirements Engineering technology as necessary to refine the requirements. The RE shall assess the cost, schedule, and quality impact of the changes and make recommendations on whether the changes should be included in the current block release or a subsequent block release.

B.2.8 Create the requirements test plan, cases and perform the testing.

The RE shall create the requirements test plan and test cases for all releases that are delivered by the FSDC. They shall be documented in test plan and description documents per DI-MCCR-80014A and DI-MCCR-80015A. The RE shall perform all requirements related tests. The RE shall document the results of the tests in a test report, per DI-MCCR-80017A.

B.2.9 Monitor FSDC Compliance With Requirements

The RE shall support the [Agency] in the review of the FSD effort to verify that the design and implementation is consistent with approved requirements. The RE shall review all FSDC deliverables for requirements compliance; and attend progress review and formal design review meetings. The RE shall identify discrepancies and anomalies between the system requirements and the system in development, recommending appropriate resolution when possible.

B.2.9.1 Corrective Action Process (CAP)

The RE shall establish and maintain a CAP for all requirements related problems detected in items under development or configuration control. This process shall be closed-loop, ensuring that all detected problems are promptly reported and entered into the ECP process, actions are initiated on them, resolutions are achieved, status is tracked and reported, and records of the problems are maintained in the Requirements Engineering Notebook for the life of the contract. The RE shall prepare reports, as required. The RE shall classify each problem identified by category (i.e., requirements, code, design, etc.) and by priority (i.e., high, medium, and low); and perform analyses to detect adverse trends in the problems reported. The RE shall closely monitor the FSD effort to verify that problems have been resolved, adverse trends have been reversed, changes have been correctly implemented in the appropriate FSDC processes and products, and no additional problems have been introduced.

B.2.10 Interact with the FSDC

The RE shall support the FSDC by answering requirements related questions, seeking clarification from the CD when necessary. The RE shall report all queries and his responses to the PM.

B.2.11 Perform System Requirements Analysis for Block Releases

The RE shall apply Requirements Engineering techniques, tools, and methodologies to define, refine, and document the evolving requirements of block releases in concert with the PM and CD. The RE shall solicit and record user feedback on their experience with fielded releases to clarify and define the evolving requirements. The RE shall revise the SSS, using ECPs to reflect the evolving requirements. Later blocks have the added constraint that they must be compatible with fielded blocks. The RE shall repeat the relevant activities in this SOW for each block release.

B.3 Reporting

B.3.1 Monthly Status Reports

The RE shall submit monthly status reports identifying the status of the development of the requirements; the areas addressed; the stakeholders that have been contacted; the requirements that have been identified; issues that have been clarified; and any problems that have been encountered. This status report shall also contain information on personnel assigned during the reporting period; personnel expected to be assigned next reporting period; travel completed this period; travel anticipated next period; costs during this period, cumulative through this period, and projected for next period; and anticipated activities for the next period.

B.3.2 Quarterly Progress Reviews

The RE shall conduct quarterly progress reviews describing all the efforts of the previous quarter. All areas addressed in the Monthly Status Reports shall be discussed, but on a quarter-wide basis.

B.4 Deliverables

B.4.1 Prototypes, Models, Simulations, and Tools

By the end of this contract, the RE shall deliver all prototypes, models, simulations, and/or tools generated in the process of developing the [system] requirements. They shall be delivered, with documentation, as proposed by the contractor and approved by [Agency], and with unlimited rights to the Government. The RE shall ensure that the systems and documentation, as delivered, are sufficient to allow each item to be installed and executable on a commercially available Government owned host computer. The RE shall insure that sufficient documentation and special purpose hardware/software are provided to enable the Government to run and modify all prototypes. [Note: Serious consideration should be given as to whether the need for acquiring the above justifies the potential costs.]

All hardware and software that was purchased by the RE with contract funds shall be delivered to the [Agency] at the end of this contract.

B.4.2 System/Segment Specification

The RE shall finalize and deliver the SSS for the [System]. The initial SSS shall be presented at a System Requirements Review for validation. The revised SSS shall be delivered for use in the [System] acquisition. The RE shall maintain this document throughout the life of this contract, providing the PM with the latest version upon request.

B.4.3 Requirements Test Plan

The RE shall develop a requirements test plan for all releases of the objective system. It shall be in the format of DI-MCCR-80014A. These plans shall be provided (# months) prior to the Governments's acceptance testing of the FSDC system releases.

B.4.4 Requirements Test Description

The RE shall specify the requirements related test cases. They shall be documented in the format of DI-MCCR-80015A. They shall be provided (# months) prior to acceptance testing of the FSDC system releases.

B.4.5 Requirements Test Report

The RE shall document the results of all requirements related tests that he performs. They shall be in the format of DI-MCCR-80017A. They shall be provided within (#) days of the tests.

B.4.6 Requirements Engineering Notebook

The RE shall develop and maintain the Requirements Engineering Notebook, providing an audit trail on the development of the [System] requirements. This notebook shall be available to the PM at any time for inspection, reference, and reproduction. This notebook shall be delivered to the [Agency] at the end of the contract.

B.4.7 Technical Reports

The RE shall provide RE technical reports as required in a mutually agreed upon format.

B.4.8 Minutes of the SSR

The RE shall provide the PM with minutes of all SRR's that are hosted.

B.4.9 Monthly Status Reports

The RE shall submit Monthly Status Reports.

B.5 Constraints

By selection as the RE for the [System], the RE shall be precluded from bidding on future FSD efforts for the [System]. In addition, the RE shall be precluded from subcontracting to perform work for the FSD effort.

Appendix C

REQUIREMENTS ENGINEERING PLAN FORMAT AND CONTENT

This appendix provides the format and content of a Requirements Engineering Plan. This plan provides the Requirements Engineering approach and identifies all activities, schedules, tools, and resources that will be used in the Requirements Engineering effort.

Since the Acquisition Model can be tailored, not all sections of this document may be applicable to a specific project.

C.1 Requirements Engineering Activities

C.1.1 Systems Requirements Analysis.

This specifies the approach for performing the objective system's requirements analysis.This should discuss the plans and schedule for interaction with the stakeholders throughout the life cycle of the effort.

C.1.2 Risk Assessment.

This section addresses the specific procurement risk assessments that will be performed for the objective system.

This should provide a plan for mitigation of risk for each risk area, specifying specific methods, techniques, and tools.

C.1.3 Alternative Concepts and Trade-off studies.

This section addresses the specific studies that are needed. This will include the aspects of the system that will be analyzed and the criteria that will be used in making trade-off decisions between conflicting requirements.

C.1.4 Systems Requirements Review.

This portion of the plan discusses the approach for the Systems Requirements Review. This should include criteria for passing the review and a plan for the validation of the functional baseline which will be formed as a result of this review.

C.1.5 Objective System RFP Enhancements.

This section identifies the products that will be developed to enhance the RFP for the objective system. This should minimally include the SSS and a recommended tailoring of the SOW and CDRLs of the objective system.

C.1.6 Cost, Schedule, and Impact Estimation

This specifies the approach for preparing cost, schedule, and quality impact analyses for proposed changes to requirements during the development of the objective system. This should discuss the measurement of the uncertainty of the estimates, based upon the uncertainty of the requirements. This section should also describe the approach for coordinating the development and data management efforts to ensure interface compatibility and maintainability.

C.1.7 Requirements Tracing.

This section identifies the method and techniques that will be used to trace the requirements.

C.1.8 FSD Contractor Monitoring Support.

This section identifies the approach and extent of support for FSD contract monitoring to insure that the objective system is in compliance with system requirements.

C.1.9 Change Management.

This section identifies the approach for supporting the management of changes to requirements. It should include change request procedures, tracking change requests and their implementation, and trend analysis.

C.1.10 Systems Analysis for Block Releases.

This section presents the approach for performing system analysis for requirements during incremental development.

C.1.11 System Requirements Testing

This section presents the approach for planning the system requirements tests, specifying the test cases, and participation in the actual testing.

C.2 **Requirements Engineering Techniques**

C.2.1 Requirements Engineering Tools

This section identifies the methodologies and tools that will be used for the development, validation, documentation, and management of requirements. This section should discuss how and when they will be used. This section should also provide the rationales for their selection. Tools should be described in terms of vendor, function, operating procedures, operational requirements, and products. When applicable, the interaction and integration of divergent tools should be discussed.

C.2.2 Prototyping.

This section should present the prototyping approach. It should address the approach for identifying those aspects of the system that need to be prototyped. This section discusses the standards for the development, documentation, and delivery of any prototypes developed during this effort.

C.2.3 Requirements Engineering Notebook.

This section proposes the format and content for the Requirements Engineering Notebook. The notebook should be constructed in such a way as to provide a traceable audit trail for the development and evolution of the system requirements for all Requirements Engineering activities and products.

C.3 Requirements Engineering Management

C.3.1 Configuration Management Plan.

This section identifies the plan for configuration management of requirements and Requirements Engineering products, such as documents and prototypes. This should address version control and cross referencing between versions of Requirements Engineering products; identification procedures; problem and change reports and review boards; configuration status accounting; audits; authentication procedures; and major milestones.

C.3.2 Resources, Organization and Staffing.

This section identifies the resources, organization, and staffing plan of the Requirements Engineering effort, describing the RE's facilities; Government-furnished equipment and services required; and organization, personnel, and resources for Requirements Engineering.

C.3.3 Total Quality Management (TQM).

This section discusses the process for establishing and performing Total Quality Management of the Requirements Engineering tasks. TQM requirements, procedures, evaluations, metrics, internal controls, and reports utilized should be specified. This should also address the software development file; associated access and control procedure; and procedures and reports used to prepare for formal reviews.

C.3.4 Technical Status Reviews and Reporting.

This section specifies the approach for providing detailed status reviews and reports for this effort. This must include, at a minimum, problems encountered, technical approaches, technical status, plans for future work, requirements, cumulative and projected costs, and schedule.

C.3.5 Evaluation, Testing, and Standards

This section discusses the approach for evaluation of Requirements Engineering products, implementation of a quality evaluation reporting system, format of all test documentation, corrective actions plan, and design and coding standards.

Appendix D

·USER INTERFACE SPECIFICATION

This appendix provides user interface and interaction requirements for a typical C2 system which should be addressed in the SSS. This includes all visual, audio, and tactical interfaces and interactions.

D.1 User Interface Hardware

A description of specified capabilities of the target user-interface hardware for the system shall be specified, including quantitative parameters such as bandwidth, response and access time, and storage capacity. The interface hardware shall include but not be limited to the following:

- Number of independent monitors supported

- Description of monitor, such as size, number of pixels, colors bit planes etc.

- Description of keyboard, such as number of function keys, keypad, etc.

- Description of mouse or trackball, such as number of buttons

- Audible signal capability

- Description of other man-machine interface related hardware, such as scanners, touch-panels, special displays, etc.

D.2 Screens

D.2.1 Formats

This shall define every class of screen presentations, including menus. The formats shall clearly identify screen zones and their purpose. The screen definitions shall include but not be limited to the following:

- Use of multiple windows. If used, how many, window moving and sizing, when is a new window created, etc.

- Screen format, including reserved zones, placement and format of classification markings, placement of titles, icons, menus, buttons, error messages etc.

- Window format, including reserved zones, placement and format of classification markings, placement of titles, icons, menus, buttons, error messages, etc.

- Use of color and their meaning, including standard colors for all screen components

- Use and type of fonts for every class of presentation.

- Vocabulary form and standard words to use for each occasion. For example, using DONE to indicate job is completed vs. OK or EXIT

- Help facilities, indicating the standard method for invoking help, and the format and contents of the help displays

- Format and usage of menus, buttons, scroll bars, icons, etc.

- Standard interaction sequences, such as a requirement to confirm every data base change, or the ability to undo or cancel some operations after they have been initiated or completed

D.2.2 Presentations and Flows

Pictures of all screen presentations and all logic flow between them shall be specified, including back-out and selection sequences. Interaction between the state of the system and screen flow shall be specified.

Screen refresh requirements shall be specified, indicating whether data appearing on screen represents information accurate only at the time the screen was generated or whether there exists a requirement to continually update presented screen data. Refresh rates shall be specified, if needed.

Density of screen content shall be specified, defining what constitutes operator overload thresholds that mandate screen declutter. Declutter techniques shall be specified.

D.2.3 Data Elements

The individual data elements which appear on the screen shall be specified, providing the meaning, significance, units, and/or data type of each data element, and the source of each data element whether calculated or retrieved from internal or external sources.

Appendix E

GLOSSARY OF TERMS AND ACRONYMS

CAP - CORRECTIVE ACTION PROCESS

CD - COMBAT DEVELOPER.

Command or agency that formulates doctrine, concepts, organization, material requirements, and objectives. For the US Army, this is the Training and Doctrine Command (TRADOC). May be used generically to represent the user community role in the material acquisition process.

END USER

The command or agency which will ultimately be the recipient and/or operator of a system under development.

FSD - FULL-SCALE DEVELOPMENT

Normally, the phase in the material acquisition process during which a system, including all items necessary for its support, is fully developed.

FSDC - FULL-SCALE DEVELOPMENT CONTRACTOR

FBL - FUNCTIONAL BASELINE

See DoD-STD-480.

INCREMENTAL DEVELOPMENT

A software system development process where the user requirements are not fully known before acquisition. The system is developed in a series of partial implementations. Each implementation is used to clarify and refine the requirements for the next implementation.

MILESTONE 0

Program Initiation/Mission-need Decision, approved by the Defense Acquisition Board (DAB) or designated authority, which determines mission-need and approves program initiation and authority to budget for a new program. Normally, a concept exploration/definition phase follows this approval.

OBJECTIVE SYSTEM

The system under consideration for development for which Requirements Engineering is needed.

PEO - PROGRAM EXECUTIVE OFFICER

Individual responsible for administering a defined number of major and/or non-major acquisition programs who reports to and receives direction from the Army Acquisition Executive.

PM - PROJECT MANAGER

Individual chartered to conduct business on behalf of the Army who reports to and receives direction from either a PEO or the Army Acquisition Executive and is responsible for the centralized management of a specified acquisition program.

