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REPORT ON RESULTS OF CONCEPT FORMULATION ACTIVITIES FOR AN ARMED AIRCRAFT QUALIFICATION RANGE SCORING SYSTEM

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STUDY, ARMED AIRCRAFT QUALIFICATION RANGE SCORING SYSTEM

ABSTRACT

This study determined the technical feasibility and optimum design analysis for an Armed Aircraft Qualification Range Scoring System in accordance with Concept Formulation outlined in AMCR 70-30 and system requirements outlined in a Small Development Requirement (SDR).

After an intensive review and analysis of the SDR Requirements had been completed, a detailed investigation was conducted of all available "OFF-THE-SHELF" scoring systems. A "Trade-Off" analysis was made of the characteristics of each of these systems versus the requirements outlined for the optimum scoring system developed by the revised SDR. A cost effectiveness effort was completed, an Operational Specification was written, and a Concept Formulation Report was prepared. The report concluded that an off-the-shelf scoring system using acoustic sensing principles be further developed to meet the functional requirements of the optimum system in order to satisfy armed aircraft gunnery scoring requirements of the 1970 to 1975 time frame.

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FOREWARD

This report describes the concept formulation work performed under NAVTRADEVCEN Contract N61339-69-C-0178 with Del Mar Engineering Laboratories and Booz-Allen Applied Research, Inc. The purpose of the study was to provide the technical, economic, and military basis for the decision to initiate engineering system development for a helicopter gunship scoring range.

The basic objectives of the study were to (1) analyze the requirements of the DA approved Small Development Requirement (SDR), (2) examine existing scoring systems in light of the SDR, and (3) propose a hardware system, requiring little research and development, to meet the requirements. The ultimate goal is a reliable, dependable, and versatile scoring system that will provide instant hit information to the attacking helicopter pilot trainee and instructor pilot. The system must perform acceptable regardless of attack angle and azimuth, type of armament selected, and type of target engaged.

The study has revealed that the technology is not sufficiently at hand to meet all of the SDR requirements. The most difficult problem areas to solve are discriminating between the different types of rounds hitting a target simultaneously, and providing a detection system that does not restrict the attack angle and is not susceptible to damage from armament fired into the target area.

Two approaches seem logical at this time: (1) reevaluate the SDR to determine the minimum essential requirements, thereby enabling existing technology to satisfactorily meet the reduced requirements or (2) embark on a research and development effort to ascertain if there is any approach that will meet the existing requirements.

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The findings in this report are not to be construed as an official Department of the Army position, unless so designated by other authorized documents.

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SECTION I

INTRODUCTION

A. GENERAL

A requirement exists for an Armed Aircraft Qualification Range Scoring System which will permit the recording of hits and near-misses on ground targets at a central location remote from a firing area. Numerous attempts by industry, both domestic and foreign, have been made to meet this need. None have fulfilled all the requirements of the optimum scoring system. This study has investigated all known scoring systems, applied those components to the optimum system needs and recommends development or augmentation of existing hardware and methods of application to provide a scoring system adequate to accomplish its goals without need for invention or scientific advances. In consonance with policy, prior to initiating work on system development, this study was directed to insure that the following system prerequisites had been met.

1. PREREQUISITE 1

Engineering rather than experimental effort is required and the technology needed is sufficiently in hand.

2. PREREQUISITE 2

The mission and performance envelopes are defined.

3. PREREQUISITE 3

The best technical approaches have been selected.

4. PREREQUISITE 4

A thorough trade-off analysis has been made.

5. PREREQUISITE 5

The cost effectiveness of the proposed system has been determined to be favorable in relationship to the cost effectiveness of competing items on a DOD-wide basis.

6. PREREQUISITE 6

The cost and schedule estimates are credible and acceptable.

The Study Tasks were developed so that all necessary prerequisite requirements were fulfilled.

SECTION II

STATEMENT OF THE PROBLEM

A. GENERAL

The objective of the study is to determine the technical feasibility as well as the economic and military considerations for the development of an Armed Aircraft Qualification Range Scoring System. This system should accurately provide both hit and miss data to an airborne gunner trainee immediately following his training exercise. This timely information would allow corrective action to be taken before his next firing pass. Information needed to improve his gunnery techniques is vector data, i.e. over-short-left or right. In selecting systems and scoring hardware, only state-of-the-art hardware and techniques should be used with little or no invention or scientific advances required.

B. DEFINITION OF THE PROBLEM

"A Study Outline for Armed Aircraft Qualification Range Scoring System", NTDC-371-1C6, Project 1951, dated 16 February 1968 and an "Approved Small Development Requirement (SDR) for an Armed Aircraft Qualification Range Scoring System" was provided as program guidance. These documents and AMCR 70-30 are included as Appendix A to this report.

SECTION III

METHOD OF PROCEDURE

A. GENERAL

In order to produce a properly validated specification for an Armed Aircraft Qualification Range Scoring System, eight specific tasks were undertaken. These tasks were accomplished in such a manner that all the necessary information would be assembled to meet the prerequisite requirements of AMCR 70-30.

1. Task #1 - Review and analyze the Small Development Requirement.

2. Task #2 - Develop system functional analysis and requirements allocation.

3. Task #3 - Identify, analyze and develop technical summary of applicable off-the-shelf systems and state-of-the-art technology.

4. Task #4 - Conduct trade-off studies of hardware identified in Task #3.

5. Task #5 - Define recommended system with consideration for maximum modular concept integration; and preparation of performance specification, cost estimates and schedules.

6. Task #6 - Identify subsystem and/or hardware areas where future development is required to optimize the recommended off-the-shelf system.

7. Task #7 - Prepare concept formulation study report.

8. Task #8 - Conduct technical reporting conferences.

B. TASK #1 REVIEW AND ANALYZE THE SMALL DEVELOPMENT REQUIREMENT

This task involved the review and understanding of the Small Development Requirement (SDR). To accomplish this, field visits were made to numerous Army installations, and conferences with senior Army aviators intimately involved in both individual and unit gunnery training programs were conducted.

The SDR was analyzed to define the essential and desirable operational characteristics of the Qualification Range Scoring System, not only in the light of scoring systems themselves, but also as the system is related to weapons systems. Specific comparisons were drawn between stated SDR requirements and those arising from aircraft armament subsystems, Government field activities, and equipment manufacturers. In this effort, we drew not only on past experience with the stated SDR parameters, but also on the results of day-to-day contact with currently operational scoring systems.

The system is to be used with targets presenting real-time projectile impact information to observers located at a point remote from the range itself. The resulting technique will replace the current practice of counting holes in a target panel, which is not only tedious and wasteful of manpower, but also ineffectual in terms of psychological impact on the attacking pilot, because of the time lapse between his firing pass and the determination of his results. It is apparent that a real-time score display (hits and misses) results in accelerated pilot gunnery training programs and qualification exercises, with a corresponding increase in range efficiency and personnel utilization. This concept should manifest itself in a higher level of gunner proficiency.

During the unit training phase the SDR recognizes that an acceptable range must present a realistic situation to the attacking pilot, with respect both to the targets themselves and to their environment. The targets must appear real in their representation of personnel, vehicles and equipment, with their appearance not compromised by the presence of scoring equipment. All system elements must be light in weight and readily portable to facilitate rearrangement of the tactical situation on a given range, or a change in locale, possibly to a different range altogether. The range equipment must be operable both day and night under typical world-wide climatic and terrain conditions, with little or no target site preparation or equipment re-calibration required.

The scoring system recommended must be compatible with contemporary weaponry such as gun-propelled projectiles from 5.56mm through 30mm, 40mm grenades and 2.75" to 6" rockets, primarily inert rounds. Rates of fire up to 24,000 rounds per minute can be expected. With airborne armament systems now including a variety of weapons on a given aircraft, the impact detection system must change its response parameters in a minimum of time to score the various projectile types which may be fired during any one mission. No scoring technique should be selected which will prohibit scoring of foreseeable future air-to-ground weapon system - the scoring system must never restrict the ability to train.

In individual and unit gunnery qualification roles, the scoring system need present only a summary of hits and misses. However, during training programs leading to qualification, it is necessary to provide vector (quadrant) information in addition to hit/miss data. The SDR recognizes that, in either role, a high level of accuracy must be demonstrable so that the pilots undergoing training or qualification will accept the results displayed, thereby enhancing their progress toward combat readiness.

Preliminary evaluation studies were conducted to define system approaches, the level of present state-of-the-art, and the risk involved in establishment of any required development activity. The emphasis of this evaluation is to interpret the feasibility of the operational characteristic identified in the SDR, and to assist in planning implementation of the other study tasks.

Attached as Appendix B is the resulting statement of understanding of the SDR, a list of installations and personnel contacted and work sheets which were prepared from information gained. At the completion of this task, a Technical Reporting Conference (TRC) was conducted and the results and findings discussed.

C. TASK #2 DEVELOP SYSTEM FUNCTIONAL ANALYSIS AND REQUIREMENTS ALLOCATION

A system's function are the various operations which are expected of the system or any of its parts to perform in order to satisfy the defined mission. The system's design results in hardware which satisfactorily performs these functions considering maximum personnel safety and the expected range of environmental conditions. An initial step in the system engineering technique consisted of the formulation of a functional analysis of the system. This functional description was a prerequisite in developing, interpreting and providing standards for design of the hardware and its interfaces.

Functional aspects to be identified within the functional analysis include (a) a description of the functions, (b) the sequence of their occurrences, (c) the logical arrangement between these functions, (d) their hierarchy.

The Small Development Requirements were assigned to each appropriate defined function. This effort translated the functions into design requirements; and, in addition, provided guidelines for evaluating the degree of acceptability in the trade-off analysis of the existing hardware (Task #4) and hardware development (Task #6).

Attached as Appendix C is the completed Functional Analysis for the Optimum Armed Aircraft Qualification Range Scoring System.

D. TASK #3 IDENTIFY, ANALYZE AND DEVELOP TECHNICAL SUMMARY OF APPLICABLE OFF-THE-SHELF SYSTEMS AND STATE-OF-THE-ART TECHNOLOGY

All promising scoring systems were investigated to determine their applicability in satisfying the demands of the Small Development Requirement; that is, whether they are suitable to be used as the basis for elements in the idealized system as outlined. This determination was accomplished by a careful parametric analysis of each technique as substantiated by field experience, manufacturer's specifications, or basic system analysis where required.

It is apperent from system considerations that three areas of investigation exist which were studies more or less independently of each other. These are the hit detection technique itself (at the target site), the data transmission link and the display elements. The study program for each of these areas is discussed below:

1. HIT DETECTION

The study was limited to currently available non-cooperative (passive) hit-detection methods so that standard combat weapons and projectiles can be used on the range. The study was further limited to those techniques which have been reduced to hardware, preferably production hardware, form. Within these limitation, the following techniques were studied to determine their suitability as the hit-detection element of the idealized system:

a. Doppler Radar

b. Pulse Radar

c. Acoustic

(1) Amplitude

(2) Time-of-arrival differential

d. Hit-Count Panels

(1) Electrically conductive

(2) Mechanically excited.

2. DISPLAY

With the entire purpose of range exercises being the immediate presentation of desired information to cognizant personnel, it is evident that the display method recommended is an extremely important element of the ideal system. The study investigated various displays from simple hit counting to sophisticated presentation of actual miss-distances, both scalar and vectorial, which may demand some form of recording or computer analysis as a part of the data reduction process.

The following display (and recording) techniques were studied:

a. Hit counting

b. Miss-distance presentation

(1) Round-by-round

(2) Mean Point of Impact (MPI)

c. Miss-direction presentation

(1) Quadrant

(2) Clock

d. Recording Techniques.

Each analysis gave due consideration to human factors in order that the information displayed will be readily grasped for timely communication to the attacking trainee pilot. Of special significance was the capability of the technique under study to accommodate the high fire rate required by the SDR.

3. DATA TRANSMISSION LINK

A significant portion of the proposed study was devoted to an investigation of data transmission links between the range itself and the display sites. The systems investigated included, but were not necessarily limited to, hard-wire links; FM telemetry, either digital or in PCM format; FM/FM telemetry. Of special importance in this phase of the study were considerations of range portability, system reliability, immunity from spurious responses, availability of r-f frequencies, and compatibility with IRIG specifications.

Attached as Appendix D is the Technical Analysis of the "Off-the-Shelf" candidate systems that were investigated and a listing of technical data that were received.

E. TASK #4 CONDUCT TRADE-OFF STUDIES OF HARDWARE IDENTIFIED IN TASK #3

The objective of this task was to validate the candidate Armed Aircraft Qualification Range Scoring System from the hardware identified in Task #3, with respect to the functional requirements specified in Task #2.

A trade-off matrix was prepared which listed the optimum system's functional requirements as well as the functional characteristics of each candidate system developed during Task #3. Each system's essential function was ranked and graded as follows: a value of "3" was given when the candidate system component met the requirement; a value of "2" was given when the candidate system component only partially met the requirmement; a value of "1" was assigned when candidate system component did not meet the requirement except to a minor degree and "0" value was assigned when the candidate system component did not satisfy any part of the optimum system's functional requirement. Upon completion of the grading, each functional characteristic was weighed in accordance with established hierarchy of importance determined in Task #2. Three levels of importance were used and the following weights were applied.

1. Level 1 (Sensing Scoring & Displaying) 50%
2. Level 2 (MPI for Miss-distance, r & θ) 25%
3. Level 3 (Data Transmission & Miscellaneous) 25%

Thus the rating value multiplied by the level of importance yielded the weighted score for each candidate system.

An attempt was made to arrive at a composite system comprising the best subsystem from the candidates, however, this effort was dropped when it became apparent that interfaces were completely incompatible.

It is also concluded that no one system, currently available, will completely satisfy the true functional requirement.

Attached as Appendix E, is the Trade-Off Analysis, the work sheets used, and a ranking table of all candidate systems considered.

F. TASK #5 DEFINITION OF THE RECOMMENDED SYSTEM PREPARATION OF PERFORMANCE SPECIFICATION, COSTS AND SCHEDULE

This task consisted of three parts; the definition of the recommended optimum scoring system, the development and preparation of a performance specification for the optimum scoring system and the cost effectiveness of the recommended system. A complete system definition and the resulting proposed performance specification 371-112A, Specification for Armed Aircraft Qualification Range Scoring System has been provided. This specification was prepared in accordance with Level III, under MIL-T-23991 and Chapter 5, DSM 41203-M.

A true cost effectiveness study for this system could not be achieved due to the lack of necessary information, both operational and vendor supplied, however, a cost model was constructed. This model and other rational is provided in Appendix F.

G. TASK #6 IDENTIFY SUBSYSTEM AND/OR HARDWARE AREAS WHERE FUTURE DEVELOPMENT IS REQUIRED TO OPTIMIZE THE RECOMMENDED OFF-THE-SHELF SYSTEM

The purpose of this effort was to determine the amount and type of development engineering effort and an estimated cost to up-date all candidate "off-the-shelf" scoring systems to meet the idealized system's functional requirements.

In study Tasks 3 and 4 it was ascertained that each of the candidate "off-the-shelf" scoring systems were functionally inadequate and none met all the requirements of the idealized system specification.

To develop a method of estimating additional development and estimated production costs for candidate systems without attempting to forecast individual company development costs, a standardized method of cost estimating was used. Details of this effort are found in Appendix "H".

H. TASK #7 PREPARE CONCEPT FORMULATION STUDY REPORT

This Concept Formulation Study Report summarizes the results of the eight study tasks and meets the requirements of NAVTRADEVCEN-STD-104D, paragraph 5.1.4, final report, as applicable. The study report fulfilled the six prerequisites specified in AMCR 70-30 and covered all of the requirements specified in the Study Outline 371-106, 16 February 1968.

J. TASK #8 CONDUCT TECHNICAL REPORTING CONFERENCES

Three Technical Reporting Conferences were conducted, the First on 23 May 1969 at the Naval Training Device Center, Orlando, Florida; the Second on 17 July 1969 at Del Mar Engineering Laboratories, Los Angeles, California and the final one on 23, 24 September 1969 at Del Mar Engineering Laboratories. Included as Appendix G are the agendas and summary report for each conference.

SECTION IV

RESULTS

A. GENERAL

The study revealed that deficiencies currently exist in four major areas pertinent to Armed Aircraft Gunnery Training Scorings:

1. Proficiency criteria for gunnery qualification is non-existent.

2. Developmental Engineering is required to modify the Candidate Scoring System found to be most effective to meet all functional, environmental and operational requirements of the Optimum Range Scoring System.

3. Candidate Scoring Systems, in an "off-the-shelf" category, do not meet all functional requirements of the idealized scoring system.

4. Operational and system costs of present scoring methods and systems have not been defined adequately enough for a thorough cost effectiveness effort to be completed herein.

B. PROFICIENCY CRITERIA

True Qualification Standards criteria has not been established for the individual training of gunnery students except for gunnery flight instructor pilots. Subjective scoring is accomplished by Gunnery Instructor Pilots using visual and judgement techniques. Standards for evaluating unit gunnery proficiency and accuracy have not been developed. Army Training Tests (ATT) do not include objective scoring of units in gunnery subjects. The lack of these critiera and standards make the task of determining the true effectiveness of an optimum scoring system difficult.

C. DEVELOPMENTAL ENGINEERING

An investigation was conducted to determine the effort and cost of up-dating each candidate "off-the-shelf" system to meet the idealized system's functional requirements. The methodology and results of this effort are shown in Appendix "H".

D. FUNCTIONAL REQUIREMENTS

The functional analysis performed in Tasks 2 and 4 revealed that candidate systems ranked in the following order: Approach 7, 8, 9, 14, 16, 3, 12, 13, 4, 1, 15, 2, 5, 6, 10 and finally 11. Approach 7 rated highest, meeting 43% of the optimum system's requirements, and Approach 11 rated the lowest, meeting only 20%. The functional and technical analysis are furnished as Appendices C and D respectively. Deficiencies common to all candidates include; scoring rates - too low, scoring radius - too small, no method of determining mean point of impact and no vector or quadrant information provided.

E. COST EFFECTIVENESS

Cost data for present day scoring methods and systems are either unclear or unavailable. Total number of aircraft hours utilized, quantities of ordnance expended, and support effort necessary to "qualify" a gunnery student have not been determined. Candidate Scoring System manufacturers have provided only "first" cost figures; mortality rates for down-range subsystems have not been estimated; operational support costs have not been calculated; estimated logistics costs have not been determined. Lacking these data a true cost effectiveness analysis cannot be completed. However, a cost effectiveness model was constructed. This formula was applied to eligible candidate systems for cost and economic considerations and the resultant rankings are as follows: Approach 8, 14, 13, 7, 9, 15, and 4.

Approach 8 was determined to be most cost/effective with a relative value of $10.34 while Approach 4 was the least cost/effective with a relative value of $33.75. Certain candidates were eliminated from consideration due to lack of adequate price and cost information or where excessive development effort was obvious. Appendix F provides details of the cost/effectiveness effort.

SECTION V

DISCUSSION

A. GENERAL

The study tasks enumerated in Section I have been promolgated to incorporate all data and information necessary for compliance with prerequisite requirements of AMCR 70-30.

1. PREREQUISITE 1

Information necessary for compliance with this prerequisite was obtained during the completion of Tasks 2, 3, 5 and 6. Task 2 developed a functional analysis of the system in conjunction with the SDR; Task 3 investigated all known scoring systems, and state-of-art technology; Task 5 defined the ultimate system required including cost/effectiveness evaluation and Task 6 identified and estimated the development effort required to optimize the recommended off-the-shelf system. Data resulting from these tasks indicate that engineering rather than experimental effort is required and technology needed is sufficiently in hand to develop the idealized scoring system.

2. PREREQUISITE 2

The Task 2 analysis defined the mission and performance envelopes for the idealized scoring system, thereby meeting the prerequisite requirements.

3. PREREQUISITE 3 & 4

Trade-off studies of candidate systems conducted under Task 4 and the review of state-of-the-art technology completed during Task 3, has insured that the best technical approach has been selected. Additionally, the complete functional comparison of all candidate systems has resulted in the selection of the best qualified off-the-shelf system which might be modified and improved, with minimal effort, to meet specification requirements.

4. PREREQUISITE 5

A cost/effectiveness model was prepared in Task 5, and applied to each candidate system. Lack of up-to-date factual information on present-day operation and maintenance costs and the limited price data furnished by candidate-system manufacturers prohibited the preparation of a more comprehensive analysis. However, estimates and weighting factors were used to provide an effective cost analysis.

5. PREREQUISITE 6

During Tasks 5 and 6 it was determined that cost estimates and time estimates were accurate and realistic within the imposed boundary conditions. These estimates include system development, testing, evaluation, acquisition, operation and maintenance costs and time.

SECTION VI

CONCLUSIONS

A. GENERAL

From the results of investigations and data compiled during the course of the study, it was concluded that acoustic sensing techniques offered the best technical approach to meet air-to-ground armament scoring system requirements. It is also apparent that a trade-off must be made to insure that all military and economic aspects of the idealized scoring system are considered. The results of functional adequacy and cost/effectiveness as discussed in Section IV as shown below:

Functional Adequacy Ranking	Percent Functional	Cost Effectiveness Ranking	C-E Value
Approach # 7	43%	Approach # 8	$10.34
8	41%	14	12.06
9	40%	13	12.16
14	38%	7	13.12
13	35%	9	15.60
4	34%	15	16.96
15	28%	4	33.75

The candidate systems which rank first, second and third in functional adequacy (Approaches #7, 8 and 9) were reviewed with candidate systems which rank first, second and third in cost/effectiveness (Approaches 8, 14, and 13) to provide a final basis for systems selection. In functional adequacy, insignificant differences existed between the leading three candidates (3%), while in the cost/effectiveness area a significant difference is apparent. It should also be noted, at this point, that approaches 13 and 14 represent systems manufactured by foreign Companies. If "Buy-America" policies are to be considered, resulting in elimination of two more candidates, the cost effectiveness value differential is quite significant (approximately 23%). It is concluded, therefore, that the candidate system represented by Approach Number 8 is the most acceptable, off-the-shelf scoring system in consideration of technical feasibility, economic and military requirements, and the development requirement.

B. MODIFIED DEVELOPMENT TIME/COST CYCLE

It is further concluded that, although technically feasible and within the state-of-the-art, it may be relatively costly and time consuming to develop a scoring capability for all projectile types (inert, HE, subsonic and supersonic projectiles) and, particularly, to develop the means to score simultaneous, multiple-type projectiles on the same target. This consideration is applicable to all candidate systems.

SECTION VII

RECOMMENDATIONS

A. GENERAL

Following the conclusions reached in Section VI, it is recommended that engineering development of this optimum scoring system be initiated, utilizing NTDC Specification 371-112A as a basis.

B. QUALIFICATION CRITERIA

It is further recommended that, concurrent with the engineering development process, qualification standards be established for gunnery proficiency ratings, based on the use of instrumented scoring systems.

C. MODIFIED DEVELOPMENT TIME/COST CYCLE

It is recommended that consideration be given to modification or deletion of the requirements to score all projectile types and to score multiple-type projectiles simultaneously on the same target.

D. SCORING SYSTEM UTILIZATION STUDY

It is also recommended that a study of the methods for best utilization of scoring systems as an aid to gunnery training be conducted. Human factors related to utilization of the scoring system as a training aid should receive the greatest emphasis. Publication of a guide for scoring systems users would be an end item for such a study.

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APPENDIX A

[illegible]
16 February 1968
Project 1952

NAVAL TRAINING DEVICE CENTER
ORLANDO, FLORIDA

STUDY OUTLINE FOR

ARMED AIRCRAFT QUALIFICATION RANGE SYSTEM
CONCEPT FORMULATION

PREPARED BY: [illegible]
Project Engineer

APPROVED BY: [illegible]
Head, Land Warfare
Department

371-106
16 February 1968
Project 1951

NAVAL TRAINING DEVICE CENTER
ORLANDO, FLORIDA

STUDY OUTLINE FOR

ARMED AIRCRAFT QUALIFICATION RANGE SYSTEM
CONCEPT FORMULATION

1. SCOPE

1.1 This study outline establishes the requirements for a study to determine the technical feasibility, economic, and military considerations for preparation to initiate development of the Armed Aircraft Qualification Range System. The study shall include a survey of the technological state-of-the-art hit and near miss detection, and data acquisition and interpretation.

2. APPLICABLE DOCUMENTS

2.1 The following documents of the issue in effect on the date of invitation for bids or request for proposal form a part of this specification to the extent specified herein:

STANDARDS

Military

MIL-STD-461	Electromagnetic Interference Characteristics Requirements for Equipment
MIL-STD-470	Maintainability Program Requirements (For Systems and Equipment)
MIL-STD-471	Maintainability Demonstration Reliability Tests Exponential Distribution
MIL-STD-785	Requirements for Reliability Program (For Systems and Equipment)

371-106

Naval Training Device Center (NAVTRADEVCEN)

NAVTRADEVCEN-STD-164	Standard for Preparation of Technical Reports

PUBLICATIONS

U. S. Army Materiel Command

Regulation 70-30	Concept Formulation, Prerequisites to Initiating Engineering or Operational Systems Development Effort

Approved Small Development Requirement (SDR) for an Armed Aircraft Qualification Range System.

(Copies of specifications, standards, drawings and publications required by suppliers in connection with specific procurement functions should be obtained from the procuring activity or as directed by the Contracting Officer.)

3. REQUIREMENTS

3.1 Background.- Army Materiel Command Regulation (AMCR) 70-30 outlines the concept formulation prerequisites that must be analyzed and evaluated prior to initiating development of an operational system. The approved SDR for Armed Aircraft Qualification Range System outlines the proposed system and its capabilities required to fulfill the Army Aviation School air-to-ground ordnance training program.

3.2 Study outline.- This study shall determine the technical feasibility and optimum design analysis for the Armed Aircraft Qualification Range System in accordance with the concept formulation outlined in AMCR 70-30 and the system requirements as outlined in the SDR. Design analysis, comparison and recommendation shall be supported by appropriate rationale and data. The concept formulation shall consist of the 6 AMCR 70-30 prerequisites and shall include, but not be limited to, the following items and analysis:

3.2.1 Prerequisite 1. Primarily engineering rather than experimental effort is required and the technology needed is sufficiently in hand.- The study document shall record the analysis, comparisons, and recommended system and components for the Armed Aircraft Qualification Range System design. The study shall establish a recommended development for the Armed Aircraft Qualification Range System which will require primarily system design, and the adaptation of subsystems and components on the basis of existing data and which will not require invention or scientific breakthrough. Prerequisite 1 shall include, but not be limited to, analysis of the following items.

(a) Various hit detection scoring techniques, components, and systems for supersonic and subsonic projectiles of various caliber. This shall include the operational parameters as well as compatability with the requirements of the SDR. Particular attention is directed to the determination of the "near miss" projectile impact point capability

(b) Various means of interfacing the hit detection systems and components with the central display unit. The interface design shall consider hit signal data conversion, timing function, data transfer from target areas to the control center, and central display unit for displaying data from target areas throughout the range system.

3.2. Prerequisite 2 - The mission and performance envelopes are defined.- Trainer performance and operating characteristics shall be analyzed and outlined in this section. These shall include, but not be limited to, the following items:

(a) Limitation on angle or entry of projectiles into the target detection zone

(b) Clearly defined maintainability and reliability outline which complies with the concepts of MIL-STD-470, MIL-STD-471, and MIL-STD-785

(c) Physical size, shape, and weight of individual system components, including containers for transport, to comply with requirements for man transportability

(d) Radio frequencies and output power of the system data link to conform to FCC regulations and availability of frequency bands

(e) Power requirements of the system, and power sources recommended to satisfy these requirements

(f) Limitations on hit detection rate and accuracy for single projectiles as well as simultaneous burst hits of various types of projectiles

(g) Feasibility of detection and scoring of both subsonic and supersonic projectiles, with any one method or concept, shall be supported by quantitative basis. Should a single method be incapable of accomplishing the desired results, the minimum number and types of system concepts or methods necessary shall be indicated

(a) [illegible] defined electromagnetic interference characteristics in compliance with the concepts of MIL-STD-461

(b) extent to which flying debris generated by "near-miss" projectiles will be a problem.

3.2.3 Prerequisite 3. The best technical approaches have been selected.- The best technical approaches shall include analysis of present design of other hit detection and data transmission systems as compared with the Armed Aircraft Qualification Range System technical approaches. The study report shall [illegible] why certain approaches are not recommended and why other approaches were selected.

3.2.4 Prerequisite 4. A thorough trade-off analysis has been made.- The trade off analysis shall also include all trade-off studies performed in determining system configurations. The studies shall include, but not be limited to performance, economics, trainer efficiency, reliability and maintainability concepts.

3.2.5 Prerequisite 5. The cost effectiveness of the proposed item has been determined to be favorable in relationship to the cost effectiveness of competing [illegible] on a DOD-wide basis. The cost effectiveness shall be oriented to illustrate the potential savings attainable through the use of the Armed Aircraft Qualification Range System in lieu of the techniques now utilized in other scoring and training methods. Consideration shall be given to the quantity of students, training proficiency requirements, and projection of future requirements and costs. The cost effectiveness analysis shall include operating cost estimates of the trainer such as reliability, maintainability, and utilization over the effective life of the trainer.

3.2.6 Prerequisite 6. The cost and schedule estimates are credible and acceptable. Complete estimate [illegible] schedules and cost information [illegible] supporting manpower and material estimates shall be provided. The estimate shall assume design and manufacture of the Armed Aircraft Qualification Range System within the fiscal year 68-70 period.

3.3 End product. The end product shall consist of a concept formulation report in accordance with the final report requirement of NAVTRADEVCEN SIL 104.

3.4 Data and reference material.- Except for the applicable document of paragraph 3.1, all data and reference material shall be obtained by the contractor. Such data shall include hit detection design and operational characteristics, projectile characteristics, cost, military utilization and [illegible] information.

3.5 Security classification.- The end product shall be unclassified.

4. QUALITY ASSURANCE PROVISIONS

4.1 The end product resulting from the study described herein shall be subject to review and approval, in writing, by the Contracting Officer. Review will include determination of compliance with the requirements of this study outline and applicable specifications.

5. PREPARATION FOR DELIVERY

5.1 The concept formulation data shall be prepared for delivery in accordance with NAVTRADEVCEN STD 104 and the Contract Schedule.

6. NOTES

6.1 Intended use.- The Concept Formulation Study will provide technical feasibility, economic considerations, and best technical approach toward development of a hardware prototype, Armed Aircraft Qualification Range System.

371-106
AMENDMENT - 1
9 July 1965
Project 1956

NAVAL TRAINING DEVICE CENTER

ORLANDO, FLORIDA

STUDY OUTLINE FOR

ARMED AIRCRAFT QUALIFICATION RANGE SYSTEM

CONCEPT FORMULATION

Prepared by: [signature]
Project Engineer

Approved by: [signature]
Head, Land Warfare
Department

371-106
AMENDMENT - 1
9 July 1968
Project 1956

NAVAL TRAINING DEVICE CENTER
ORLANDO, FLORIDA

STUDY OUTLINE FOR
ARMED AIRCRAFT QUALIFICATION RANGE SYSTEM
CONCEPT FORMULATION

This amendment forms a part of and shall be attached to Study Outline 371-106, dated 16 February 1968.

On the cover page: Add the word "Scoring" between the words "Range" and "System".

Page 1, in the Title: Add the word "Scoring" between the words "Range" and "System".

Page 1, paragraph 1.1: In line 4, add the word "Scoring" between the words "Range" and "System".

Page 2, paragraph 3.2: In line 2, add the word "Scoring" between the words "Range" and "System".

Page 2, paragraph 3.2.1: In line 4 and line 6, add the word "Scoring" between the words "Range" and "System".

Page 3, paragraph 3.2.1(a): Delete the words "near miss".

Page 3, paragraph 3.2: Change paragraph identification to read "3.2.2".

Page 3, newly identified 3.2.2(b): In line 1, add the words "Quantitatively expressed" between the words "outline" and "which"

Page 4, newly identified paragraph 3.2.2: Add "(j) Probability of an actual hit not being detected or recorded".

Page 4, paragraph 3.2.3: Delete in its entirety and substitute in lieu thereof: "3.2.3 Prerequisite 3. The best technical approach has been selected. - The Technical Approach which best satisfies the requirements of the SOR shall be presented. This approach shall be based upon the best balance between all factors considered in the other prerequisites. The study report shall indicate why other approaches are not recommended and why the proposed approach was selected."

371-106
AMENDMENT - 1

Page 4, paragraph 3.2.5: In line 5, add the word "Scoring" between the words "Range" and "System".

Page 4, paragraph 3.2.6: In line 5, add the word "Scoring" between the words "Range" and "System".

Page 4, paragraph 3.3: In line 2, insert the words "that satisfies the requirements of AMCR 70-30 and its six prerequisites and is" between the words "report" and "in".

Page 5, paragraph 6.1: In line 4, add the word "Scoring" between the words "Range" and "System".

DEPARTMENT OF THE ARMY APPROVED SMALL DEVELOPMENT REQUIREMENT (SDR) FOR AN ARMED AIRCRAFT QUALIFICATION RANGE SYSTEM

1. Purpose and Operational Characteristics: A requirement exists for a range system which will permit the recording of hits on ground targets at a central location remote from a firing area used by US Army armed aircraft. This system will be used in the training of aircraft crews, maintaining proficiency of trained crews, and associated applications. As the projectiles used in the training and proficiency roles will be primarily of an inert nature, a means for scoring near misses will be required in order to determine adjustments needed to improve accuracy.

a. (Essential) Targets used must realistically represent personnel, combat and tactical vehicles and crew-served ground weapons appropriate to the terrain and environment in which installed.

b. (Essential) The system must be adaptable to the simulation of various field tactical situations.

c. (Essential) Targets, hit count measurement and transmission devices and a hit count and register central display unit must be included as a part of the system.

d. (Essential) All components of the range system must be portable in nature and easily assembled and disassembled.

e. (Essential) The range system must be capable of operation through an area 2000 meters in width and 6000 meters in length, down to a minimum of 400 meters in width and 2500 meters in length.

f. (Essential) The range system must be capable of day and night operations under intermediate climatic conditions as outlined in Change 1, AR 705-15. Kits will be provided, if required, for use in cold, hot-dry climates.

g. (Essential) The range system must acquire and record scoring (hit and near miss) data on the following armament subsystems:

(1) (Essential) 7.62 machineguns.

(2) (Essential) 50 caliber machineguns.

(3) (Essential) Rockets and missiles (2.75 to 6").

(4) (Essential) 40mm grenade launchers.

(5) (Essential) 20mm and 30mm automatic gun.

h. (Essential) The system must be capable of scoring a single machinegun or multiple machineguns with rates of fire up to 6000 spm on a single firing run and combinations of those subsystems outlined in g above, on consecutive, but separate firing runs.

i. (Desired) The system must be capable of recording the combinations of the different weapons outlined in g above in a single firing run.

j. (Essential) The system must be capable of recording the distances of their terminal projectile positions from the target centers up to miss distances of 30 meters (recording of the azimuths and elevations desired if development time and cost is not excessive). Miss distance recordings of 0 to 15 meters must be within ±2 percent accuracy; for distances between 15 and 30 meters, accuracy must be within ±10 percent. If the desired azimuth and elevation recording is not achieved, target hits will be scored for small targets only and zone scoring is not achieved, target hits will be scored for small targets only and zone scoring will be used for all targets.

k. (Essential) The range system must be capable of collecting and recording data from each individual target and up to a minimum of six targets simultaneously.

l. (Desired) The range system must be capable of collecting and recording data simultaneously from ten targets.

m. (Essential) Targets and any associated instrumentation must:

(1) Be easy to install with little or no site preparation.

(2) Be portable by medium helicopter sling load to facilitate rearrangement of target arrays.

(3) Be realistic in appearance.

(4) Simple to repair and capable of individual component of module replacement.

(5) Require minimum maintenance as outlined in paragraph 5.

(6) Require no excessive calibration prior to operation.

(7) The hit count and register central display unit must have a self-contained lighting capability for effective night operations.

n. (Essential) The system must be capable of storage and transit under the conditions outlined in AR 705-15 (i.e., Army aircraft).

o. (Essential) The system must be adaptable to various types of terrain, i.e., desert, mountain, and jungle (see para 2f).

p. (Desired) The system must be capable of prolonged periods of inactivity while exposed to the local environmental climate (not to exceed 30 days), without requiring extensive preparation prior to activation.

q. (Essential) The command/control system must be adaptable to the electrical power available in CONUS and overseas or be capable of operation utilizing standard US Army generators.

r. (Essential) If batteries are used as power source for target arrays, they must be capable of 24-hour operation prior to recharge.

s. (Essential) The range system must be simple to establish, operate, and require a minimum or organizational maintenance (see para 5.)

t. (Essential) The system should have an expansion capability so as to accommodate future developed aerial weapons and platforms, e.g., Advanced Aerial Fire Support System.

u. (Essential) The hit count and register central display unit should be capable of being mounted in the back of a standard US Army 3/4-ton vehicle or 3/4-ton trailer (1/4-ton truck or 1/4-ton trailer desired).

v. (Essential) The system will have a minimum acceptable mean-time between failure of twenty hours under relatively heavy usage conditions.

2. Supporting Justification and Data:

a. Reasons for Requirement:

(1) As the helicopter is employed as an aerial platform for a variety of weapons systems, a formal program for the initial training and/or qualification of armed aircraft crews is required. Training programs must develop and maintain skills in target acquisition; identification, neutralization, and destruction. This new equipment will greatly reduce the time now required to train individual aviators in air-to-ground gunnery techniques. Substantial savings will result in ammunition expended, helicopter flight time reduced and overall student training efficiency increased.

(2) Current ranges used for this helicotper gunnery training utilize old ground-to-ground scoring techniques which require that scoring be accomplished by a "shoot and count holes" procedure or in-flight observation. The former is time-consuming and requires the range to be closed while personnel are in the firing areas; the latter scoring method is inaccurate as it provides only general hit or miss data. There is presently no means to count and locate relative to the target those projectiles which are near misses. This information is necessary in order to properly assess the effectiveness of the fire. Overall, the present type of scoring operation is inefficient, time consuming, and expensive. The training time lost, to include the down-time of the helicopter, is excessive and wasteful. The new proposed range system will eliminate all of these disadvantages now found in current range scoring training programs of instruction.

(3) A range system is required by US Army Aviation School and other commands with armed aircraft which will have the capability of accurately detecting target hits and near misses and displaying these data at a central location. These range systems will be authorized in Department of the Army Tables of Allowance (TA 23) of Army Aviation Training Centers in Continental United States and overseas, and will be utilized in the training of Army armed aircraft crews in order to:

(a) Provide for a more efficient utilization of personnel and aircraft involved.

(b) Expedite and improve the quality of initial crew training in armed aircraft.

(c) Improve the method of analyzing the armed aircraft crew proficiency (annual qualification).

(d) Improve all current scoring methods.

(e) Improve current range operating efficiency.

(4) Maintenance Concept. Organizational maintenance personnel should be able to accomplish the majority of the maintenance of this system on site. Such organizational maintenance should be restricted to minor, readily accomplished repairs, so that it will not interfere with the training program. Mechanisms requiring repair beyond the scope of organizational maintenence should be removed on site and evacuated through normal maintenance channels to the appropriate Direct, General or Deport maintenance facility. It is expected that a minimal training program for organizational maintenance personnel on the electronics portion of this device will be required. Maintenance functions will be accomplished by military personnel of MOS series 35B (Electronic Instrument Repairman) or equivalent DA civilian personnel. The maintenance required (all categories) for the Range System will not exceed one hour for each ten hours of training under normal circumstances. One hour of maintenance for twenty hours of training is desired.

DEPARTMENT OF THE NAVY
NAVAL TRAINING DEVICE CENTER
ORLANDO, FLORIDA [illegible]

IN REPLY REFER TO:
1572: [illegible]
N61339-69-C-0178

Fr.: Commanding Officer, Naval Training Device Center, Orlando, Florida 32813
To: [illegible] Engineering Laboratories, 6911 West [illegible] Highway, Los Angeles, California [illegible]

Subj: Contract N61339-69-C-0178, USA Materiel Command Regulation 70-36, forwarding of

Ref: (a) [illegible] ltr [illegible] of 8 April 1969

Encl: (1) Regulation 70-36

1. Enclosed herewith publication requested in reference (a).

[illegible]
Contracting Officer

HEADQUARTERS
UNITED STATES ARMY MATERIEL COMMAND
WASHINGTON, D.C. 20315

AMC REGULATION
NUMBER 70-30

16 May 1966

RESEARCH AND DEVELOPMENT

CONCEPT FORMULATION--PREREQUISITES TO INITIATING ENGINEERING OR OPERATIONAL SYSTEMS DEVELOPMENT EFFORT

Paragraph

1. Purpose. This regulation sets forth requirements that must be met prior to submitting a request to U.S. Army Material Command (AMC) for approval to enter a project into engineering or operational systems development.

2. Scope. This regulation applies to:

a. Headquarters, AMC; AMC major subordinate commands; project managers; and separate installations and activities reporting directly to Headquarters, AMC, and performing research and development functions.

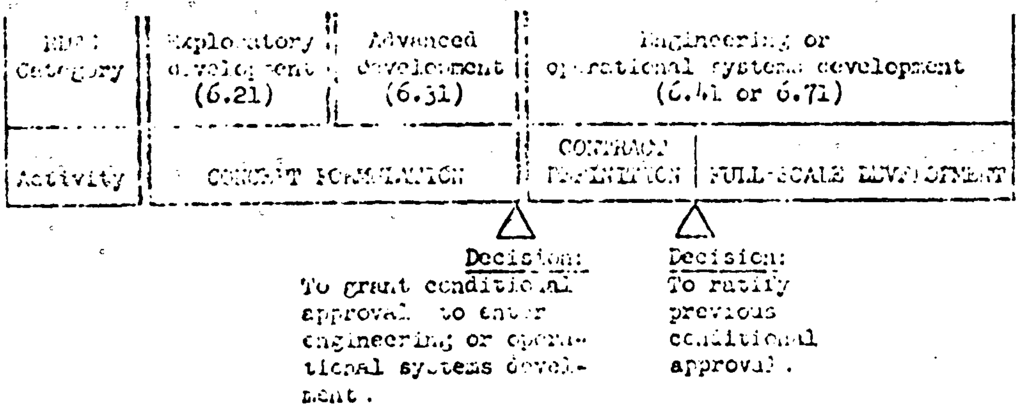
b. Research, development, test, and evaluation (RDTE) projects funded in the AMC mission program that are proposed for engineering development (RDTE category 6.41) or operational systems development (RDTE category 6.71).

3. Definitions. a. Concept formulation describes the activities preceding a decision to carry out engineering or operational systems development. The activities include the experiments, tests, and engineering and analytical studies conducted under exploratory and advanced development (RDTE categories 6.21 and 6.31, respectively) and they provide the technical,

economic, and military bases for the decision to initiate development of an item or system. Concept formulation starts early enough in time to include all activities that can be recognized as directly leading to, or supporting, the project to be qualified and approved for engineering or operational systems development; it ends with the AMC Technical Committee action establishing the project. Its relationship to other activities in the research and development cycle is shown schematically in figure 1.

b. Contract definition (formerly referred to as project definition phase) is the first step in engineering or operational systems development and immediately precedes full-scale development. It is a formal step during which preliminary design and engineering are verified or accomplished and firm contract and management planning are performed. AR 705-5 specifies that all new (or major modifications of existing) engineering developments or operational systems developments estimated to require cumulative RDTE funding in excess of $25 million, or estimated to require production investment procurement of equipment and missiles, Army (PEMA), and Military Construction, Army (MCA), not related to research and development (R&D) in excess of $100 million will include a contract definition period unless waived in writing by Headquarters, Department of the Army. Below these thresholds, contract definition may be required by Headquarters, DA, or the Headquarters, AMC, and may be recommended by commanders of commodity commands or project managers, if circumstances warrant.

SCHEMATIC RELATIONSHIP OF CONCEPT
FORMULATION TO RESEARCH AND DEVELOPMENT CYCLE



Note. In cases where contract definition is not required, the two decision points will coincide and a single decision will be made to approve entry into engineering or operational systems development.

Figure 1.

e. Full-scale development. That period of engineering or operational system development during which the actual category 6.4 or 6.5 engineering development effort and testing occurs; it follows contract definition when that step is required. It begins with the award of the principal contract(s) for category 6.4 or 6.5 item or system hardware development effort, or initiation of comparable in-house effort, and ends when development and testing activity is no longer significant, usually with classification as an adopted category type in accordance with AR 700-20.

4. General. a. A development project, if it is to meet its operational, cost, and schedule objectives, must be founded on sound military, technical, economic, and management bases. However, unless these bases have been established before the development starts, the probability of meeting the objectives will be low. The timely provision of these bases, therefore, dictates that a continuing emphasis be placed on the concept formulation activities preceding the request to enter engineering or operational systems development.

b. Approval to initiate work in engineering or operational systems development is a decision that will be based in great measure on how well the results of the concept formulation effort preceding the request for this approval have met certain requirements. These requirements, or prerequisites to entry into engineering or operational system development, specified in AR 705-5, are listed in paragraph 5, and elaborated upon in appendix I. Although concept formulation normally precedes contract definition, these prerequisites are equally applicable to all hardware item or system projects, regardless of whether contract definition is required.

c. Development of a qualitative materiel requirement (QMR) and the appendix thereto (see AR 705-5) is a process not normally conducted in the breadth and depth indicated for concept formulation. For this reason, the qualitative materiel requirement (QMR) or small development requirement (SDR) [illegible] that after all aspects and alternatives have been considered, the resultant project will provide greater military utility for the resources expended than any of the other alternatives. Therefore, the QMR and SDR must be backed up by the results of the concept formulation effort.

5. Prerequisite conditions. In consonance with paragraph 4, before any request is made to Headquarters, AMC, for approval to initiate work in engineering or operational systems development, the project concerned, in addition to having an approved QMR or SDR, must have met the following prerequisites:

a. Prerequisite 1. Primarily, engineering rather than experimental effort is required and the technology needed is sufficiently in hand.

b. Prerequisite 2. The mission and performance envelopes are defined.

c. Prerequisite 3. The best technical approaches have been selected.

d. Prerequisite 4. A thorough trade-off analysis has been made.

e. Prerequisite 5. The cost effectiveness of the proposed item has been determined to be favorable in relationship to the cost effectiveness of competing items on a Department of Defense (DOD)-wide basis.

f. Prerequisite 6. Cost and schedule estimates are credible and acceptable.

6. Depth of accomplishment. The prerequisites listed in paragraph 5 must be satisfied before a project can be considered properly prepared for entering engineering or operational systems development. However, for some projects below the thresholds for mandatory contract definition (para 3b) particularly for those of low total cost, it is realized that the relative payoff of satisfying in depth certain of the prerequisites, or aspects of them (as an example, the somewhat extensive cost effectiveness studies are [illegible]) may not justify diversion of the necessary effort from other [illegible] cost or higher priority projects. Therefore, it is expected that the amount of effort expended on the accomplishment of the prerequisites, and the depth of this accomplishment will be in proportion to what the project deserves, in consideration of the dollar value and the importance of the project.

7. Verification of prerequisite accomplishment. a. There is no established format for documenting the evidence that the prerequisites specified in paragraph 5 have been accomplished. The necessary proof that the prerequisites have been met may be contained all in one document or in several documents, but should be presented in a single package. However, a [illegible] outline organizing this evidence, to facilitate review and approval, is contained in appendix II. The detailed technical development plan (TDP) or the DD Form 1634 (Research and Technology Resume), when used, should make reference to these documents and the detailed TDP also should include summaries of their contents, as indicated in AR 705-5.

b. This regulation should not be considered in isolation from the requirements of other directive documents. It is intended that the data and [illegible] that normally should be developed during the course of preparing a project for engineering or operational systems development be developed and assembled with the six prerequisites of paragraph 5 in mind. The results of the efforts to produce the data, studies, and documentation required by other regulations and directives (AR 11-25, AR 705-5, AMCR 11-4, and AMCR 70-[illegible], are some examples) should provide the basic data and [illegible] necessary to satisfy the requirements of this regulation. There should be many cases when the same documentation used to meet other requirements [illegible] without modification, be used to satisfy one or more of the prerequisites of paragraph 5. Conversely, after complying with this regulation, there should be very little additional effort required to meet the objectives of the in-process reviews for technical and engineering characteristics (AMCR 70-5).

c. For those projects exceeding the thresholds of paragraph 3b, the proof of prerequisite accomplishment should accompany the request (from the responsible commodity commander or project manager to Headquarters, AMC, and from Headquarters, AMC, to Headquarters, DA) to approve entry into contract definition. For those projects below the thresholds of paragraph 3b, the proof of accomplishment must be submitted and approved in accordance with d below, prior to requesting AMC Technical Committee action to establish the project in accordance with AMCR 705-8.

d. Paragraph 5, AMCR 70-5, sets forth the principle of stratification regarding the level of authority for decisions required during full-scale development. One of the thresholds specified in AMCR 70-5 is also applicable to the approval of the concept formulation results as follows:

(1) For projects or tasks below $50 million estimated combined RDTE and PEMA funding, and which do not exceed the thresholds of paragraph 3b, for mandatory contract definition, the commodity commander will assure himself that the prerequisites of paragraph 5, have been satisfied and that the project is in fact ready to enter engineering or operational systems development. An information copy of the supporting material will be forwarded to the Commanding General, AMC, ATTN: AMCRD concurrently with the request for AMC Technical Committee action.

(2) For projects or tasks above $50 million estimated combined RDTE and PEMA funding, documented evidence showing the facts and reasoning leading to the conclusion that the prerequisites of paragraph 5 have been met will be forwarded to the Commanding General, AMC, ATTN: AMCRD, prior to the request for AMC Technical Committee action.

(3) For projects that are project-managed and that do not exceed the thresholds for mandatory contract definition, the project manager will assure himself that the prerequisites have been satisfied and that the project is ready to enter [illegible] development. The determination of a project's readiness to enter engineering or operational systems development will be made by the Commanding General, AMC, or Deputy Commanding General, AMC, after review by the Director of Research and Development, Headquarters, AMC, and prior to the request for AMC Technical Committee action.

(3) Those projects that exceed the thresholds for mandatory contract definition will be project-managed in accordance with AR 70-17. The determination of a project's readiness to enter engineering or operational systems development will be made by the Commanding General, AMC, or Deputy Commanding General, AMC, after review by the Director of Research and Development, Headquarters, AMC.

8. Responsibilities. a. The Director of Research and Development, Headquarters, AMC, has AMC staff responsibility for assuring that the prerequisites specified in this regulation have been satisfactorily accomplished for each project or task exceeding the threshold of paragraph 7a(2), prior to approval to initiate effort in engineering or operational systems development.

b. Directors and chiefs of separate staff offices, Headquarters, AMC, are responsible, within their functional areas, for providing all necessary assistance in meeting the requirements specified in this regulation.

c. Each major subordinate commander, project manager, and the commander of each installation or activity reporting directly to Headquarters, AMC, is responsible for assuring that the prerequisites listed in paragraph 5, are satisfied for those projects, or portions of projects, for which he is responsible, prior to submitting requests for initiation of effort in engineering or operational systems development to Headquarters, AMC.

9. Implementation. a. The prerequisites listed in paragraph 5 must be fulfilled for all projects or tasks which:

(1) Are approaching, but not approved, for engineering or operational systems development.

(2) Have been directed for project initiation by Headquarters, DA, but which have not been established as projects by technical committee action in accordance with AR's 700-20 and 705-9.

(3) Have been approved for engineering or operational systems development, but for which the determination and findings (D&F) have not been forwarded to Headquarters, AMC, for approval.

b. Further action to satisfy the prerequisites for entry into engineering or operational systems development, unless otherwise directed by Headquarters, AMC, need not be made for:

(1) Projects already approved for engineering or operational systems development and for which the DF has been submitted to Headquarters, AMC (AMCRD), for approval.

(2) Projects already in engineering or operational systems development.

10. Waivers. If, in the judgment of the commander of a commodity command or a project manager, it appears to be in the best interests of the Government to waive all or a portion of the requirements of this regulation, a request for the waiver must be submitted to Headquarters, AMC, for review and approval. The request must state specifically which requirements are to be waived and give reasons therefor.

11. References. a. AR's 11-25, 70-17, 700-20, 705-5, 705-9, 705-12, and 705-27.

b. AMCR's 70-5, 70-28, 705-8.

Appendix I

DISCUSSION OF PREREQUISITES

Section I. Introduction

Approval of a project to enter engineering or operational systems development depends very much on how well the six prerequisites discussed in paragraphs 1 through 6, this appendix, have been accomplished during the concept formulation period. The results of meeting these prerequisites must produce a high degree of confidence that: technology will permit a desirable development schedule to be met, and; the project will result in greater military utility for the resources expended than the alternatives could offer. Since it is intended that each of the six prerequisites be specifically addressed in the concept formulation period preceding engineering or operational systems development, the following discussion is offered as guidance. The mandatory provisions of this regulation are contained in paragraphs 1 through 10 above; guidance contained in this appendix is permissive.

Section II. Discussions

1. Prerequisite 1. Primarily engineering rather than experimental effort is required, and the technology needed is sufficiently in hand. To satisfy the requirement that the necessary technology be in hand, it must be established that the proposed development will require primarily system design, and the adaption of components and components to it, on the basis of existing data, and that there will be no need for invention or scientific advances; engineering advances, however, are permitted.

a. This prerequisite does not mean that a system must be limited to an assembly of off-the-shelf components. However, it does mean that when components or "building blocks" do not already exist, the technology

[illegible]

[illegible] sufficiently advanced state to provide them benefit during the [illegible]; it does mean that the technology required to [illegible] specification be in hand and demonstrable; and it does mean that experimental apparatus under laboratory conditions must have shown the quantitative [illegible] that are required for the operational equipment. Further, any projections based upon these quantitative results must be made on the probability of matching them but not exceeding them during engineering or operational systems development.

b. It is not intended that, to meet this prerequisite, technological thinking should be stagnated to where the item becomes obsolete even before it is produced. It is intended that components required for a system be available (perhaps only in developmental form), or, that it will be possible to confirm them fully by extrapolating the existing laboratory technology within the timeframe of the system development. It is intended that exploratory development (DoD category 6.21) be completed prior to engineering (6.41) or operational systems (6.71) development; although some advanced development effort (6.31) may be carried into the engineering or operational systems development phase provided that it will be completed in time to meet the requirements of an acceptable development schedule.

c. The key criterion, then, in determining how much of a technological advance is allowable, is the level of confidence that the development will be successful, that is, successful in terms of operational effectiveness, cost, and timing.

2. Prerequisite 2. The mission and performance envelopes are defined. The definition of mission and performance envelopes usually include such detailed factors as threat-handling or target-kill capacity and summary performance characteristics (such as mission profiles, range, speed, payload, altitude, fuel consumption, lethality, accuracy, reliability, maintainability, and all others appropriate to the item or system under consideration). Although the definition of mission and performance envelopes, arrived at after repetitive and searching analyses, is meant to be a firm basis for development, it is not so firm as to be "set in concrete." The envelopes can be changed after contract definition, or prior to full-scale development, upon valid indication that they cannot be met within acceptable costs, can easily be exceeded without undue cost, or are more than required. The optimum mission and performance envelopes should be identified through the use of the cost effectiveness analysis conducted to support the trade-off analysis required by prerequisite 4 and the cost-effectiveness comparisons required by prerequisite 5.

3. Prerequisite 3. [illegible] technical approaches [illegible]. The selection of the technical approach [illegible] must be based upon the trade-off analyses and cost effectiveness studies of prerequisites 4 and 5, respectively, but must be kept within the technology limits specified by prerequisite 1.

[illegible] will represent the [illegible] between all [illegible] prerequisites 2 and [illegible].

4. Prerequisite 4. A thorough trade-off analysis [illegible] made [illegible] examine the utility of the [illegible] systems in the light of operational and economic factors. The impact of variations in the detailed parameters on each of the logical alternatives for meeting the military objectives must be examined. The analyses must be planned, conducted, and presented to show clearly the alternative mission and performance [illegible] together with associated technical approaches and implications regarding operational value, technical feasibility, cost, risk, and schedule. The trade-off analyses may well result in changing tentative military objectives, in conjunction with United States Army Combat Developments Command (USACDC), and upon approval of Headquarters, DA, toward either higher or lower performance. Since elements of the discussions of prerequisites 4 and 5 can apply to either or both, some of the discussion which could be presented here, for the sake of eliminating duplications, is presented in the paragraph for prerequisite 5.

5. Prerequisite 5. [illegible] of the proposed item [illegible] reasonable [illegible] that [illegible] is [illegible] effective relative to the cost involved, the [illegible] system, or combination of systems must be compared with [illegible] available throughout DOD (new, existing, or modified systems) for meeting the operational requirement.

a. In contrast to the trade-off analysis of prerequisite 4, that involves comparison of alternatives within the system being considered, the cost effectiveness analyses are used in this prerequisite to compare one system with another. (Both prerequisites are normally concerned with operational effectiveness, cost, and time.) The following example illustrates the relationship of the analyses of prerequisites 4 and 5.

(1) A trade-off analysis should be made to determine how the payload in a missile should be allocated between reentry vehicles, with warheads and penetration aids to achieve maximum effectiveness against a defended target. The [illegible] system should have a large number of warheads and [illegible] and, at the same time, as much destruction potential as possible. But, [illegible] beyond a certain point, the total destruction potential [illegible] decreases as the number of warheads and [illegible] increases. [illegible] the trade-off between the number of warheads and [illegible] a [illegible] of penetration, and total destruction potential must be [illegible] the optimum combination of subsystems within [illegible] trade-off analysis. The system is then compared to other systems by cost-effectiveness analysis and the best of competing systems is selected as the one to be developed.

[illegible]

(2) The purpose of a cost-effectiveness analysis, then, is to aid a program decision [illegible] to answer the central question: Does the system or change being proposed have sufficient utility to warrant the expenditure of resources that is required to develop and deploy it?

b. Cost-effectiveness studies, as well as trade-off analyses, whenever possible, should be based on the best available estimate of the total cost of acquisition and ownership for the total system.

(1) This total system total cost includes development and test, production, operation and maintenance costs of the item itself, as well as all such related costs as data, personnel training and training support facilities, maintenance and maintenance support facilities, transportation and storage, assembly and checkout, spares, logistic support facilities, etc. (Amortized costs of programs that would be funded regardless of the fate of the proposed system should be excluded from the total costs.)

(2) Further, comparisons should be made in the context of the complete system of which two competing items may form a part. For example, in comparing the costs of two missiles, comparisons must include not only the incremental costs and effectiveness of the two systems but also costs of the transporters, the mobile and fixed launching facilities and the detection and fire control equipment, and the support and repair facilities. While it is not necessary to compute all these costs accurately, a picture must be presented of the two missiles and their relative incremental cost against the background of the complete operation in which they will be used.

c. Operational effectiveness, likewise, should be more inclusive than the scope which usually first comes to mind. In addition to those performance elements such as speed, payload, accuracy, etc., such factors as reliability, maintainability, and logistics should also be considered.

d. To be effective, both trade-off and cost-effectiveness analyses must be conducted in an objective manner and they should be viewed as tools for the decision makers and should be presented to enlighten instead of to present a one-sided case. It should be pointed out that both the trade-off and the cost-effectiveness analyses, although very important, are incomplete tools, by themselves, for decisions must be considered with other information from other sources.

6. Prerequisite [illegible]. The cost and schedule estimates are credible and [illegible]. Time schedules and cost estimates for developing, testing, evaluating, acquiring, operating, and maintaining the system must be realistic, and they must be based on previous experience and on the development status of the required subsystems, components, and other building blocks. Cost schedules should be consistent with standardized cost estimating data when such data are applicable and available. Cost estimates, while not expected to [illegible] prior to contract definition [illegible] at a time when [illegible] contract definition is not required), should be broken down in sufficient detail to permit their correlation with the cost estimating data.

Appendix 1

SUGGESTIONS FOR PRESENTING
EVIDENCE OF PREREQUISITE ACCOMPLISHMENT

1. Purpose. The suggestions contained in this appendix are included as assistance in assembling and presenting the documentary evidence that the concept formulation effort has satisfied the six prerequisites for entering engineering or operational systems development (see para 5, page 3). It is not intended to restrict or inhibit the exercise of imagination and ingenuity in presenting a clear, logical, easily followed manner the proof that a project is, in fact, ready to enter engineering development. However, regardless of how the supporting material is organized, it should be done while keeping in mind the problems of those who must review and act on the evidence presented.

2. The outline. Figures 2 and 3 are outlines of one method of presentation. It is important, whether or not the suggested outline is used, to address each prerequisite individually and to reference each significant supporting document. The necessity for actually including a specific document will depend upon how well its contents are already known, how many copies are in circulation, and how available a copy may be to the headquarters to make the review.

a. Although there may well be a number of reports, studies, summaries, analyses, and other documents required to report the concept formulation results, they should all be included in a single package. The package should be introduced and summarized by a cover paper as outlined in figure 2.

b. Each prerequisite may be addressed in a separate section of the concept formulation package or, if the volume of material dictates, in a subpackage. For each prerequisite, the pertinent portions of the more significant supporting documents should be summarized even though the documents themselves may be included.

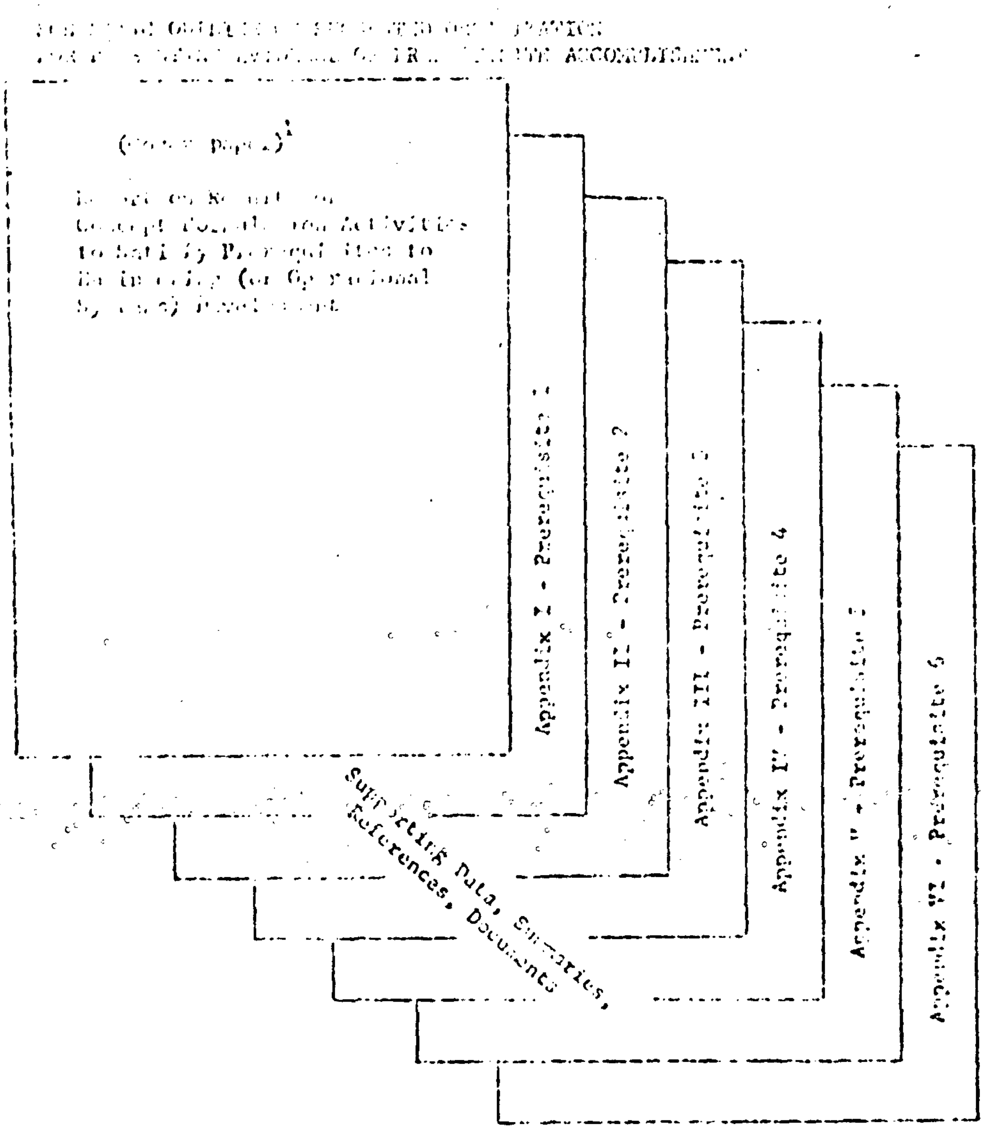

Appendix I - Prerequisite
Appendix II - Prerequisite 2
Appendix III - Prerequisite
Appendix IV - Prerequisite 4
Appendix V - Prerequisite
Appendix VI - Prerequisite 6
Supporting Data,
References, Documents

Figure 2.

[illegible]

OU[illegible] FOR SUGGE[illegible] CO[illegible]S OF C[illegible] P[illegible]ER

(A letter format may be used)

1. An introduction (purpose of report, how report is organized, indication of depth of effort to satisfy prerequisites, etc.).

2. Description of [illegible] or system (what the item is, what it is intended to do, threat it is intended to meet, [illegible] and desired performance characteristics, [illegible] unusual features, overall program ([illegible], [illegible] and O&M) cost estimates, item or system being replaced, competing items or systems, etc.).

3. Requirements and limitations affecting results and conclusions reached in [illegible] analyses (unusually stringent [illegible] requirements, fiscal guidance [illegible] funds availability, urgency of need, requirement to accelerate development, etc.).

4. [illegible] of [illegible] ([illegible] of conclusions, key unresolved problems and prospect of [illegible], etc., with appropriate references made to supporting documents).

Figure 3.

[illegible]

([illegible])

FOR THE COMMANDER:

SELWYN D. SMITH, JR.
Major General, USA
Chief of Staff

OFFICIAL:

[illegible]
Colonel, [illegible]
Chief, [illegible] Office

[illegible]
[illegible], AMCMR, [illegible]
[illegible] AMCPC, [illegible], AMCGC, and AMC[illegible]
[illegible]

[illegible]

APPENDIX B

NAVTRADEVCEN 69-C-0178-1

REVIEW AND UNDERSTANDING OF THE SMALL DEVELOPMENT REQUIREMENT FOR AN ARMED AIRCRAFT QUALIFICATION RANGE SCORING SYSTEM

The first task to be accomplished in this Concept Formulation Study for an Armed Aircraft Qualification Range Scoring System is the completion of a review and analysis of the pertinent Small Development Requirement (SDR). (Refer to Task 1, [illegible] Report No. [illegible], 17 September 1968.) To initiate this review and analysis, specific comparisons have to be made between stated SDR requirements and those current requirements arising from the lastest helicopter armament subsystems, aviation practical gunnery training methods, etc. To determine these comparisons and to underline the validity of comparison results, conferences were held with representatives of various aerial gunnery training facilities/installations. (See Appendix A and Appendix B). These conferences produced the most current information on Army aviation gunnery training, including equipment, techniques of training and scope of instruction. With this information, requirements stated in the SDR could be augmented to provide the breadth and depth necessary for the Concept Formulation Study (See Paragraph 4.c - AMCR 70 - 30).

Information derived from the conferences conclusively established that individual (or basic) gunnery training programs and unit (tactical) gunnery training programs currently employ different practical instructional methods and, in fact, aim at different levels of proficiency as training objectives. It was necessary to investigate and identify these variances in order to reference them to appropriate sections of the SDR. This results in arriving at a comprehensive, current statement of the need as related to scoring hardware. When coupled to weapon characteristics and aircraft performance envelopes in the 1969-1975 era, the scoring system performance criteria can be defined.

So that the aforementioned comparisons may be more readily identified, each paragraph of the approved Small Development Requirement for an Armed Aircraft Qualification Range Scoring System is reproduced here as it appears in the SDR. Following each SDR paragraph is a clarification and expansion of that paragraph, if appropriate, as determined from the conferences and discussions conducted with [illegible], responsible representatives of aerial gunnery training facilities and organizations in the U.S. Army.

Clarifying paragraphs are identified by enclosure within vertical bars on either side of the page.

1. Purpose and Operational Characteristics: A requirement exists for a range [illegible] targets at a [illegible] from a [illegible] Army armed aircraft. This [illegible] maintaining [illegible] As the projectiles used in [illegible] proficiency [illegible] of an inert nature, a [illegible] will be required in order to determine adjustments needed to improve accuracy.

1. Purpose and Operational Characteristics: The purpose of the Armed Aircraft Qualification Gunnery Scoring System is to provide a practical means by which projectile-effect data can be determined and processed, from which individual, aircrew and aviation-unit training status can be objectively assessed and developed. This is expected to result in an increase in overall training efficiency and effectiveness. Such a requirement demands a scoring system be utilized in conjunction with armed aircraft gunnery training. The scoring system will provide a remote real-time display of projectile "hit" data and/or projectile "miss" data relative to the ground target(s), and will permit recording of such data at a location remote from the target or weapons range area. The system will be used in the training of individual pilot/gunner and door gunner personnel, and in the training of armed aircraft units and crews thereof, both in qualification training and testing, and in annual proficiency testing. The scoring system must be capable of functioning with both explosive and inert ordnance of types and sizes currently being utilized, or projected for utilization in the 1969-1975 timeframe.

a. (Essential) Targets must realistically represent personnel, combat and tactical vehicles and crew-served ground weapons appropriate to the terrain and environment in which installed.

a. It is essential that realistic, representative tactical targets be employed during those phases of unit training which incorporate gunnery tactics (i.e. - target acquisition, target identification, gunship ingress and egress routes, ordnance selection, damage assessment, etc.). For individual basic gunnery ("marksmanship") qualification phases of training, however, simple and readily discernible aiming points are desired in lieu of realistic tactical targets.

b. (Essential) The system must be adaptable to the simulation of various field tactical situations.

b. The scoring system must be adaptable both to a simulated tactical environment for unit tactical training and to a basic gunnery "marksmanship" training environment.

c. (Essential) Targets, hit count measurement and transmission devices and a hit count and register central display unit must be included as a part of the system.

c. The system will consist of the following major components.

- Target (tactical targets and/or simple aiming point targets, depending upon training application)

- Sensor ("hit" sensors and/or "miss" sensors)
- Data Transmitter (via radio, wire, etc.)
- Data Receiver (via radio, wire, etc.)
- Scoring Display
- Recorder (manual or automatic)

d. (Essential) All components of the range system will be portable in nature and easily assembled and disassembled.