REQUIREMENTS

Requirements are the quantifiable and verifiable behaviors that a system must possess and constraints that a system must work within to satisfy an organization's objectives and solve a set of problems.

RE - REQUIREMENTS ENGINEER

A functional entity comprised of Government and/or contractual personnel that performs the Requirements Engineering tasks required by the PM.

REP - REQUIREMENTS ENGINEERING PLAN

REQUIREMENTS ENGINEERING

Requirements Engineering is the disciplined application of scientific principles and techniques for developing, communicating, and managing requirements. See Appendix B.

RFP - REQUEST FOR PROPOSAL

STAKEHOLDERS

All commands, agencies, or personnel who are directly concerned or affected with the outcome of a system acquisition. Stakeholders may include the end user, the developing agency, post deployment software support centers, the test and evaluation agencies, operational commanders, logistics support agencies, and many others, depending on the system.

SSS - SYSTEM/SEGMENT SPECIFICATION

A system level requirements specification whose format is specified in DoD Data Item Description DI-CMAN-80008A.

SRR - SYSTEM REQUIREMENTS REVIEW

UNPRECEDENTED SYSTEM

A system which does not parallel a system which has been previously developed. This may be due to the planned use of new technologies, a new mission-need, a need that has never been met, or a significant increase over previous system capabilities and performance.

Appendix F

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[5] Sumrall, George E., "Requirements Engineering and Ada," Proceedings of the 6th National Conference on Ada Technology, March 1988.

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Appendix G

GRAPHICAL OVERVIEW OF THE ACQUISITION MODEL
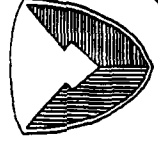
The CECOM CSE Acquisition Model Stresses Requirements Engineering, Emphasizing Techniques For Requirements Definition And Change Management.

It Recommends Six Risk Reduction Strategies, Which Can Be Tailored To Apply To A Wide Range Of Acquisitions.
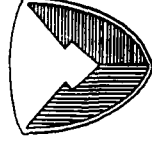
ACQUISITION MODEL FOR THE CAPTURE AND MANAGEMENT OF REQUIREMENTS FOR BATTLEFIELD SOFTWARE SYSTEMS

ORDER OF PRESENTATION

- The Problem And Its Significance

- Proposed Approach - An Acquisition Model

    - Six Risk Reduction Strategies

    - Relevance Of The Model To US Army System Acquisition

    - Application Of The Model To US Army System Acquisition

- Plans For Implementation
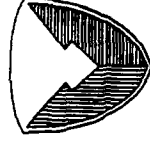
The Problem And Its Significance

- The Problem And Its Significance

- Proposed Approach - An Acquisition Model

  - Six Risk Reduction Strategies

  - Relevance Of The Model To US Army System Acquisition

  - Application Of The Model To US Army System Acquisition

- Plans For Implementation
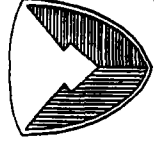
Software Needs Are Great And They Are Growing Exponentially

World

U.S.

U.S.
DoD

800

400

63

36

250

125

140

70

11

$1000B

$500B

$200B

$100B

$50B

$20B

$10B

Software Costs

1980   1985   1990   1995   2000
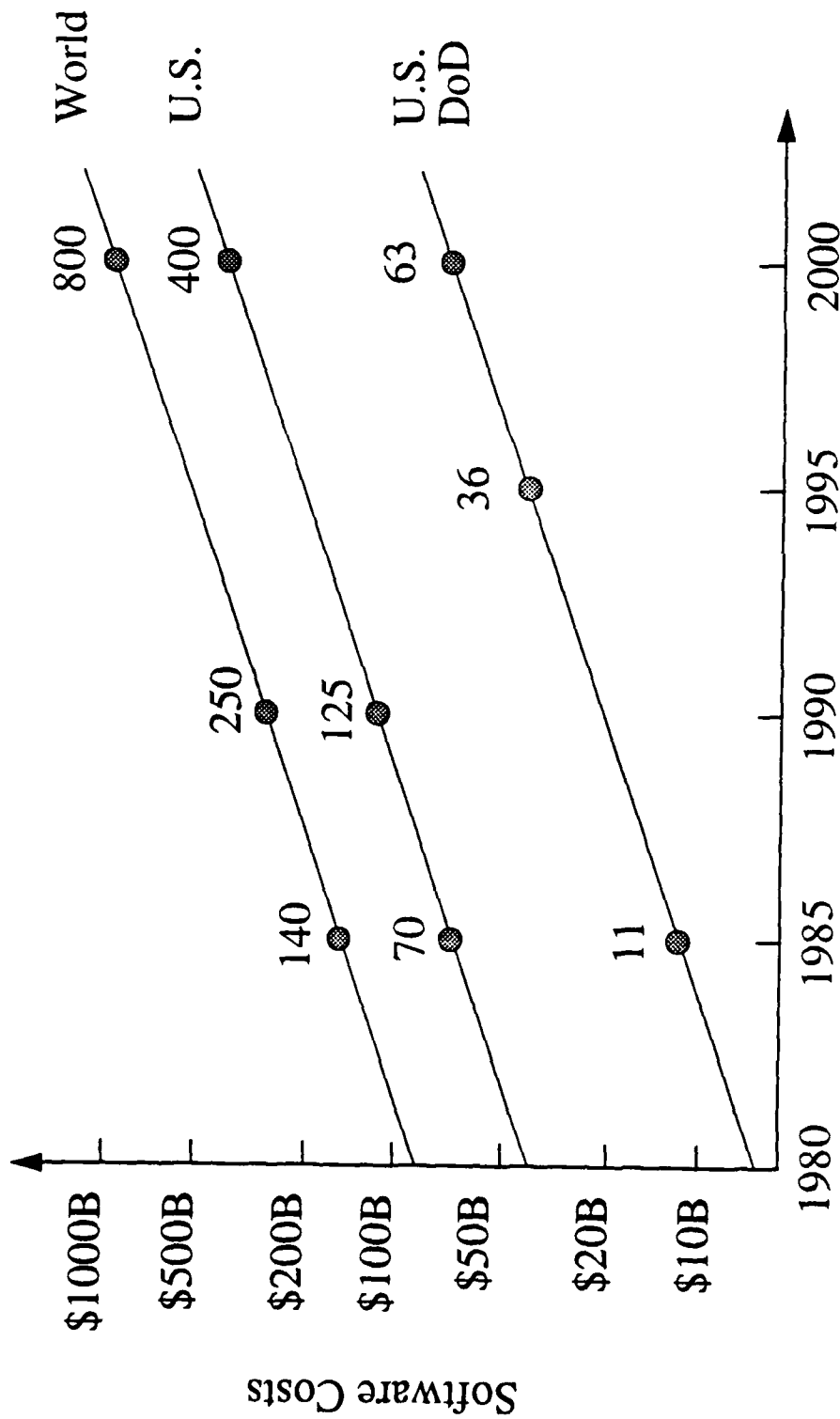
Source: Barry W. Boehm, "Improving Software Productivity", IEEE Computer Sept'87
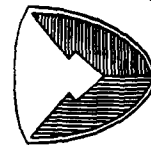
The Cost of Software Dominates Total System Costs
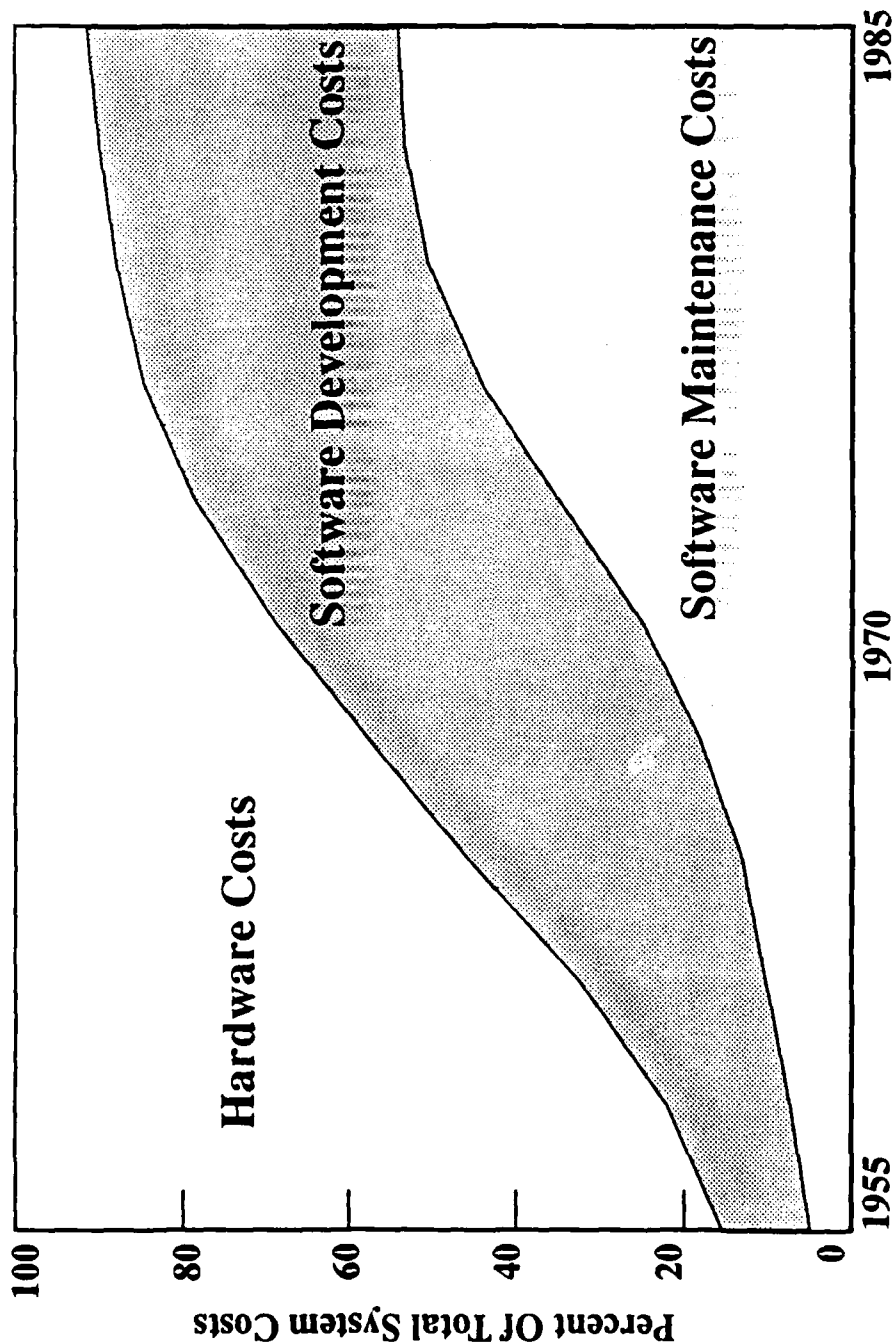
Software Versus Hardware Cost Trends

Source: Barry W. Boehm, "*Software Engineering Economics*", New Jersey: Prentice Hall Inc.
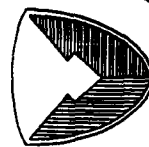
Software Problems Have A History And A Reputation

Software was usable as delivered ($119,000) (1.8%)

Software was usable after some changes ($198,000) (3%)

Software was paid for but not delivered ($1.95M) (29%)

Software was delivered but never successfully used ($3.2M) (47%)

Software was usable after extensive rework ($1.3M) (19%)
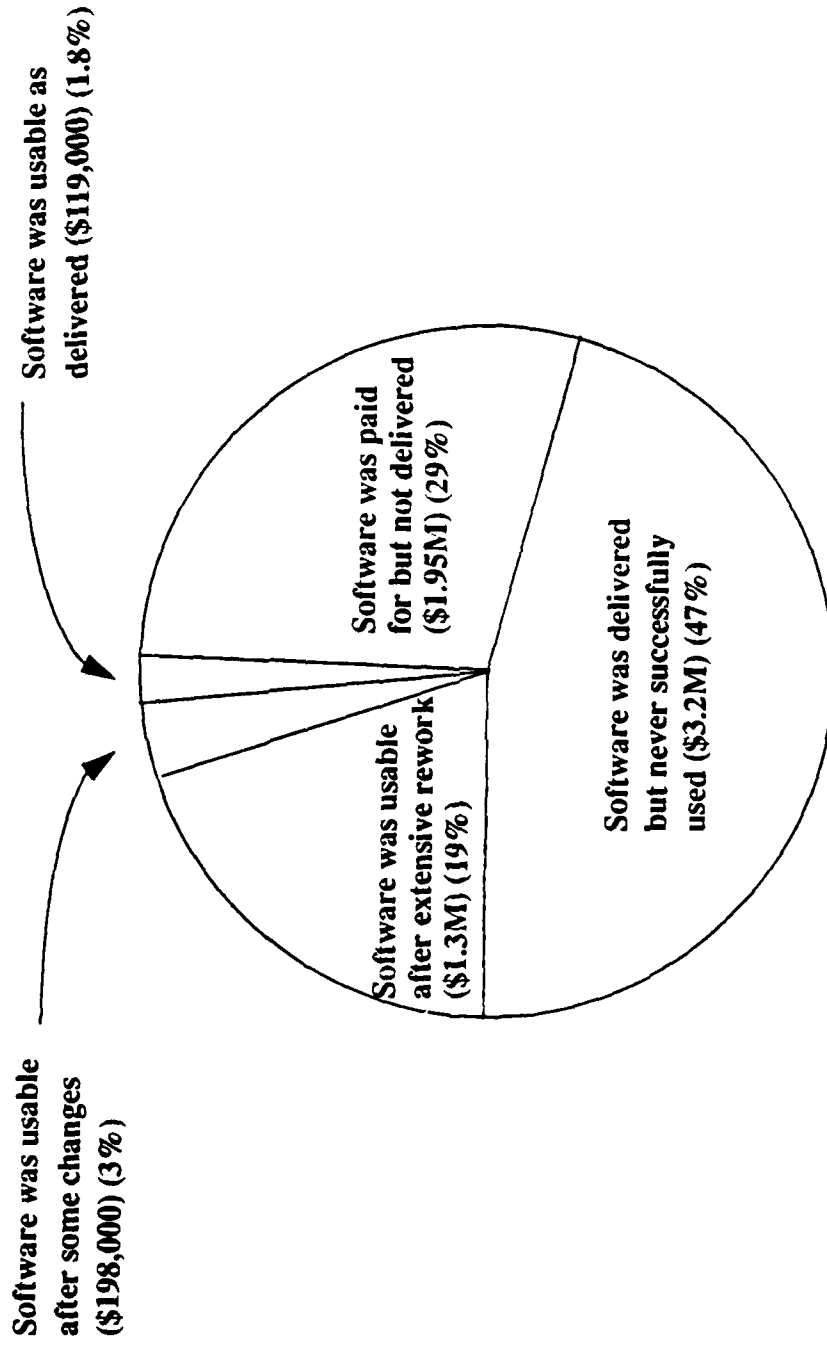
1979 GAO Survey of nine acquisitions totaling $6.8M identified major problems in contracting for software.
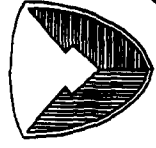
Intensive Efforts Were Devoted To Finding The Causes Of Software Acquisition Problems.