> d. It is essential that all major components of the scoring system be portable and incorporate sectional (targets) and modular construction methods.

e. (Essential) The range system must be capable of operation through an area 2000 meters in width and 6000 meters in length, down to a minimum of 400 meters in width and 2500 meters in length.

> e. It is essential that the scoring system be capable of operation through an area of 30,000 meters in width and 30,000 meters in length (tactical unit training) down to a minimum area of 400 meters in width and 2500 meters in length (individual qualification).
>
> Aircraft performance, weapons systems and type-training desired are considerations which influenced the determination of optimum range size.

f. (Essential) The range system must be capable of day and night operations under intermediate climatic conditions as outlined in Change 1, AR-705-15. Kits will be provided, if required, for use in cold-hot-dry climates.

g. (Essential) The range system must acquire and record scoring (hit and near miss) data on the following armament subsystems:

(1) (Essential) 7.62mm machineguns.

(2) (Essential) 50 caliber machineguns

(3) (Essential) Rockets and missiles (2.75 to 6")

(4) (Essential) 40mm grenade launchers

(5) (Essential) 20mm and 30mm automatic gun.

h. (Essential) The system must be capable of scoring a single machinegun or multiple machineguns with rates of fire up to 6000 spm on a single firing run and combinations of those subsystems outlined in g. above, on consecutive, but separate firing runs.

i. (Desired) The system must be capable of recording the combinations of the different weapons outlined in g. above in a single firing run.

(1) The system must be capable of scoring inert and HE ammunition delivered by the armament subsystems listed in Paragraph 1.g., above.

(2) Each scoring system must be capable of sensing target hits and near-misses at impact rates not less than those indicated below for each type weapon:

SIZE	TYPE	IMPACT RATES (MAX) (ROUNDS/MIN)
5.56mm	Machine gun (MG)	24,000
7.62mm	Machine gun (MG)	24,000
12.6mm	Machine gun (MG)	6,000
20mm	Automatic cannon (AC)	6,000
30mm	Automatic cannon (AC)	6,000
40mm	Grenade launcher (GL)	400
2.75 in.	Folding-fin aerial rocket (FFAR)	12 per sec.
5 inch	Aerial rocket (AR)	2 per sec
5 inch	Wire-guided missile (WGM)	2

Cyclic rate of fire and simultaneous multiple weapons usage are the primary consideration determining system response.

(3) For basic gunnery ("marksmanship") qualification, the system must score only one of the size/type weapons listed in Paragraph h./i., (2), above, on a single firing run. The system must provide scoring data from all on-range targets/aiming points, attacked sequentially in a single firing run.

(4) For crew/fire team/aviation unit tactical gunnery training, the system must score the weapon size/type mixes indicated below, and must be capable of providing scoring data on at least two targets attacked simultaneously by an aircraft in a single firing run. (Tactical gunnery training will require scoring the weapons of as many as two attack aircraft, each firing any of the weapon mixes indicated below, simultaneously against a single target.)

NUMBER	SIZE	TYPE
Up to four	5.56mm	Machine Gun
or four	7.62mm	Machine Gun, M-134
or two	12.6mm (50 cal)	Machine Gun
or two	20mm	Automatic Cannon
or two	30mm	Automatic Cannon

- OR:

NUMBER	SIZE		TYPE
Up to four	5.56mm MG		2.75" FFAR
or			or
four	7.62mm MG		40mm Grenade
or			or
two	12.6mm MG	AND	5" Wire Guided Missile
or			or
two	20mm AC		6" Wire Guided Missile
or			
two	30mm AC		

j. (Essential) The system must be capable of recording the distances of the terminal projectile positions from the target centers up to miss distances of 30 meters (recording of the azimuths and elevations desired if development time and cost is not excessive). Miss distance recordings of 0 to 15 meters must be within ±2 percent accuracy; for distances between 15 and 30 meters, accuracy must be within ±10 percent. If the desired azimuth and elevation recording is not achieved, target hits will be scored for small targets only and zone scoring will be used for all targets.

j. (1) The weapons listed in Paragraph 1.g., above, can be classified as either point weapons or area weapons. Only the 5" wire guided missile (M-22 sub-system) and the TOW missile are classified as point weapons, with the remaining weapons classified as area weapons. It is desired that area weapons fire be scored in terms of projectile ground impact within a circular horizontal plane on the ground centered on the target. It is desired that point weapons fire be scored in terms of a projectile hit, excluding a ricochet hit, on the physical confines of the target; further, point weapons fire miss-information is desired in terms of projectile passage through an extended vertical target plane which is terminated at the ground, and through a horizontal target plane lying on the ground between the weapon and the target and terminating at the target.

(2) It is essential that the scoring system furnish vector scoring data (i.e. - indicate an intersection of a projectile trajectory with the target or a nonphysical extension of the target, and provide a measurement of the direction and distance from the point of aim to the point of intersection). This is particularly important during those phases of gunnery training when inert grenade, rocket and/or missile ammunition is utilized.

(3) Vector score (direction and distance relative to a target/aiming point) can be expressed in polar coordinates (r , θ) within the scoring planes discussed in Paragraph 1.j. (1) and (2), above. Polar coordinates provide specific impact location information relative to a reference point (target/aiming point), the format in which this information is presented is easily interpreted and understood; direction (θ) and distance (r) can be expressed as falling within pre-defined areas or zones.

(4) The following table indicates the effective miss-distance of machine gun, HE automatic cannon and HE rocket/missile projectiles (area weapons). It is readily apparent that effective miss-distance increases as the size of the projectile increases. Thus the pre-defined scoring zones from 1.j. (3), above, should be remotely adjustable, during the basic gunnery qualification (marksmanship) training phase only, if a score of effective fire is to be furnished.

SIZE	TYPE	EFFECTIVE MISS-DISTANCE FEET
5.56mm	MG	5
7.62mm	MG	5
12.6mm	MG	10
20mm	AC	10
30mm	AC	10
40mm	GL	20

SIZE	TYPE	EFFECTIVE MISS-DISTANCE FEET
2.75 in. (10 lb. warhead)	FFAR	50
5 in.	AR	50

(5) The scoring system should be capable of scoring projectiles impacting at radial miss-distances of up to 54 meters within the scoring plane; it is essential that projectiles impacting at radial miss-distances of up to 15 meters be scored (2.75" FFAR - 10 lb. warhead).

(6) The scoring system must sense those projectiles which impact within the scoring plane to an accuracy of 95% ± 5%. The projectiles sensed must be correctly located within the pre-defined distance/direction ($r - \theta$) zone(s) in which they impact, to an accuracy of 95% ± 5%. These accuracies must be maintained throughout all sensing/scoring exercises; any deviation from these accuracy requirements during any single firing run/pass is unacceptable.

k. (Essential) The range system must be capable of collecting and recording data from each individual target and up to a minimum of six targets simultaneously.

l. (Desired) The range system must be capable of collecting and recording data simultaneously from ten targets.

k./l. An individual scoring system, major components of which are listed in Paragraph 1.c., above, must be capable of operating in conjunction with a minimum of five additional scoring systems on the gunnery range (six systems, total). On some tactical unit aerial gunnery training ranges, it may be desirable to emplace and operate up to ten scoring systems on the range. However, at no time will more than two targets on the range, and their associated scoring systems, be required to sense and score simultaneously.

m. (Essential) Targets and any associated instrumentation must:

(1) Be easy to install with little or no site preparation.

(2) Be portable by medium helicopter sling load to facilitate rearrangement of target arrays.

(3) Be realistic in appearance.

(4) Simple to repair and capable of individual component or module replacement.

(5) Require minimum maintenance as outlined in Paragraph 5.

(6) Require no excessive calibration prior to operation.

(7) The hit count and register central display unit must have a self-contained lighting capability for effective night operations.

m. It is essential that:

- aiming points, utilized during basic aerial gunnery (marksmanship) qualification training, must be simple, easily discernible and relatively invulnerable to catastrophic damage by weapons fire.

- tactical targets, utilized during unit (aircrew, fire-team, etc.) tactical training, must be realistic representations of combat targets, providing a means of acquisition/identification through all attack azimuths up to 360-degrees. Tactical targets must be easy to emplace on-range, must be portable by utility helicopter to facilitate replacement or rearrangement of target locations.

- all scoring components, including targets/aiming points, must be easy to install with little or no site preparation, must require minimum maintenance (as outlined in Paragraph 4, below), require little or no calibration prior to operation (should operate without calibration for at least 125 hours utilization). A means must be provided at the remote central scoring center to alert operator personnel to system malfunction and to identify system malfunction. The scoring display unit must include a self-contained lighting capability for effective night operations.

n. (Essential) The system must be capable of storage and transit under the conditions outlined in AR 705-15 (i.e., Army aircraft).

o. (Essential) The system must be adaptable to various types of terrain, i.e., desert, mountain, and jungle (see Paragraph 2.f.).

p. (Desired) The system must be capable of prolonged periods of inactivity while exposed to the local environmental climate (not to exceed 30 days), without requireing extensive preparation prior to activation.

q. (Essential) The command/control system must be adaptable to the electrical power available in CONUS and overseas or be capable of operation utilizing standard U.S. Army generators.

r. (Essential) If batteries are used as power source for target arrays, they must be capable of 24-hour operation prior to recharge.

s. (Essential) The range system must be simple to establish, operate, and require a minimum of organizational maintenance (see Paragraph 5.).

t. (Essential) The system should have an expansion capability so as to accommodate future developed aerial weapons and platforms, e.g., Advanced Aerial Fire Support System.

t. (1) The system must provide a scoring capability which will support individual qualification training and unit tactical training in the Model AH-56A (Advanced Aerial Fire Support System). To effectively score weapons systems of the AH-56A, and to incorporate into gunnery training the full capability of these weapons systems, it is essential that the scoring system be capable of operation at variable attack azimuths through 360-degrees.

(2) The scoring data receiver/display unit, located at a site remote from the target range, should provide a means to interface with an external automatic data recorder. This capability permits permanent logging of student, crew and/or unit gunnery performance data and subsequent monitoring or analyses of qualification criteria.

u. (Essential) The hit count and register central display unit should be capable of being mounted in the back of a standard U.S. Army 3/4-ton vehicle or 3/4-ton trailer (1/4-ton truck or 1/4-ton trailer desired).

v. (Essential) The system will have a minimum acceptable mean-time-between-failure of twenty hours under relatively heavy usage conditions.

v. The scoring system, not including targets/aiming points, must provide a minimum mean-time-between-failure (MTBF) of 1200 hours, and a maximum mean-time-to-restore (MTR) of 30 minutes. The MTBF does not consider component failures caused directly by weapons fire damage.

2. Supporting Justification and Data:

a. Reasons for Requirement:

(1) As the helicopter is employed as an aerial platform for a variety of weapons systems, a formal program for the initial training and/or qualification of armed aircraft crews is required. Training programs must develop and maintain skills in target acquisition, identification, neutralization, and destruction. This new equipment will greatly reduce the time now required to train individual aviators in air-to-ground gunnery techniques. Substantial savings will result in ammunition expended, helicopter flight time reduced and overall student training efficiency increased.

(2) Current ranges used for this helicopter gunnery training utilize old ground-to-ground scoring techniques which require that scoring be accomplished by a "shoot and count holes" procedure or in-flight observation. The former is time-consuming and requires the range to be closed while personnel

are in the firing areas; the latter scoring method is inaccurate as it provides only general hit or miss data. There is presently no means to count and locate relative to the target those projectiles which are near misses. This information is necessary in order to properly assess the effectiveness of the fire. Overall, the present type of scoring operation is inefficient, time consuming, and expensive. The training time lost, to include the down-time of the helicopter, is excessive and wasteful. The new proposed range system will eliminate all of these disadvantages now found in current range scoring training programs of instruction.

(3) A range system is required by U.S. Army Aviation School and other commands with armed aircraft which will have the capability of accurately detecting target hits and near misses and displaying these data at a central location. These range systems will be authorized in Department of the Army Tables of Allowance (TA 23) of Army Aviation Training Centers in Continental United States and overseas, and will be utilized in the training of Army armed aircraft crews in order to:

(a) Provide for a more efficient utilization of personnel and aircraft involved.

(b) Expedite and improve the quality of initial crew training in armed aircraft.

(c) Improve the method of analyzing the armed aircraft crew proficiency (annual qualification).

(d) Improve all current scoring methods.

(e) Improve current range operating efficiency.

(4) Maintenance Concept. Organizational maintenance personnel should be able to accomplish the majority of the maintenance of this system on site. Such organizational maintenance should be restricted to minor, readily accomplished repairs, so that it will not interfere with the training program. Mechanisms requiring repair beyond the scope of organizational maintenance should be removed on site and evacuated through normal maintenance channels to the appropriate Direct, General or Depot maintenance facility. It is expected that a minimal training program for organizational maintenance personnel on the electronics portion of this device will be required. Maintenance functions will be accomplished by military personnel of MOS series 35B (Electronic Instrument Repairman) or equivalent DA civilian personnel. The maintenance required (all categories) for the Range System will not exceed one hour for each ten hours of training under normal circumstances. One hour of maintenance for twenty hours of training is desired.

DATA SHEETS

ARMED AIRCRAFT QUALIFICATION RANGE SCORING SYSTEM

CONTRACT NO: N61339-69-C-0178-1

SDR ANALYSIS

1. Range Characteristics
2. Scoring Characteristics
3. Data Display
4. Data Transmission
5. Training Use
6. Miscellaneous

CONTRACT NO.: N61339-69-C-0178
NTDC

DATA SHEET
ARMED AIRCRAFT QUALIFICATION RANGE SCOPE

ITEM	UNIT FORT MACPHEARSON			UNIT FORT BENNING			FORT RUCKER INDIV SCHOOL			FORT RUCKER H[illegible]			FORT RUCKER TRNG CDC			STE[illegible]		
	MINIMUM	ESSENTIAL	DESIRED	MINIMUM	ESSENTIAL	DESIRED	MINIMUM	ESSENTIAL	DESIRED	MINIMUM	ESSENTIAL	DESIRED	MINIMUM	ESSENTIAL	DESIRED	MINIMUM	ESSENTIAL	
1-1 Range Size																		
400M X 2500M																		
2000M X 6000M																		
6000M Dia.																		
Other								X			X						X	
2000M X 10,000			X			X			X			X						X
20,000M X 30,000		X			X													
1-2 Number of Targets For (Simultaneous Scoring)																		
Six (6)		X			X													
Ten (10)			X			X												
Other Target Sites			20			20												
One								X			X						X	
1-3 Target Realism																		
Yes (Config, Size, Color)		X			X													
No																		
Aiming Point Only (Config, Size, Color)								X			X						X	
1-4 Tactical Simulation																		
Yes (Layout)		X			X													
No								X			X						X	
Other, Specify																		

...NGE SCORING SYSTEM

RANGE CHARACTERISTICS

DEL MAR ENGINEERING LABS (DMEL)
BOOZ-ALLEN APPLIED RESEARCH INC (BAARINC)

FORT STEWART MINIMUM	FORT STEWART ESSENTIAL	FORT STEWART DESIRED	INDIV TNG MINIMUM	INDIV TNG ESSENTIAL	INDIV TNG DESIRED	UNIT TNG CENTER MINIMUM	UNIT TNG CENTER ESSENTIAL	UNIT TNG CENTER DESIRED	CDC MINIMUM	CDC ESSENTIAL	CDC DESIRED	REMARKS
	X			X								Minimum: - 400M x 5500M Maximum: - 2000M x 10,000
		X			X							
							X					
							X					
								X				
								?				
	X			X								
							X					
	X			X								
							X					
	X			X								

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DATA SHEET

ARMED AIRCRAFT QUALIFICATION RANGE SCOR

CONTRACT NO.: N61339-69-C-0178
NTDC

ITEM	UNIT FORT MACPHEARSON			UNIT FORT BENNING			FORT RUCKER SCHOOL			[illegible]			CDC			F[illegible] STE[illegible]	
	MINIMUM	ESSENTIAL	DESIRED	MINIMUM	ESSENTIAL	DESIRED	MINIMUM	ESSENTIAL	DESIRED	MINIMUM	ESSENTIAL	DESIRED	MINIMUM	ESSENTIAL	DESIRED	MINIMUM	ESSENTIA
1-5 Day-Night Operations																	
% Day		75	50		80		80	60									
% Night		25	50		20		20	40									
1-6 Climatic Conditions																	
Temperature		X			X			X			X						X
Arctic	X						X				X					X	
Tropic		X					X				X					X	
Desert							X				X					X	
Other																	
Train in Rain			X			X		X			X						X
1-7 Range Conditions																	
Water Range	X			X			X			X						X	
Land Range		X			X			X			X						X
Generally Dry		X			X			X			X						X
Swamp		X			X			X			X						X
1-8 Defensive Simulated Fire From Target			X			X											

[illegible]ET
[illegible] RANGE SCORING SYSTEM

RANGE CHARACTERISTICS

DEL MAR ENGINEERING LABS ([illegible]MEL)
BOOZ-ALLEN APPLIED RESEARCH INC (BAARINC)

CDC		FORT STEWART			EQUAT[illegible]			[illegible]NARS			CDC			REMARKS
ESSENTIAL	DESIRED	MINIMUM	ESSENTIAL	DESIRED	MINIMUM	ESSENTIAL	DESIRED	MINIMUM	ESSENTIAL	DESIRED	MINIMUM	ESSENTIAL	DESIRED	
														No artificial illumination condition, because it would be same as day.
			X			X			X					
		X				X			X					
		X				X			X					
		X				X			X					
			X			X			X					
		X												
			X											
			X											
			X											

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DATA SHEET

ARMED AIRCRAFT QUALIFICATION RANGE SCOR[illegible]

[illegible]ONTRACT NO. [illegible]-9-C-[illegible]78

[illegible]TDC

ITEM	FORT MACPHEARSON Minimum	FORT MACPHEARSON Essential	FORT MACPHEARSON Desired	FORT BENNING Minimum	FORT BENNING Essential	FORT BENNING Desired	FORT RUCKER School Minimum	FORT RUCKER School Essential	FORT RUCKER School Desired	FORT RUCKER H[illegible]ED Minimum	FORT RUCKER H[illegible]ED Essential	FORT RUCKER H[illegible]ED Desired	FORT RUCKER CDC Minimum	FORT RUCKER CDC Essential	FORT RUCKER CDC Desired	F[illegible] STE[illegible] Minimum	F[illegible] STE[illegible] Essential	F[illegible] STE[illegible] D[illegible]
1-8 Terrain																		
Level		X			X			X										
Woody		X			X													
Hilly		X			X													
Mountainous			X			X												
Other								X										
1-9 Type Soil																		
Hard		X			X			X									X	
Soft Surface			X			X		X									X	
Other																	X	

ET
RANGE SCORING SYSTEM
[illegible]
R

RANGE CHARACTERISTICS

DELMAR ENGINEERING LAB (MEL)
BOOZ-ALLEN APPLIED RESEARCH INC (BAARINC)

CDC		FORT STEWART			[illegible]			[illegible]			CDC			REMARKS
ESSENTIAL	DESIRED	MINIMUM	ESSENTIAL	DESIRED	MINIMUM	ESSENTIAL	DESIRED	MINIMUM	ESSENTIAL	DESIRED	MINIMUM	ESSENTIAL	DESIRED	
														School(Ft.Rucker): Safety considerations dictate generally level, cleared area.
			X											
			X											
			X											Ft. Stewart: Must operate in swamp (5" to 20" deep water)

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DATA SHEET

ARMED AIRCRAFT QUALIFICATION RANGE SCOR

CONTRACT NO.: N61339-69-C-0178
NTDC

ITEM	FORT MACPHEARSON MINIMUM	FORT MACPHEARSON ESSENTIAL	FORT MACPHEARSON DESIRED	FORT BENNING MINIMUM	FORT BENNING ESSENTIAL	FORT BENNING DESIRED	FORT RUCKER SCHOOL MINIMUM	FORT RUCKER SCHOOL ESSENTIAL	FORT RUCKER SCHOOL DESIRED	FORT RUCKER [illegible] MINIMUM	FORT RUCKER [illegible] ESSENTIAL	FORT RUCKER [illegible] DESIRED	FORT RUCKER CDC MINIMUM	FORT RUCKER CDC ESSENTIAL	FORT RUCKER CDC DESIRED	F STE MINIMUM	F STE ESSENTIAL
2-1 Target Hit Count																	
Yes/[illegible] (Point Targets)		X			X		X									X	
(Hit-Sensitive Panels)																	
2-2 Miss Distance (Area)		X			X			X									
Zone (No. of Zones)		X			X			X									
Feet																	
Meters																	
Other																	
2-3 Vector																	
High-Low		X			X				X								
Left-Right		X			X				X								
Clock	X																
Other																	

RANGE SCORING SYSTEM

SCORING CHARACTERISTICS

DEL MAR ENGINEERING LABS (DMEL)
BOOZ-ALLEN APPLIED RESEARCH INC (BAARINC)

CDC		FORT STEWART			[illegible]			CONARC [illegible]			CDC			REMARKS
ESSENTIAL	DESIRED	MINIMUM	ESSENTIAL	DESIRED	MINIMUM	ESSENTIAL	DESIRED	MINIMUM	ESSENTIAL	DESIRED	MINIMUM	ESSENTIAL	DESIRED	
		X												
														Ft. Rucker/Ft. Stewart
									X					- Only when inert ammo is used with point fire weapon (TOW), vector is desired.
									X					

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DATA SHEET

ARMED AIRCRAFT QUALIFICATION RANGE SCOR[illegible]

CONTRACT NO.: N61339-69-C-0178
NTDC

ITEM		FORT MACPHEARSON			FORT BENNING			FORT RUCKER: SCHOOL			FORT RUCKER: H[illegible]RO			FORT RUCKER: CDC			F[illegible] STE[illegible]		
		MINIMUM	ESSENTIAL	DESIRED	MINIMUM	ESSENTIAL	DESIRED	MINIMUM	ESSENTIAL	DESIRED	MINIMUM	ESSENTIAL	DESIRED	MINIMUM	ESSENTIAL	DESIRED	MINIMUM	ESSENTIAL	[illegible]
2-4	**Ordnance-Scored**																		
	7.62mm		X			X			X									X	
	50 Cal.	X			X			X									X		
	2.75" SSFFAR		X			X			X									X	
	40mm Grenade		X			X			X									X	
	20mm Auto. Wpn.		X			X			X									X	
	30mm Auto. Wpn.		X			X			X									X	
	Tow		X			X			X									X	
	Other 2.75 Flechette		X			X			X									X	
	M-22 (SS-11)		X			X		X											X
	Proximity Fuse (VT)									X									X
2-5	**Scoring Rate**																		
	>6000 RPM		X			X			X									X	
	<6000 RPM																		
	Mean Point of Impact		X			X													
	Individual Pnt of Impact							X									X		
	Zone								X									X	

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RANGE SCORING SYSTEM

SCORING CHARACTERISTICS

DEL MAR ENGINEERING LABS (DMEL)
BOO? -ALLEN APPLIED RESEARCH INC (BAARINC)

CDC DESIRED	FORT STEWART MINIMUM	FORT STEWART ESSENTIAL	FORT STEWART DESIRED	CONARC CCS/ T MINIMUM	CONARC CCS/ T ESSENTIAL	CONARC CCS/ T DESIRED	CONARC MINIMUM	CONARC ESSENTIAL	CONARC DESIRED	CDC MINIMUM	CDC ESSENTIAL	CDC DESIRED	REMARKS
		X											
	X												
		X											
		X											
		X											
		X											
		X											
		X											
			X										
			X										
		X											
	X												
		X											

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DATA SHEET
ARMED AIRCRAFT QUALIFICATION RANGE SCOR

CONTRACT NO.: N61339-69-C-0178
NTDC

ITEM	FORT MACPHEARSON			FORT BENNING			FORT RUCKER SCHOOL			FORT RUCKER HumRRO			FORT RUCKER CDC			F STE	
	MINIMUM	ESSENTIAL	DESIRED	MINIMUM	ESSENTIAL	DESIRED	MINIMUM	ESSENTIAL	DESIRED	MINIMUM	ESSENTIAL	DESIRED	MINIMUM	ESSENTIAL	DESIRED	MINIMUM	ESSENTIA
2-6 Mixed Weapon Scoring																	
Yes		X			X			X									X
Sequential/Simultaneous		Sim			Sim			Seq									Seq
If Sequential, Time Between Employment																	
Different Targets Simultaneously		X			X		X									X	
2-7 Power Supply																	
Commercial	X			X													
Generator	X			X													
Battery		X			X												
Other Most economical & maintainable								X									X
2-8 Accuracy																	
0-15M ± 2%		X	100%		90%	100%		See Note									
15-30M ± 10%		X	100%														
Implications of MPI or Individual Round Scoring Accuracy																	

T
RANGE SCORING SYSTEM

SCORING CHARACTERISTICS

DELMAR ENGINEERING LABS (DMEL)
BOOZ-ALLEN APPLIED RESEARCH INC (BAARINC)

CDC		FORT STEWART			CONARC DCS/T			CONARC DCS/...			CDC			REMARKS
...TIAL	DESIRED	MINIMUM	ESSENTIAL	DESIRED	MINIMUM	ESSENTIAL	DESIRED	MINIMUM	ESSENTIAL	DESIRED	MINIMUM	ESSENTIAL	DESIRED	
		X												
		Seq												On sequential scoring, time between target engagements can be 1 second.
	X													
		X												
														(Ft. Rucker/Stewart) Although scoring accuracy should be 90-95%, the most important requirement is one of repeatable performance bias, from student to student.

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CONTRACT NO.: N61339-69-C-0178
NTDC

DATA SHEET
ARMED AIRCRAFT QUALIFICATION RANGE SCOR

							FORT RUCKER											
	FORT MACPHEARSON			FORT BENNING			SCHOOL			HumRRO			CDC			F STE		
ITEM	MINIMUM	ESSENTIAL	DESIRED	MINIMUM	ESSENTIAL	DESIRED	MINIMUM	ESSENTIAL	DESIRED	MINIMUM	ESSENTIAL	DESIRED	MINIMUM	ESSENTIAL	DESIRED	MINIMUM	ESSENTIAL	
2.9 Scoring Plane																		
Referenced Vertically		7.62 mm X																
Point of Reference Above Ground																		
Point of Reference at Ground																		
Referenced Horizontally		All Other X			X			X										
Point of Reference Above Ground																		
Point of Reference at Ground		X			X			X										
2.10 Lethality Criteria for Determination of Hit/Miss for Ordnance from 2-4																		
7.62mm																		
50 cal.																		
2.75" SSFFAR (10#&17#)																		
40mm Grenade																		
20mm Auto Wpn																		
30mm Auto Wpn																		
Tow Missile																		
Other																		

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N RANGE SCORING SYSTEM

ER

SCORING CHARACTERISTICS

DEL MAR ENGINEERING LABS (DMEL)
BOOZ-ALLEN APPLIED RESEARCH, INC (BAARINC)

CDC		FORT STEWART			CONARC DCS/T			CONARC DCS/			CDC			REMARKS
ESSENTIAL	DESIRED	MINIMUM	ESSENTIAL	DESIRED	MINIMUM	ESSENTIAL	DESIRED	MINIMUM	ESSENTIAL	DESIRED	MINIMUM	ESSENTIAL	DESIRED	

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DATA SHEET

ARMED AIRCRAFT QUALIFICATION RANGE SC

CONTRACT NO.: N61339-69-C-0178
NTDC

ITEM	FORT MACPHEARSON			FORT BENNING			FORT RUCKER SCHOOL			FORT RUCKER H[illegible]			FORT RUCKER CDC			S	
	MINIMUM	ESSENTIAL	DESIRED	MINIMUM	ESSENTIAL	DESIRED	MINIMUM	ESSENTIAL	DESIRED	MINIMUM	ESSENTIAL	DESIRED	MINIMUM	ESSENTIAL	DESIRED	MINIMUM	ES
2.11 Type Ammunition																	
Inert		X			X			X									X
High Explosive		X			X			X									X
Special Purpose Training Ammunition		X			X			X									X
2.12 Gun-Target Delivery Ranges (Parameters in Meters)																	
7.62mm																	
50 Cal.																	
2.75" SSFFAR (10#&17#)																	
40mm Grenade																	
20mm Auto Wpn																	
30mm Auto Wpn																	
Tow																	
Other																	

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N RANGE SCORING SYSTEM

SCORING CHARACTERISTICS

DELMAR ENGINEERING LABS (DMEL)
BOOZ-ALLEN APPLIED RESEARCH INC (BAARINC)

ER

CDC		FORT STEWART			CONARC [illegible]			CONARC [illegible]			CDC			
ESSENTIAL	DESIRED	MINIMUM	ESSENTIAL	DESIRED	MINIMUM	ESSENTIAL	DESIRED	MINIMUM	ESSENTIAL	DESIRED	MINIMUM	ESSENTIAL	DESIRED	REMARKS
			X											
			X											
			X											
														Minimum range is 300 to 500 meters in all cases.
														Maximum range is the same as either maximum effective range of weapon or range limits, whichever is least.

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DATA SHEET

ARMED AIRCRAFT QUALIFICATION RANGE SCC

CONTRACT NO.: N61339-69-C-0178
NTDC

ITEM	FORT MACPHEARSON			FORT BENNING			FORT RUCKER: SCHOOL			FORT RUCKER: [illegible]			FORT RUCKER: CDC			FORT RUCKER: S…	
	MINIMUM	ESSENTIAL	DESIRED	MINIMUM	ESSENTIAL	DESIRED	MINIMUM	ESSENTIAL	DESIRED	MINIMUM	ESSENTIAL	DESIRED	MINIMUM	ESSENTIAL	DESIRED	MINIMUM	ESSENTIAL
2.13 Maneuver Considerations																	
Attack Azimuths																	
Single																	
Multiple		360° X			360° X			Hdg. 20°	?								Hdg. 270°
Dive Angle																	
(Vertical Angle of Projectile Entry)		15° - 20°	60° - 80°		15° - 20°	60° - 80°		15° - 20°	60° - 80°								15° - 20°

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RANGE SCORING SYSTEM

SCORING CHARACTERISTICS

DEL MAR ENGINEERING LABS (DMEL)
BOOZ-ALLEN APPLIED RESEARCH INC (BAARINC)

CDC		FORT STEWART			COHAR CCS/T			CONARC			CDC			REMARKS
ESSENTIAL	DESIRED	MINIMUM	ESSENTIAL	DESIRED	MINIMUM	ESSENTIAL	DESIRED	MINIMUM	ESSENTIAL	DESIRED	MINIMUM	ESSENTIAL	DESIRED	
			Hdg. ±70°	115°										
			15° - 20°	60° - 80°										

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DATA SHEET
ARMED AIRCRAFT QUALIFICATION RANGE SCORING

CONTRACT NO.: N61339-69-C-0178
NTDC

ITEM	FORT MACPHEARSON			FORT BENNING			FORT RUCKER – SCHOOL			FORT RUCKER – HumRRO			FORT RUCKER – CDC			FORT STEWART			
	MINIMUM	ESSENTIAL	DESIRED	MINIMUM	ESSENTIAL	DESIRED	MINIMUM	ESSENTIAL	DESIRED	MINIMUM	ESSENTIAL	DESIRED	MINIMUM	ESSENTIAL	DESIRED	MINIMUM	ESSENTIAL	DESIRED	MI
-1 Data to be Displayed																			
Hits (MPI or Indiv.)		X			X			X											
Miss, Feet																			
Miss, Meters																			
Miss, Zones		X			X			X											
Miss, Other																			
Vector, Hi-Lo (Over-short)		X			X														
Vector, R-L		X			X														
Vector, Clock								X											
Vector, Other																			
-2 Display Lighting																			
Yes/No		X			X			X											
Variable Intensity		X			X				X										
-3 Location								X											
Range Tower																			
Vehicle											See note.								
Aircraft									X										
Other (With Control Element)		X			X														

RANGE SCORING SYSTEM	DATA DISPLAY DEL MAR ENGINEERING LABS (DMEL) BOOZ-ALLEN APPLIED RESEARCH INC (BAARINC)													
CDC		FORT STEWART			CONARC			CONARC			CDC			
ESSENTIAL	DESIRED	MINIMUM	ESSENTIAL	DESIRED	MINIMUM	ESSENTIAL	DESIRED	MINIMUM	ESSENTIAL	DESIRED	MINIMUM	ESSENTIAL	DESIRED	REMARKS
														(HumRRO) - "Extremely desirable to provide scoring data to firing student immediately, whether by read-out onboard aircraft or immediate communication.

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DATA SHEET

ARMED AIRCRAFT QUALIFICATION RANGE SCORIN

CONTRACT NO.: N61339-69-C-0178
NTDC

ITEM	FORT MACPHEARSON			FORT BENNING			FORT RUCKER: SCHOOL			FORT RUCKER: [illegible]			FORT RUCKER: CDC			FORT STEW		
	MINIMUM	ESSENTIAL	DESIRED	MINIMUM	ESSENTIAL	DESIRED	MINIMUM	ESSENTIAL	DESIRED	MINIMUM	ESSENTIAL	DESIRED	MINIMUM	ESSENTIAL	DESIRED	MINIMUM	ESSENTIAL	DES
3-4 Data Recording																		
Yes, (Some means of recording data)			X			X												
Automatic ([illegible])								X										
Storage (Printer)								X										
Other (Manual)		X			X													
Auto Growth			X			X		X										
3-5 Power Supply																		
Commercial		X			X			X									X	
Generator (Field)		X			X			X									X	
Battery		X			X			X									X	
Other																		
Depends on Location								X									X	

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RANGE SCORING SYSTEM

DATA DISPLAY

DELMAR ENGINEERING LABS (DMEL)
BOOZ-ALLEN APPLIED RESEARCH INC (BAARINC)

CDC		FORT STEWART			CONARC			CONARC			CDC			REMARKS
ESSENTIAL	DESIRED	MINIMUM	ESSENTIAL	DESIRED	MINIMUM	ESSENTIAL	DESIRED	MINIMUM	ESSENTIAL	DESIRED	MINIMUM	ESSENTIAL	DESIRED	
		X												
		X												
		X												
		X												

2

DATA SHEET
ARMED AIRCRAFT QUALIFICATION RANGE SCORING

CONTRACT NO.: N61339-69-C-0178
NTDC

	ITEM	FORT MACPHEARSON			FORT BENNING			FORT RUCKER: SCHOOL			FORT RUCKER: HQ [illegible]			FORT RUCKER: CDC			FORT STEW[illegible]		
		MINIMUM	ESSENTIAL	DESIRED	MINIMUM	ESSENTIAL	DESIRED	MINIMUM	ESSENTIAL	DESIRED	MINIMUM	ESSENTIAL	DESIRED	MINIMUM	ESSENTIAL	DESIRED	MINIMUM	ESSENTIAL	DESIRED
4-1	**Radio**		X			X		**Require portability, but no down-range calibration, adjustment, battery pack, etc. (suggests wired sites)**											
	Telemetry F/M																		
	Telemetry FM/FM																		
	Pulse Code Modulation																		
4-2	**Wire**																		
	Cable, Multi-Cond																		
	Coax																		
	Other																		
4-3	**Laser**																		

T
RANGE SCORING SYSTEM

DATA LINK

DEL MAR ENGINEERING LABS (DMEL)
BOOZ-ALLEN APPLIED RESEARCH INC (BAARINC)

CDC		FORT STEWART			CONARC DCS/ T			CONARC DCS/CFNS			CDC			REMARKS
ESSENTIAL	DESIRED	MINIMUM	ESSENTIAL	DESIRED	MINIMUM	ESSENTIAL	DESIRED	MINIMUM	ESSENTIAL	DESIRED	MINIMUM	ESSENTIAL	DESIRED	

2

DATA SHEET
ARMED AIRCRAFT QUALIFICATION RANGE SCORIN

CONTRACT NO.: N61339-69-C-0178
NTDC

	ITEM	FORT MACPHEARSON			FORT BENNING			FORT RUCKER: SCHOOL			FORT RUCKER: HumRRO			FORT RUCKER: CDC			FOR STEW		
		MINIMUM	ESSENTIAL	DESIRED	MINIMUM	ESSENTIAL	DESIRED	MINIMUM	ESSENTIAL	DESIRED	MINIMUM	ESSENTIAL	DESIRED	MINIMUM	ESSENTIAL	DESIRED	MINIMUM	ESSENTIAL	DESI
5-1	**Attack Range**																		
	Individual Training		X			X			X									X	
	Familiarization		X			X													
	Qualifications		X			X			X									X	
	Unit		X			X													
	Other																		
	Annual Proficiency Training (IP)								X										
5-2	**Door Gunner Range**																		
	Individual			X		X			X								X		
	Familiarization			X		X											X		
	Qualification			X		X			X								X		
	Unit			X		X													
	Other																		
	Annual Proficiency Training (IP)								X								X		
5-3	**Gunnery Instructor**			X			X		X									X	
5-4	**Weapon Systems**																		
	Fixed		X			X													
	Flexible		X			X													
	Swiveling		X			X													
	Other																		
5-5	**AAF88 Range (Considerations)**		X			X													

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RANGE SCORING SYSTEM

TRAINING USE

DEL MAR ENGINEERING LABS (DMEL)
BOOZ-ALLEN APPLIED RESEARCH INC (BAARINC)

:R

CDC		FORT STEWART			CONARC DCS/T			CONARC DCS/...			CDC			REMARKS
ESSENTIAL	DESIRED	MINIMUM	ESSENTIAL	DESIRED	MINIMUM	ESSENTIAL	DESIRED	MINIMUM	ESSENTIAL	DESIRED	MINIMUM	ESSENTIAL	DESIRED	
														School - No requirement to score
			X											familiarization training.
			X											
		X												Ft. Stewart does not conduct door-gunner
		X												training.
		X												
		X												
			X											
									X					
									X					
									X					
									X					

DATA SHEET
ARMED AIRCRAFT QUALIFICATION RANGE SCORING

CONTRACT NO.: N61339-69-C-0178
NTDC

ITEM	FORT MACPHEARSON			FORT BENNING			FORT RUCKER: SCHOOL			FORT RUCKER: HumRRO			FORT RUCKER: CDC			FORT STEWART			
	MINIMUM	ESSENTIAL	DESIRED	MINIMUM	ESSENTIAL	DESIRED	MINIMUM	ESSENTIAL	DESIRED	MINIMUM	ESSENTIAL	DESIRED	MINIMUM	ESSENTIAL	DESIRED	MINIMUM	ESSENTIAL	DESIRED	MIN
6-1 Reliability																			
MTTR (30 min)		X			X			X									X		
MTBF (20 hrs)		?			?			1200									1200		
Relative Vulnerability to Weapons Damage							All components, including down range, must provide minimum life (vulnerability) of 125 hours.												
Survivability																			
-2 Maintainability																			
Skill Level (Org)		X																	
Skill Level (Intm)	X																		
Other		X																	
-3 Transportability																			
1/4T or 1/4 Trlr.		X				X		X											
3/4T or 3/4 Trlr.		X				X													
Aircraft		X			X			X											
Other																			
6-4 Calibration																			
None			X			X	Essential, no down range calibration within 125 Hour limit - Desire self-test feature by operator & display.												
1/16% of Use		X			X														
Other																			
							Maximum down range calibration is monthly.												

/

ET
RANGE SCORING SYSTEM

MISCELLANEOUS

DEL MAR ENGINEERING LABS (DMEL)
BOOZ-ALLEN APPLIED RESEARCH INC (BAARINC)

ER

	CDC		FORT STEWART			CONARC DCS/IT			CONARC DCS/CPNS			CDC			
	ESSENTIAL	DESIRED	MINIMUM	ESSENTIAL	DESIRED	MINIMUM	ESSENTIAL	DESIRED	MINIMUM	ESSENTIAL	DESIRED	MINIMUM	ESSENTIAL	DESIRED	REMARKS
				X 1200											Electronic component.
own range, must rability) of 125															
ibration within test feature by															
on is monthly.															

2

CONTRACT NO.: N61339-69-C-0178
NTDC

DATA SHEET
ARMED AIRCRAFT QUALIFICATION RANGE SCOR

	ITEM	FORT MACPHEARSON			FORT BENNING			FORT RUCKER: SCHOOL			FORT RUCKER: [illegible]			FORT RUCKER: CDC			F STE	
		MINIMUM	ESSENTIAL	DESIRED	MINIMUM	ESSENTIAL	DESIRED	MINIMUM	ESSENTIAL	DESIRED	MINIMUM	ESSENTIAL	DESIRED	MINIMUM	ESSENTIAL	DESIRED	MINIMUM	ESSENTIAL
6-5	Degree of Site Preparation per Target/Per Range		-12 Man Hours X			-12-24 X			-4 Man Hrs. Per Target									
	Ground Burial of Equipment Acceptance	X	-5 Man Hours						X									
	Construction of Bunkers on Range Acceptance								X									

1

EET
N RANGE SCORING SYSTEM

MISCELLANEOUS

DELMAR ENGINEERING LABS (DMEL)
BOOZ-ALLEN APPLIED RESEARCH INC (BAARINC)

ER

CDC		FORT STEWART			CONARC DCS/T			CONARC DCS/...			CDC			REMARKS
ESSENTIAL	DESIRED	MINIMUM	ESSENTIAL	DESIRED	MINIMUM	ESSENTIAL	DESIRED	MINIMUM	ESSENTIAL	DESIRED	MINIMUM	ESSENTIAL	DESIRED	

FOLLOWING MILITARY INSTALLATIONS WERE VISITED

LOCATION:	3rd U.S. Army - Headquarters Ft. McPherson, Atlanta, Georgia
Date:	Monday, 21 April 1969
LOCATION:	10th Aviation Group Fort Benning, Georgia
Date:	Tuesday, 22 April 1969
LOCATION:	U.S. Army Aviation School Ft. Rucker (Ft. Stewart Representatives)
Date:	Wednesday, 23 April 1969
LOCATION:	Headquarters, Continental Army Command (CONARC) Ft. Monroe, Virginia
Date:	Thursday, 24 April 1969

28 Personnel

CONCEPT FORMULATION STUDY:

(ARMED AIRCRAFT QUALIFICATION RANGE SCORING SYSTEM)

Ref: Contract N61339-69-C-0178

FIELD TRIP CONFERENCE
(Attendees)

LOCATION: 3rd U.S. Army - Headquarters
Ft. McPherson - Atlanta, Georgia
DATE: Monday, 21 April 1969

NAME	RANK	DEPT/GROUP	TITLE
CONTRACTOR PERSONNEL:			
John Ford	Civ	BAARINC	Project Scientist
Wally Brondstatter	Civ	DMEL	Program Manager
Jack Hammond	Civ	DMEL	Military Relations Rep.
U. S. ARMY PERSONNEL:			
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Lauren S. Davis	LTC	DCS - O & T (AVN)	Chief, AVN. Trng. Opns. & Plans Brnch.
Hemlick	LTC	DCS - O & T (AVN)	Trng. Opns & Plans Branch (AVN)

NAVTRADEVCEN 69-C-0178-1

CONCEPT FORMULATION STUDY:

(ARMED AIRCRAFT QUALIFICATION RANGE SCORING SYSTEM)

Ref: Contract N61339-69-C-0178

FIELD TRIP CONFERENCE
(Attendees)

LOCATION: 10th [illegible] Group
Ft. [illegible], Georgia

DATE: [illegible]

NAME	RANK	DEPT/GROUP	TITLE
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[illegible] O'Leary	LTC	Hq.-10th Avn. Gp.	Safety Off.
D. [illegible]	LTC	Hq.-10th Avn. Gp.	Dep. C. O.
D. R. West	Maj.	[illegible]th TransCo.([illegible])	Cmdn'g Off.
R. G. Chain	Maj.	1[illegible]th Avn. Co. ([illegible])	Cmdn'g Off.
J. R. [illegible]	Maj.	Hq.-10th Avn, Grp.	Asst. S-3
[illegible]	Capt.	[illegible]th Trans. Co. ([illegible])	Exec. Off.
[illegible]	Capt.	1[illegible]th Avn. Co. ([illegible])	[illegible] Off.
[illegible]	Col.	Hq. 10th Avn. Grp.	[illegible]

CONCEPT FORMULATION STUDY:

(ARMED AIRCRAFT QUALIFICATION RANGE SCORING SYSTEM)

Ref: Contract N61339-69-C-0178

FIELD TRIP CONFERENCE
(Attendees)

LOCATION: U.S. Army Aviation School Ft. Rucker / Ft. Stewart Representatives)

DATE: Wednesday, 2[illegible] April 19[illegible]9

NAME	RANK	DEPT/GROUP	TITLE
CONTRACTOR PERSONNEL:			
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Wally Brandstatter	Civ	[illegible]	Program Manager
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U. S. ARMY PERSONNEL:			
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Dudley J. Carver, Jr.	Maj.	Avn Armt Div/DOI	Chf - Spec. Proj.
Robert W. Michel	LTC	Plans, DOI	Chf - Plans Br.
Dale Hill	Civ	Secretariat/DTC DOCS	El. Spec.
James W. Lloyd	Capt.	Avn Armt Div/DOI Hunter	Project Officer
William R. Taylor	Maj.	DOI, USAAVNS Elm	Plans Officer
A. L. Bowne	Maj.	G-3 (Ft. Stewart)	Range Control Off.
J. A. Bond	LTC	G-3, Ft. Rucker	Ell. Trg. Dirt.
John H. Bowden	Maj.	Plans Br. DOI	Project Officer
Robert E. [illegible]	Civ	[illegible]	Sr. Scientist

Ft. Stewart (bracketed: James W. Lloyd, William R. Taylor, A. L. Bowne)

CONCEPT FORMULATION STUDY:

(ARMED AIRCRAFT QUALIFICATION RANGE SCORING SYSTEM)

Ref: Contract N61339-69-C-0178

FIELD TRIP CONFERENCE
(Attendees)

LOCATION: Headquarters Continental Army Command (CONARC) Ft. Monroe, Virginia

DATE: [illegible]

NAME	RANK	DEPT/GROUP	TITLE
CONTRACTOR PERSONNEL:			
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Wally Broadst[illegible]	Civ	[illegible]	Program Manager
Jack Hammond	Civ	[illegible]	Military Relations Rep.
U. S. ARMY PERSONNEL:			
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[illegible]	LTC	DCSOPS - AVN	R & D Monitor
Donald J. [illegible]	LTC	DCSOPS - AVN	Opns
[illegible] R. Parker	Maj.	DCSIT - (RD - ID)	Trng. Programs Ind. Trng.
Donald E. [illegible]	LTC	DCSOPS - AVN	Ops-Trng. Staff Officer
W. R. [illegible]	Col.	DCSOPS - AVN	Chief, Ops, Trng. Branch.

APPENDIX C

FUNCTIONAL ANALYSIS

1. INTRODUCTION

1.1 How the Task 2 Study is Organized

The functional formulation task starts with a statement defining what task the range scoring system is expected to perform in support of the overall Army Armed Aircraft Military Mission. This becomes the statement of requirement leading to a description of the operational function the system is required to perform. A system description, in engineering terms, derived from system function will be prepared (Tasks 3, 4, 5, 6, and 7). Tradeoff studies of "off-the-shelf hardware" will be conducted to determine how well a selected configuration combination matches the needed system requirement. Finally, a recommended best technical approach statement will be prepared. This may include a recommended program for a hardware development if it becomes apparent that currently available equipment will not suffice.

Throughout the study attention will be continually directed toward:

- Feasibility
- Mission effectiveness
- Cost of ownership
- Cost effectiveness
- Availability
- Reliability and maintenance

1.2 Study Rationale

Provide a specification for a range scoring system that most closely matches the requirement in all respects. Over-design of hardware is to be avoided in all cases to preclude purchase of overpriced, over-complicated hardware. Inadequate design is likewise to be avoided to obviate inadequate performance.

1.2.1 Background

In order to satisfy the foregoing, it was first necessary to establish what task the range scoring system is expected to perform for the user. The SDR analysis has been completed and user agencies have been contacted to ascertain the training requirements by training phase. Results of this combined analysis, starting with the mission (objective of armed aircraft gunnery training programs), are stated in the succeeding paragraphs.

2. MISSION (OBJECTIVE)

U. S. Army armed aircraft individual familiarization and qualification training, unit qualification and tactical training using simulated targets and gunnery scoring methods.

3. FUNCTION

When the mission is broken down into first level functions, two significant categories emerge: (1) individual familiarization and qualification; (2) unit qualification and tactical training. The two functions are mutually dependent.

Figure 1 shows the overall armed aircraft gunnery training mission broken down into training functions.

3.1 Individual Training

Figure 2 shows the individual training requirements broken down to scoring systems functions.

FIGURE 1
Overall Training Mission
Requirements and Function

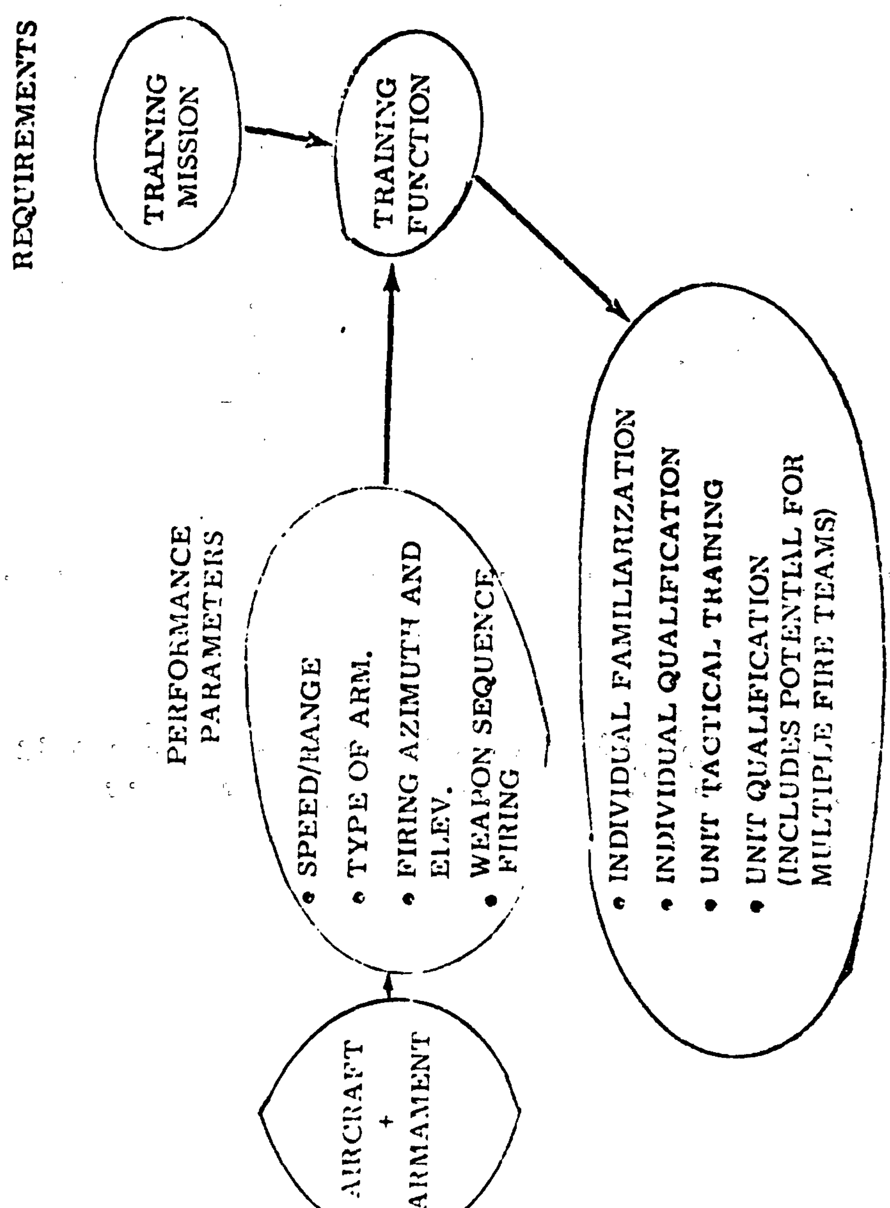
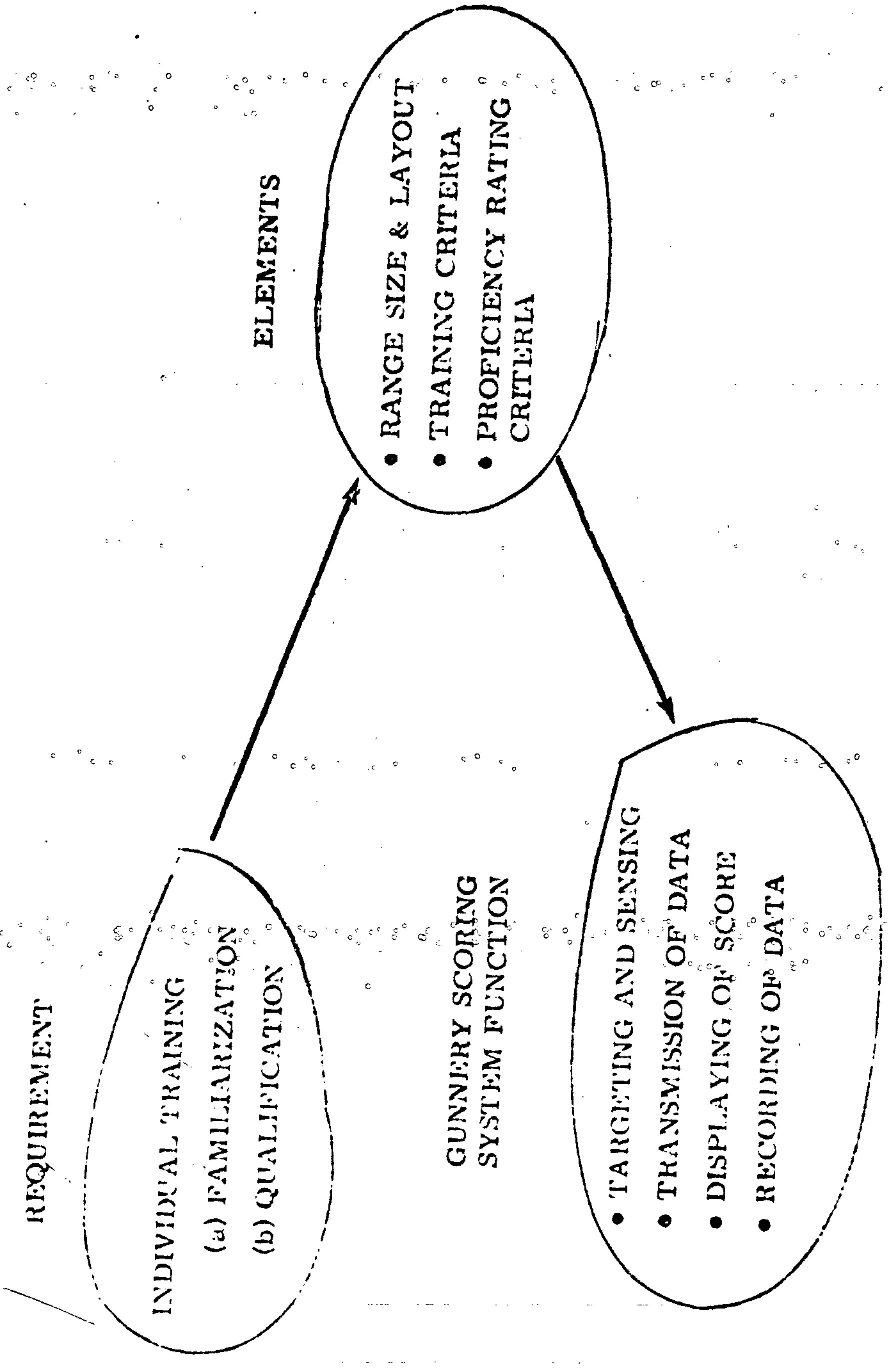


FIGURE 2
Individual Training Requirements
and Scoring System Function



3.1.1 Familiarization

Objective: to familiarize the individual with the aircraft ordnance under in-flight conditions. Both day and night operations are included. The student is schooled to get the "feel" of the aircraft and its armament in a live ammunition firing situation. Primary grading is on his performance in following prescribed operating procedures, and safety criteria. Equipment malfunction (both simulated and real) is included, and improvision techniques are graded.

An aiming point is provided; however, the student is not expected to provide accurate fire during this phase.

3.1.1.1 Method of Scoring

We concur with the Training Command's conclusion, as stated in Department of the Army Publication 1-40, that the instructor pilot scoring by manual notation will suffice during this phase of training.

3.1.2 Qualification

Objective: to develop the student's proficiency in placing accurate fire on the target. Both day and night operations are included. Primary grading should be on his ordnance delivery proficiency and accuracy.

3.1.2.1 Method of Scoring

An accurate measure of qualification level per student can be established when standards are well defined and tests become independent of individual interpretation.

Following gunnery familiarization training and starting with the qualification phase for Individual Training, the scoring task becomes more stringent, demanding precise assessment of target kill potential. A machine scoring system is essential during this phase of training in order to establish a uniform method of proficiency rating not open to individual interpretation.

3.1.2.2 Targets

A most important criteria is establishment of target standardization. The targets provided for individual qualification should be point of aim, semi-fixed, multiple target complexes on a typical firing range. Figures 3, 4, 5, and 6 describe circular and elliptical fire dispersion patterns.* Reference Appendix IV for target dimensions and layout.

3.1.2.3 Armament

- Rapid fire (6,000 rounds per minute) machine guns - 7.62 mm, 5.56 mm.
- 50 caliber machine guns
- Rockets and missiles (2.75 to 6 in)
- 40 mm grenade launcher
- 20 mm and 30 mm automatic guns

Inert rounds as well as HE and tracer will be employed during the training phase.

All ordnance except the TOW and M-22 (wire-guided) missiles are classified as "area weapons." TOW and M-22 are "point of impact weapons."

3.1.2.4 Scoring

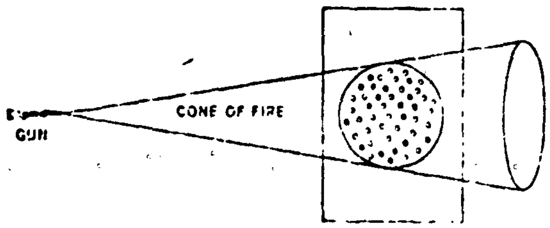
The scoring system sector coverage from the target forward direction has been stated as being $\pm 45°$ in azimuth and $0°$ to $80°$ vertical elevation.

Accuracy of projectile or burst count (for rapid fire weapons) should be 95% $\pm$ 5%.

* Calculations for elliptical patterns are contained in Appendix I.

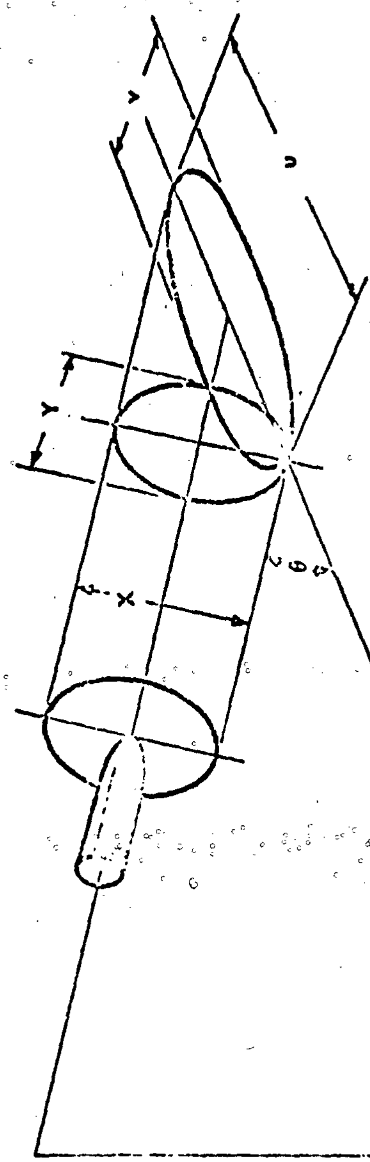
NAVTRADEVCEN 69-C-0173-1 FIGURE 3

Circular Dispersion Pattern on Plane
Intersecting Cone of Fire



Reference: FM-1-40, "Attack Helicopter Gunnery," U.S. Army Aviation School, Fort Rucker, Alabama. April, 1968.

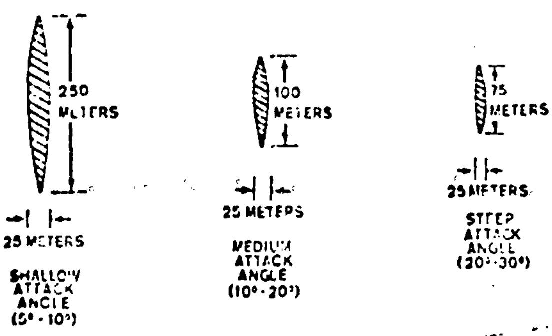
FIGURE 4
Projection of Trajectory Normal
Dispersion onto Ground Plane



Reference: Booz, Allen Applied Research, Inc. Report No. 141-2-14-R2, "Hit Probabilities in the Elliptical Normal Case Considering Angle of Attack," June, 1963.

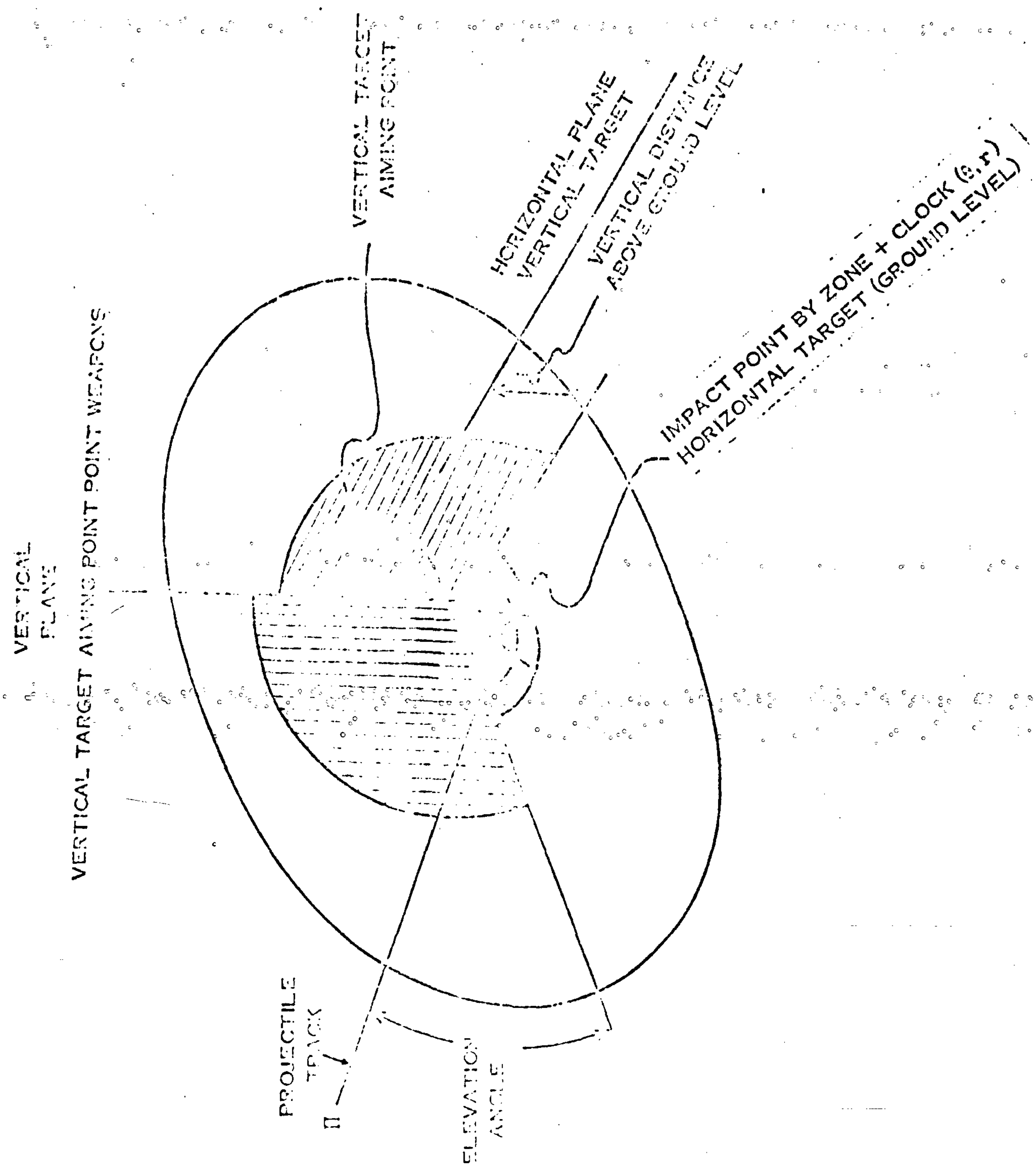
FIGURE 5

Elongated Beaten Zone for 7.62 mm Machinegun



Reference: FM-1-40, "Attack Helicopter Gunnery," U. S. Army Aviation School, Fort Rucker, Alabama, April, 1968.

FIGURE 6
Target Problem



Over, short, left, or right to locate mean point of impact "miss location" is the coverage required in the horizontal plane at ground level for area weapons; "Point" type weapons require the same coverage in the vertical plane. Only hits within the pre-defined target zone must be scored (counted). Misses in "over/short"-"left/right" zones need not be scored. (See Appendix IV.)

3.1.2.5 Scoring Sensor(s)

The sensor(s) installed at the target site must be capable of responding to a rate of fire 6,000 rounds per minute. The rate of information transmission to display and recording instruments can be as low as a rate determined by dividing two times the shortest burst duration a gunner is able to fire (human reaction time) into a unit of elapsed time; i.e., 1 sec/0.25 = 4 per sec.

3.1.2.6 Data Transmission and Display

Human factors engineering studies indicate the fastest response to perform this function is in the order of 1/4 second. Therefore, the information data rate of 10 words per second for each target will suffice. (See Appendix II, Scoring Rate.)

Scoring and miss data may be transmitted via buried hard-wire cable or wireless telemetry from targets to display units in the control tower. Each target should be displayed individually. Individual target data need to be transmitted via wireless telemetry to the firing aircraft where the instructor pilot can select and display the target being engaged, if it is within the capability or physical limitations of the aircraft. Maximum delay time between projectile impact and display is 250 milliseconds (as requested by Training Commands).

3.1.2.7 Recording

Sorting of ordnance by type and by firing aircraft for interwoven aircraft firing runs (up to four aircraft in a race track pattern is possible on each range) must accompany the scoring records. This may be accomplished by various means such as a voice or tone index that identifies firing aircraft, target engaged, run number, and ordnance used.

Automatic recording of scoring data is virtually essential due to the large volume of data to be handled plus the need for precise measurement of student gunnery proficiency during the qualification phase.

3.1.2.8 Power

Power for instrumentation at the target site may be supplied via underground cable along with a hard-wire telemetry cable. (Note: Training Commands are opposed to batteries.)

3.2 Unit Training

Figure 7 shows the unit training requirements broken down to scoring systems functions.

3.2.1 Unit Tactical Training

For unit tactical training the basic scoring equipment functional and performance requirements for individual qualification can be used if additional capabilities are added. These are:

(1) Increase sensor coverage from 90° azimuth to 360°. (Provided the range can accommodate uncontrolled approach up to 360°.) (Figure 8)

(2) Provide wireless telemetry from target with a range of 30,000 meters.