Requirements Related Problems Were Frequently Involved.

"In nearly every software project which fails to meet performance and cost goals, requirements inadequacies play a major and expensive role in project failure." [1]

"There are four kinds of problems that arise when one fails to do adequate requirements analysis: (a) top-down design is impossible, (b) testing is impossible, (c) the user is frozen out, and (d) management is not in control." [2]

Development of the requirements specification "in many cases seems trivial, but it probably is the part of the process which leads to more failures than any other." [3]

[1] M. W. Alford and J. T. Lawson, *Software Requirements Engineering Methodology (Development)*, (USAF RADC-TR-79-168).

[2] W. W. Royce, "Software Requirements Analysis" in *Practical Strategies for Developing Large Software Systems*, E. Horowitz, editor.

[3] J. L. Schwartz, "Construction of Software: Problems and Practicalities," in *Practical Strategies for Developing Large Software Systems*, E. Horowitz, editor.
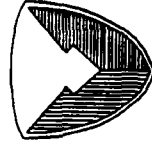
The Cost Of Solving Requirements Related Problems Increases Drastically With The Time Of Detection

Relative Cost to Fix an Error

$600

$200
$100
$50

$20
$10
$6

$2
$1

Large Software Developments

Small Software Developments

Requirements   Design   Code   Development Test   Acceptance Test   Operation
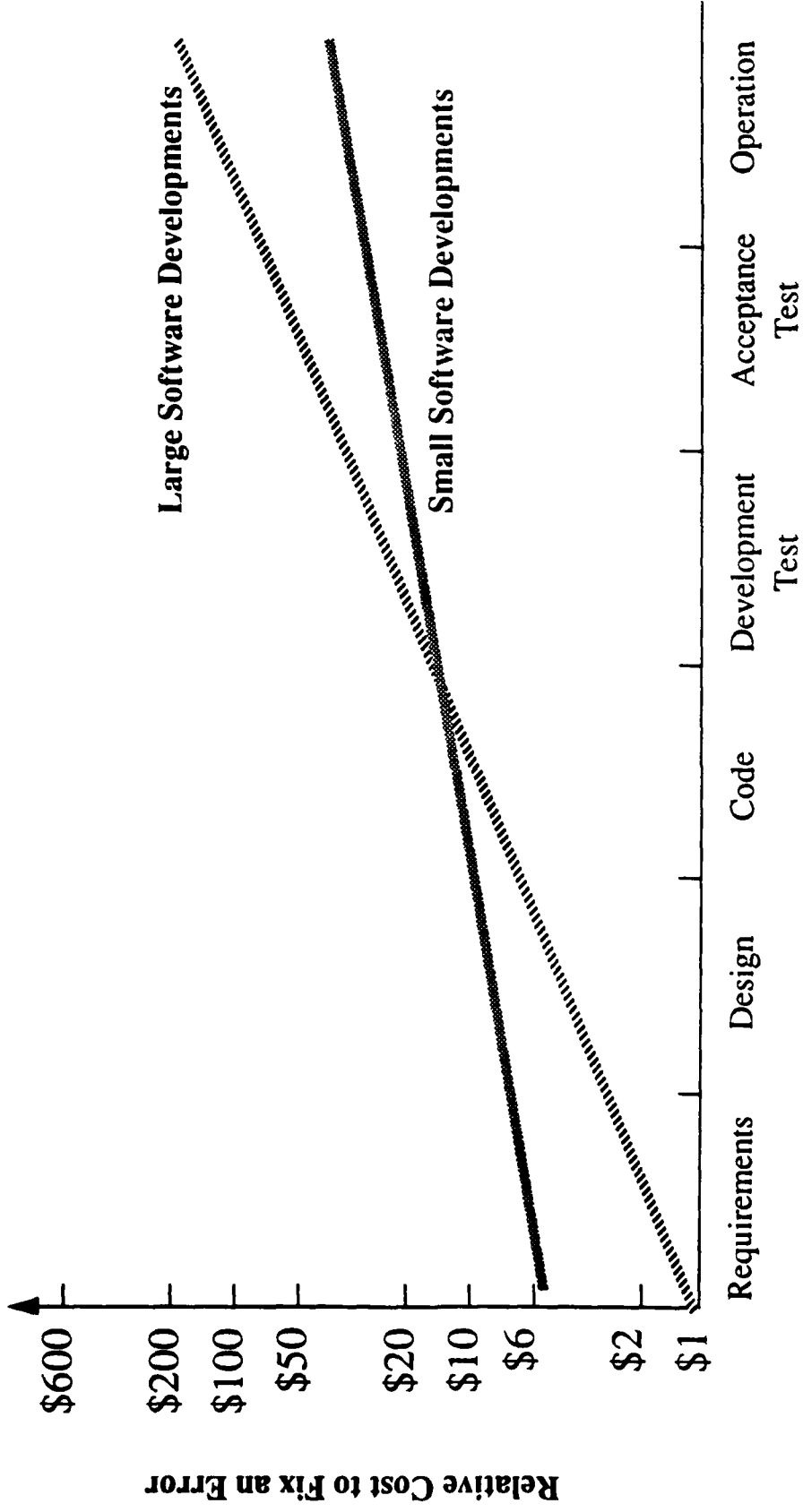
Phase During Which an Error Was Detected and Corrected

Source: Barry W. Boehm, *Software Engineering Economics*, New Jersey: Prentice Hall, Inc.
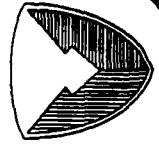
Most Software Faults Are Introduced In The Requirements & Functional Design Phase.

CENTER FOR SOFTWARE ENGINEERING
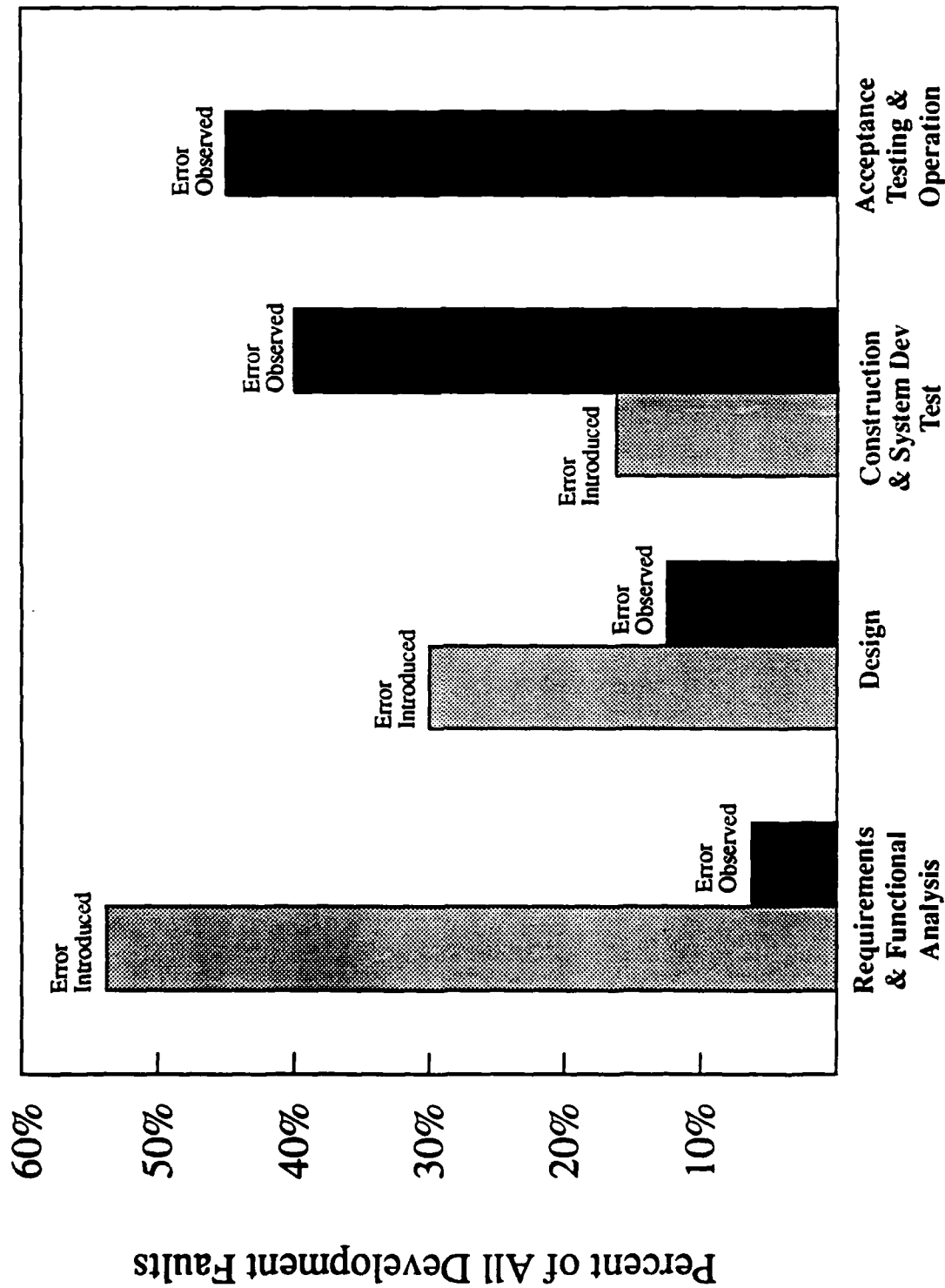
Source: "Software Engineering,", Ramamoorthy, et al., IEEE Computer, 10/84

SOFTWARE PROCESS ENGINEERING TECHNOLOGY

G-10

US ARMY CECOM
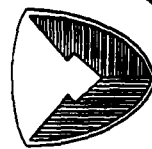
Defense System Software Development Establishes Requirements For Software Development,

Mandating An Extensive Sequential Review Process And List Of Deliverables.

Milestones   0   I   II   III

Project Phase

Concepts Exploration	Demonstration & Validation	Full Scale Development		Production & Deployment

System Development Activity

| Mission/System Requirements Definition | System/Software Requirements Definition | Computer Software Development | System Integration & Testing | Operational Testing & Eval | Production & Deployment |

Software Development Activity

Software Requirements Analysis

Preliminary Design

Detailed Design

Coding & Unit Testing

CSC Integration & Testing

CSCI Level Testing

Software-Related Reviews & Audits
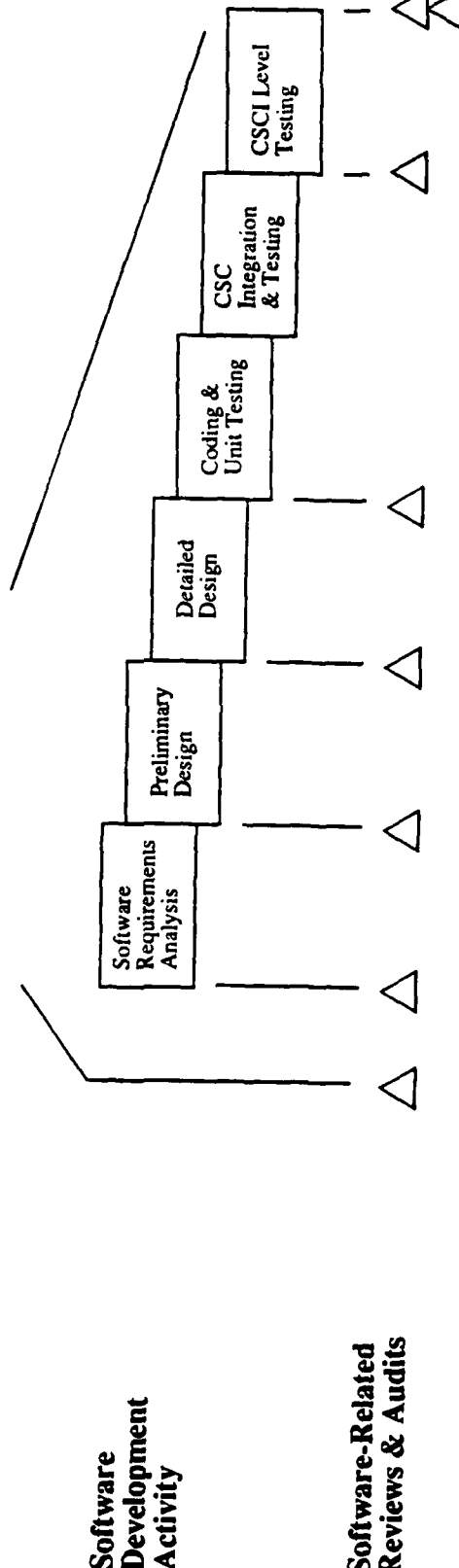
Software-Related Deliverable Documents

DoD-STD-2167A

Relative Cost To Fix An Error

Large System

Small System

$600
$200
$100
$50
$20
$10
$6
$2
$1

Requirements & Functional Analysis | Design | Construction & Development Testing | Acceptance Testing & Operation

Phase Faults Were
I=Introduced
O=Observed

Development Faults

60%
50%
40%
30%
20%
10%
0

Requirements & Functional Analysis | Design | Construction & Development Testing | Acceptance Testing & Operation

Phases: {

= = Deliverable
△ = Review

1 1
△

14   5   22   7

Cumulative 2167A Deliverables and Reviews
By the End of Each Development Phase

Requirements & Functional Analysis | Design | Construction & Development Testing | Acceptance Testing & Operation

Phases: {

Latent System Requirements Defects May
Cause Massive Rework, Substantially
Impacting Cost, Schedule, And Quality.
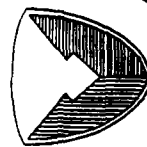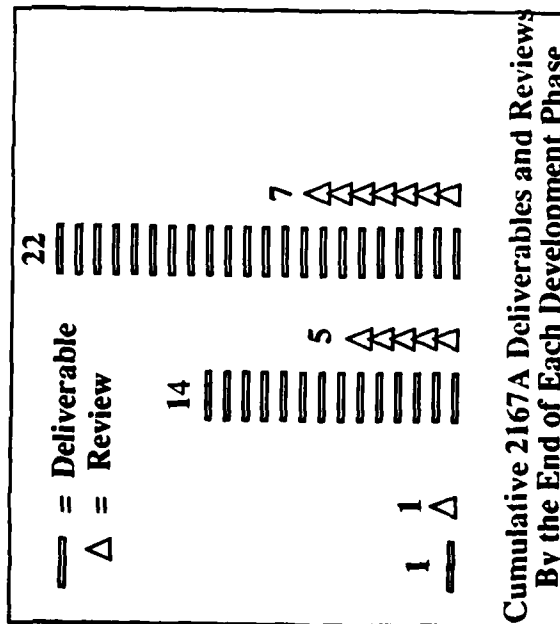
Developing Large-Scale Systems Is A Tough Job! Despite Everyone's Good Intentions And Expertise, Things Don't Always Turn Out Right.