FIGURE 7
Unit Training Requirements
and Scoring System Function

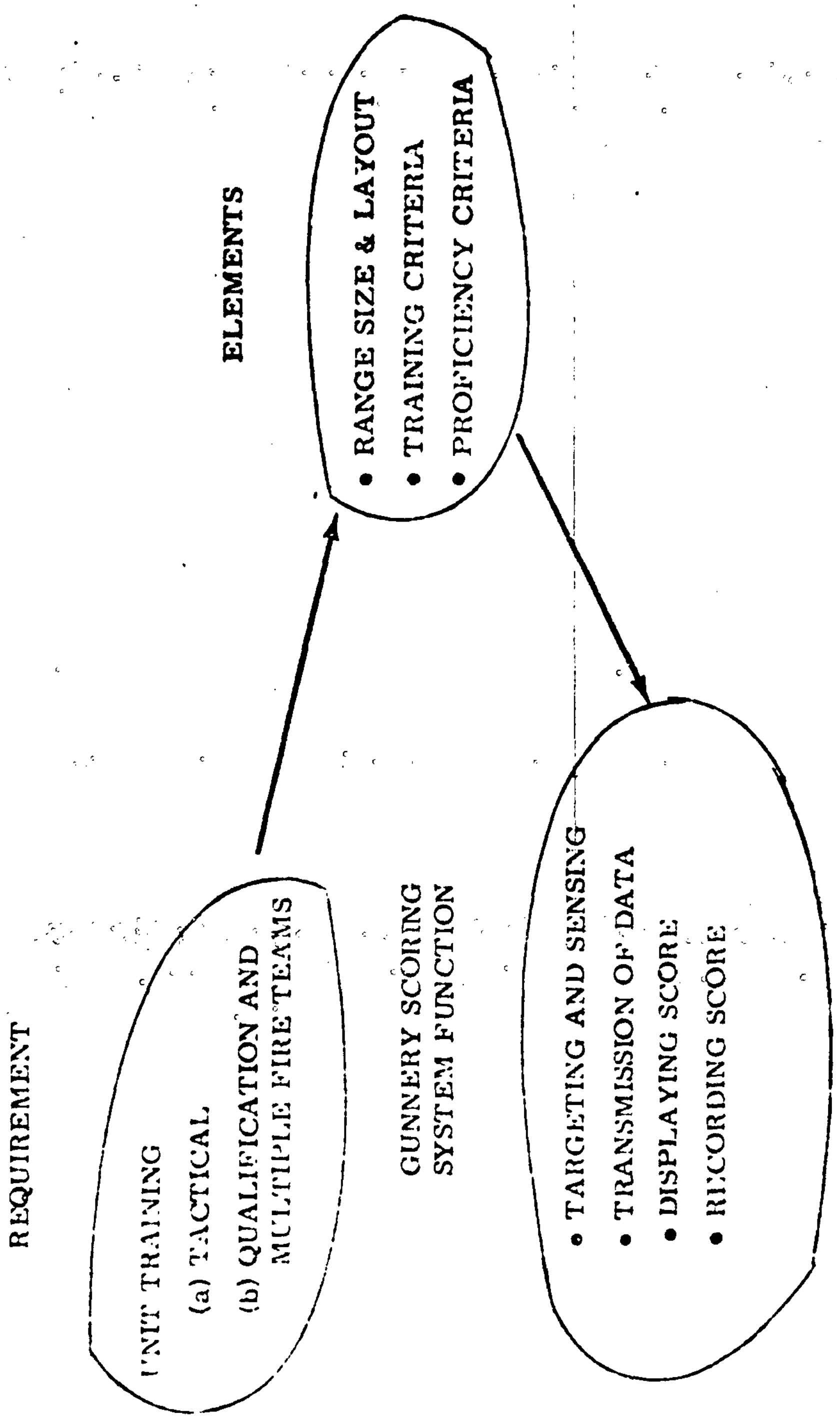
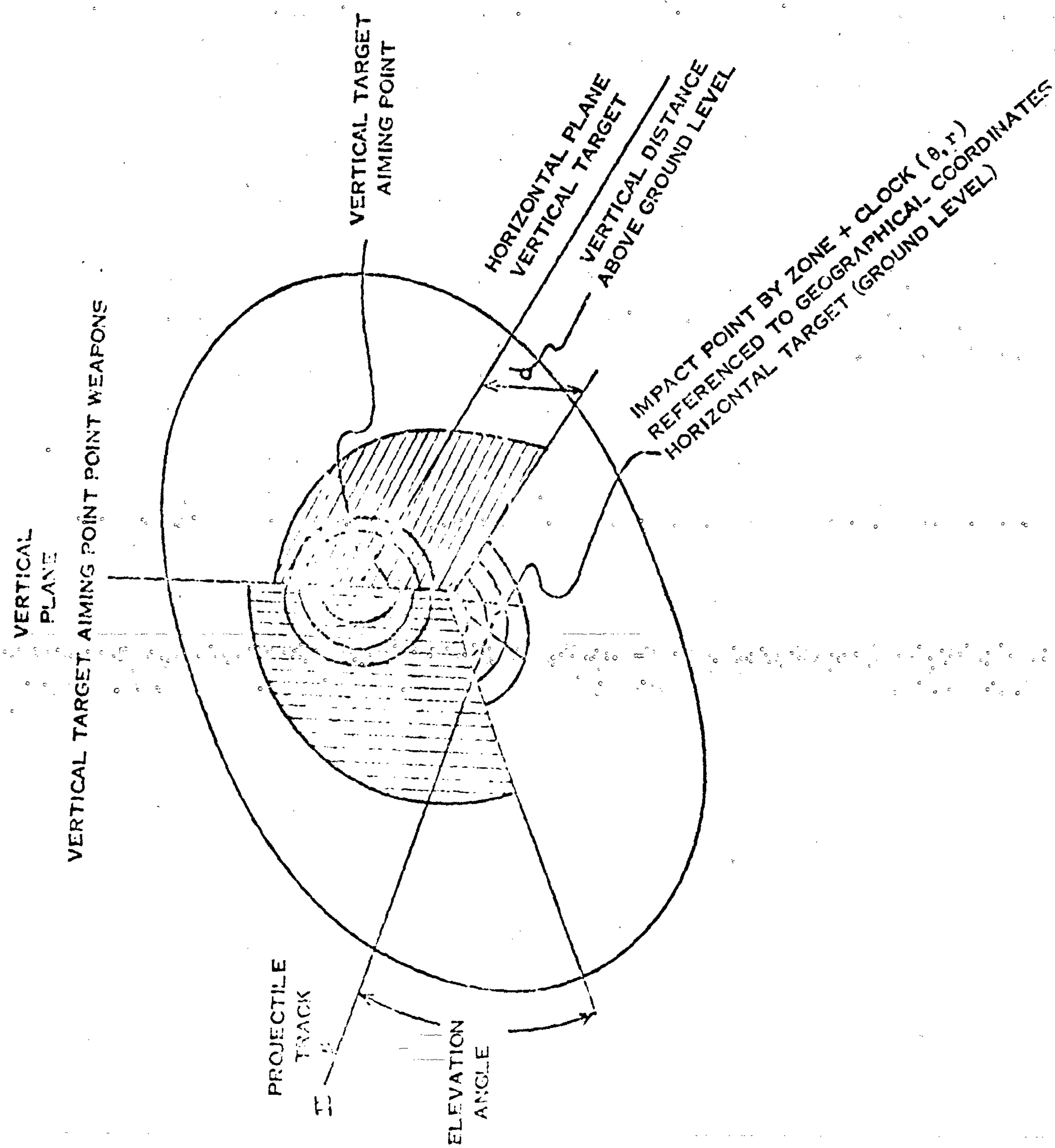


FIGURE 8
Target Problem -
Unit Training



(3) Provide self contained air transportable scoring system, including power source. Reference Appendix IV.

(4) Increase scoring rate (system wide) to 24,000 rpm.

(5) Provide scoring for simultaneous fire with mixed weapon fire from single or multiple aircraft, in addition to automatic sorting of firing A/C.

3.2.2 Unit Qualification and Multiple Team Fire

Unit qualification and multiple unit firing does not require additional scoring capability beyond that required in Individual Training.

3.3 Sequence of Occurrence and Conceptual Flow Diagram

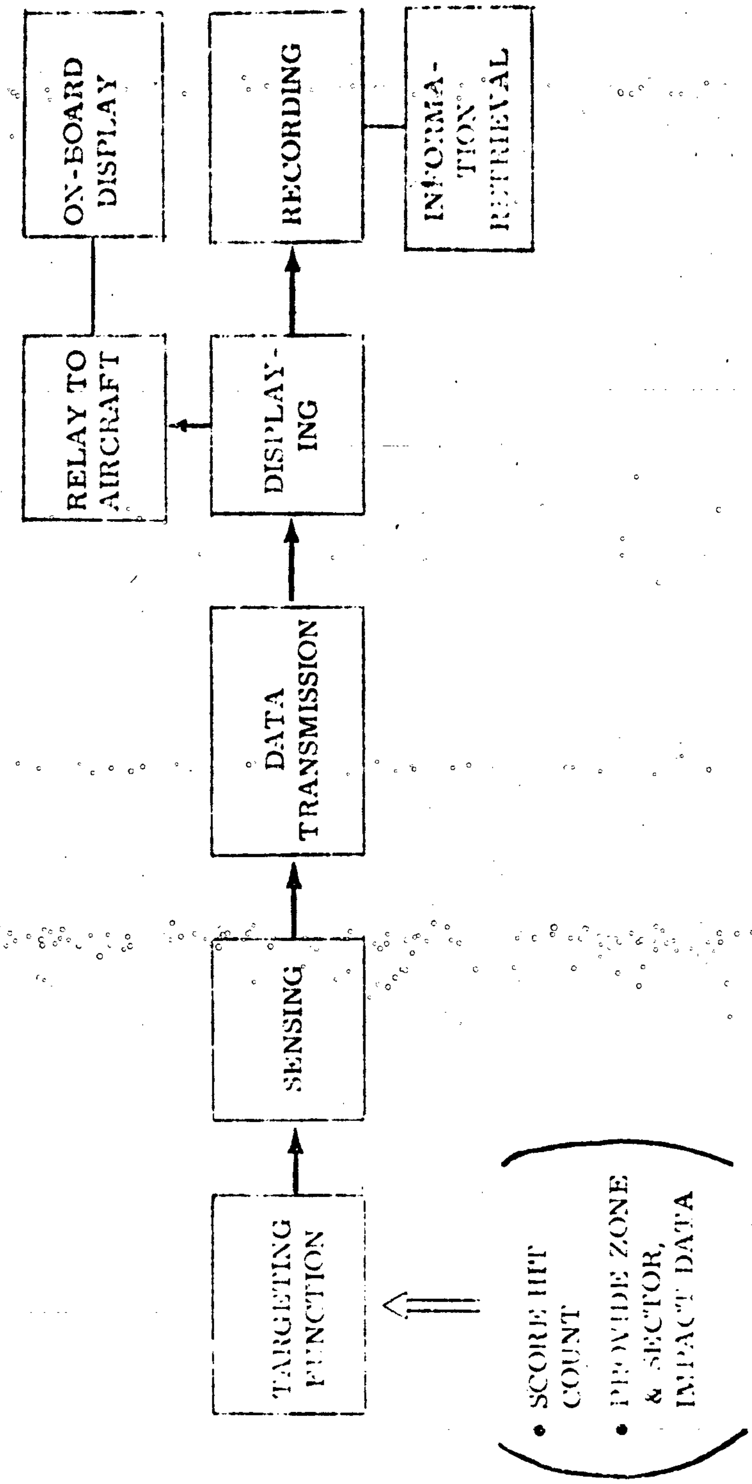
Figure 9 describes the sequence of information flow.

Figures 10 and 11 show samples of the next lower level flow diagram and the associated data rate.

4. RELIABILITY

Reliability is of paramount importance to successful employment of any scoring system. If confidence in reliable performance is low, the entire gunnery mission will suffer; therefore, reliability becomes a key consideration in systems cost effectiveness. The burden of any added expense incurred by slowing down gunnery training due to poor reliability must be charged to the system.

FIGURE 9
Sequence of Occurrence



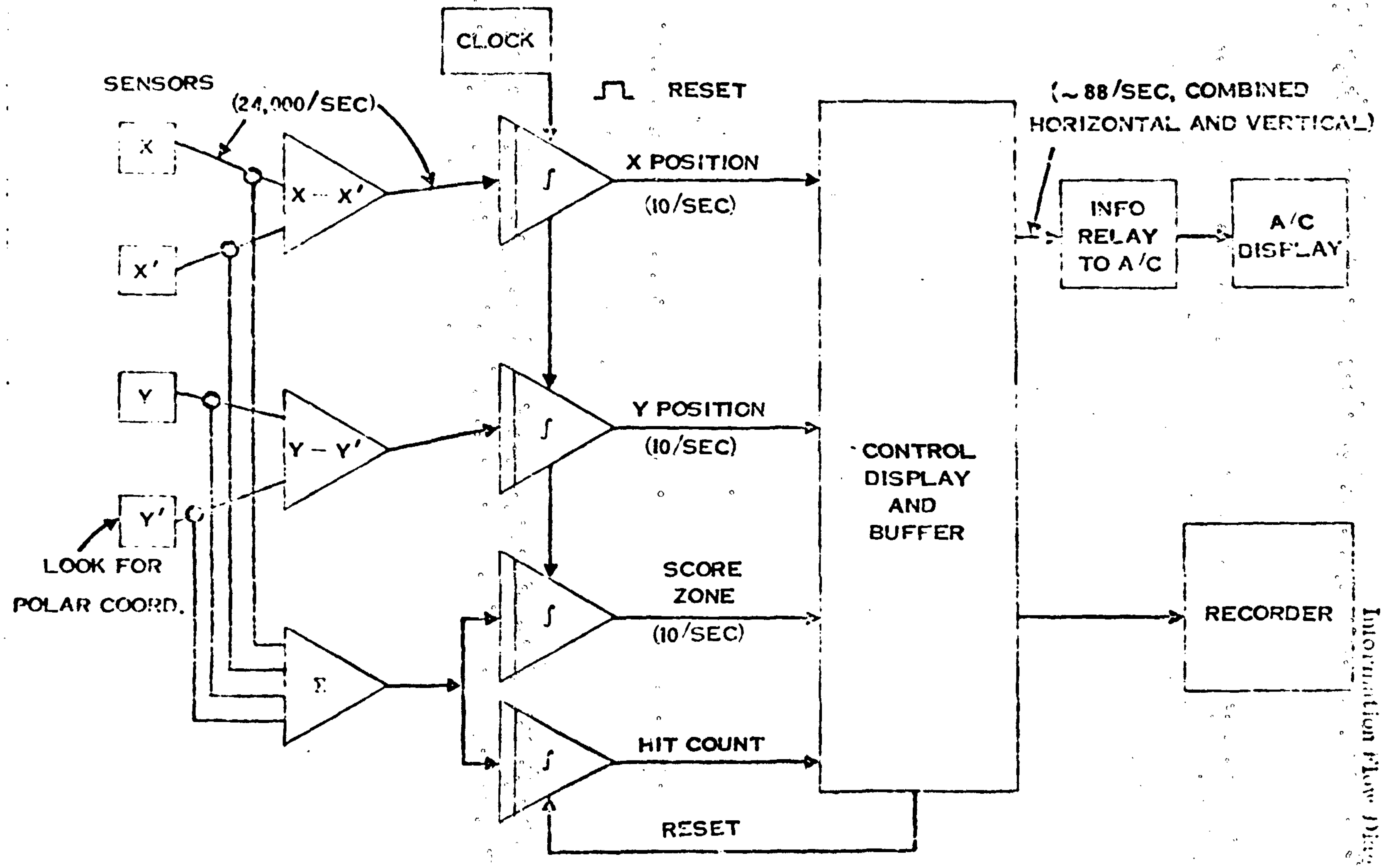


FIGURE 10
Example of One Conceptual
Information Flow Diagram

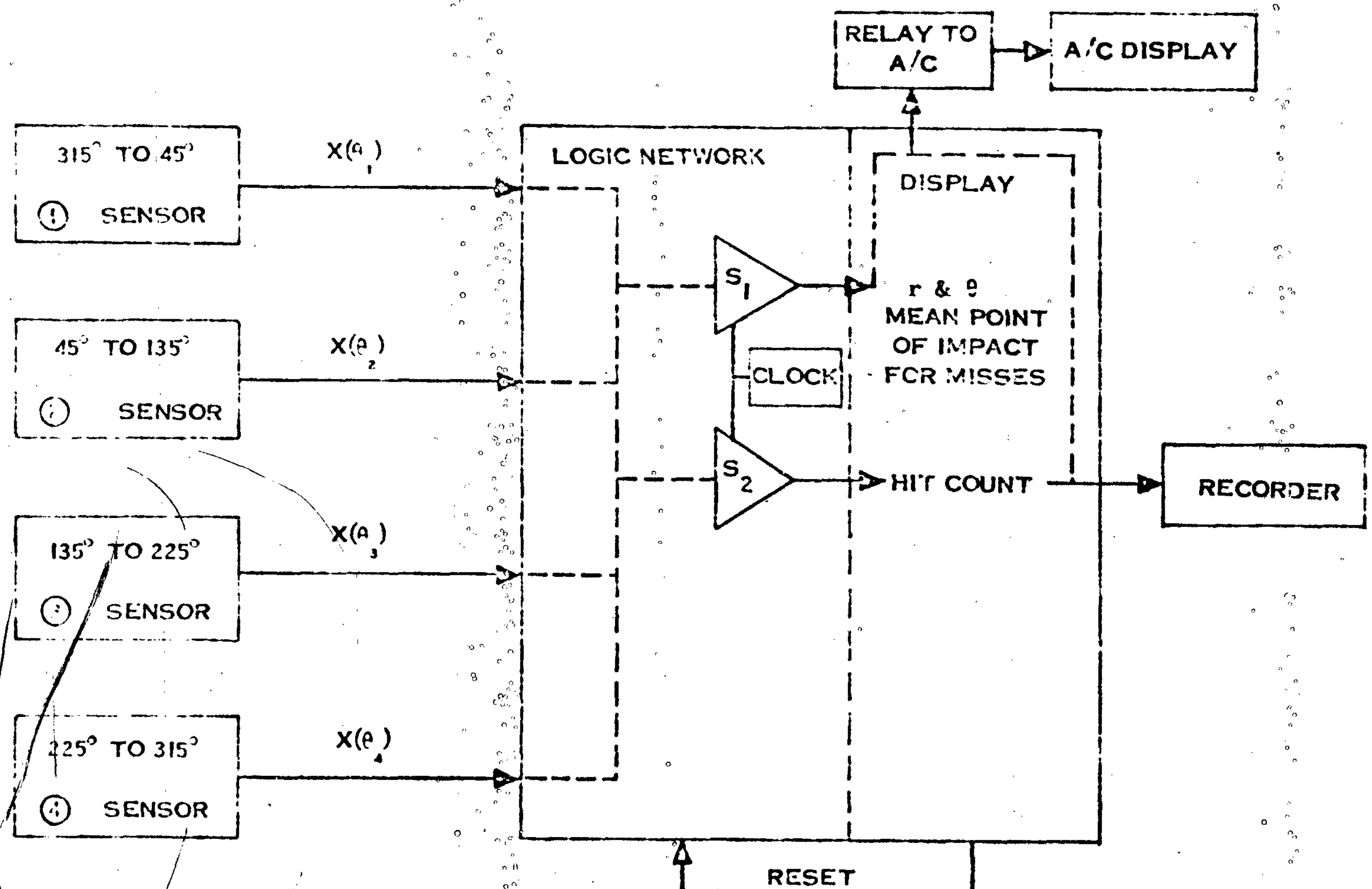


FIGURE 11
Example of an Alternate
Flow Diagram

Reliability of the candidate equipment will be analyzed during Task 4 to determine performance conformity to MIL-STD 785. A further requirement requested by user agencies is 1200 hours mean time between failure for the entire system. All components downrange, (in the vicinity of the target), must provide unattended service, including vulnerability, of at least 120 hours range operation time.

5. MAINTAINABILITY

Ideally, a system should require no maintenance; however, in real systems this becomes virtually an impossibility. The maintenance effort required must be kept as low, simple, and as infrequent as possible.

Modular construction where system major components may be replaced quickly and easily has been employed successfully in many cases. Modular construction is included as part of the scoring systems study.

A maintainability plan should accompany the system during the hardware design conceptual phase.

Upon delivery and installation of any scoring system, a maintainability demonstration should be required. A maintenance training syllabus should also be included as part of the deliverable end product.

Maintainability of the candidate equipment will be analyzed during Task 4 to determine adherence to MIL-STD-470 and -471. In addition, the user agencies require a maximum time of 30 minutes for maintenance or replacement of all downrange equipment. Level of skill required to maintain, "trouble shoot," and replace damaged or defective subsystems is limited to standards of field organizational maintenance personnel. Major repairs or maintenance will be accomplished at a general or depot maintenance facility.

6. SCORING SYSTEM "TRADE-OFF" OF REQUIREMENTS

Figure 12 describes the system functions in order of importance, Level 1 being the most important. The most important functions are to sense hits, score hits versus rounds expended, provide an aiming point, and to display these data at the range central control station and in the aircraft for the benefit of the instructor pilot.

The next most important function is to provide miss distance information by r and θ zones.

Data transform, transmission methods, and recording for post-operative review are considered as lower level since these parameters, although important, do not constitute the fundamental function of range scoring.

FIGURE 12
Scoring System Functions
Hierarchy of Importance

Level 1	Sensing hits	Scoring • Hits versus rounds fired • Aiming point	Displaying
Level 2	Miss distance r/θ by zone		
Level 3	Data transformation • Sorting of ordnance • Sorting of firing A/C	Data transmission • Rate • Method • Format	Data recording • Information storage and retrieval

APPENDIX I

APPENDIX I

PROBLEM STATEMENT

In general, if $f(X, Y)$ represents the probability density for random ground impacts for a given weapon type, and if $f(X, Y)$ can be transformed into the probability density $h(r, \phi)$, in polar coordinates, then the probability of an impact occurring in a circle of radius r_o, is given by the expression

$$P(r_o) = \int_0^{2\pi} \int_0^{r_o} g(r, \phi)\, dr\, d\phi\ . \tag{1}$$

In a true exterior ballistics problem, the weapon rarely impacts with the ground at a 90° angle. Therefore, it seems reasonable to assume that the distribution about the expected trajectory may be elliptical normal, where the probability density is given by

$$f(X, Y) = \frac{1}{2\pi\sigma_x\sigma_y} e^{-\left\{\frac{X^2}{2\sigma_x^2} + \frac{Y^2}{2\sigma_y^2}\right\}}\ . \tag{2}$$

Here, X is measured in the range direction, Y in the deflection direction; and $\mu_x = \mu_y = 0$. The angle of impact, θ, is now defined by the tangent to the trajectory at the point of impact. Furthermore, σ_x and σ_y should be dependent in some sense upon the trajectory length, but independent of each other.

The problem then becomes one of mapping the probability density f(X, Y) onto the ground plane, transforming the new function to polar coordinates, and then integrating over circles of various radii.

PROBLEM SOLUTION

The ground impact probability density is obtained by letting

$$X = u \sin \theta \quad \text{and} \quad Y = v \; . \tag{3}$$

The probability density for u and v then becomes

$$g(u, v) = \frac{\sin \theta}{2\pi\sigma_x \sigma_y} \, e^{-\left\{\frac{u^2 \sin^2 \theta}{2\sigma_x^2} + \frac{v^2}{2\sigma_y^2}\right\}} \; . \tag{4}$$

it is seen that $g(u, v)$ is also an elliptical normal distribution in u and v with

$$\text{and} \quad \begin{aligned} \sigma_u^2 &= (\sigma_x / \sin \theta)^2 \\ \sigma_v^2 &= \sigma_y^2 \ . \end{aligned} \tag{5}$$

The usual transformation to polar coordinates,

$$\text{and} \quad \begin{aligned} r \sin\phi &= v/\sigma_v \ , \\ r \cos\phi &= u/\sigma_u \ , \end{aligned} \tag{6}$$

yields the resulting probability distribution of impacts on the ground as

$$h(r, \phi) = \frac{r}{2\pi} e^{-r^2/2} \ . \tag{7}$$

It is desired to integrate the function $h(r, \phi)$ over circles of various radii and for selected values of $k = \sigma_y / \sigma_x$. The detailed numerical integration procedures appear in another paper. Reference BAARINC "Hit Probabilities in the Elliptical Normal Case Considering Angle of Impact, Part II: Theoretical Considerations," report to U. S. Naval Weapons Laboratory, Dahlgren, Virginia, June 1963.

APPENDIX II

APPENDIX II

1. REDUCED SCORING RATE

Maximum scoring rate may be limited to the human factor reaction time of the gunner. A gunner under the most favorable environment with fast reflexes cannot be expected to react (fire the weapon in the shortest burst possible) faster than approximately 1/4 second. Therefore; for rapid fire weapons (greater than 500 rpm) single projectile scoring may not be required. (Example: 6000 rpm, 1/4 second burst = $\frac{6000 \times .25}{60}$ or 25 shells fired; [240 rpm].)

Statistically, the probability of hit (S/N) for 95 percent confidence level is 44%. If four gunners are firing at a single target during unit training, each at an individual rate of 240 rounds/minute (rpm), then:

$$4 \times 240 \times .44 = 522.4 \text{ hits/minute} .$$

Scoring count accuracy = 95% ± 5%.

$\frac{522.4}{.90}$ = 574 rpm maximum rate. (100% ± 10% or $\frac{1}{.90}$ = 110% for worst case.)

2. CONCLUSION

An arbitrary maximum scoring rate per target of 600 per minute with a count accuracy of 95% ± 5% may suffice, provided an individual round history is not required at the display site.

APPENDIX III

1. DISCUSSION OF DESTRUCTIVE FIRE IN A TARGET AREA

Using a hypothetical model for purposes establishing downrange equipment (targets and sensors etc.), maximum destructive fire over a 120-hour range operating time at eight hrs/day is as follows:

(1) Stated survivability = 120 hours unattended performance.

(2) Predicted target hits are based on the performance envelope of the Advanced Aerial Fire Support System (AAFSS).

(3) Other considerations:

(a) Four (4) aircraft firing in racetrack pattern

(b) Two flights each per day for five days

(c) Duration of each flight - airborne for three hours

(d) Firing run time - 1-1/2 hours per flight

(e) Time per lap - 10 minutes

(f) Six (6) targets per range (two point plus four area).

(4) AAFSS armament total maximum rounds per flight and two flights per day in two different configurations (same aircraft).

Morning Flight Inventory (assumed)

Weapon Type	Armament	Rounds Total
Area	7.62 mm	11,570
Area	30 mm	2,010

Afternoon Flight Inventory (assumed)

Weapon Type	Armament	Rounds Total
Area	30 mm	2,010
Area	40 mm	780
Area	2.75	152
Point	Tow and SS11	2

Total Rounds Carried - Five (5) Days of Flight

Weapon Type

Area

11,570
2,010
2,010
780
152
16,522 x 5 = 82,760 total rounds fired per week per aircraft

Point

2 x 5 = 10 total rounds fired per week per aircraft

Range Operating Time

$$\frac{120 \text{ hours total}}{8 \text{ hrs/day} \times 5 \text{ days/week}} = 3 \text{ weeks}$$

Total Rounds/Number of Targets

Weapon Type

Area $$\frac{82,760 \times 4 \times 3 \times 0.5^{*}}{4} = 124,140 \text{ hits (120 hrs)}$$

Point $$\frac{10 \times 4 \times 3 \times 0.7^{**}}{2} = 42 \text{ hits (120 hrs)}$$

By providing separate targets for point and area weapons, it should be possible to enhance target survivability.

Following this argument to its logical conclusion suggests that some measure of ordnance sorting is automatic since one type target is used for "point" weapons, the projectiles all being supersonic; and, another type target is used for "area" weapons consisting of both supersonic and subsonic projectiles.

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* For purposes of estimating, a 50 percent hit probability for all area weapons rounds fired is assumed. Actual experience suggests a hit probability of less than 10 percent; however, this can be expected to improve through the use of machine-scoring systems in gunnery training. A 70 percent hit probability is assumed for point weapons.

** Assumes uniform density over the entire target area.

APPENDIX IV

APPENDIX IV

DISCUSSION OF VERTICAL AND HORIZONTAL TARGET ZONE DIMENSIONS

1. POINT WEAPONS ZONE DIMENSIONS

The solution of vertical target zone size is relatively simple. A circular target area comprising the cone of fire circular normal dispersion is usually considered a target "hit" zone. All rounds passing within an impact area have to be sensed and scored.

Rounds which pass the target at any greater radial distance are classified as misses. Since target criteria for direction of miss is limited to "over" "under," "left" or "right," it is only necessary to provide instrumentation that will sense the miss in quadrants. The target zone may be arbitrarily reduced in size and shaped to conform to a realistic silhouette for some phases of training.

Probably the best solution for Individual Training would be to restrict the radial distance (starting at target center) to some arbitrary value which approximately duplicates a realistic target size.

For Unit Training on "point" weapons, the most desirable solution would be to construct the "hit zone" in the same configuration as real targets (tanks, vehicles, etc.). Any departure will result in establishing an unrealistic target; i. e., either rounds that would normally be hits would be classified as misses, or rounds that are actually misses would be counted as hits. The degree of discrepancy depends on the relationship of real target geometrical boundaries deviation from a circle.

2. AREA WEAPONS ZONE DIMENSIONS

The horizontal target zone for area weapons is a difficult problem since the shape is elliptical due to the plane change from circular cone of fire to horizontal impact zone. The width and length of the elliptical "beaten zone" are both variables, depending principally on gun-to-target range, attack angle, and stability of the firing platform.

Three solutions are possible:

(1) Construct an elliptical target at ground level to sense and count impacts within the target geometry; or

(2) Use an offset vertical circular sensing zone system and count the rounds passing through this zone area; or

(3) Chose an arbitrary shape similar to the unit training realistic targets, modified for ease of installation, replacement, etc.

The problem of providing a continuously changing target beaten zone is very complex, requiring equipment sophistication well beyond that needed for gunnery training.(1)

Use of the offset vertical sensing zone requires a continuously changing dimension of sensor-to-aiming point and a coupled plane change from near-vertical to near-horizontal orientation. (2)

Since proficiency rating is a hit percentile against the norm for classes of students, it is not necessary to score every round that would impact in the beaten zone for given angles of attack and range. It is only necessary to score on the percentage of hits to rounds expended, student versus student; therefore, the size and shape of scoring area become arbitrary. The target shape in the horizontal plane should be similar to that encountered in unit training, modified in dimension to conform to an easily handled size. (3)

A circular target will generally meet these requirements with the added advantage of closely relating to explosive warhead effective burst radii (circular).

Once a target shape and dimension is chosen it should not be altered; otherwise the proficiency rating standards will become obsolete and invalid. It is necessary to count all rounds that hit within this area. It is not essential to locate a mean point of impact within the "hit" area. Conversely, it is essential to locate the mean point of impact outside this envelope. (It has been stated that mean point of impact by clock position and zone is required for misses.) If two zone depths are to be used, each should be one-half the maximum radial miss distance equipment sensitivity limits minus the "hit" zone radius from target center; however, analysis of the purpose and use of the information derived on "misses" suggests that "miss" sensing by quadrant instead of clock position will suffice.

The miss zone sector becomes four pie-shaped wedges 45 degrees wide, starting at the exterior limits of the hit zone.

3. CONCLUSION

For individual training, separation of point and area weapons targets into two separate targets would be the simplest solution; all other considerations being equal.

For unit training, a natural separation does occur, because ordnance is selected for target type. (Example: Vehicles→point weapons and personnel→area weapons.)

Point Weapon Target Geometry - Individual Training

Hit zone - circular arbitrary size approximates "real" target size; plus miss sensing in four quadrants.

Area Weapon Target Dimensions - Individual Training

Hit zone - circular or some other arbitrary shape. Dimension chosen on the basis of convenience of target erection, etc.

Miss zone - sectored: Four quadrants ("over, short, left, or right").

Horizontal Target Dimensions - Unit Training

Same as Individual Training.

TECHNICAL DATA

BA-1	MIL-T-0023991C Contract N61339-69-C-0178
BA-2	MANUAL 4120.3-M Standardization Policies, Procedures & Instructions
BA-3	NAFI TR-578 Cooperative Doppler Scoring System Study
BA-4	NAVWEPS RPT 8674 Design for a Laser Rangefinder
BA-5	BRL NOTE NO. 1409 A Microwave Modulation Telemetering
BA-6	AF MANUAL 50-18 Weapons Ranges
BA-7	TECH. MEMO 11-65 Transducer Techniques for Measuring the Effect of Small-Arms Noise on Hearing
BA-8	TC 1-22 Rotary Wing A/C Gunnery Armament Sub-System, Helicopter, 7.62mm Machinegun (XM-6 Series) Quad Gun
BA-9	NAVTRADEVCEN STD 115 Environmental Testing of Training Devices Designed for Use in Field Exercises & Installation on Military Vehicles
BA-10	AMC REGULATION NO. 70-30 Research & Development-Concept Formulation--Prerequisites to Initiating Engineering or Operational Systems Development Effort
BA-11	AD NO. ____ 465235 Acoustic Amplification in III-V Compounds (Second Interim Report)
BA-12	AD NO. ____ 465234 Acoustic Amplification in III-V Compounds (First Interim Report)
BA-13	AD-245-655 Electronic Control & Guidance Division Report on Experimental Investigation of a Miss-Distance Indicator Using Radioactive Techniques
BA-14	AD-418-204 Instrument Operations on Test Department Ranges

BA-15 Feasibility Study of Stabilizing the Line of Sight of an Automatic Miss Distance Indicator for Tanks

BA-16 ST 1-100-1
Reference Data for Army Aviation in the Field Army

BA-17 FM 17-36
Divisional Armored and Air Cavalry Units

BA-18 TM9-6920-210-14
Targets, Target Material, and Training Course Layouts

BA-19 TOE 1-111T (Test)
Special Army Training Test 1-111 (TOE 1-111T)

BA-20 TOE 1-111T (Program)
Special Army Training Program 1-111 (TOE 1-111T)

BA-21 FM 1-40
Attack Helicopter Gunnery (Illustrations)

BA-22 FM 1-40
Attack Helicopter Gunnery (Text) Volume 1 of 2

BA-23 FM 1-40
Attack Helicopter Gunnery (Text) Volume 2 of 2

BA-24 AD 465 673
Propagation of Sound in Air-A Bibliography with Abstracts

BA-25
Gunnery Instructor Pilot Handbook

BA-26 67-289-40
UH-1 IP Gunnery Qualification Course

BA-27 9-68
Program of Instruction for OH-58 Transition/Gunnery IP Qualification Course

BA-28 4-68 2C-F15
Program of Instruction for AH-1G (Huey Cobra) Pilot Transition/Gunnery Course

BA-29 5-68 2C-F14
Program of Instruction for AH-1G (Huey Cobra) Instructor Pilot (Transition/Gunnery) Qualification Course

BA-30 J-69 2C-F19
Program of Instruction for UH-1 Pilot Transition Course (Navy)

BA-31 7-68 600-67N20
Program of Instruction for UH-1 Repair Course

BA-32 2-69 2C-F9
Program of Instruction for (Wire Guided Missile) M22 Gunnery Qualification Course

BA-33 1-69 2C-1981-B/2C-C62B-B
Program of Instruction for Officer/Warrant Officer Rotary Wing Aviator Course

BA-34 2-69 2C-1981-D/2C-C62B-D
Program of Instruction for Officer/Warrant Officer Rotary Wing Qualification Course (Active Army)

BA-35 3-69 2C-1981-A/2C-C62B-A
Program of Instruction for Officer/Warrant Officer Rotary Wing Qualification Course (Reserve Component/Allied)

BA-36 2-69 2C-F3
Program of Instruction for UH-1 (Iroquois) Instructor Pilot (Transition/Gunnery) Qualification Course

BA-37 12-68 2C-F13
OH-6 Transition/Gunnery IP Qualification Course

BA-38 LOH-IP
Gunnery Qualification Course
Flight Syllabus & Standardization Guide

BA-39 3,160,415
Strafing Target Using Schlieren Effect

BA-40 3,147,333
Optical Miss-Distance Indicator

BA-41 3,201,791
Near Miss-Distance Scoring System Using Doppler Effect

APPENDIX D

TECHNICAL ANALYSIS

OF

ELECTRONIC SCORING SYSTEM, MODEL 800B

BABCOCK ELECTRONICS CORPORATION

This Electromagnetic Pulse-Doppler Scoring System was designed primarily for use with airborne targets and has been produced for the U.S. Army and Air Force. Although the scoring principles used in this system could satisfy a number of the functional requirements of the Armed Aircraft Qualification Range Scoring system, limitations in the following areas have been defined:

Scoring Radius: Limited to 50 feet

Accuracy: Adequate only with large caliber weapons
Two square feet radar cross section or more

Caliber/Type Weapon: No capability with 5.56 or 7.62mm

Vector: No vector information provided

Data Display: No real-time hit, miss and vector data displayed

Malfunction/Damage Alarm: None

See Worksheet "A"

TECHNICAL ANALYSIS

OF

PERSONNEL TARGET SCORING SYSTEM

BABCOCK ELECTRONICS CORPORATION

This system which is under development for the U.S. Army is designed to sense misses of projectiles from flechette to 40mm in size and the point-of-impact for 40mm grendades surrounding a personnel type target. Application of this system to the functional requirements of the Armed Aircraft Qualification Range Scoring System leaves deficiencies in the following general areas:

Scoring Radius: Limited to 20 meters

Accuracy: Unstated (developmental system)

Caliber/Type Weapons: Limited to projectiles 5.56 to 40mm

Data Display: No real time display of hit-miss or vector data

Vector: No vector data provided

Malfunction/Damage Alarm: None

See Worksheet "A"

TECHNICAL SUMMARY
"OFF-THE-SHELF" SCORING
ARMED AIRCRAFT QUALIFICATION RAN
(WORK SHEET)

FUNCTIONAL REQUIREMENT	→	→	"Off-the-Shelf"	24,000 RPM	0 -54 M	95 ± 5%	
SYSTEM MANUFACTURER	TYPE	MODEL	STATUS	RATE	RADIUS	ACCURACY	CA
Babcock Electronics (USA)	Electromagnetic Pulse-Doppler	800B **	Production	Variable depending on projectile velocity & scoring radius	5-50 Ft.	± 1 Ft. Radar Cross Section 1 sq.ft. to 70 sq. ft.	
	Electromagnetic (near miss) Infra-Red-Acoustic (HE) (PO1)	PTSS	Development	Variable depending on projectile velocity & scoring radius	1 & 3 meters MDI 4 - 20 meters HE	± 25 cm	

** Primarily Air-to-Air and/or Ground-to-Air.

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...CHNICAL SUMMARY
..."-SHELF" SCORING SYSTEMS
...UALIFICATION RANGE SCORING SYSTEMS
(WORK SHEET)

NAVTRADEVCEN 69-C-0178-1

	95 ± 5%	5.56mm 7.62mm 40mm 50 cal 2.75" 20mm tow 30mm	Zone & Vector	Vertical & Horizontal Plane	HE - Inert Sub-sonic Super-sonic	Up to 2	Yes	Radio - UT Radio or Wire - IT
		SCORING		Scoring Plane	Ammo Type			
	ACCURACY	CALIBER/TYPE	ZONE/VECTOR	SENSITIVE AREA	CHARACTER-ISTICS	SIMULTANEOUS NUMBER OF TARGETS PER SYSTEM	SIMULTANEOUS MULTIPLE-TYPE WEAPONS	DATA TRANSMISSION MEANS
t.	± 1 Ft.	50 cal & up	1 zone	Sphere	Super & Subsonic	1 ea	Yes	TM/FM
	Radar Cross Section				No HE			
	1 sq.ft. to 70 sq. ft.							
	± 25 cm				HE	1 ea		
					Point of Impact			
		5.56mm to 40mm grenade	Yes	Not stated	Sub & Super-sonic		Yes	TM

Worksheet "A"

TECHNICAL SUMMARY
"OFF-THE-SHELF" SCORING
ARMED AIRCRAFT QUALIFICATION RAN
(WORK SHEET)

FUNCTIONAL REQUIREMENT	1710-1850 MHz	30,000 RPM	Hit, Miss & Vector	Yes	Intermediate Climatic Zone	ARMY A/C 3/4 T Truck 1/4 T Truck	
SYSTEM MANUFACTURER	FREQUENCY BAND	DATA TRANSMISSION RANGE	DATA DISPLAY	DATA RECORDING CAPABILITY	ENVIRONMENTAL CHARACTERISTICS	PORTABILITY	
Babcock Electronics	216-240 MC	Not stated	TM/Revr	Ampex 600	All	Transportable	
(USA)	.5W	15 + miles		mag tape Oscillograph	-54 to +71°C		
	Not stated	Not stated	Computer	Mag tape	No limitations	Transport-	N
	TM "S" band	15 + miles	inputs	TTY		able	

TECHNICAL SUMMARY
B-SHELF" SCORING SYSTEMS
QUALIFICATION RANGE SCORING SYSTEMS
(WORK SHEET)

NAVTRADEVCEN 69-C-0178-1

ate .c	ARMY A/C 3/4 T Truck 1/4 T Truck	1200 Hrs.	Aiming Pt and 3-D Tactical	0° to 80°	360° Unit 45° Individ	Minimum	Minimum	Minimum
- R-	PORTABILITY	MTBF	TARGET TYPE	DIVE ANGLE	APPROACH AZIMUTH	VULNER-BILITY	TARGET SITE EQUIP. WT.	DISPLAY SITE EQUIP. WT.
	Transport-able	Not stated	Aerial	Omni-directional	Omni-directional	Antennas TM must be	6#	Not stated
71°c		1200	tow target			bunkered		
.ta-	Transport-	Not stated	Personnel	Omni-	Omni-	Sensors & Antennas	Not stated	N/A
r-	able	1200+	type	directional	directional	Remaining target site equipment protected	10#	

Worksheet "A"
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ARMED AIRCRAFT QUALIFICATIO
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FUNCTIONAL REQUIREMENT	24 Hrs. of Operation	110VAC Comm'l or Generator	Minimum	Sub-sonic Super-sonic	N/A	REQUIRED
SYSTEM MANUFACTURER	POWER TARGET SITE	POWER DISPLAY SITE	SYSTEM SUPPORT EQUIPMENT	PROJECTILE VELOCITY	COST	MALFUNCTION OR DAMAGE ALARM
Babcock Electronics (USA)	24-32VDC	110VAC 60Hz	Not stated Doppler Simulator	500/5000 ft/sec	Not stated Lots of 20 $4,000	
	Not stated	110VAC	Not stated Doppler Simulator	Not stated	Not stated	

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	REQUIRED							
	MALFUNCTION OR DAMAGE ALARM							
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Worksheet "A"
(Cont'd)

TECHNICAL ANALYSIS

OF

MISS DISTANCE ACOUSTIC DETECTOR

SFENA MODEL MAE 12B

This acoustic (amplitude) system was designed primarily for use with aerial targets and has been in use by the French Air Force and Army for several years. The principles of operation and scoring methods used are adaptable to the Armed Aircraft Qualification Range Scoring System but in many regards are not compatible with its functional requirements. The major diversions are as follows:

Scoring Rate: Not stated

Scoring Radius: Limited to 4.5 meters

Accuracy: Not stated

Caliber/Type Weapon: Used with 50 caliber and 30mm only (super-sonic)

Vector: No vector information provided

Number of Targets per System: Limited to 1 target per system

Simultaneous Multiple Type Weapons: Limited to 1 type of weapon

See Worksheet "B"

TECHNICAL ANALYSIS

OF

RADAR SCORING SYSTEM, MODEL RASCORE AP

SANDERS ASSOCIATES, INC.

This electromagnetic scoring system was designed for use with a single personnel type target. It is based on the pulsed doppler radar principle, amplitude intensity. This system's characteristics, when applied to the functional requirements of the Armed Aircraft Qualification Range Scoring System are inconsistent in many respects. Major inconsistencies are as follows:

Scoring Radius: Limited to 4 meters

Caliber/Type Weapons: Limited to 5.56mm to 50 caliber

Zone/Vector: No vector data provided

Horizontal/Vertical Plane: Half hemisphere only each plane

Data Display: No special display for real time readout

Approach Azimuth: 0 - 180°

Malfunction/Damage Alarm: None

MTBF: 100 hours

See Worksheet "B"

TECHNICAL ANALYSIS

OF

RADAR SCORING SYSTEM MODEL RASCORE-S

SANDERS ASSOCIATES, INC.

This electromagnetic scoring system is designed for air-to-ground strafing use. It is basedon the pulsed doppler radar principle, amplitude intensity. When applied to the functional requirements of the Armed Aircraft Qualification Range Scoring System, some significant diversions are observed and follow:

Scoring Radius: Limited to 20 feet

Caliber/Type Weapons: 7.62mm to 40mm only

Zone/Vector: Single Zone/no vector

Vertical/Horizontal Plane: Vertical only (point weapons)

Ammo Characteristics: Inert only

Data Trans Range: 1 mile

Dive Angle: Limited to between 5° and 15°

Approach Azimuth: 15° - 0° - 15°

Vulnerability: Due to bulk of sensing hardware, down range equipment must be protected.

Malfunction/Damage Alarm: None

See Worksheet "B"

TECHNICAL ANALYSIS

OF

RADAR SCORING SYSTEM, MODEL [illegible]SCORE-M

SANDERS ASSOCIATES, INC.

This electromagnetic scoring system was designed for use in either an air-to-air or a ground-to-air application. It gives continuous miss distance scale data and is based on the pulsed doppler correlation radar principle using pseudo-random coded phase reversal modulation techniques. Primary intended use is with missiles having a reasonably large radar cross section. The characteristics of this system when correlated with the functional requirements of the Armed Aircraft Qualification Range Scoring System reveals that some essential qualities are lacking, namely:

Scoring Rate: Approximately 860 RPM

Caliber/Type Weapon: Only missiles with 2 square feet radar reflectivity

Zone/Vector: No zone, no vector data

Malfunction/Damage Alarm: None

MTBF: 100 hours

See Worksheet "B"

FUNCTIONAL REQUIREMENT	→	→	"Off-the-Shelf"	24,000 RPM	0-5M	95 ± 5%
SYSTEM MANUFACTURER	TYPE	MODEL	STATUS	RATE	RADIUS	ACCURACY
SFENA (France)	Acoustic (Amplitude)	SFENA MAE 12B **	Production	Not stated	2.8-4.5M	Not stated
Sanders (USA)	Electromagnetic (Amplitude Intensity) Pulsed Doppler PW 10ns X-Band	Rascore S	Production	20,000 RPM	20 Ft.	± 12"
	Electromagnetic (Amplitude intensity) Pulsed Doppler 8 ns L-Band	Rascore-AP ***	Production	20,000 RPM	2 & 4M	±.2M
	Electromagnetic Pulsed Doppler 10ns L-Band Amplitude Intensity	Rascore-M **	Production	Continuous Miss Distance Scaler	0-275 Ft	±2.5'@115' ±5' @115-275'

** Primarily Air-to-Air and/or Ground-to-Air.

*** Used primarily w/personnel type target.

HNICAL SUMMARY
HELF" SCORING SYSTEMS
IFICATION RANGE SCORING SYSTEM

NAVTRADEVCEN 69-C-0178-1

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95 + 5%	5.56mm 7.62mm 40mm 50cal 2.75" 20mm tow 30mm	Zone & Vector	Vertical & Horizontal Plane	HE-Inert Sub-sonic Super-sonic	Up to 2	Yes	Radio - UT Radio or Wire - IT
SCORING					NUMBER OF TARGETS PER SYSTEM SIMULTANEOUS	SIMULTANEOUS MULTIPLE-TYPE WEAPONS	DATA TRANSMISSION MEANS
ACCURACY	CALIBER/TYPE	ZONE/VECTOR	SENSITIVE AREA	CHARACTER-ISTICS			
Not stated	50 cal 30 mm	2' Zone	Sphere	Super-sonic	1	No	TM
± 12"	7.62 to 40 mm (inert)	1 Zone	Vertical (Plane)	Super & Sub-sonic + HE	1	Yes	Coax Cable or FM/FM TM
±.2M	5.56mm to 50 cal	2 & 4M Zones	Half Hemisphere	Both Sub & Super-sonic rounds	1	Yes	Not stated
t ±2.5'@115' ±5' @115-275'	Missiles w/2 sq.ft. Radar Re-flect at 275'	No			1	N/A	FM/FM PCM

Worksheet "B"

TECHNICAL SUMMA
"OFF-THE-SHELF" SCORIN
ARMED AIRCRAFT QUALIFICATION RA
(WORK SHEET)

FUNCTIONAL REQUIREMENT	1710-1850 MHz	30,000M	Hit, Miss & Vector	Yes	Intermediate Climatic Zone	ARMY A/C 3/4 T Truc 1/4 T Truc
SYSTEM MANUFACTURER	FREQUENCY BAND	DATA TRANSMISSION RANGE	DATA DISPLAY	DATA RECORDING CAPABILITY	ENVIRONMENTAL CHARACTERISTICS	PORTABILITY
SFENA (France)	150-165MHz	65 miles	2 Decade Counter	No	Not stated	Transportable
Sanders (USA)	Not stated IRIG	1 mile	4 digit counter	Yes paper tape	Not stated Army Ground System Specification	Fixed
	Not stated ***		Mag tape E'ec counter TM link	Yes	Notstated Army Ground System Specification	Fixed
	Not stated	Not stated	Mag tape or FM/FM/PCM 43 Indicator lights	Yes Serial Parallel analog	Not stated MIL-E-5400	Transportable

*** Used primarily w/personnel type target.

iate ic	ARMY A/C 3/4 T Truck 1/4 T Truck	1200 Hrs.	Aiming Pt & 3-D Tactical	0° to 80°	360° Unit 45° Individ	Minimum	Minimum	Minimum
N- L ER- S	PORTABILITY	MTBF	TARGET TYPE	DIVE ANGLE	APPROACH AZIMUTH	VULNER-BILITY	TARGET SITE EQUIP. WT.	DISPLAY SITE EQUIP. WT.
ted	Transport-able	Not stated	Airborne Target	Airborne	Airborne	Airborne TM/Trans-mitter & Antenna must be protected	Approx. 10#	Not stated
ed	Fixed	1300	Panel (Bulls Eye)	5 to 15°	15°-0°-15°	Must be bunkered	33#	Not stated
ation								
d	Fixed	100	Personnel	0 - 90°	0 - 180°	Must be protected	15#	Not stated
tion								
ed 00	Transport-able	100	Drone aerial targets	All	0 - 360°	TM & Antennas	27.5#	Not stated

Worksheet "B"
(Cont'd)

TECHNICAL SUM
"OFF-TH"-SHELF" SCOR
ARMED AIRCRAFT QUALIFICATION
WORK SHEET

FUNCTIONAL REQUIREMENT	24 Hrs.of Operation	110VAC Comm'l. or Generator	Minimum	Sub-sonic Super-sonic	N/A	REQUIRED
SYSTEM MANUFACTURER	POWER TARGET SITE	POWER DISPLAY SITE	SYSTEM SUPPORT EQUIPMENT	PROJECTILE VELOCITY	COST	MALFUNCTI OR DAMAGE ALARM
SFENA (France)	Battery	220VAC 50 Hz	Noise Generator			
Sanders (USA)	+28VDC or 110VAC 60Hz 50W	115VAC 100W	GunScope		Not stated 15 - 17 K	
	28VDC 1A	Not stated			Not stated Lots of 50 $1,500	
	28VDC 2.5A	115VAC			Not Stated $3,500 - 4,000	

REQUIRED							
MALFUNCTION OR DAMAGE ALARM							

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Worksheet "B"
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NAVTRADEVCEN 69-C-0178-1

TECHNICAL ANALYSIS

OF

ACCUSTIC & VIBRATION SCORING SYSTEM DA-2

DEL MAR ENGINEERING LABORATORIES

This scoring system was designed to collect both hit and miss distance data from personnel type targets when fired on with small arms (5.56mm, 7.62mm and flechette) and to collect zones miss data when fired on by 40mm grenades.

Scoring Rate: 12,000 RPM-Hit, 6000 RPM-Miss, 500 RPM-Grenade

Scoring Radius: 0 - 2 meters

Caliber/Type Weapon: Small arms & 40mm Grenade

Transmission Range: 10,000 feet

Data Display: Computer inputs

MTBF: 500 hours

Attack Azimuth: Hit count panel: 0° - 60°

All others: 360°

Malfunction/Damage Alarm: None

See Worksheet "C"

NAVTRADEVCEN 69-C-0178-1

TECHNICAL ANALYSIS

OF

ACOUSTIC SCORING SYSTEM, MODEL DA-3/F

DEL MAR ENGINEERING LABORATORIES

This acoustic (amplitude) scoring system is in wide use by U.S. Navy and Air Force as an air-to-ground strafing/gunnery trainer. When comparing the operational characteristics of this system to the functional requirements of the Armed Aircraft Qualification Range Scoring System, the following inadequacies have been noted:

Scoring Rate: Presently limited to 10,000 RPM

Scoring Radius: Presently limited to 15 meters

Zone/Vector: No multiple zone - no vector data

No. of Targets per System: Limited to 1 f/simultaneous scoring

Simultaneous Multiple Type Weapons: One caliber/type at a time

MTBF: 700 hours

Data Recording: No provisions for

See Worksheet "C"

TECHNICAL ANALYSIS

OF

ACOUSTIC SCORING SYSTEM, MODEL DA-3/E

DEL MAR ENGINEERING LABORATORIES

This fixed acoustic (amplitude) scoring system is in use at helicopter gunnery training schools of the U.S. Army. A comparison of the operational characteristics of this system with the functional requirements of the Armed Aircraft Qualification Range Scoring System reveals that it meets all requirements except the following:

Scoring Rate: Up to 6,000 RPM

Transmission Range: Up to 10,000M (Wire)

Data Display: No vector

MTBF: 700 hours

Zone/Vector: Partial vector (Combination of 2 or more sensors)

See Worksheet "C"

TECHNICAL ANALYSIS

OF

ACOUSTIC SCORING SYSTEM, MODEL DA-3/A

DEL MAR ENGINEERING LABORATORIES

This acoustic (amplitude) scoring system used by the U.S. Army for weapons system evaluation and possible training mission application. It was designed primarily for air-to-ground (helicopter) gunnery scorings. When comparing the operating characteristics of this system with the functional requirements of the Armed Aircraft Qualification Range Scoring System, limitations have been defined in the following areas:

Scoring Rate: 6,000 RPM

Zone & Vector: No vector, information data

Simultaneous Multi-Weapon: One type ammo at a time

MTBF: 700 hours

Malfunction/Damage Alarm: None

See Worksheet "C"

TECHNICAL SUMMA
"OFF-THE-SHELF" SCORIN
ARMED AIRCRAFT QUALIFICATION RA
(WORK SHEET)

FUNCTIONAL REQUIREMENT	→	→	"Off-the-Shelf"	24,000 RPM	0-54M	95 ± 5 %
SYSTEM MANUFACTURER	TYPE	MODEL	STATUS	RATE	RADIUS	ACCURACY
Del Mar Engineering Laboratories (USA)	Acoustic (Amplitude)	DA-3F* (3H18C)	Production	10,000 RPM	Adjustable 1.5 to 15m Increments of 5 ft.	> 95%
	Acoustic (Amplitude & Hit Panel)	DA-3E* (3H18B)	Production	6,000 RPM	5.56 - 20mm: 1-50 meters; 40mmHegren: 1-30 meters; 2.75m FFAR 1-54 meters	> 95% Acoustic; > 98% Hit Panel
	Acoustic (Amplitude)	DA-3A	Pre-production	6,000 RPM	3-250 Ft. (5-zone)	> 95%
	Piezo-elect Sensor & Acoustic Amp	DA-2	Production	12,000 RPM Hit; 6,000 RPM Miss	Personnel Panel; 4 Zones of Miss 0-2 Meters	> 98%; > 95%
	1 Zone Acoustic Grenades			300 RPM	1 Zone 5 Meters	> 90%

* Has cable and/or sensor fault detection.

ICAL SUMMARY
LF" SCORING SYSTEMS
ICATION RANGE SCORING SYSTEMS
RK SHEET)

95 ± 5 %	5.56mm 7.62mm 40mm 50 cal 2.75 20mm tow 30mm	Zone & Vector	Vertical & Horizontal Plane	HE-Inert Sub-sonic Super-sonic	Up to 2	Yes	Radio-UT Radio or Wire - IT
	SCORING						
ACCURACY	CALIBER/TYPE	ZONE/VECTOR	SENSITIVE AREA	CHARACTER-ISTICS	SIMULTANEOUS NUMBER OF TARGETS PER SYSTEM	SIMULTANEOUS MULTIPLE-TYPE WEAPONS	DATA TRANSMISSION MEANS
> 95%	5.56 to 155mm inert -Supersonic HE Subsonic	1-Zone	Radial Plane	90° Horiz Vertical to Supersonic Projectile Flight Path Horiz at Ground for HE Scoring	8	No	TM(FM Burst) (Up to 8 Active Targets on a Single RF Channel in a Sequential Firing Mode)
> 95% Acoustic > 98% Hit Panel	5.56 to 70mm Inert - HE	3 Zone on HE R/L Vector (Multiple Sensor) 1 Zone on Hit or S.A.	Radial Plane	Same as above Except 3 Zone HE Scoring	3	No	Wire (Coax)
> 95%	5.56 to 155mm Inert-Supersonic	5-Zone & Scalar distance in feet	Radial Plane	90° Horz & Vert to supersonic flight path	8	No	Same as DA-3F above
> 98% > 95%	All Small Arms	Both	Panel Area & Radial Plane	Hit Panel in 1/2 meter increments 0 - 2 meters radial 0 - 5 meters horizontal for grenades	Limited by Computer Input Typical 180	Yes No	Wire
> 90%	40mm HE Grenades	1 Zone				No	

Worksheet C

2

TECHNICAL SUMM
"OFF-THE-SHELF" SCORI
ARMED AIRCRAFT QUALIFICATION R
(WORK SHEET)

FUNCTIONAL REQUIREMENT	1710 - 1850 MHz	30,000M	Hit, Miss & Vector	Yes	Intermediate Climatic Zone	ARMY A/C 3/4 T Truck 1/4 T Truck
SYSTEM MANUFACTURER	FREQUENCY BAND	DATA TRANSMISSION RANGE	DATA DISPLAY	DATA RECORDING CAPABILITY	ENVIRONMENTAL CHARACTERISTICS	PORTABILITY
Del Mar Engineering Laboratories (USA)	1710 - 1850 MHz (Furnished w/4 selectable frequencies)	(2 watts) 5 miles	3 digit NIXI	No	Full MIL	Transportab
	N/A	>10,000ft.	3-3 digit IHS Mechan Counters	No	MIL	Fixed
	220-240MHz	(2 watts) 5 miles	5-3 digit NIXI (Miss distance to tenths of ft. available	Provisions		Transportab
		10,000 ft. wire	Computer	Yes		Fixed

ARMY A/C 3/4 T Truck 1/4 T Truck	1200 Hrs.	Aiming Pt and 3-D Tactical	0° to 80°	360° Unit 45° Individ	Minimum	Minimum	Minimum
PORTABILITY	MTBF	TARGET TYPE	DIVE ANGLE	APPROACH AZIMUTH	VULNER-BILITY	TARGET SITE EQUIP. WT.	DISPLAY SITE EQUIP. WT.
Transportable	700 hrs.	All	0-90°	360°	Sensor only	30#	45#
Fixed	700 hrs.	All	0-90°	360°	Sensor only	1#	45#
Transportable	(Approx) 700 hrs.	All	0-90°	360°	Sensor only	30#	50#
Fixed	500 hrs. (Approx)	Personnel & Panel Type	0-60° 0-90°	± 60° Hit 360°	Target & Sensors	300#	Various Computer Periphals
			0-90°	360°			

Worksheet.C (Cont'd)

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TECHNICAL
"OFF-THE-SHELF"
ARMED AIRCRAFT QUALIFICAT
(WORK S

FUNCTIONAL REQUIREMENT	24 Hrs. of Operation	110VAC Comm'l or Generator	Minimum	Sub-sonic Super-sonic	N/A	REQUIRED
SYSTEM MANUFACTURER	POWER TARGET SITE	POWER DISPLAY SITE	SYSTEM SUPPORT EQUIPMENT	PROJECTILE VELOCITY	COST	MALFUNCTI OR DAMAGE ALARM
Del Mar Engineering	30 VDC Nicad Batt.	115VAC	Test Calibrator		$25,000	
Laboratories (USA)	6 watts 24 hrs. @ + 25°C	(60 W)	Battery Charger			
	None	(100 watts) 115VAC	Test Calibrator		$20,000 Less cable	
	30V DC 6 watts Nicad	(60 watts) 115VAC	Test Calibrator Battery Charger		$50,000	
	1220V 60	110V 60	Test Calibrator Tgt & Gun Test Set			

	REQUIRED							
	MALFUNCTION OR DAMAGE ALARM							
s								
able								

Worksheet C (Cont'd)

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NAVTRADEVCEN 69-C-0178-1

TECHNICAL ANALYSIS

OF

HIT SENSITIVE PANEL TARGET SYSTEM, X3A109/1

DEL MAR ENGINEERING LABORATORIES

This hit panel type scoring system was designed primarily for use on tank gunnery ranges in both a stationary and mobile configurations. Comparing the characteristics and capabilities of this system to the functional requirements of the Armed Aircraft Qualification Range Scoring System, it is evident that the following areas are not fulfilled:

Scoring Rate: 60 RPM

Scoring Radius: Dependent on panel size

Zone/Vector: Neither is furnished

Data Transmission: Wire

Data Display: None

Dive Angle: 0° - 60°

Approach Azimuth: ± 60°

Malfunction/Damage Alarm: None

See Worksheet "D"

TECHNICAL ANALYSIS

OF

HIT PANEL SCORING SYSTEM, MODEL BT-14

SAAB AKTIEBOLAG (SWEDEN)

This hit panel type scoring system was designed for use by strafing aircraft during individual training. A comparison of this system's characteristics with the functional requirements of the Armed Aircraft Qualification Range Scoring System results in the following discrepancies:

Scoring Rate: 9,000 RPM

Caliber/Type Weapon: 7.62 - 40mm

Zone/Vector: No zone, no vector

Scoring Radius: 20 feet

Data Transmission Range: 1000M (Wire)

Data Recording: No provisions

Portability: Fixed

Dive Angle: 10° - 30°

Approach Azimuth: ± 30

Malfunction/Damage Alarm: None

See Worksheet "D"

TECHNICAL ANALYSIS

OF

ACOUSTIC (AMPLITUDE) SCORING SYSTEM, MODEL BT-23

SAAB-BULOW (SWEDEN)

This acoustic (amplitude) scoring system was designed for use with aerial targets. A comparison of this system's characteristics with the functional requirements requirements of the Armed Aircraft Qualification Range Scoring System results in the following discrepancies:

Scoring Rate: Up to 9,000 RPM

Zone/Vector: No vector data obtained

Simultaneous Multiple Weapons: One type/caliber weapon at a time

MTBF: Not stated

Malfunction/Damage Alarm: None

See Worksheet "D"

TECHNICAL ANALYSIS

OF

ACOUSTIC (AMPLITUDE) SCORING SYSTEM, MODEL AS-100

AERONIC AB (SWEDEN)

This acoustic (amplitude) scoring system was designed for use with aerial targets. As in all acoustic (amplitude) scoring systems, a number of the requirements can be satisfied, but when the system's characteristics are compared to the functional requirements of the Armed Aircraft Qualification Range Scoring System, the following limitations are apparent:

Scoring Rate: 2,000 RPM

Scoring Radius: 2 - 20M

Accuracy: 90%

Zone/Vector: 12 zones - 4 sector under development

Scoring Charts: Supersonic only (No HE or subsonic)

MTBF: Not stated

Malfunction/Damage Alarm: None

Number of Targets per System: Limited to 1 target per system

Simultaneous Multiple Type Weapons: Limited to 1 type of weapon

See Worksheet "D"

TECHNICAL ANALYSIS

OF

ACOUSTIC (AMPLITUDE) SCORING SYSTEM MODEL MAE-14

SFENA (FRANCE)

This fixed acoustic scoring system was designed for air-to-ground gunnery scoring using the amplitude principle. It has been used by the French Air Force in aerial gunnery training. When comparing the characteristics of this system to the functional requirements of the Armed Aircraft Qualification Range Scoring System, the following essential elements are,

Scoring Rate: 8,000 RPM

Scoring Radius: 10M

Zone/Vector: No vector data furnished

Type/Caliber: Up to 30mm

Simultaneous Multiple Type Weapons: One caliber at a time

Data Transmission: Wire only, no TM

Attack Azimuth: ±20°

Dive Angle: 10 ± 5°

Malfunction/Damage Alarm: None

Number of Targets per System: Limited to 1 target

Data Recording: No provisions

See Worksheet "D"

TECHNICAL SUMMA

"OFF-THE-SHELF" SCORING

ARMED [illegible] CRAFT [illegible] ATION R

(WORK SHEET)

FUNCTIONAL REQUIREMENT	→	→	"Off-the-Shelf"	24,000RPM	0 - 5M	95 ± 5%
SYSTEM MANUFACTURER	**TYPE**	**MODEL**	**STATUS**	**RATE**	**RADIUS**	**ACCURAC**
Del Mar Engineering Laboratories (USA)	Vibration Sens. Target	X3A109/1	Production	60 RPM	Panel Size up to 7.5 x 7.5'	98% for S to 200 rou per sq.ft. area; 90% for la rockets fo distributi of 1 per sq. ft.
SAAB Aktiebolag (Sweden)	Hit Panel (Piezo Elec. Sensor)	BT-14	Production	9,000 RPM	20' x 11' Panel; 5 - 4' Panels each w/sensor	94 - 98%
SAAB-Bulow (Sweden)	Acoustic (Amplitude)	BT-23 **	Production	Up to 9,000 RPM	1-1/2' to 430' depending on ammo size	90%
Air Target Ltd. Aeronic AB (Sweden)	Acoustic (Amplitude)	AS-100 **	Production	2,000 RPM	2 to 20 M	80 - 90%
SFENA (France)	Acoustic (Amplitude)	MAE SFENA 14	Production	8,000 RPM	0-3M-7.62; 0-10M 30mm	90%

** Primarily Air-toAir and/or Ground-to-Air.

ECHNICAL SUMMARY
~~"SHELF" SCORING SYSTEMS~~
[illegible] SCORING SYSTEMS
(WORK SHEET)

NAVTRADEVCEN 69-C-0178-1

M	95 + 9%	[illegible] 40mm .50 cal 2.75 20mm tow 30mm	Zone & Vector	Vertical & Horizontal Plane	HE - Inert Sub-sonic Super-sonic	Up to 2	Yes	Radio - UT Radio or Wire - IT
	SCORING							
S	ACCURACY	CALIBER/TYPE	ZONE/VECTOR	SENSITIVE AREA	CHARACTERISTICS	NUMBER OF TARGETS PER SYSTEM SIMULTANEOUS	SIMULTANEOUS MULTIPLE-TYPE WEAPONS	DATA TRANSMISSION MEANS
to [illegible]	98% for SA to 200 rounds per sq.ft. area 90% for large rockets for distribution of 1 per sq. ft.	556 to 155 mm	8 Separate Panels	7.5 x 7.5' or Personnel Target	Hit Panel	8	Yes	Wire
1' Panels sensor	94 - 98%	7.62 - 40mm Inert	1-Zone	Panel Area	Preamplifier Adjusted for different calibers	1 or 2	No	(20 conductor) Wire
9430' ing size	90%	7.62mm to 76mm inert	Zone (Vector under development)	Radial Plane	3 Zone Adjustable Actual Miss Distance on Single	4 (2 RF Frequencies)	No	Radio PDM/FM
) M	90 - 90%	7.62mm to no limit	Both (in front in back) or (4 Sectors)	Radial Plane	Supersonic Projectile	1	No	TM
62 mm	90%	7.62mm 30mm higher	1-Zone	Radial Plane			No	Direct Burial Cable

Worksheet "D"

TECHNICAL SUMM
"OFF-THE-SHELF" SCORI
ARMED AIRCRAFT QUALIFICATION
(WORK SHEET

FUNCTIONAL REQUIREMENT	1710 - 1850 MHz	30,000M	Hit, Miss & Vector	Yes	Intermediate Climatic Zone	3/4 T Truc 1/4 T Truc
SYSTEM MANUFACTURER	FREQUENCY BAND	DATA TRANSMISSION RANGE	DATA DISPLAY	DATA RECORDING CAPABILITY	ENVIRONMENTAL CHARACTERISTICS	PORTABILIT
Del Mar Engineering Laboratories (USA)	N/A	N/A	None	Signal output	MIL	Fixed
SAAB Aktiebolag (Sweden)	N/A	1000M	1 or 2 - 2 digit counters	No	-25° to 50°C 50G-20,000 cycle Hermetically Sealed	Fixed
SAAB-Bulow (Sweden)	70-150MHz	3 miles	3 - Zone 3 digit counters 1 -2digit NIXI	Yes	-50C for Transmission Unit designed for MIL	Transportable
Air Target Ltd. Aeronic AB (Sweden)	25-170MHz 220-260MHz	50 miles	12-3 digit counters	Yes	Not stated	Transportable
SFENA (France)	N/A	Not stated	Single digital counter	No	Not stated	Fixed

ate e	3/4 T Truck 1/4 T Truck	1200 Hrs.	Aiming Pt. and 3-D Tactical	0° to 80°	360° Unit 45° Individ	Minimum	Minimum	Minimum
. (-	PORTABILITY	MTBF	TARGET TYPE	DIVE ANGLE	APPROACH AZIMUTH	VULNER-BILITY	TARGET SITE EQUIP. WT.	DISPLAY SITE EQUIP. WT.
	Fixed	1200	Panel & Personnel	0°-60°	±60°	SCTU requires bunker or protection	160	None
)°C) Ly	Fixed	Unknown	Panel	10°-30°	±30°	Preamplifier & Sensor as well as target sub-ject to gun-fire damage	100# Approx.	22#
.on med	Transport-able	Not stated	Airborne target	If used in environment 0-90°	ground would say 360°	Sensor to transmitter	> 6#	Not Stated
	Transport-able	Not stated	Airborne target	0-90°	360°	Sensor	Approx. 9#	Not stated
	Fixed	Not stated	Aiming point 4 meters high	10°+5°	±20		34#	Not stated

Worksheet "D"
(Cont'd)

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TECHNICAL SU
"OFF-THE-SHELF" SCC
ARMED AIRCRAFT QUALIFICATIC
(WORK SHE

FUNCTIONAL REQUIREMENT	24 Hrs. of Operation	110VAC Comm'l or Generator	Minimum	Sub-sonic Super-sonic	N/A	REQUIRE
SYSTEM MANUFACTURER	POWER TARGET SITE	POWER DISPLAY SITE	SYSTEM SUPPORT EQUIPMENT	PROJECTILE VELOCITY	COST	MALFUNC OR DAMA ALARM
Del Mar Engineering Laboratories (USA)	12V DC 1 Amp		System Calibrator			
SAAB Aktiebolag (Sweden)	From Display	110-220VAC 30 W	None stated		$20,000 2 Targets Less cable	
SAAB-Bulow (Sweden)	Battery	28VDC or 110-220VAC 50-60Cy C	Bang Generator Test TX Power Meter			
Air Target Ltd. Aeronic AB (Sweden)	Turbine or Battery 28VDC	220VAC-15W 25W	Bang Generator Test Trans. Power Meter		$10,000 Grnd Sta $400-$900 Target Unit	
SFENA (France)	From Rec'r Sta	115 or 220 VAC	None		4 Targets 2 Grn Sta 15 Micro $40,000	

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	REQUIRED							
	MALFUNCTION OR DAMAGE ALARM							
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Worksheet "D"
(Cont'd)

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APPENDIX E

TRADE-OFF ANALYSIS

1. TASK IV

The objective of Task IV is to evaluate and validate candidate hardware systems applicable to the requirements for the Armed Aircraft Qualification Range Scoring System.

The selection of hardware is accomplished by relating hardware functional performance and design features in matrix form on the summary trade-off sheets prepared from data derived from Tasks I, II, and III.

During Step 1 the essential parameters functional and design requirements are entered under "nomenclature" on the summaries. These data resulted from the analysis of Task II wherein the system functional requirements were established, independent of available equipment considerations.

Step 2 identifies criticality of candidate systems hardware parameters and each is listed in descriptive form opposite the functional requirements.

Step 3 is the evaluation phase of this task. It is the initial step in evaluating Systems Effectiveness (part of the cost/effectiveness analysis). In Step 3, the term Functional Operational Adequacy (F_o) is introduced.

Functional Operational Adequacy

Functional Operational Adequacy (F_o) is defined as the difference between Functional Requirement (F_r) and Systems Functional Capability (F_c). (I. e., a system whose functional adequacy exactly matches the requirement is neither over-designed, nor under-designed.)

In order to provide the most accurate appraisal and to minimize influencing bias, the candidates were broken down into major subsystems functional descriptions.

In arriving at F_o, each major subsystem is evaluated separately using the trade-off summary sheets. Comparative rankings are graded using the schedule:

3 = Meets requirement

2 = Partially meets requirement or partially over-designed

1 = Does not meet requirement or grossly over-designed

0 = Does not meet requirements in any respect.

Ratings for each subsystem are calculated on total points scored/total points achievable. Weighting of individual subsystems will follow the established hierarchy of importance.