What The RFP Really Asked For
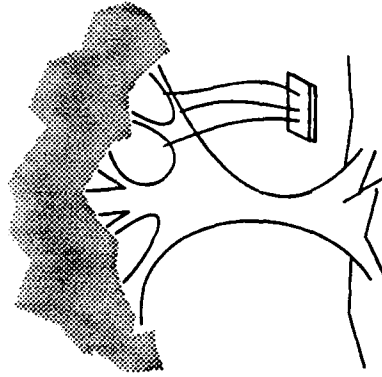
What The Contract Said Would Be Delivered
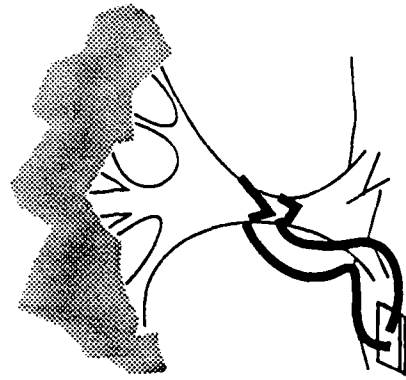
What Engineering Designed
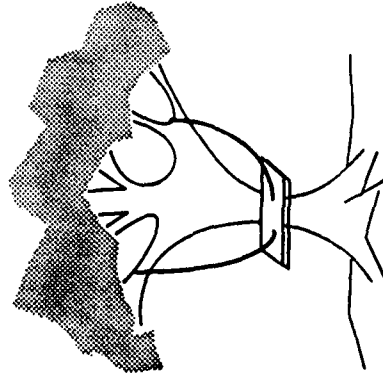
What Was Built
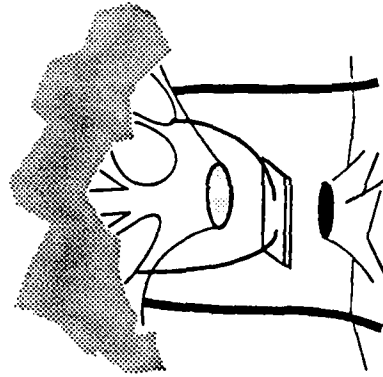
How It Got Tested

What The User Really Wanted
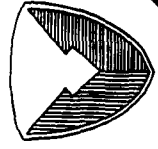
Proposed Approach - An Acquisition Model

- The Problem And Its Significance

- Proposed Approach - An Acquisition Model

  - Six Risk Reduction Strategies

  - Relevance Of The Model To US Army System Acquisition

  - Application Of The Model To US Army System Acquisition

- Plans For Implementation
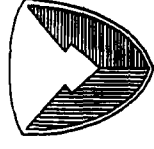
Six Risk Reduction Strategies

❶ Engineer The Requirements

❷ Decouple Requirements Definition

❸ Functional Baseline Before RFQ

❹ User Interface & Testing In SSS

❺ Provide Structure For FSD Relationship

❻ Evolutionary System Development
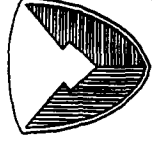
Preface #1:

The US Army CECOM Center For Software Engineering Recommends Six Strategies For Software Intensive Acquisitions.

When Applied Properly, They Should REDUCE Requirements-Related RISKS
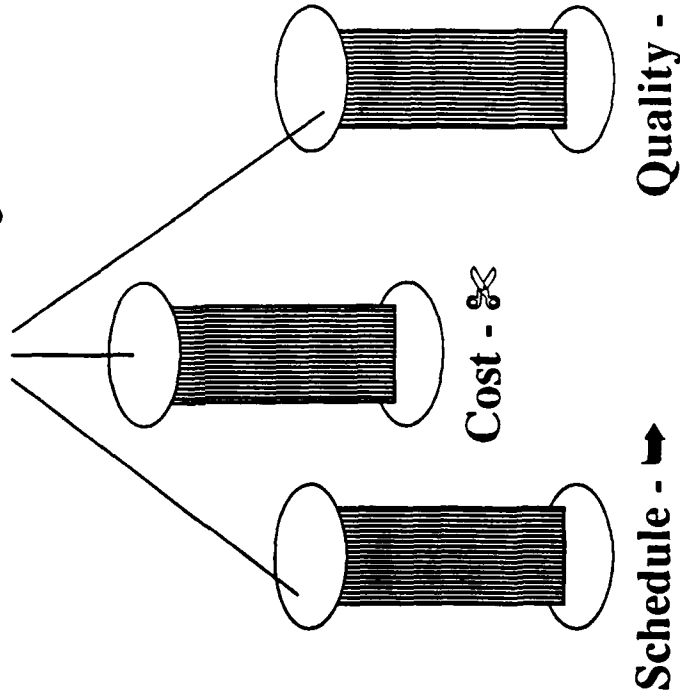
These strategies have already been recommended by numerous DoD studies and workshops.

While this model should reduce the quantity and severity of requirements related problems, it is not envisioned that they will or can ever be eliminated. We will always have valid needs to change requirements, from such reasons as advances in technology and changes in enemy tactics and capabilities.

Successful System

Cost - ✂

Schedule - ➡

Quality - ①
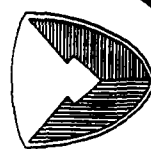
Preface #2:

👢👢👢👢👢👢👢👢👢👢👢👢

WE CAN NO LONGER AFFORD TO *WRITE REQUIREMENTS.*

RATHER, REQUIREMENTS MUST BE *ENGINEERED* and *MANAGED.*
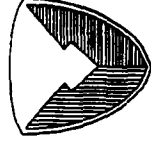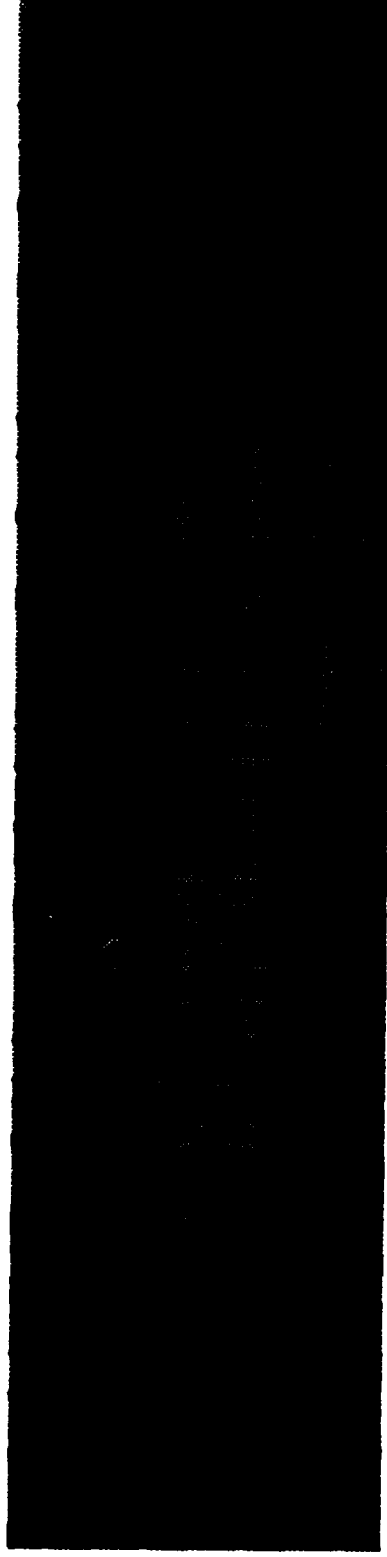
∃Ω∑∫≠Π⏀φΠℵ∂∴∂⸫θρτψυπασδφγ

Requirements are the quantifiable and verifiable behaviors that a system must possess and constraints that a system must work within to satisfy an organization's objectives and solve a set of problems.

Requirements Engineering is the disciplined application of scientific principles and techniques for developing, communicating, and managing requirements.

Requirements Engineering
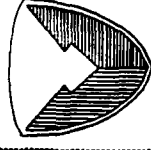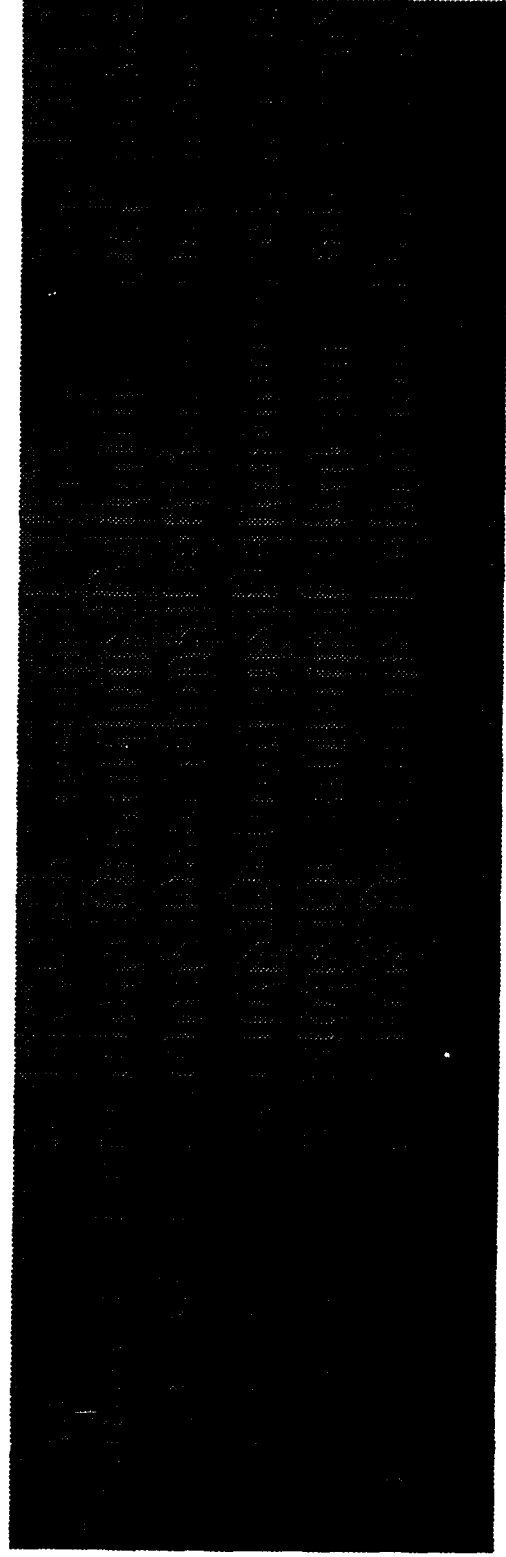
Requirements Engineering deserves recognition as a branch of the engineering sciences.

Civil Engineering

Electrical Engineering

Industrial Engineering

Mechanical Engineering

Requirements Engineering

Software Engineering
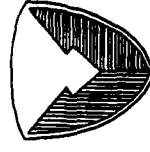
The CECOM CSE Acquisition Model Stresses Requirements Engineering, Emphasizing Techniques For Requirements Definition And Change Management.

It Recommends Six Risk Reduction Strategies, Which Can Be Tailored To Apply To A Wide Range Of Acquisitions.

The Six Strategies Are As Follows:

❶ Designate a Requirements Engineering effort which applies Requirements Engineering techniques from the early project phases and on.

❷ Contractually decouple requirements definition from the Full Scale Development Effort.

❸ Establish a Functional Baseline with an approved System/Segment Specification (SSS) prior to the solicitation and make the SSS a part of the solicitation package.

❹ Document the user interface and interaction in the SSS, together with system testing information.

❺ Provide structure for the relationship and interaction between the user and the full-scale development contractor for all requirements related matters

❻ Plan to develop systems in an incremental, evolutionary manner.

Relevance Of The Model To US Army System Acquisition

- The Problem And Its Significance

- Proposed Approach - An Acquisition Model

  - Six Risk Reduction Strategies

  - Relevance Of The Model To US Army System Acquisition

  - Application Of The Model To US Army System Acquisition

- Plans For Implementation
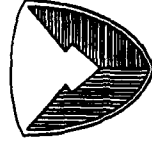
The Army Material Command, The Software Buyer, Must Translate User Requirements Into Acquisition Documents.

This Task Requires Significant Expertise.

Milestones

0   I   II   III

Project Phase

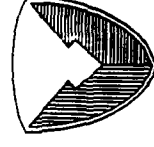| Concepts Exploration	Demonstration & Validation	Full Scale Development	

System Development Activity

Mission/System Requirements Definition	System/Software Requirements Definition	Computer Software Development	System Integration & Testing	Operational Testing & Eval

(USER DEFINES HIS NEEDS)

USER (Rep)
BUYER
BUILDER

Training & Doctrine Command • • • • •

Army Material Command • • • • •

F$_{ULL}$ S$_{CALE}$ D$_{EVELOPMENT}$ Contractor

P
A
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S

The Full Scale Development Contractor Is Typically Responsible For Requirements-Related Tasks

Besides Constructing the System, He Helps To Define It.

But, If The System Needs Significant Definition, How Are We Able To Engage The Development Contractor, Beforehand?
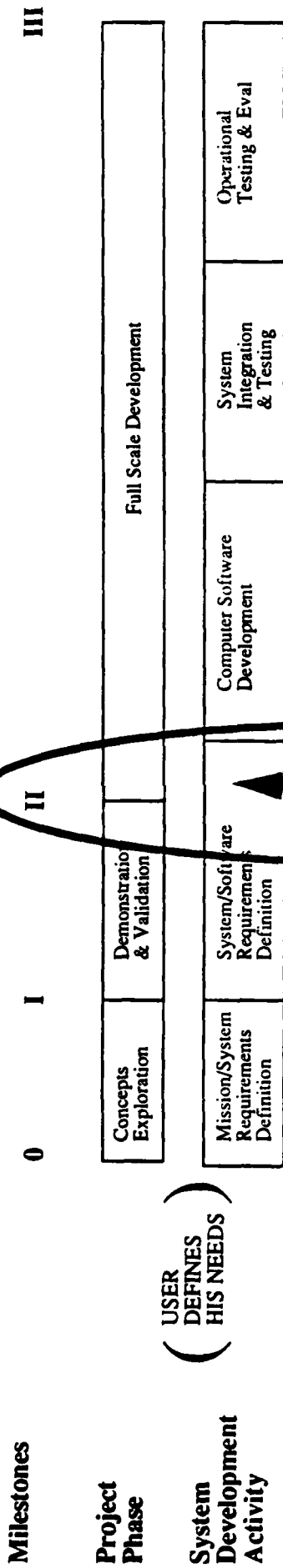
Milestones	0	I	II	III

Project Phase	Concepts Exploration	Demonstration & Validation	Full Scale Development	

System Development Activity	Mission/System Requirements Definition	System/Software Requirements Definition	Computer Software Development	System Integration & Testing	Operational Testing & Eval

(USER DEFINES HIS NEEDS)

Training & Doctrine Command • • • • • • •

Army Material Command • • • • • • •

F~ull~ S~cale~ D~evelopment~ Contractor

System Requirements Review

System/Segment Specification
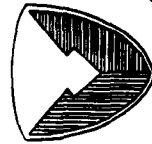
We Can Significantly Improve The Acquisition Process By Improving The Quality Of The Solicitation Package.

Solicitation
Package
Quality

System
Cost,
Schedule,
Quality
Slippage
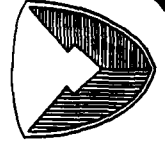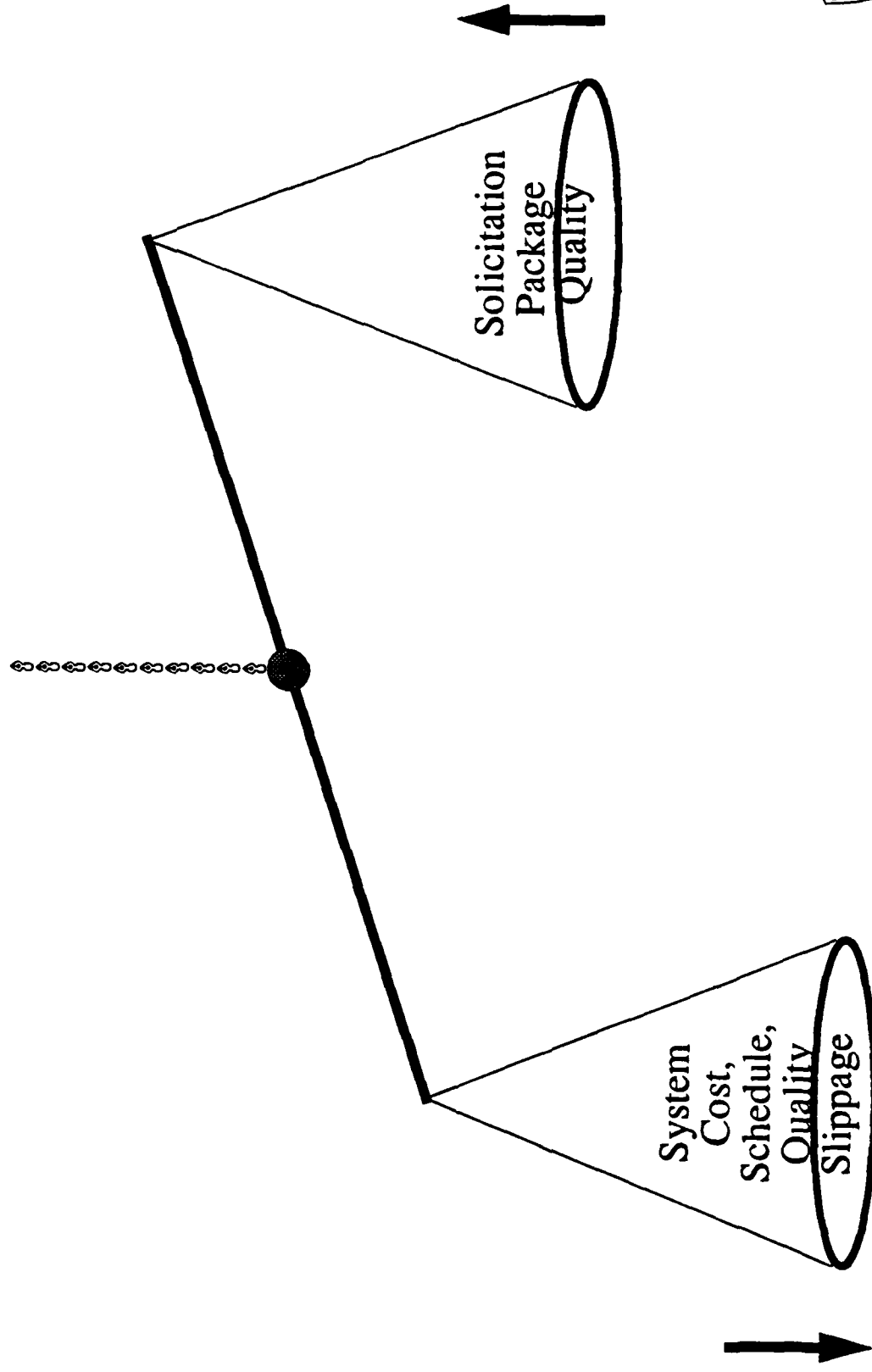
Quality Solicitation Packages Need Quality Requirements Documentation.

Solicitation
Package
Quality

Quality Requirements
Documentation

System
Cost,
Schedule,
Quality
Slippage
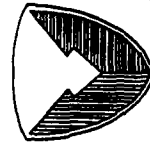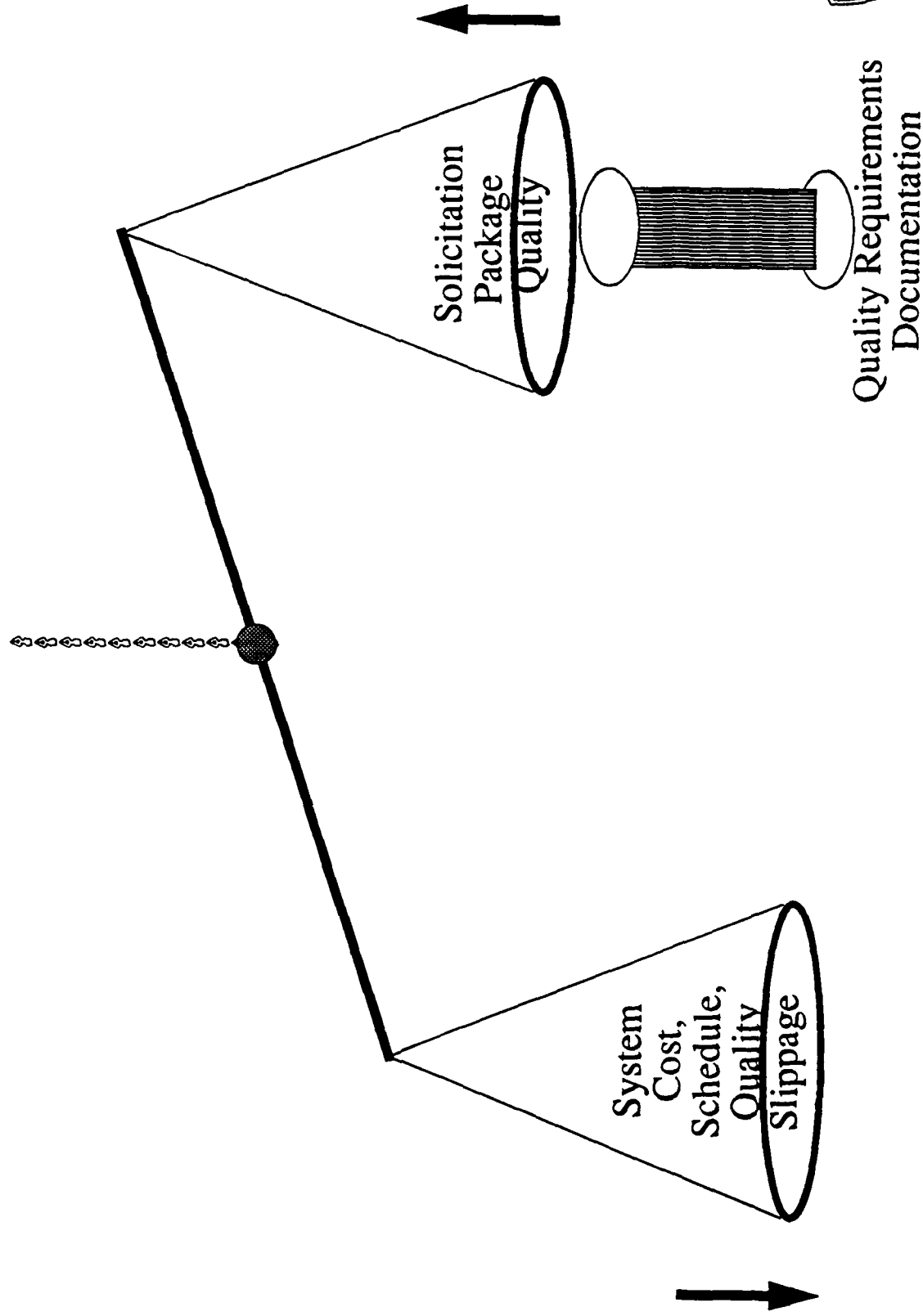
Sadly, Crucial Details, Such As The User Interface, Are Not Always Specified In Detail Until The Critical Design Review (!)

By The Time The System Reaches That Stage, Changes And Improvements Are Very Costly In Cost And Schedule
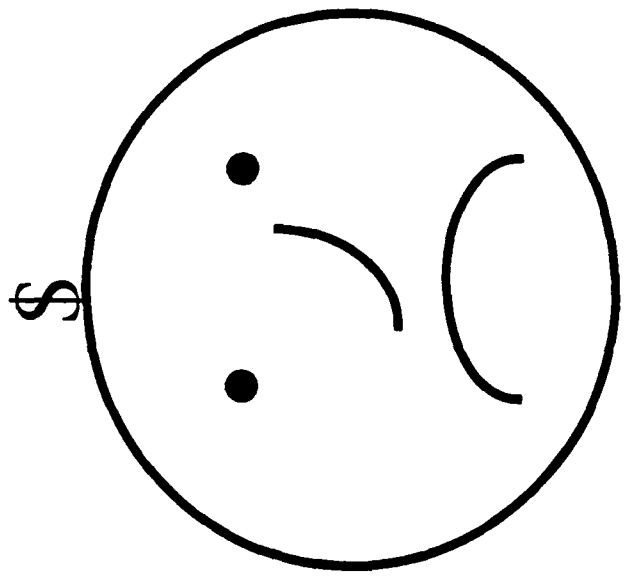
The Requirements Related Role That Has Been Given To The FSD Contractor Can, At Times, Have The Appearance Of A Conflict Of Interests.
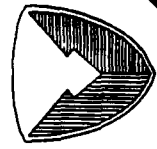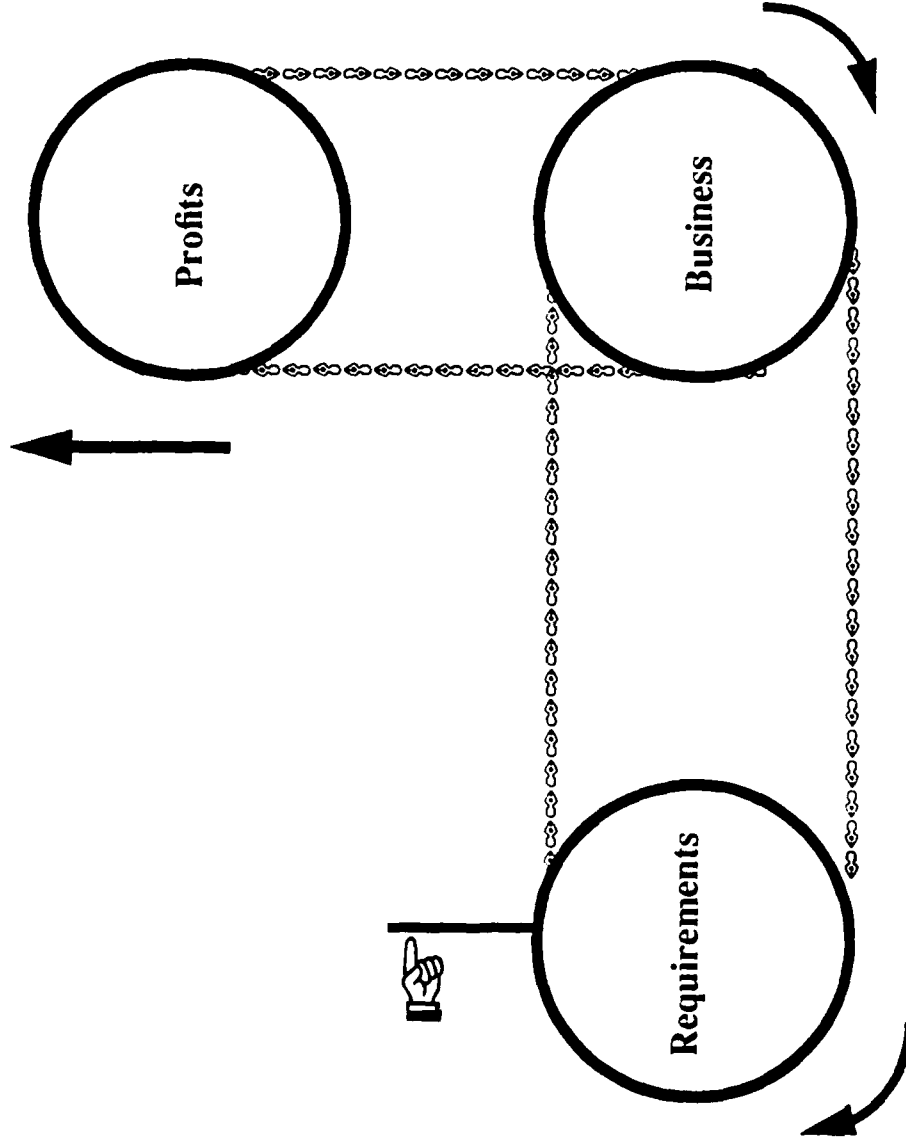
To Serve The Customer And The Country, The FSD Contractor Must Keep The Government Apprised Of New Capabilities That Can Enhance The System.