Level 1 = 50 percent (sensing, scoring, displaying)

Level 2 = 25 percent (mean point of impact for miss + r and θ

Level 3 = 25 percent (data transform, data transmission, targeting, recorder output features)

Thus, rating value x level of importance = weighted score. The total Score F_o is the sum of the subsystems weighted scores during the projected systems life cycle in years $\left(\sum_{n=1}^{y}\right)$.

Figures E-1 through E-3 are the completed trade-off summary sheets.

TRADE-OFF WORK SHEETS

The following pages contain the trade-off work sheets with critical parameters, functional and technical design requirements entered. Accompanying each work sheet is a short summary statement amplifying the most significant parameter entries. Targets and recorders are excluded in the rankings primarily because these equipment are not normally supplied as part of the basic scoring systems hardware inventory. These items are included in the trade-off work sheet descriptive section for two reasons: (1) for completeness of description, and (2) because of their impact on the functional interfaces with each system.

1.F TARGETS - INDIVIDUAL TRAINING

It is essential in Individual Training to provide a well-defined aiming point for two types of weapons. "Point" weapons require a vertical aiming point at some distance "d" above ground level. The "area" weapons require a horizontal aiming point at ground level with an arbitrary "aim" zone. The angle of attack may range from 0° to 80° elevation with [illegible] the ground plane and ± 45° sensitivity in azimuth from the firing weapon.

Targets for Individual Training comprise a complex made up of both types. Up to six (6) target complexes should be provided on each gunnery range.

The target site is semi-permanent, prepared in advance. Target repair or replacement time is limited to 30 minutes. Each target should provide survivability of 120 hours of unattended performance. It is estimated that the point weapon target will sustain approximately 42 "hits" for each 120 hours of range operation time; and that the area weapon target can sustain up to 124, 000 hits in each 120 hours of operation if the target area is large (~ 1500 meters^2) and the gunnery is exceptionally accurate (50 percent (hits)). Total "hits" are primarily a function of target area and gunner accuracy.

1. 2 TARGETS - UNIT TRAINING

It is essential that the targets for Unit Training be realistic, simulating combat and tactical vehicles, crew-served ground weapons, and personnel. Up to 10 targets per range may be employed. The scoring system for unit training targets must provide coverage for 360° in azimuth and 0° to 80° dive angle.

Targets must be air transportable for either repair/replacement or relocation to any one of up to 20 previously prepared sites.

Target repair or replacement time is limited to 30 minutes.

The target complex must be self-contained, including power.

Modular construction is essential for maintenance and repair.

Each target should provide a survivability of 120 hours unattended performance, including survival from ordnance fire.

1.3 SENSING - INDIVIDUAL AND UNIT TRAINING

Sensors and associated electronics located at the target complex must be capable of 120 hours of range operation including survivability from ordnance fire.

For Individual Training the required sensitive region is ± 45° in a direction facing the firing weapon, and 0° to 80° elevation above the ground. Sensor coverage for Unit Training encompasses 360° in azimuth and dive angle from 0° to 80° elevation. Point weapon sensing is:

(1) "Target" zone hit count (scoring)

(2) Over/short, left/right zone coverage for misses and direction information.

Area weapons fire is sensed in the horizontal plane referenced to an aiming point (see Appendix IV). Therefore, an arbitrary area within the beaten zone must be sensed and scored. Misses occurring

[illegible]	APPROACH 1 [illegible] [illegible]	APPROACH 2 BABCOCK PISS	APPROACH 3 SEENA MAE 12B [illegible]	APPROACH 4 SANDERS RASCORE [illegible]	APPROAC[illegible] SANDER[illegible] RASCORE [illegible]
Status [illegible]	[illegible] sensor)	Development (ground sensor)	Production (airborne sensor)	Pre-production (ground sensor)	Pre-production (ground sensor)
[illegible]	[illegible] than 24,[illegible]	Est. above 10,000 [illegible] [illegible] less than 24,000 [illegible]	Est. above 6,000 rpm, but less than 10,000 rpm	20,000 rpm	20,000 rpm
[illegible]	[illegible] factory-set [illegible]	[illegible] radius of [illegible] meters [illegible] [illegible] made [illegible] 20 [illegible]	4 [illegible] radius of two zones [illegible] 2.8 meters & [illegible] meters)	Available as factory-set Radius of up to 20 ft	Available as fac[illegible] 4-m radius of t[illegible] 2-m each zone
[illegible]	[illegible]	[illegible]	Est. at approximately [illegible]	± 12 in.	± [illegible] 2 m
[illegible]	[illegible]	[illegible] Within unspecified [illegible] velocity para[illegible]	[illegible] supersonic [illegible] caliber	Inert only [illegible] from 7.62 [illegible] 40 [illegible]	Inert only sub[illegible] [illegible] from [illegible] [illegible] caliber
[illegible]	[illegible]	[illegible] horizontal plane [illegible] sector for 40 [illegible] ground [illegible]	Senses projectile passage thru [illegible] acoustic [illegible] directional sphere [illegible] point when projectile [illegible] closest [illegible] sensor [illegible]	Senses projectile passage thru radar-sensitive vertical [illegible] (score/no score)	Senses projecti[illegible] sage thru [illegible] sensitive, [illegible] vertical pla[illegible] [illegible] score)
[illegible] Az[illegible]	[illegible]	[illegible]	[illegible]	[illegible] angle [illegible] Azimuth [illegible]	[illegible] angle [illegible] 0 Azimuth [illegible]

[illegible]PROACH 5 [illegible]ANDERS [illegible]SCORE AP	APPROACH [illegible] SANDERS RASCORE [illegible]	APPROACH 7 DEL MAR DA-[illegible]	APPROACH [illegible] DEL MAR DA-[illegible]F	APPROACH [illegible] DEL MAR DA-[illegible]A	APPROACH 10 DEL MAR DA-2	AP[illegible] D[illegible] X3[illegible]
[illegible]duction [illegible] sensor)	Production (airborne sensor)	Production (ground sensor)	Production (ground sensor)	Preproduction (ground sensor)	Production (ground sensor)	Develop[illegible] (ground[illegible]
[illegible] rpm	Est [illegible] not more than [illegible] rpm	[illegible],000 rpm	[illegible],000 rpm	[illegible]	12,000 rpm (hit count) [illegible],000 rpm (miss count)	60 rpm[illegible]
[illegible] as factory set [illegible] radius of [illegible] zone	Radius of [illegible]	Field adjustable from [illegible]	Small Arms [illegible] adjustable [illegible] HE [illegible] FAP [illegible]	[illegible] radius [illegible] adjustable [illegible]	Hit count [illegible] target impact Small Arms [illegible] in four zones of [illegible] each [illegible] HE [illegible] horizontal zone	Hit cour[illegible] (7[illegible] ft [illegible] get pane[illegible]
	± 2.5 ft out to [illegible] ±5.0 ft [illegible] for projectiles with [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	95% ± 5[illegible]
[illegible] super[illegible]	Inert [illegible] supersonic [illegible] projectiles with [illegible] radar [illegible] section [illegible] velocity [illegible] 3,000 [illegible]	[illegible] HE [illegible] supersonic [illegible]	Inert projectiles [illegible] supersonic [illegible] supersonic [illegible] supersonic [illegible] 40 [illegible] HE [illegible]	Inert only [illegible]	[illegible] supersonic [illegible] supersonic [illegible] super[illegible] sonic [illegible] to 40 mm	Inert [illegible]
[illegible] past [illegible]	Senses [illegible] passage [illegible] within [illegible] sensitive [illegible] (score [illegible])	Senses [illegible] within [illegible] sensitive [illegible] sphere (score [illegible])	Senses projectile [illegible] within [illegible] sensitive hemisphere (score [illegible]) for HE	Senses projectile pass[illegible] sensitive hemisphere [illegible] (score [illegible])	Senses [illegible] target [illegible] passage thru acoustic sensitive hemisphere (miss) [illegible] blast within [illegible] ground [illegible] zones	Senses[illegible] on targ[illegible] (score[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Dye [illegible] Azi[illegible]	Dye [illegible] Azi[illegible]

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PROACH 11 DEL MAR A 109 [illegible]	APPROACH 12 SAAB BT-14	APPROACH 13 SAAB BT-23	APPROACH 14 AIR TARGET AS 100	APPROACH 15 SEFNA MAF 14	APPROACH 16 JOANELL
[illegible]ment [illegible] sensor)	Production (ground sensor)	Production (airborne sensor)	Production (airborne sensor)	Production (ground sensor)	Production (ground sensor)
	9,000 rpm	[illegible]000 rpm	2,000 rpm	[illegible]000 rpm	10,000 rpm
[illegible] target [illegible]	[illegible] target [illegible]	[illegible] with radius of [illegible] size	[illegible] with radius of [illegible] to 20 [illegible] dependent [illegible] size	Radius [illegible] dependent on [illegible] size	Depends on panel size [illegible] panels
[illegible]	[illegible]	[illegible]	80° to 90°	90°	100° [illegible] actual penetration of panel
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Dive angle 0 - 30 Azimuth 0 - 180

3

[illegible]	APPROACH 1 [illegible]	APPROACH 2 [illegible]	APPROACH 3 [illegible]	APPROACH 4 SANDERS RASCORE[illegible]S	APPR[illegible] SAND[illegible] RASCO[illegible]
[illegible]	Yes	Yes	No	Yes	Yes
[illegible]			Yes	[illegible]	No [illegible] sensi[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible] vulnerable	Sensor [illegible] transmitting antenna vulnerable	Sensor [illegible] transmitting vulnerable
[illegible]	[illegible]	[illegible]	[illegible]	Uses [illegible] of modular [illegible] construction	Uses mix of [illegible] modular
[illegible]	[illegible]	[illegible]	Display component does not appear to be weather-proof	Display component does not appear to be weather proof	Meets U.S. [illegible] for ground-[illegible]
[illegible]	[illegible]	No [illegible]	[illegible]	[illegible]	No [illegible]
[illegible]	[illegible]	22 [illegible]	Battery [illegible]	24 [illegible] battery [illegible] 24 [illegible]	28 V DC batt[illegible] current req[illegible] would suppo[illegible] 24 hr [illegible]

[illegible]	[illegible] SANDIA BASE [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible] max [illegible] mod [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible] 3401	[illegible] NA [illegible] STD [illegible]	[illegible] NA [illegible] STD-11	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	Yes [illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

2.

[illegible]	APPROACH 12 [illegible]	APPROACH 13 [illegible]	APPROACH 14 AIR TARGET [illegible]	APPROACH [illegible] SEFNA MAF 14	APPROACH 16 JOANELL[illegible]
			No	No	Yes
[illegible]	[illegible] semi-fixed [illegible] portable	[illegible]	Yes	No - semi-fixed	Sensor - semi-fixed Display - portable
[illegible]	[illegible] 00 hrs	Est [illegible] hrs	Est [illegible]	Est [illegible]00 hrs	Est 400 hrs
[illegible]	[illegible] pkg [illegible] vulnerable	Conditioning [illegible] sensor & [illegible]	Conditioning transmitter vulnerable can be [illegible] Sensor & trans [illegible]	Conditioning pkg [illegible] Sensor protected [illegible] spe[illegible] dive N's and [illegible]	Target sensor and target functionally vulnerable
[illegible]	[illegible]	Est modular	Est [illegible]	Est modular	Est modular
[illegible]	[illegible] 20 [illegible]	[illegible]	Est meets temperature [illegible]	Est meets temperature climate requirements	Est meets temperature requirements
		N[illegible]	N[illegible]	No	No
	N[illegible]	N[illegible]		No	Yes System go signal
[illegible]	[illegible] facility supply thru display component	[illegible] battery (Est less than 24-hr [illegible])	[illegible] DC battery (Est less than 24-hr [illegible])	[illegible] AC commercial power - from main facility supply thru display component	[illegible]10-V generator at target site

Statu[illegible]
Sens[illegible]
Sens[illegible]
Sens[illegible]
Pro[illegible]
Sens[illegible]
Dive[illegible]
Sense[illegible]
Prota[illegible]
Vulne[illegible]
Resto[illegible]
Const[illegible]
Envir[illegible]
Dam[illegible]
Sens[illegible]
Sens[illegible]
To[illegible]
To[illegible]

3

TRADE-OFF SUMMARY

REQUIREMENTS (CONT)

APPROACHES	Criteria	1	2	[illegible]	4	[illegible]	[illegible]	7	[illegible]	[illegible]	10	11	12	13	14	[illegible]	16
	Status	[illegible]	1	1	2	2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1	[illegible]	3	3	[illegible]	3
	[illegible]	[illegible]	[illegible]	2	[illegible]		[illegible]	2	1	1	2	0	2	2	1	2	2
[illegible]	[illegible]	[illegible]	[illegible]	1	[illegible]	1	[illegible]	1	[illegible]	[illegible]	1	1	1	[illegible]	2	1	1
	[illegible]	[illegible]	[illegible]	2			[illegible]	[illegible]	[illegible]	[illegible]	2	[illegible]	[illegible]	2	2	2	[illegible]
	[illegible]	[illegible]		[illegible]	1	[illegible]	[illegible]	2	2	2	2	2	1	1	[illegible]	1	1
	[illegible]	[illegible]	2	[illegible]	1	1	[illegible]	1	1	2	2	1	1	1	1	1	[illegible]
[illegible]	[illegible]	[illegible]	2	[illegible]	1	2	[illegible]	[illegible]	[illegible]		2	2	2	[illegible]	1	1	2
	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	2	2	2	2	[illegible]	1	[illegible]	1	2
Est 400 hrs	[illegible]	[illegible]			[illegible]	[illegible]	[illegible]		2		2	2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]	[illegible]	[illegible]	1	1	1	2	2	[illegible]	1	2	2	2	2	[illegible]	1
Target sensor and target [illegible]	Restoration (MTTR)	1	1	2	[illegible]	2		[illegible]	[illegible]	[illegible]	2	[illegible]	[illegible]	[illegible]	3	[illegible]	2
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	1	[illegible]	[illegible]	2	2	2	2	[illegible]
	[illegible]	[illegible]	[illegible]	[illegible]	2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]	0	0	[illegible]	0	0	1	[illegible]	[illegible]		0	0	0	0	0	0	0
	[illegible]			[illegible]	0	[illegible]		0	0	0	0		[illegible]	0	1	0	
	[illegible]	2	1	2	[illegible]	[illegible]		2	[illegible]	2	1	2	1	2	2	1	1
Est modular	Total Score	[illegible]	26	26	24	26	26	[illegible]	37	[illegible]	28	30	28	[illegible]	28	[illegible]	[illegible]
	Total Possible	[illegible]	48	48	48	48	[illegible]	48	48	[illegible]	48	49	48	48	48	49	48

System go signal

Clock generator in target [illegible]

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outside the zone must be detected, the mean point of impact automatically determined, and data derived for zone and over/short or left/right zone.

Maximum sensing rate is 24,000 rounds per minute (both subsonic and supersonic, inert and high explosive projectiles).

Maximum range of sensitivity from target center is three times the maximum effective fire radius of ordnance being fired.

Sensors must be compatible with target power systems.

1.4 DATA CONVERSION SYSTEM

Must be able to accept raw data from sensors and convert to hit count (score) plus r and θ information on misses. This function is first order data reduction for transmission to the balance of the system.

Converters must be extremely stable, contributing less than one tenth percent error to the scoring system. Data rate input is up to 400 bits per second.

1.5 DATA TRANSMISSION (Target to Control)

Data transmission system should be essentially noise-free with an accuracy of at least 99.9 percent.

[illegible]	[illegible]	APPROACH 2 BABCOCK PTSS	APPROACH 3 SEENA MAE 12B	APPROACH 4 SANDERS RASCORE 'S'	APPROAC[illegible] SANDERS RASCORE [illegible]
Data Transmission [illegible]	[illegible]	S-Band [illegible]	[illegible]	FM/FM TM or coax	TM Link
[illegible]	[illegible]	[illegible]	[illegible]	1 mi coax, 15 mi TM	Not stated, 5-15 [illegible]
[illegible]	[illegible]	[illegible]	[illegible] MHz	IRIG	IRIG
[illegible]	24-[illegible]	Not stated	28-VDC [illegible]	28-VDC or 110-VAC 50/60 c, 50 W	28-VDC - 1A ba[illegible]

ACH [illegible] BS [illegible] F [illegible] AP	APPROACH 6 SANDERS RASCORE [illegible]	APPROACH 7 DEL MAR DA-3F	APPROACH 8 DEL MAR DA-3B	APPROACH 9 DEL MAR DA-3A	APPROACH 10 DEL MAR DA-2	APPR DE X3A
	FM FM PCM	TM (FM [illegible])	Coax	TM (FM burst)	Wire (twisted pair)	N/A
[illegible] mi (Est.)	Not stated [illegible] mi (est.)	[illegible] mi	10,000 ft	5 mi	10,000 ft	N/A
[illegible]	[illegible]	1710-1850 MHz (four [illegible] frequencies)	N/A	220-240 MHz	N/A	N/A
batteries	[illegible] VDC [illegible]	[illegible] VDC NI-AD	None	[illegible] VDC NI-AD	N/A	N/A

2

APPROACH 10 DEL MAR [illegible]-2	APPROACH 11 DEL MAR X3A 10[illegible] [illegible]	APPROACH 12 SAAB BT-14	APPROACH 13 SAAB BT 2[illegible]	APPROACH 14 AIR TARGET AS-100	APPROACH 15 SFENA MAE 14
Wire (twisted pair)	N/A	Wire (20 cond)	TM	TM	OB cable
[illegible],000 ft	N/A	1,000 m	[illegible]	50 m	Est. 10,000 ft
N/A	N/A	N/A	70-150 MHz	25-170 MHz 220-260 MHz	N/A
N/A	N/A	N/A	N/A	Air-driven Turbine or 28-VDC battery	N/A

References	1	2	3	4
Transmission Means	2	2	2	[illegible]
Range	3	3	[illegible]	[illegible]
Total Score	5	5	[illegible]	6
Total Possible	[illegible]	[illegible]	6	[illegible]

3

[illegible]

[illegible]CH 12 [illegible]P [illegible]4	APPROACH 13 SAAB BT [illegible]	APPROACH 14 AIR TARGET AS-100	APPROACH 15 SFENA MAE 14	APPROACH 16 JOANELI	
D	TM	TM	OB cable	Wire of RF links 149-150 MHz	
	[illegible] mi	50 mi	Est. 10,000 ft	Up to [illegible] mi norm 4-6 mi	
	70-150 MHz	25-170 MHz 220-260 MHz	N/A	149-150 MHz	
	N/A	Air-driven Turbine or 28-VDC battery	N/A	110 VAC 50/60 c	

References	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Transmission Means	2	2	2	[illegible]	2	2	2	2	2	2	0	2	2	2	2	2
Range	3	3	[illegible]	[illegible]	2	2	2	1	2	1	0	2	1	3	1	2
Total Score	5	5		6	4	4	[illegible]	[illegible]	4	[illegible]	0	4	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]			[illegible]	6	6	[illegible]

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It must have linear response over the operating range and be capable of transmitting all data at a rate commensurate with the balance of the scoring system.

The system needs to be essentially maintenance-free (MTBF 1200 hours).

Minimum cross-talk between channels is essential.

It is desirable that the transmission system require zero calibration. It must present a proper impedence match for input and output interfaces.

Note:

(1) If data conversion is provided at the target site the information rate per function drops from a maximum of 400 hits per second to 10 bytes per second (see data conversion) (a separate trade-off analysis may be performed to compare transmission with conversion versus transmission without).

(2) For individual training the using Training Command suggests a buried hard-wire power and data link.

(3) For Unit Training it is concluded that wireless transmission is required because of the need for single package portability for relocation.

Range: 30,000 meters.

1.0 DISPLAYING

A continuous display of the data and operational status of each target is required in the range control center.

The display system requires a built-in scoring (hit count) register and visual display of these data. Data should be stored until reset is activated. Manual reset functions after each target engagement should be incorporated. In addition, r and θ information on target misses must be displayed. The format must be easily read, requiring no interpretation on the part of the operator.

The display system needs to be easy to operate. It should be of modular construction and be easy to maintain by field organizational maintenance personnel.

The display function should also incorporate the buffer function of converting sensor-derived information to hit count plus zone and sector information for score recording and for remote display units if required.

The display system should incorporate system test and calibration features. Equipment should be operable from either 60 cycle 110 volt or 24 volt direct current truck power (commercial power or mobile in order to achieve the greatest flexibility).

[illegible]	APPROACH 1	APPROACH 2	APPROACH 3	APPROACH 4	APPR[illegible]
[illegible] Requirements	[illegible]	BABCOCK [illegible]	[illegible]	SANDERS RAS-[illegible]	SAN[illegible] RASCO[illegible]
[illegible]	[illegible] Data [illegible]	[illegible] display [illegible] computer [illegible]	Display [illegible] counter	Displays [illegible] counter	[illegible] counter
[illegible]	No display	No display	No display, no MPP, vector	No display, no MPP, no vector	No display
[illegible]	N/A	N/A	[illegible]	No [illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible] counter [illegible] Power meter	N/A	
[illegible]	N/A	N/A	Yes	Yes	N/A
[illegible]	N/A	N/A	220 VAC [illegible] Hz	[illegible] VAC [illegible] Hz [illegible]	N/A
[illegible]	[illegible]	N/A	No	Yes [illegible] paper tape printer	N/A
[illegible] Printer	N/A	N/A	Yes	Yes,	N/A
[illegible]	N/A	N/A	None	None	N/A
[illegible] to Aircraft Display	N/A	N/A	None	None	N/A
[illegible]	N/A	N/A	Yes	N[illegible]	N/A

APPROACH 5 SANDERS RASCORE AP	APPROACH 6 SANDERS RASCORE M	APPROACH 7 DEL MAR DA-3F	APPROACH 8 DEL MAR DA-3F	APPROACH 9 DEL MAR DA-3A	APPROACH 10 DEL MAR DA-2	
[illegible] Data output [illegible] [illegible] TM or electronic	No display - Data output to mag tape or TM [illegible]	Displays hits on [illegible]-digit electronic counter	Displays hits on [illegible] digit HS mechanical counter	Displays hits on 4-digit NIXI	No display - Data output to computer	No [illegible] hit [illegible]
[illegible]play	No display	No display, no MPI, no vector	Displays [illegible] misses on 3 - 3 digit counters, no MPI, R [illegible] only vector	Displays misses, 5 zones [illegible] digit NIXI - mass dist [illegible] no MPI, no vector	No display	No [illegible]
	No	Yes - targets 1 thru 8	Yes - targets 1 thru [illegible]	Yes - targets 1 thru 8	N/A	N/A
	N/A	Easily read - reset provisions	Easily read - reset provisions	Easily read & operate - reset provisions	N/A	N/A
	N/A	Yes	Yes	Yes	N/A	N/A
	N/A	1[illegible] VAC, 60 Hz, [illegible] A	115 VAC, 60 Hz, 100 W	115 VAC, 60 Hz, [illegible]0 W	N/A	N/A
	N/A	None	None	Yes	N/A	N/A
	N/A	Yes - 4[illegible] lbs	Yes - 45 lbs	Yes - 50 lbs	N/A	N/A
	N/A	Yes - free running counter	Yes - free running counter	No	N/A	N/A
	N/A	None	None	No	N/A	N/A
	N/A	No	No	No	N/A	N/A

2

APPROACH 11 DEL MAR [illegible]	APPROACH 12 SAAB BT-14	APPROACH 13 SAAB BT-21	APPROACH 14 AIR TARGET AS-100	APPROACH 15 SFENA MAE 14	APPROACH 16 JOANELL
No display. Data output to hit indicator or target mechanism	Displays hit for two targets on [illegible] counter	Displays hits. 2-digit NIXI displays actual miss distance code	Displays hits	Displays hits on 2-digit counter electronic	Displays hits
No display	No display, no MPI, no vector	Displays [illegible]-zone misses on [illegible] digit counters; no MPI, no vector	Displays 12-zone misses in 3 digit [illegible] counters, no MPI, no vector	Not displayed	Not displayed
N/A	Yes - targets 1 or 2	No	No	No provisions	No provisions
N/A	Easily read & [illegible] Reset provisions	Easily read [illegible] calibration chart to get [illegible] miss distance. Reset buttons provided	Easily read, reset buttons, simple controls	Reset provided, easily read	Est., O.K.
N/A	Assume modular const	Modular construction	Modular construction	Assume modular const	Assume modular const
N/A	110/220 [illegible] 40 W	28 VDC [illegible] A, 110/220 VAC [illegible] Hz	24 [illegible], 220 VAC, 15 W	110/220 VAC, 20 Ma/220 [illegible]	110 VAC [illegible] 50/60 [illegible]
N/A	None	Yes - tape recorder	Yes - paper tape ultrasonic	No	Yes - tape recording
N/A	Yes 22 lbs	Yes approximately [illegible] lbs	Yes 11 lbs	Yes Est. less than 50 lbs	Marginal, 75 lbs
N/A	No	No	No	No damage alarm feature	No damage alarm
N/A	No	No	No	None provided	None provided
N/A	No	No	No	No	System "go" signal

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DISPLAYING

	APPROACH 15 SEENA MAE 14	APPROACH 16 JOANELI
	Displays hits on 2-digit counter electronic	Displays hits
[illegible]ses [illegible]	Not displayed	Not displayed
	No provisions	No provisions
	Reset pro[illegible]	Est. [illegible]
	Assume modular const	Assume modular const
W	[illegible] 220 [illegible]	110 VAC [illegible]
	No	Yes [illegible] tape recording
	[illegible] less than [illegible]	[illegible]
	No damage alarm feature	No damage alarm
	None provided	None provided
	N[illegible]	System [illegible]

References	Comparative Rankings 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Display Hits	0	0	1	2	0	0	2	2	2	0	2	2	2	2	2	2
Display Misses	0	0	0	0	0	0	1	1	0	0	0	0	1	1	0	0
Display Vector	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
Target Identification	0	0	0	0	0	0	3	[illegible]	3	0	0	3	0	0	0	0
Ease of Operation	0	0	3	0	0	0	3	[illegible]	3	[illegible]	0	[illegible]	[illegible]	[illegible]	3	[illegible]
Modular Construction	0	0	3	3	0	0	[illegible]	[illegible]	[illegible]	0	0	2	[illegible]	[illegible]	2	2
Power	0	0	2	2	0	0	2	2	2	0	0	2	[illegible]	3	2	2
Recorder Output	0	0	0	0	0	0	0	0	[illegible]	0	0	0	[illegible]	[illegible]	0	[illegible]
Portability	0	0	[illegible]	[illegible]	[illegible]	0	3	[illegible]	[illegible]	0	0	[illegible]	[illegible]	[illegible]	[illegible]	2
[illegible] Display	0	0	0	0	0	0	[illegible]	[illegible]	0	[illegible]	0	0	[illegible]	0	0	0
Output to Ac	0	[illegible]	0	0	0	0	0	0	0	0	0	[illegible]	[illegible]	0	0	0
S[illegible] Test	0	0	[illegible]	0	0	0	0	0	0	0	0	0	0	0	0	3
Total Score	0	0	15	1[illegible]	0	0	21	20	19	0	2	15	18	18	12	17
Total Possible	36	36	36	36	36	36	36	36	36	36	36	36	36	36	36	36

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It may be desirable to incorporate multiple target displays in a single unit. This should be considered in the trade-off analysis.

For automatic weapons, only the mean point of impact is required for establishing the direction and zone location reference point on target misses. This becomes an averaged value over some discrete interval of time. One-tenth second has been arbitrarily chosen (less than one-half shortest burst duration for rapid fire weapons). The display-buffer unit should contribute less than 0.1 percent error to the scoring system.

1.7 DATA TRANSMISSION TO FIRING AIRCRAFT

Target data information transmission to firing aircraft is only required for individual qualification training and proficiency rating.

Information on all targets on the range should be transmitted to firing aircraft during individual qualification training.

If data conversion and reduction is performed by ground equipment the band pass requirement is greatly reduced. Example: assuming 10 bytes/second for $x - x'$ data and 10 bytes/second for $y - y'$ plus total bit count $\approx$ 20 bytes per second for each target x 6 targets $\approx$ 120 bytes/second. A 240 Hz band pass would be more than ample.

The data transmission system should be kept as simple as possible and utilize equipment common to the aircraft if possible: example - use one channel of existing communications equipment.

1.8 DISPLAYING IN AIRCRAFT

The displaying of target information on a selective basis in the aircraft for the benefit of the instructor pilot is essential during individual qualification. This comprises both score- and target miss-type information.

The requirement for display capability is limited to one target at a time (target engaged). Therefore the instructor pilot should be able to select any one of the six targets on the range.

The aircraft display unit should be kept as simple as possible and require no modification to the aircraft. The display must be readable under all lighting conditions normally encountered during aircraft operation.

In view of the limitations for modification to Army aircraft, the on-board display system will have to be a self-contained, self-powered unit issued to an instructor pilot for the training mission. Weight should be five pounds or less. Package size and shape should be easily operated and carried (hand-held).

1.9 RECORDING

Only the scoring data (hits) from each target need to be recorded. Some means for aircraft identification, firing run number, and target being engaged need to accompany the record for post-operational evaluation.

2.0 SCORE

Individual scores are based on the following schedule:

In production = 3 points

Pre-production = 2 points

Developmental = 1 point

Closest approach to:

24,000 rpm = 3 points

16,000 rpm = 2 points

8,000 rpm = 1 point

Closest approach in range to:

54 m = 3 points

36 m = 2 points

18 m = 1 point

Closest accuracy to

95 percent	= 3 points
85 percent	= 2 points
80 percent or less	= 1 point

Projectile sensing;

All	= 3 points
Two-thirds	= 2 points
One-half or less	= 1 point

Zone/vector sensing;

Zone plus vector	= 3 points
Vector only	= 1 point
Zone only	= 1 point

Multiple fire;

Mixed with sorting	= 3 points
Mixed - no sorting	= 2 points
One type only	= 1 point

Range in meters (TM);

20,000 to 30,000 m = 3 points

10,000 to 20,000 m = 2 points

10,000 m or less = 1 point

All other categories are based on subjective judgment of how near the requirement is fulfilled.

2.1 RANKING F_o

In arriving at a total score the telemetry to the aircraft and display in the aircraft are included in the rankings. No single "off-the-shelf" hardware system includes these features. These deficiencies are factored into the total score for each candidate system in order to establish the value of F_o relative to an optimized system that satisfies all requirements. Eighteen points are added to the sensing/displaying score potential (50 percent weight factor) for the aircraft display rating. Parameters considered are: hit display, miss display, target identification, ease of operation, power, and portability, each worth three points.

In a similar manner, data transmission to the aircraft is included in the total potential score (25 percent weight factor). Parameters considered are: transmission means and range; added points are six.

Table I is a tabulation of the weighted scores (F_o) resulting from evaluation and comparison of "off-the-shelf" hardware systems with the optimized requirement (Task II). The most significant value is the highest percentage.

Table 1

References	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Combined sensing and displaying score	29	26	41	34	26	26	57	57	52	28	32	43	47	46	36	46
Potential score	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84
Percent score (weighted)	18%	16%	25%	21%	16%	16%	35%	35%	32%	17%	20%	27%	29%	28%	22%	23%
(Points total / Points possible x 50 percent = weighted percent)																
Combined data transmission score	5	5	5	6	4	4	4	3	4	3	0	4	3	5	3	4
Potential score	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12
Percent score (weighted)	10%	10%	10%	13%	8%	8%	8%	6%	8%	6%	0%	8%	6%	10%	6%	8%
(Points total / Points possible x 25 percent = weighted score)																
F_0 score	.28	.26	.35	.34	.24	.24	.43	.41	.40	.23	.20	.35	.35	.32	.28	.36

5. CONCLUSIONS, TASK IV

Systems' References 3, 4, 7, 8, 9, 12, 13, 14, and 16 rank significantly higher than other candidates for functional/operational adequacy (F_o).

It can be concluded that the highest ranking system only meets 43 percent of the actual functional requirements.

As the cost/effectiveness analysis proceeds, it is expected that the most acceptable system or systems will be more clearly indicated.

APPENDIX F

TASK V
COST EFFECTIVENESS MODEL

The objective is to define a recommended system with full consideration for concept integration, performance, and cost estimate. Required is a cost effectiveness evaluation of all candidates compared to an optimized set of requirements.

COST/EFFECTIVENESS

Cost/effectiveness analysis is normally defined as Life Cycle Costs in dollars, normalized for each of the candidate systems, divided by the effectiveness of a system; a qualitative assessment expressed in numerical terms.

COST

LCC includes cost of all elements pertaining to acquisition and use of candidate systems. Examples are development costs, system costs in production, installation costs, maintenance cost, training costs of personnel to be able to operate and maintain the system(s), logistics costs including system spares, utilization costs accumulated for support of the gunnery training program such as aircraft operating costs, school costs, salaries of personnel (both of operating personnel and students), costs of consumables used in training, etc. A typical analysis is shown in Equation (1).

$$LCC = \sum_{n=1}^{Y} K_d \left[(C_D + C_{INV} + C_{OPER}) \right]_n \qquad (1)$$

where:

LCC	=	Discounted life-cycle cost of candidate system throughout its operational lifetime, in dollars
K_d	=	Discount factor applied from base year
n	=	Index of years over which costs are accumulated
Y	=	Number of years over which candidate system life-cycle costs are accumulated
C_{RD}	=	Research and Development cost of candidate systems, in dollars
C_{INV}	=	Initial investment cost of candidate systems, in dollars
C_{OPER}	=	Annual operating cost of a candidate system in dollars

To construct a complete costs analysis of candidate scoring systems would require answers in the following specific parameters:

(1) Discounted life-cycle cost

(2) Discount factor applied from base year

(3) Number of years over which costs are accumulated

(4) Number of years life for each system

(5) Development cost of the system

(6) Initial investment cost of candidates

(7) Cost of operation (annual) for each system

(8) Cost of spares

(9) Number of military officers receiving training and average salaries plus allowances

(10) Number of aviation instructors required to conduct initial training on systems

(11) Duration of initial training session

(12) Number of students per class

(13) Number of classes per instructor

(14) Number of depot personnel requiring training

(15) Average salary plus allowances of depot personnel

(16) Estimate of time required to reach a prescribed level of training without system

(17) Estimate of time required to reach a prescribed level of training with candidates by candidate

(18) Estimate of R&D required to improve system to meet requirements

(19) Estimate of cost of ultimate system (in production)

(20) Estimate of annual savings in manpower through use of ultimate system

(21) Estimate of cost of spares in ultimate system

(22) Cost of aircraft operation/training period

(23) Cost of expendables/training period

(24) Cost of range operation per hour or per year

(25) Etc.

Answers to many of the questions on cost are not readily available and are beyond the scope of this contract to develop.

Therefore, the cost model will be constructed as follows. The candidate system normalized cost analysis in dollars will be constrained to cost per system in production (N_p) + development cost (if applicable) (N_d) + estimated annual maintenance cost (N_m) + estimated cost of installation (N_i) + estimated annual operating costs (N_o) for

$$\sum_{N=1}^{Y}$$

EFFECTIVENESS

Effectiveness is a figure of merit usually derived from a qualitative analysis expressed in numerical terms. Normally, a mathematical model is used for rating and ranking candidate systems. The model is constructed using identified critical parameters. In application, the end product achieved through intended use of scoring systems or methods is a level of proficiency (P_o) achieved by an individual student graded against a norm times the number of student(s) trained during the lifetime of the system for all candidate systems.

$$Eff = P_o N \tag{2}$$

The absolute value of P_o is currently poorly defined. Unit proficiency is likewise poorly defined and measured using current methods.