Users Are Typically Receptive And Supportive Of Additional Requirements, Which They Perceive As Providing More Options And Functionality.

In The Complex FSD Relationship, The Contractor Has Ample Access To The User And Is In An Awkward Position Of Appearing To Drive Up The Requirements.

Requirements

FSD Contractor

TRADOC

AMC
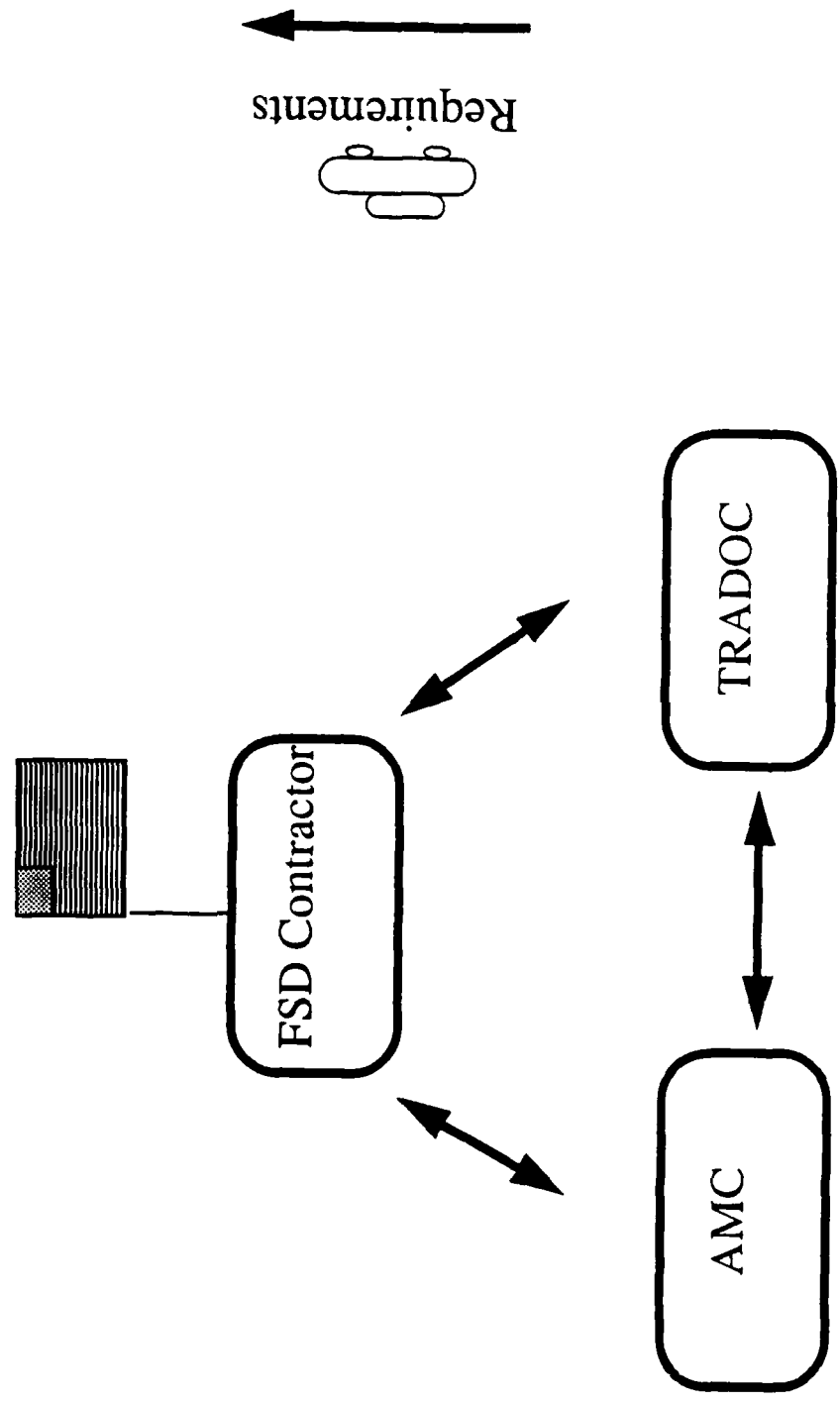
At Times, A System Acquisition Team Plans To Develop And Field The System In A Single Step, Not Allowing New And Unforeseen Requirements That Materialize As The System Matures To Be Easily Incorporated.
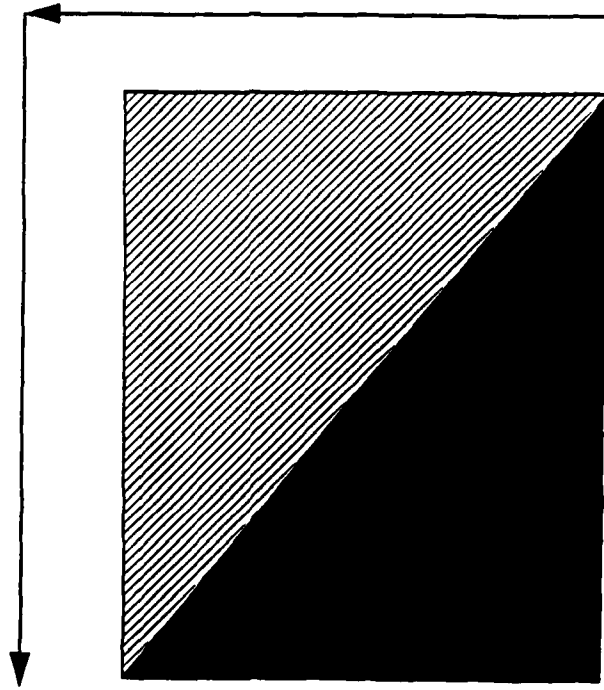
STEP BY STEP
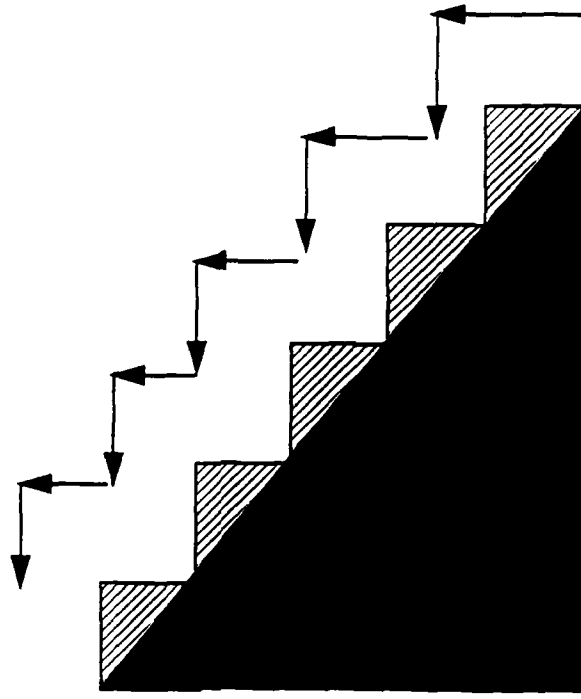
SINGLE STEP

Application Of The Model To US Army System Acquisition

- The Problem And Its Significance

- Proposed Approach - An Acquisition Model

  - Six Risk Reduction Strategies

  - Relevance Of The Model To US Army System Acquisition

  - Application Of The Model To US Army System Acquisition

- Plans For Implementation

The Model

❶ Engineer The Requirements

❷ Decouple Requirements Definition

❸ Functional Baseline Before RFQ

❹ User Interface & Testing In SSS

❺ Provide Structure For FSD Relationship

❻ Evolutionary System Development
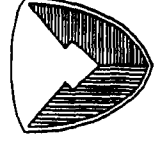
- Designate a Requirements Engineering effort which applies Requirements Engineering techniques from the early project phases and on.

The Requirements Engineer is a consultant. He should be under the control and direction of the Project Manager. He, or his team, must have the needed expertise.

He must wear many hats.

To the developer, he is the user, answering requirements related questions.

To the Project Manager, he is a consultant on requirements and their impact.
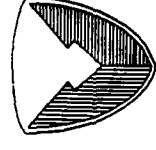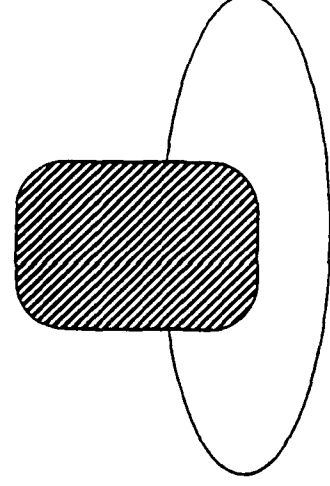
To the user, he is a developer, exploring the feasibility and impact of their requirements and then validating them.

- • Designate a Requirements Engineering effort which applies Requirements Engineering techniques from the early project phases and on.

The Requirements Engineer's role is much like that of an architect in a building construction project.
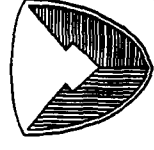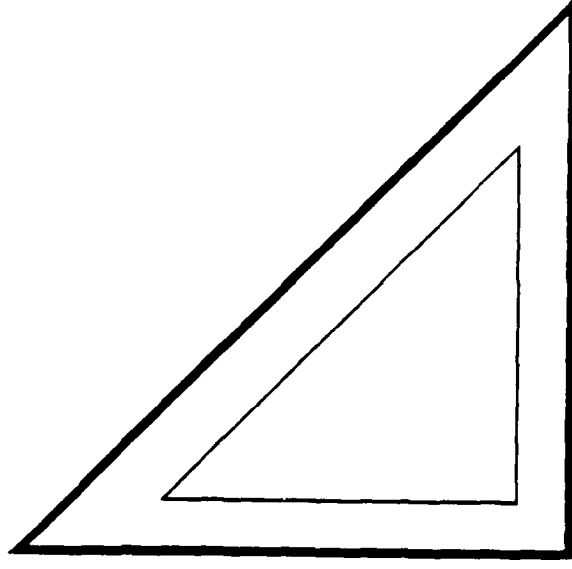
- Designate a Requirements Engineering effort which applies Requirements Engineering techniques from the early project phases and on.

The Requirements Engineer must have expertise and capabilities to apply the latest Requirements Engineering techniques and technologies.

JOINT APPLICATION DEVELOPMENT

RAPID PROTOTYPING
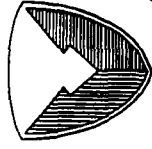
SIMULATION

CENTER FOR SOFTWARE ENGINEERING

- Designate a Requirements Engineering effort which applies Requirements Engineering techniques from the early project phases and on.

This model recommends that the Requirements Engineer be involved with requirements related activities throughout the lifetime of the project.

USER FEEDBACK

REQUIREMENTS VERIFICATION
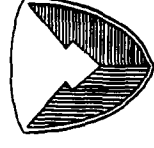
REQUIREMENTS TRACING

SUPPORT DURING REVIEWS

- • Designate a Requirements Engineering effort which applies Requirements Engineering techniques from the early project phases and on.
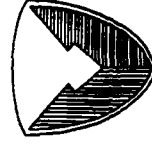
The Requirements Engineering function should be filled by Government personnel. Alternatively it may be performed via contract.

The Project Manager must carefully assess the requirements for this effort and monitor it carefully. Just as with the Full Scale Development effort, the risk of requirements proliferation exists. Unlike the Full Scale Development effort, this effort is on a much smaller scale, reducing impact of risk.
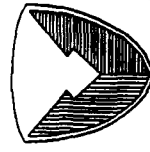
- • Designate a Requirements Engineering effort which applies Requirements Engineering techniques from the early project phases and on.

Army Material Command

Full Scale Development Contractor

Requirements Engineer

TRADOC

TIME →
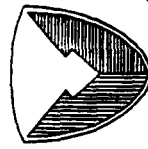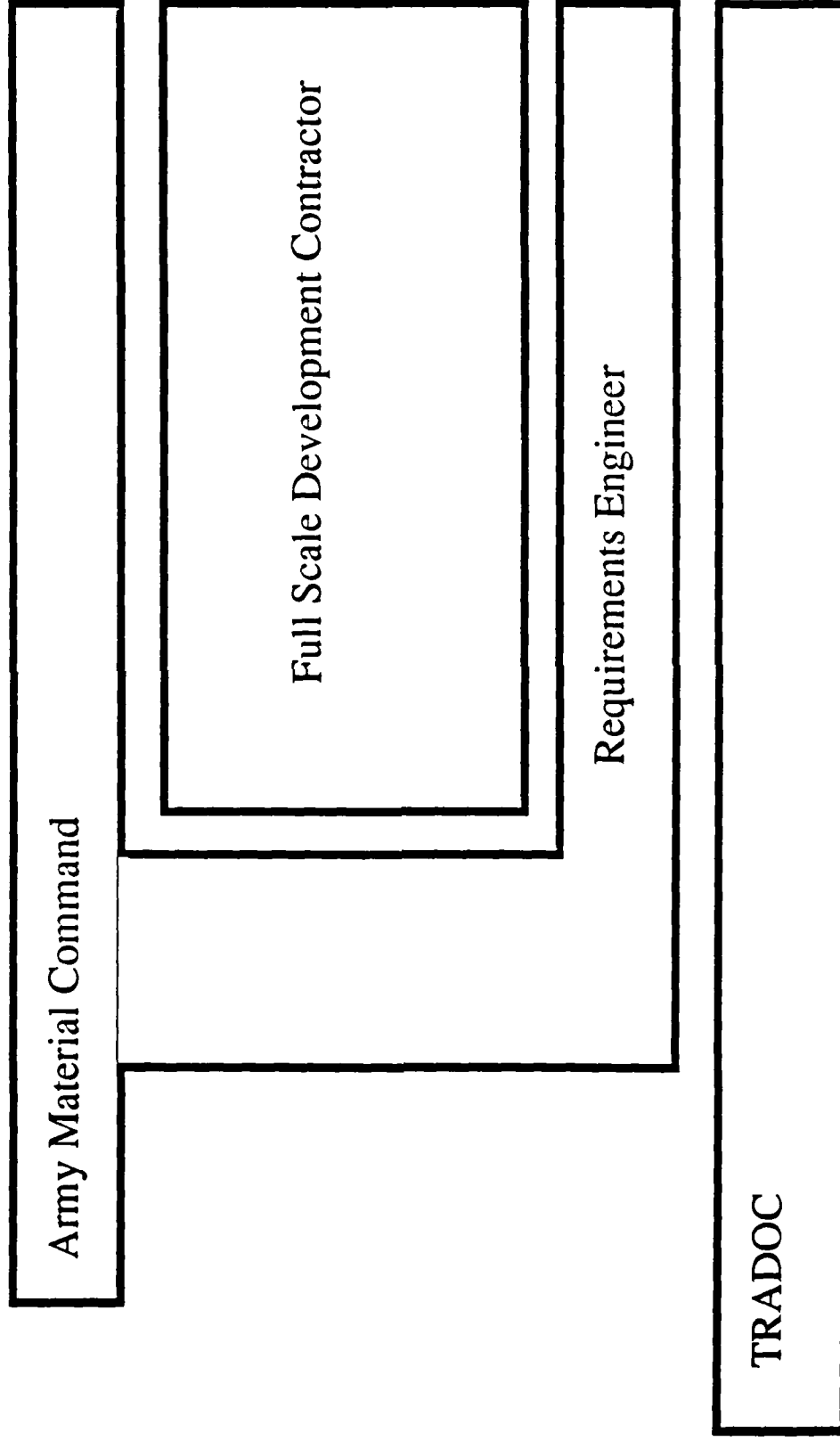
❷ • Contractually decouple requirements definition from the Full Scale Development Effort.

The Requirements Engineer, if he is a contractor, should be precluded from the Full Scale Development competition and subcontracting, to maintain his independence.
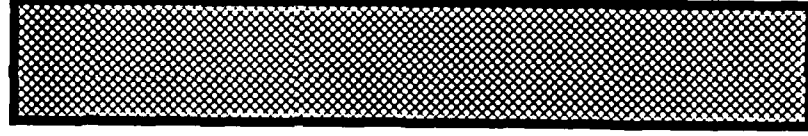
The Full Scale Development Contractor should only be responsible for activities beginning with software requirements analysis. This would insure that the design effort commences with a well stated set of requirements.

- Establish a Functional Baseline with an approved System/Segment Specification (SSS) prior to the solicitation and make the SSS a part of the solicitation package.

QUALITY

RFP → Full Scale Development Contract Award

SSS

Requirements Engineering Effort →
(+ System Requirement Review)

In doing so, we will better know what we are buying and bidders will know what we really want.

This approach does not eliminate the possibility of requirements changes during the solicitation period. It does, however, reduce the opportunities for changes with serious impact to occur.

- Document the user interface and interaction in the SSS, together with system testing information.

User Interface
& Interaction
Requirements

NO

YES

Design
Documents

System /
Segment
Specification

- **Document the user interface and interaction in the SSS, together with system testing information.**

System / Segment Specification

Pass

Fail
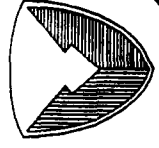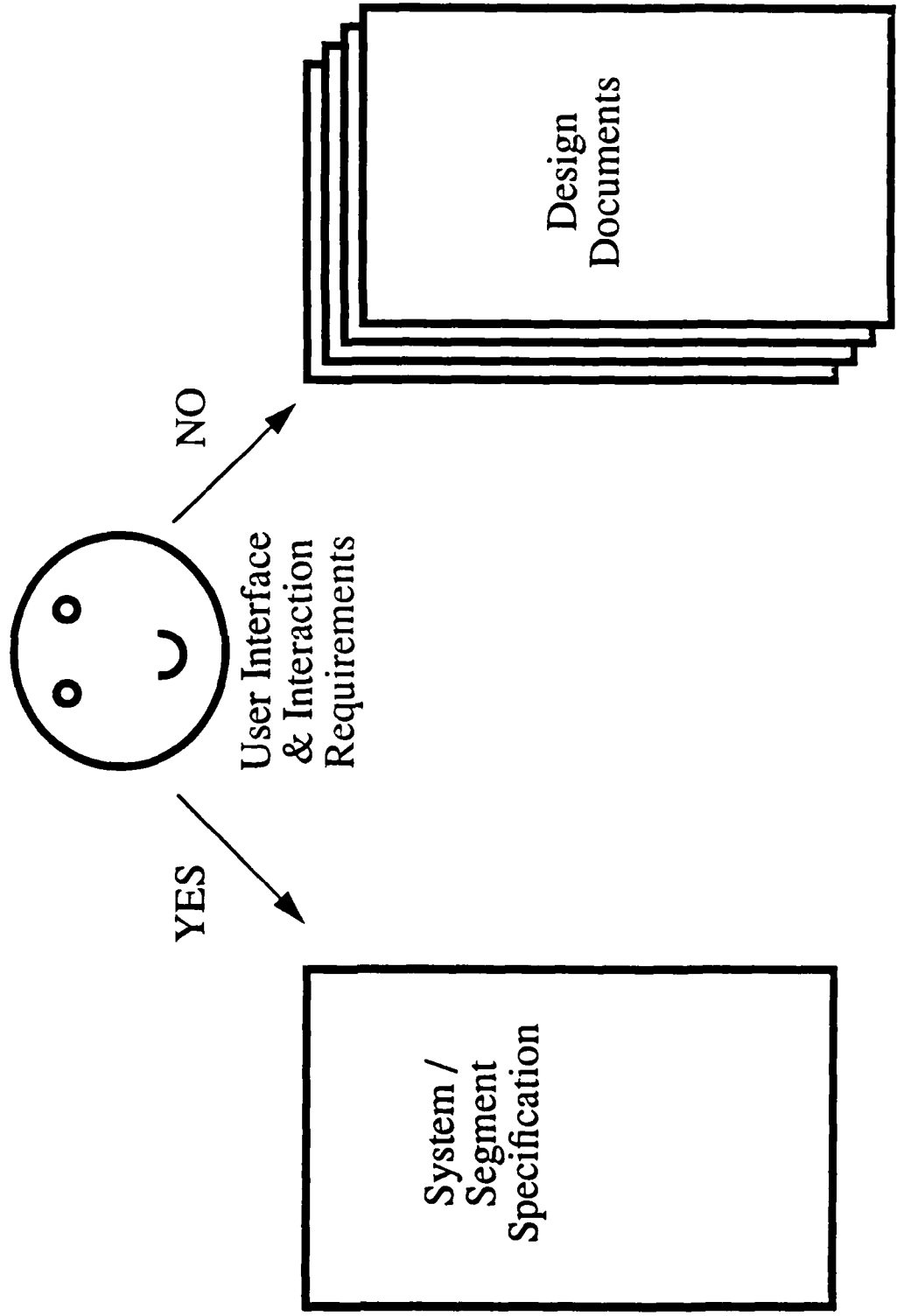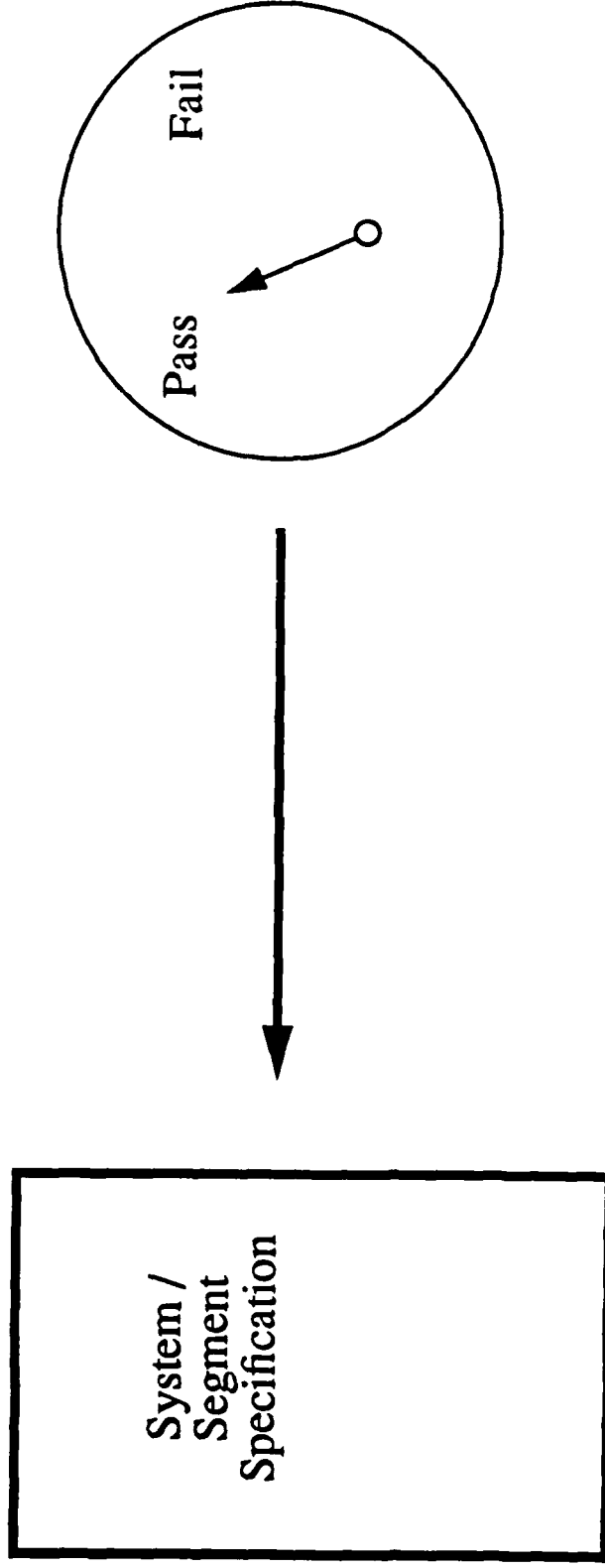
It should be noted that section 4.0 of the SSS deals with provisions for quality assurance. Test case requirement coverage and general system test philosophy should be specified by the RE in this section. Additionally, the RE should specify the system requirements test plan and cases in separate documents and perform the actual testing.
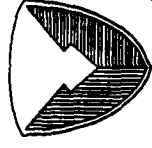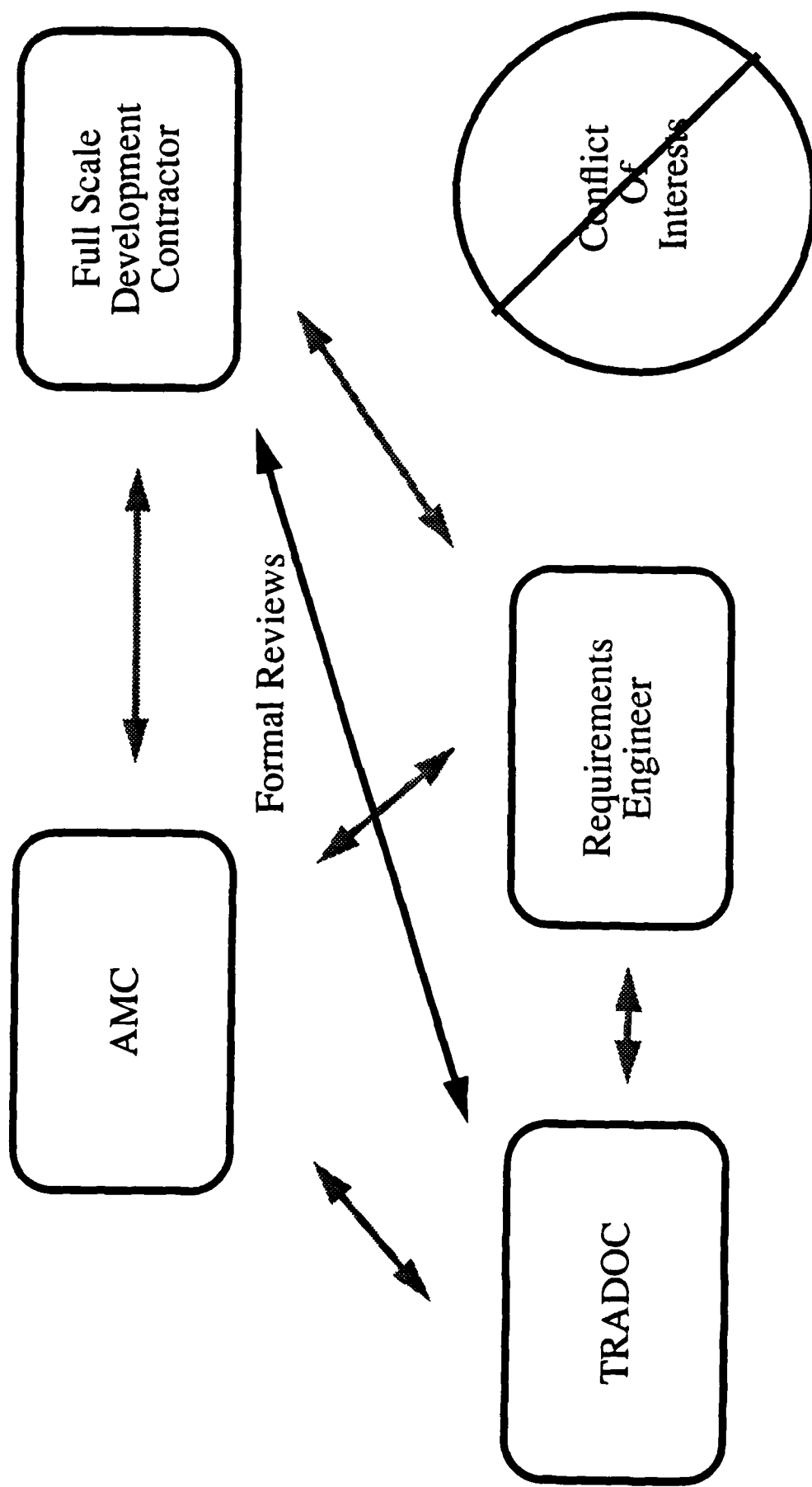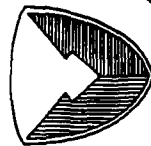
- Provide structure for the relationship and interaction between the user and the full-scale development contractor for all requirements related matters.

Full Scale
Development
Contractor

Conflict
Of
Interests

AMC

Requirements
Engineer

TRADOC

5

- Provide structure for the relationship and interaction between the user and the full-scale development contractor for all requirements related matters.

Full Scale Development Contractor

AMC

Requirements Engineer

TRADOC

Conflict Of Interest
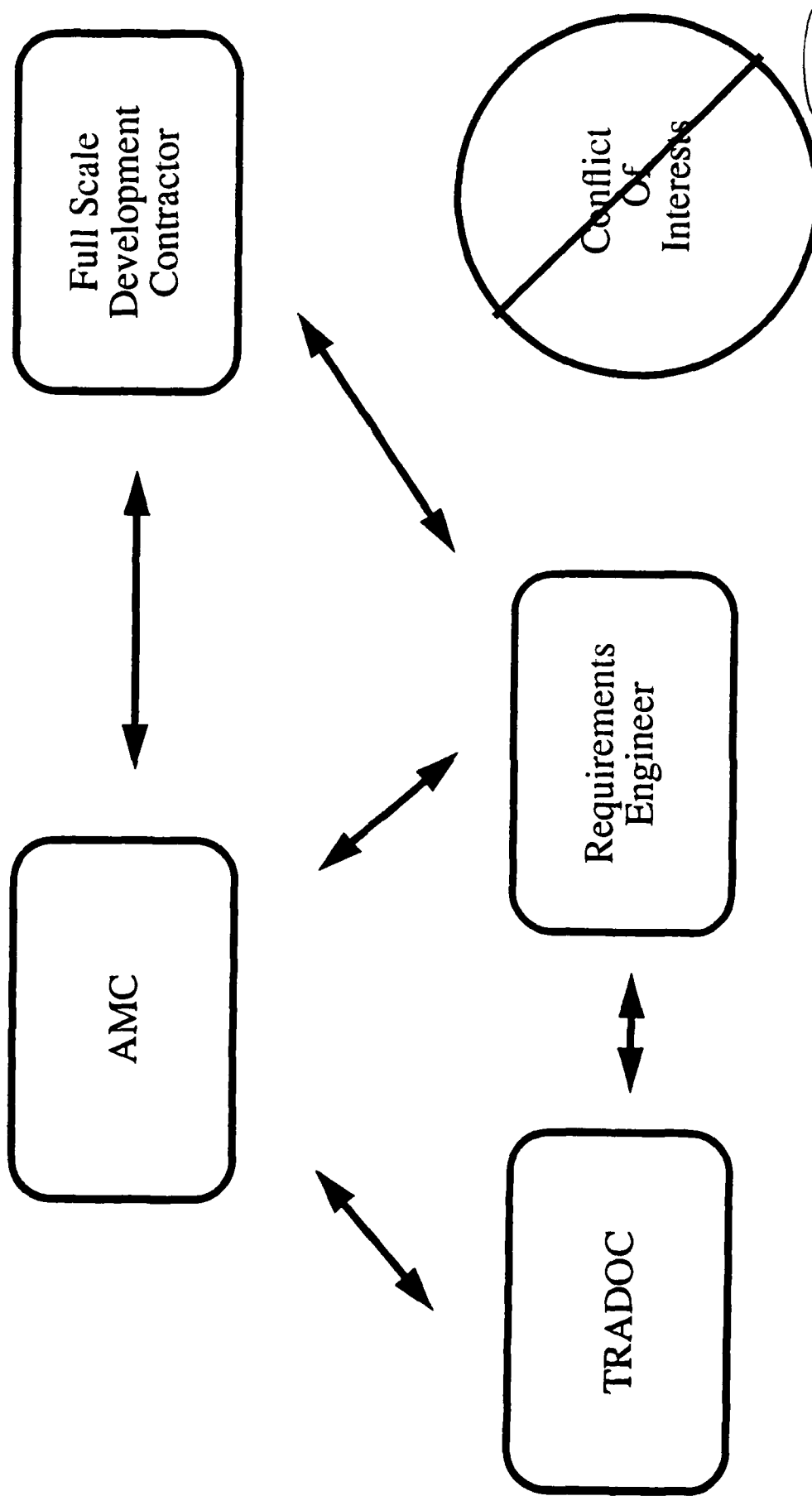
Formal Reviews

The Combat Developer should be an active participant in the system's formal reviews.

⑤ • Provide structure for the relationship and interaction between the user and the full-scale development contractor for all requirements related matters.
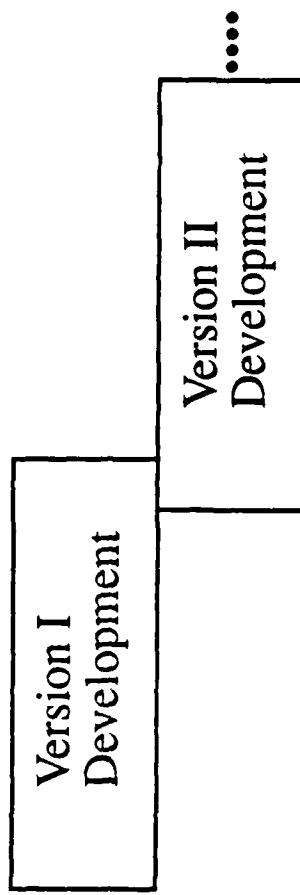
Full Scale Development Contractor

AMC

Requirements Engineer

TRADOC
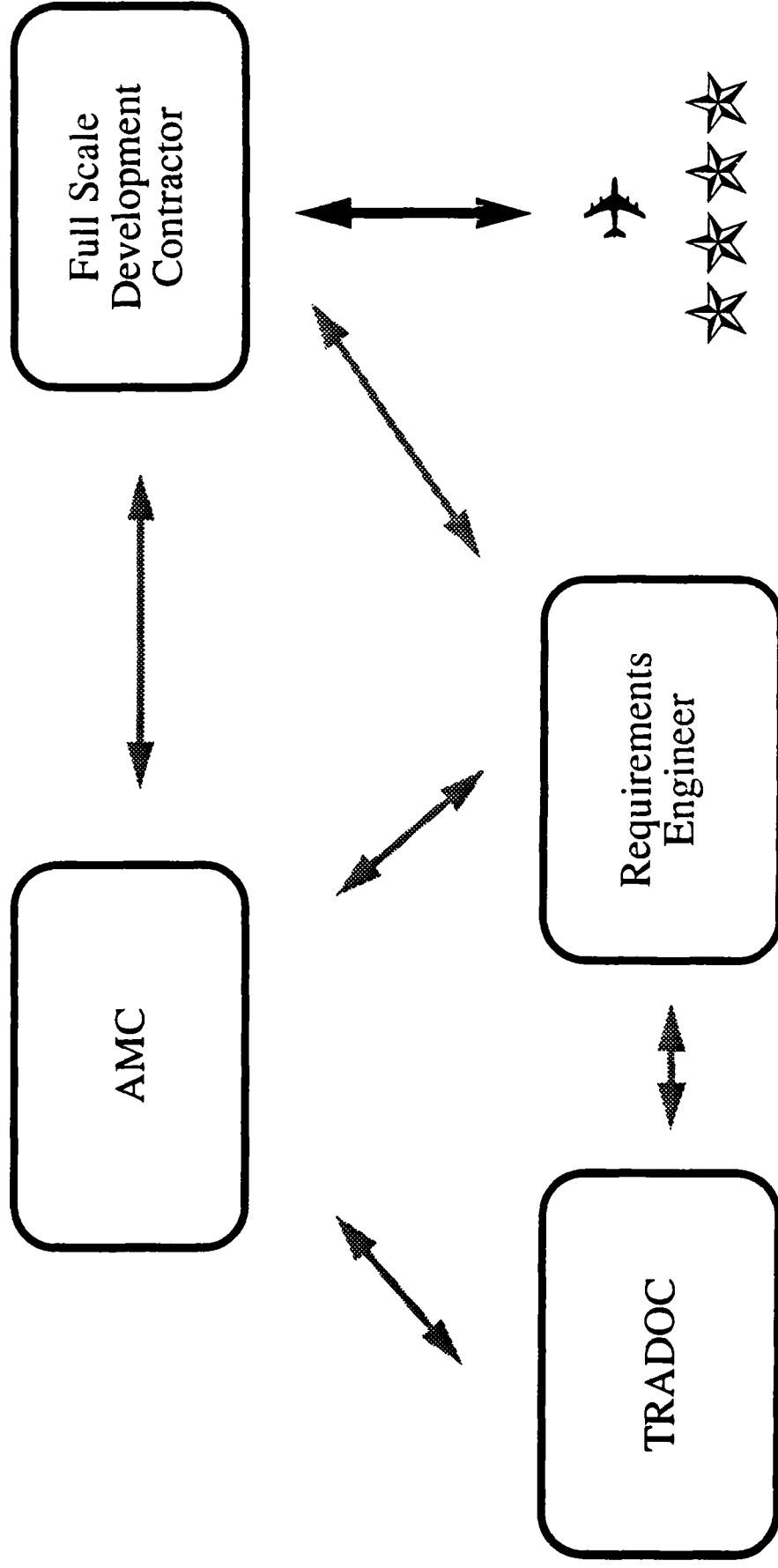
This does not preclude the system end user from participating in system testing and training at the contractor's site, under formal arrangements.
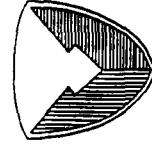
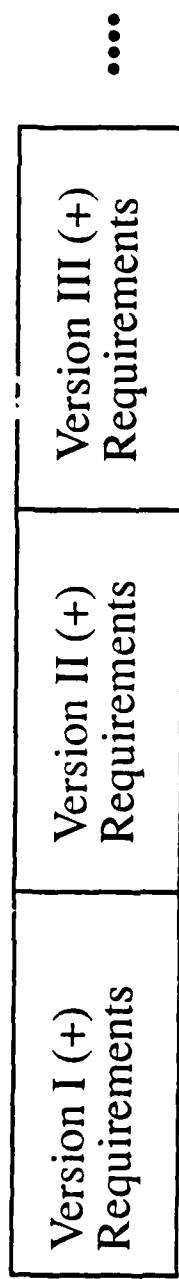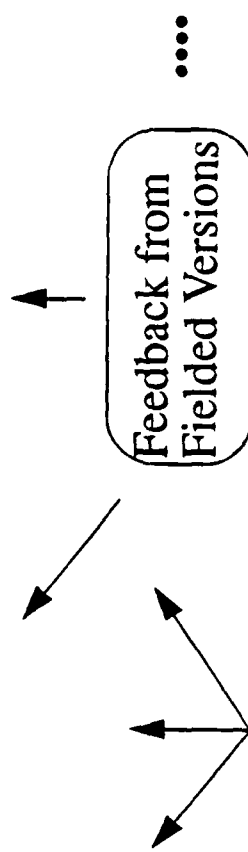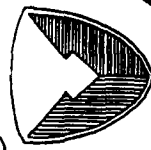❻ • Plan to develop systems in an incremental, evolutionary manner.

Full Scale Developer

Version I Development

Version II Development

Requirements Engineer

Version I (+) Requirements

Version II (+) Requirements

Version III (+) Requirements

Feedback from Fielded Versions

'User'

Requirements Specification, Validation, Prioritization

The CECOM CSE Acquisition Model Stresses Requirements Engineering, Emphasizing Techniques For Requirements Definition And Change Management.

It Recommends Six Risk Reduction Strategies, Which Can Be Tailored To Apply To A Wide Range Of Acquisitions.

❶ • Designate a Requirements Engineering effort which applies Requirements Engineering techniques from the early project phases and on.

❷ • Contractually decouple requirements definition from the Full Scale Development Effort.

❸ • Establish a Functional Baseline with an approved System/Segment Specification (SSS) prior to the solicitation and make the SSS a part of the solicitation package.

❹ • Document the user interface and interaction in the SSS, together with system testing information.

❺ • Provide structure for the relationship and interaction between the user and the full-scale development contractor for all requirements related matters.

❻ • Plan to develop systems in an incremental, evolutionary manner.