Some other method for evaluating "effectiveness" had to be determined during the course of this study. (For purposes of evaluation the proficiency term (P_o) is assumed to be uniform "student-for-student" and "unit-for-unit" at end of qualification <u>regardless of the scoring system or method used.</u>

The term N is also substituted.

Effectiveness for purposes of evaluation during this study will consider only F_o, A_o, U_o.

Functional operation adequacy (F_o) has been previously defined. Operational availability, A_o is defined as;

$$A_o = \frac{MTBF}{MTBF + MTTR + MLDT} \tag{3}$$

where

MTBF = Mean time between failures

MTTR = Mean time to repair

MLDT = Mean logistics downtime

The utilization factor (U_o) for the systems, is the yearly hours of use divided by annual range operating time in hours:

$$U_o = \frac{S_o}{R_o} \tag{4}$$

where

S_o = Estimated systems operational hours of use (potential)

R_o = Total range operational time (range availability)

The measure of effectiveness can now be expressed as:

$$Eff = F_o A_o U_o \tag{5}$$

SUBSTITUTED COST/EFFECTIVENESS MODEL

$$C/E = \sum_{N=1}^{Y} \left(\frac{N_p + N_d + N_m + N_i + N_o}{F_o A_o U_o} \right) \tag{6}$$

The lowest figure of C/E will have the highest figure of merit. In addition to the Cost/Effectiveness Analysis, completion of Task V will include preparation of a performance specification, cost estimates, and schedule base on utilization of "off-the-shelf" hardware.

Table 1 derived from Appendix J cost estimates provides a summary of estimated dollar values for the cost model;

$$\text{Cost} = \sum_{N=1}^{Y} (N_d + N_p + N_i + N_o + N_m) \qquad (7)$$

where y = 10 years for all systems. (Note: During analysis of systems costs in Appendix H candidates 1, 2, 3, 5, 6, 10, 11, 12, and 16 were eliminated.) Normalized values referenced to $1.00 are tabulated in the bottom column of Table 1.

Table 2 provides values of A_o for each candidate based on Equation (3). The term MTTR was redefined to Mean Time To Restore instead of the classical Mean Time To Repair, since it is meaningless to estimate repair on systems that have virtually no history of extended operational use. Conversely, it is reasonable to estimate restoration time for the same systems. A basic assumption in establishing values of A_o is that damaged modules replaced will not be repaired. (The cost of parts (modules) replaced is included in the cost analysis.)

Table 1
Cost Analysis

Candidates	No. 4	No. 7	No. 3	No. 9	No. 13	No. 14	No. 15
Development Cost (N_d)#	840,000	705,000	580,000	960,000	255,000	425,000	830,000
Production Cost (N_p)#	58,000	60,250	49,000	78,000	19,500	32,250	56,500
Installation Cost (N_i)#	3,500	250	5,750	250	250	250	5,750
Annual Operating Cost (N_o)#	8,000	8,000	8,000	8,000	8,000	8,000	8,000
Annual Maintenance Cost (N_m)#*	4,800 57,300	2,400 22,025	2,000 20,900	2,400 23,800	2,400 17,950	2,400 19,225	2,400 21,650
Estimated Cost Totals	80,950	42,000	39,275	46,825	31,600	35,000	42,425
Normalized Value	$8.10	$4.20	$3.93	$4.68	$3.16	$3.50	$4.24

\# Derived from Appendix H.

* Includes spares.

Table 2
Availability Analysis

Candidates	No. 4	No. 7	No. 8	No. 9	No. 13	No. 14	No. 15	
MTBF(1) Hours	1200	1200	1200	1200	1200	1200	1200	
*MTTR(2) Hours/Repair	52.0	13	13	13	13	13	26	One failure each 120 hours
MLDT(3) Man-hours/Year	26	26	0	26	26	26	0	
Total	1278	1239	1213	1239	1239	1239	1226	
$A_o = \left(\frac{MTBF}{MTBF + MTTR + MLDT}\right)$	.94	.86	.99	.86	.86	.86	.98	

* Mean time to replace. Assumes 26 failures per year.

The utilization factor - U_o - (Equation (4)) for each remaining candidate is shown in Table 3. Annual hours of useful service for each candidate are calculated based on total range time less the estimated time to start up and shut down the scoring system.

The yearly range operating time (3220 hours) assumes 5 days per week, 14 hours per day in two shifts, and 50 weeks per year less 250 hours for contingencies (lost time due to range operational problems).

Table 4 summarizes the cost/effectiveness model,

$$C/E = \sum_{N=1}^{N=10} \left(\frac{\text{Normalized Cost}}{F_o \cdot A_o \cdot U_o} \right)$$

for candidates 4, 7, 8, 9, 13, 14, and 15. The lowest "dollar" value is the most cost/effective system.

Table 3
Utilization Analysis

Candidates	No. 4	No. 7	No. 8	No. 9	No. 13	No. 14	No. 15
Annual Hours of Useful Service (assumes no failures) (S_o)	2600	2800	3000	2800	2800	2800	3000
Annual Range Operating Time (14 hours/day - 5 days/week - 50 weeks/year) (R_o)	3220	3220	3220	3229	3220	3220	3220
$U_o = \frac{S_o}{R_o}$	.75	.88	.93	.88	.88	.88	.93

Table 4
Cost/Effectiveness Summary

Candidates	No. 4	No. 7	No. 8	No. 9	No. 13	No. 14	No. 15
F_o From Table 1 - Appendix E	.34	.43	.41	.40	.35	.38	.28
A_o From Table 2 - Appendix G	.94	.86	.99	.86	.86	.86	.98
U_o From Table 3 - Appendix G	.75	.88	.93	.88	.88	.88	.93
Cost (normalized) From Table 1 - Appendix G	$8.10	$4.20	$3.93	$4.68	$3.16	$3.50	$4.24
Product of $F_o \cdot A_o \cdot U_o$	.24	.32	.38	.30	.26	.29	.25
C/E $= \frac{\text{Normalized Cost}}{F_o \cdot A_o \cdot U_o}$	$33.75	$13.12	$10.34	$15.60	$12.16	$12.06	$16.96

CONCLUSION

1. Candidate 8 at $10.34 is the best choice with candidate 14 at $12.06 following in second place. The separation between these two candidates is quite significant.

2. The effectiveness of candidate 8, currently configured, meets about 38 percent of the optimum systems effectiveness requirements. (Average = 29 percent.)

3. Selection of a system based on the combination of earliest capability and best cost/effectiveness would place the order of preference:

- Candidate 8 = best choice
- Candidate 14 = second best choice
- Candidate 13 = third best choice

APPENDIX G

NAVTRADEVCEN 69-C-0178-1

AGENDA

FIRST TECHNICAL REPORTING CONFERENCE

23 May 1969

Contract N61339-69-C-0178-1

Armed Aircraft Qualification Range Scoring System

I PROGRAM PLAN

Purpose of the Study

Tasks to be Accomplished

Program Schedule

II ACCOMPLISHMENTS DURING THE REPORT PERIOD

A. Requests for Technical Data from All Known Scoring System Manufacturers

B. Requests for Technical Document and Studies Relative to Scoring Systems

C. Field Visits to Military Installations

D. Completion of SDR Review (Task 1)

E. Started Preliminary Functional Analysis and Requirement Allocation Effort (Task 2)

F. Started Preliminary Identification, Analysis and Development of Applicable Off-the-Shelf Systems and State-of-Art Technology (Task 3)

III PROBLEM AREAS

A. Anticipate Problem in Obtaining In-Depth Information From Equipment/Component Manufacturers (Including Cost Ranges)

B. Input Data for Cost Effectiveness

IV WORK TO BE ACCOMPLISHED BEFORE NEXT TECHNICAL REPORTING CONFERENCE

A. Complete Tasks 2 and 3

B. Initiate Task 4

V WORK STATUS

Approximately 28% of work effort has been accomplished.

CA-134-69
WWB:mek
27 May, 1969

To: Department of the Navy
Naval Training Device Center
Orlando, Florida 32813

Attention: Mr. K. W. Peterson, Code 371
Project Engineer
Army Participation Group

Reference: Contract N61339-69-C-0178,
Armed Aircraft Qualification Range Scoring
System Study

Subject: First Technical Reporting Conference
23 May 1969

1. The first Technical Reporting Conference for the Armed Aircraft Qualification Range Scoring System Study was conducted at the Naval Training Device Center, Orlando, Florida, on 23 May 1969. The following personnel were in attendance:

	Mr. Paul S. Walker	- Army Participation Group, NTDC Code 381
	Mr. K. W. Peterson	- Project Engineer, NTDC Code 371
**	Mr. Art Drucker	- Contracting Officer, NTDC Code 1532
**	Lt.Col. Frank Miller	- Army Participation Group, NTDC Code 381
	Lt.Col. D.J. Palczynski	- DCSOPS-AVN, USCONARC
	Mr. John P. Ford	- Booz-Allen Applied Research, Los Angeles
	Mr. Wally Brondstatter	- Del Mar Engineering Labs., Los Angeles

** partial participation

NAVTRADEVCEN 69-C-0178-1

To: Naval Training Device Center
Orlando, Florida

CA-134-69
WWB:mck
27 May 1969
-2-

Attention: Mr. K. W. Peterson, Code 371

2. Transmitted herewith, in triplicate, are copies of the conference agenda and all information and back up material discussed. It is understood that this volume (in triplicate) is acceptable to NTDC and will serve as both the minutes of the conference and constitute the report for the First Technical Reporting Period. The major portion of the conference was devoted to a review of the Contractor's approach to the problem and his accomplishments to date. It was concluded that this effort is being performed in a satisfactory manner and in accordance with the contract schedule.

3. It is estimated that Tasks 2 and 3 will be completed, and Task 4 started, by mid-July. It is therefore recommended that the Second Technical Reporting Conference be scheduled for the week starting 14 July 1969.

DEL MAR ENGINEERING LABORATORIES

R. E. Denney

Enc: As noted

AGENDA

SECOND TECHNICAL REPORTING CONFERENCE

17 July 1969

Contract N61339-69-C-0178

ARMED AIRCRAFT QUALIFICATION RANGE SCORING SYSTEM

I PURPOSE AND REVIEW

II DESCRIPTION OF TASK #2 AND #3

III PROGRAM SCHEDULE

IV ACCOMPLISHMENTS DURING THE REPORT PERIOD

A. Analysis of System Functions - Task #2

B. Translation of Functions into Design Requirements - Task #2

C. Review of Documents, Studies, ATT, ATP, etc.

D. Review of Technical Data from Known Scoring System Manufacturers - Task #3

E. Analysis of Scoring Systems - Task #3 (Hardware in Comparison to Functional Requirements)

F. Initiate Task #4

V PROBLEM AREAS

A. Input Data f/Cost Effectiveness

B. Lack of Information from Some System Manufacturers

VI WORK TO BE ACCOMPLISHED BEFORE NEXT TRC

A. Complete Task #4

B. Initiate Task #5 & #7

VII WORK STATUS

Approximately 40% of the study effort has been accomplished with same percentage of man/hour expenditure.

CA-191-69
RED:bat
23 July 1969

To: Department of the Navy
Naval Training Device Center
Orlando, Florida 32813

Attention: Mr. K. W. Peterson, Code 371
Project Engineer
Army Participation Group

Reference: Contract N61339-69-C-0178
(Armed Aircraft Qualification Range
Scoring System Study)

Subject: Second Technical Reporting Conference, (TRC)
17 July 1969

1. The Second Technical Reporting Conference for the Armed Aircraft Qualification Range Scoring System Study was conducted at Los Angeles, California on 17 July 1969. The following personnel were in attendance:

Mr. Paul S. Walker	Army Participation Group, NTDC Code 381
Mr. K. W. Peterson	Project Engineer, NTDC Code 371
Mr. John P. Ford	Booz-Allen Applied Research, Los Angeles
Mr. Art Sullivan	Booz-Allen Applied Research, Los Angeles
Mr. Wally Brondstatter	Del Mar Engineering Labs., Los Angeles
Mr. John M. Hammond	Del Mar Engineering Labs., Los Angeles

2. Attached as Enclosure 1 is the Technical Reporting Conference Agenda covering topics which were discussed, and insert data for updating the TRC Manual. Item I of the Agenda covered the purpose of the conference and a review of what had been accomplished prior to the first TRC. Item II consisted of a description of Study Tasks #2 and #3, while Item III was a review of the program schedule. It was pointed out during this discussion that the program was on schedule, and that tasks were being

Naval Training Device Center
Orlando, Florida
Attention: Mr. K. W. Peterson

CA-191-69
23 July 1969
-2-

completed as planned. Item IV of the Agenda, "Accomplishments During the Report Period," was divided into six sub-items. Sub-items A and B concerned Task #2; sub-items C and D concerned the review of technical data and "off-the-shelf" scoring systems (Task #3); sub-item E was an analysis of "off-the-shelf" systems and a comparison of these systems to the optimum system's functional characteristics as determined in Task #2; sub-item F concerned work being done on Task #4.

3. During the discussion of Task #2 accomplishments, it was agreed that the contractor's development of functional requirements for the system was correct and that the results appeared adequate. A detailed write up of accomplishements for this task is furnished herewith and should be included as Tab VIII of the TRC Manual.

4. Discussions concerning the review of technical documents, ATPs, ATTs, etc., revealed that all technical information requested has been received and that no problem area exists. However, it was reported by the Contractor that information requested from manufacturers concerning "off-the-shelf" scoring systems, generally was incomplete, and that several manufacturers had not responded to the request for system specifications. The contractor informed Government representatives that a "second request" letter had been transmitted to these manufacturers. A copy of this letter is provided and should be included with Tab 4 of the TRC Manual.

5. In conjunction with the review of "off-the-shelf" scoring system specifications, mentioned above, an analysis was made of each system in terms of the functional characteristics of the Armed Aircraft Qualification Range Scoring System. Work-sheets and summaries prepared in conjunction with the review are furnished herewith for insertion as Tab IX to the TRC Manual. These worksheets and summaries will be used during the execution of Task #4.

6. The status of Task #4 accomplishments was discussed and the work reviewed. Details are furnished on Pages 23 through 45, Tab VIII of the TRC Manual.

7. Anticipated problem areas were discussed. These are: 1) cost effectiveness trade-offs and the lack of good information on level of proficiency on which to base a measure of performance; 2) a good definition of operational effectiveness of trainees and; 3) complete information on "off-the-shelf" hardware (vendor-supplied information). It was agreed that the contractor would make assumptions on performance and proficiency for the purpose of completing the cost effectiveness modeling. The basis for the assumptions are to be described in order to provide a measure of confidence level on accuracy of the estimates. When better information becomes available

Naval Training Device Center
Orlando, Florida
Attention: Mr. K. W. Peterson

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23 July 1969
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The Contractor will continue to attempt acquisition of more information from vendors on "off-the-shelf" hardware throughout the study program, up until conclusion of Task #4.

8. No exception to current program direction or results was taken by Government representatives. It was agreed to accept the Contracto's recommendations for

1. Separating the point weapon targets from area weapon targets during Individual Training.

2. Compression of maximum data rate for display, from rate of five (up to 24,000 RPM) to 1/4 second for reduced scoring rate.

3. Change of horizontal scoring plane (area weapons) from clock to quadrant and the reduction of 2 miss zones to 1 for over, short, left, or right, the latter for consistency with the vertical scoring plane (point weapon) requirement.

9. It was agreed that the Third Technical Reporting Conference would be held during the last week of August 1969, the date and place to be mutually agreed upon. The Contractor stated that by that time, Task #4 would be complete and that Tasks #5 and #7 would be well under way.

10. It was stated by the Contractor that it is estimated that the study is approximately 40% complete and that approximately 50% of the authorized man/hour effort had been expended.

11. This report is furnished to comply with the requirements set forth in Section "C", Item 2.d. of the referenced contract.

DEL MAR ENGINEERING LABORATORIES

R. E. Denney
Administrative Assistant

SECOND TECHNICAL REPORTING CONFERENCE (TRC)

17 JULY 1969

DEL MAR ENGINEERING LABORATORIES AND
BOOZ-ALLEN APPLIED RESEARCH INC.
LOS ANGELES, CALIFORNIA

ARMED AIRCRAFT QUALIFICATION RANGE SCORING SYSTEM

CONTRACT N61339-69-C-0178
DATED 24 APRIL 1969

DEL MAR ENGINEERING LABORATORIES
BOOZ-ALLEN APPLIED RESEARCH INC.

AGENDA

SECOND TECHNICAL REPORTING CONFERENCE

17 JULY 1969

I PURPOSE & REVIEW

II DESCRIPTION of TASK 2 & 3

III PROGRAM SCHEDULE

IV ACCOMPLISHMENTS DURING THE REPORT PERIOD

A. Analysis of System Functions-Task #2.
B. Translation of Functions into Design Requirements - Task #2.
C. Review of Technical Data from known scoring system mfgs. Task #3.
D. Analysis of Scoring Systems-Task #3. (Hardware in comparison to functional req's.)
E. Review of Documents, Studies, ATT, ATP, etc.
F. Initiate Task #4

V PROBLEM AREAS

A. Input Data f/Cost Effectiveness
B. Lack of Information from Some System Manufacturers.

VI WORK to be ACCOMPLISHED BEFORE NEXT TRC

A. Complete Task #4
B. Initiate Task #5 & #7

VII WORK STATUS

Approximately 40% of the Study effort has been accomplished with some percentage of man/hour expenditure.

PURPOSE

The purpose of the study is to establish the requirements and to determine technical feasibility, economic and military considerations for the development of an ARMED AIRCRAFT QUALIFICATION SCORING SYSTEM.

The study will result in the preparation of a CONCEPT FORMULATION REPORT and a SYSTEM PERFORMANCE SPECIFICATION.

PROGRAM TASKS

1 SDR Review and updating.
2 System functional analysis.
3 Summarize 'Off-the-shelf' systems and State-of-art technology.
4 'Trade-off' studies of hardware.
5 Prepare recommended scoring system performance specifications.
6 Determine future development requirements (if any).
7 Prepare CONCEPT FORMULATION REPORT.
8 Conduct Technical Reporting Conferences.

TASK-2

OBJECTIVE:

Develop System Functional Analysis & Requirements Allocation

MAJOR AREAS TO BE CONSIDERED:

Hierarchy of Importance.
Operational Requirements.
Functional Constraints

TASK 3

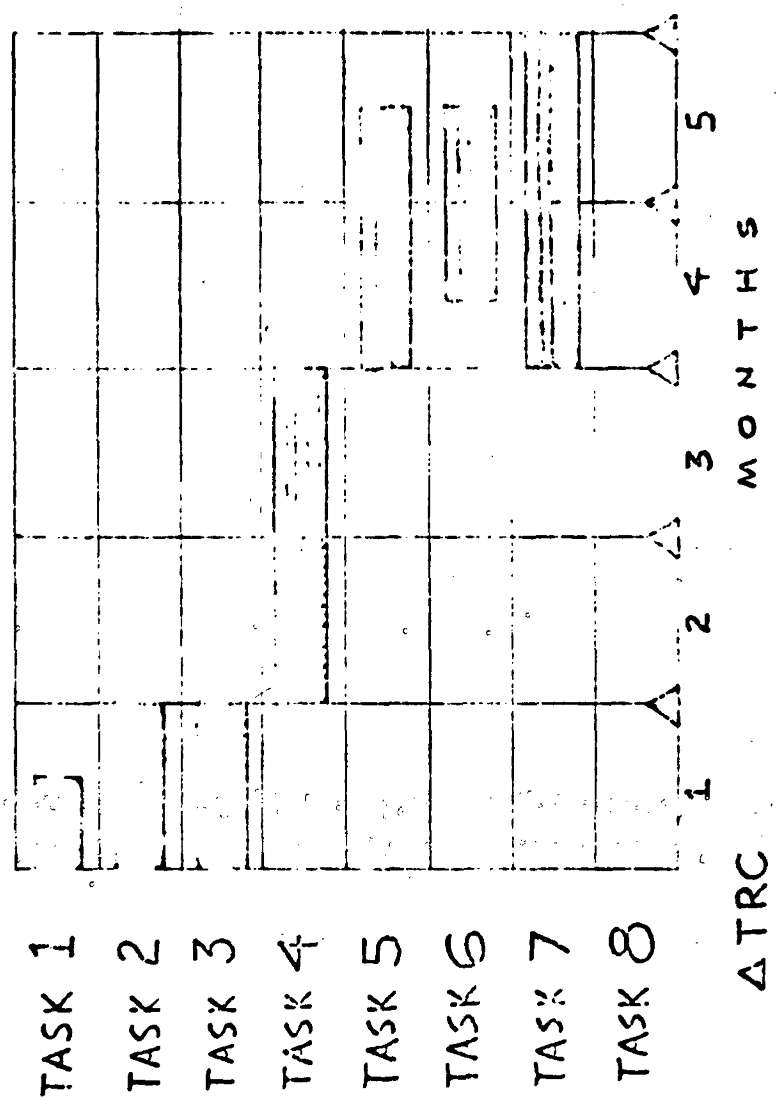
OBJECTIVE:

Identify, analyze and develop Technical Summary of 'Off-the-Shelf' systems and 'State-of-Art' technology.
(Joint Task - DM/BAAR Inc)

The three major areas to be considered are:

Hit Detection
Data Transmission
Display (Information Retrieval)

PROGRAM SCHEDULE

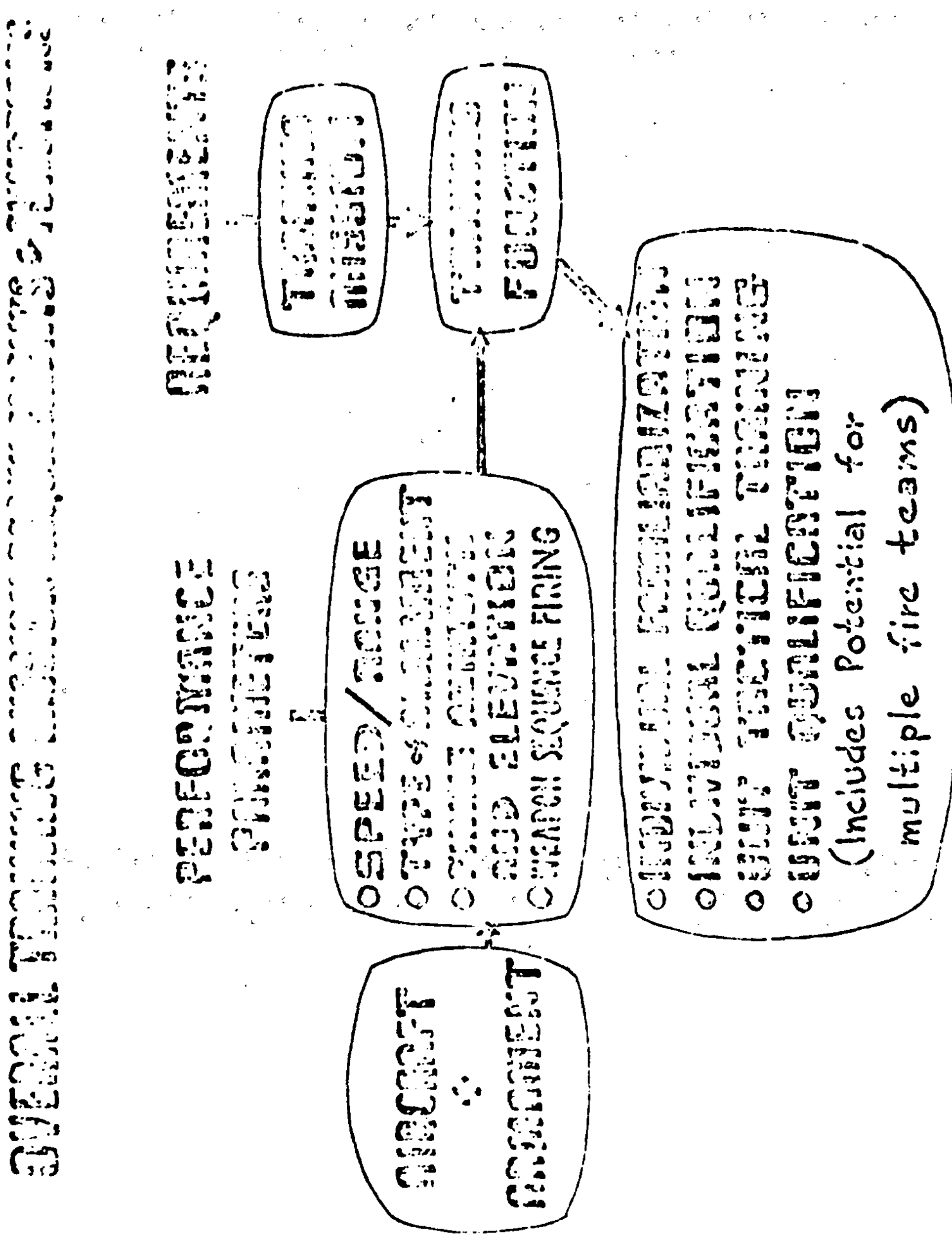


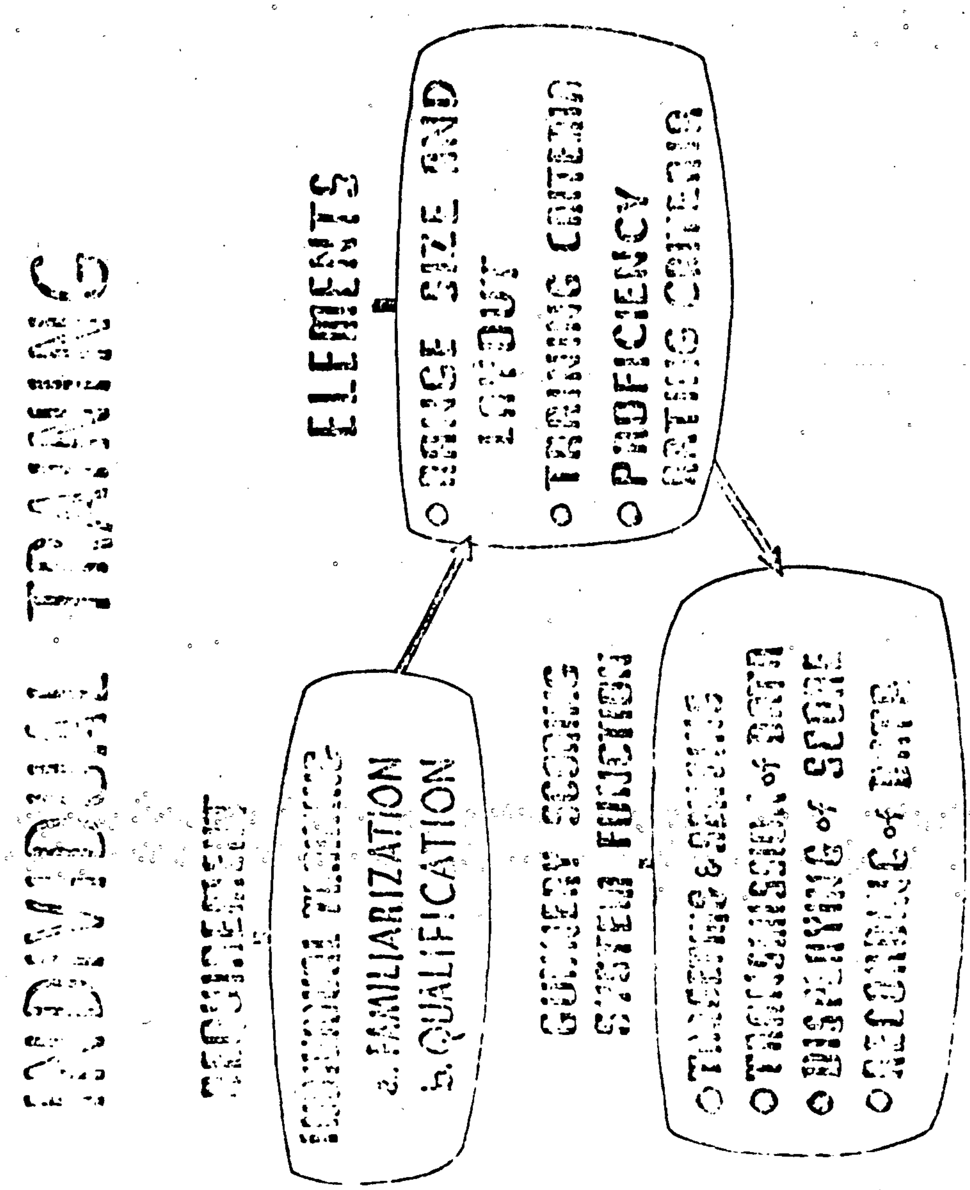
TASK 2 Starts with

- Statement of Requirement developed in TASK 1 (SDR)

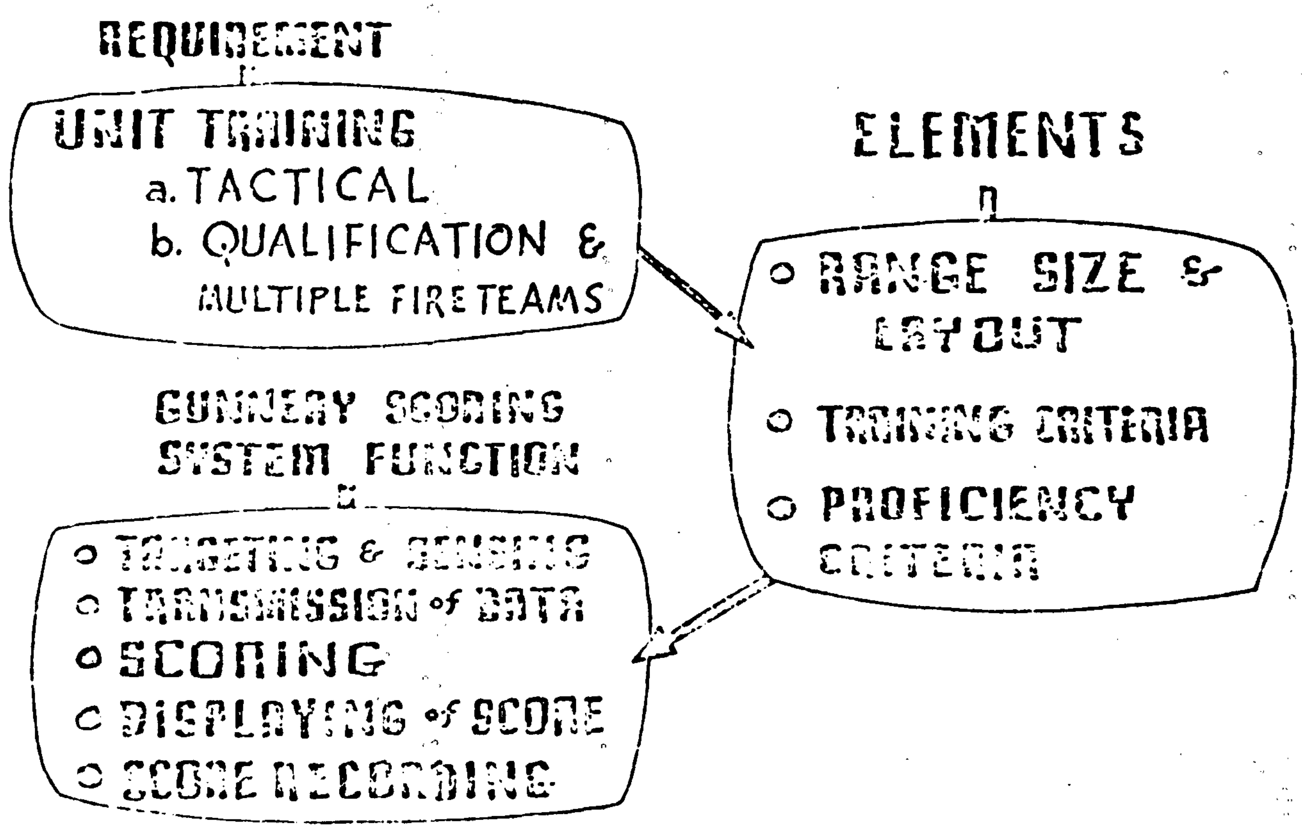
Leads to

- Operational Function of the System


PERFORMANCE
AIRCRAFT
ARMAMENT
SPEED/RANGE
AND ELEVATION
WEAPON SEQUENCE FIRING
INDIVIDUAL QUALIFICATION
UNIT TACTICAL TRAINING
UNIT QUALIFICATION
(Includes Potential for multiple fire teams)

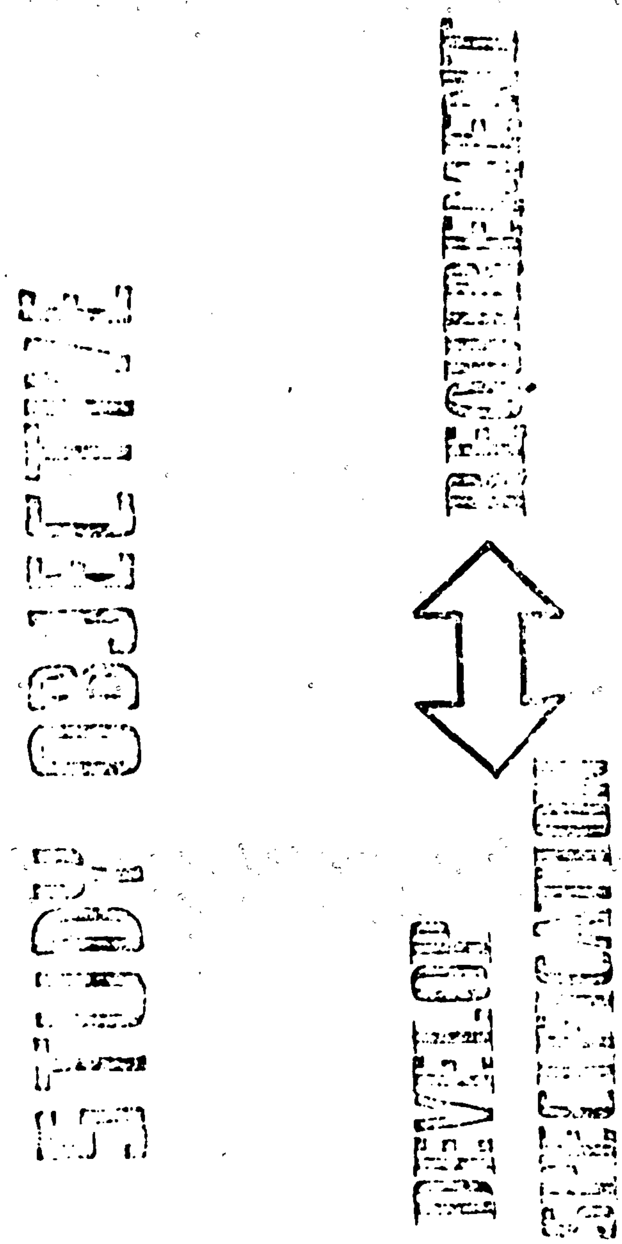

INDIVIDUAL TRAINING
REQUIREMENT
a. FAMILIARIZATION
b. QUALIFICATION
ELEMENTS
o RANGE SIZE AND LAYOUT
o TRAINING CRITERIA
o PROFICIENCY RATING CRITERIA
GUNNERY SCORING SYSTEM FUNCTION
o TARGETING & SENSING
o TRANSMISSION of DATA
o DISPLAYING of SCORE
o RECORDING of DATA

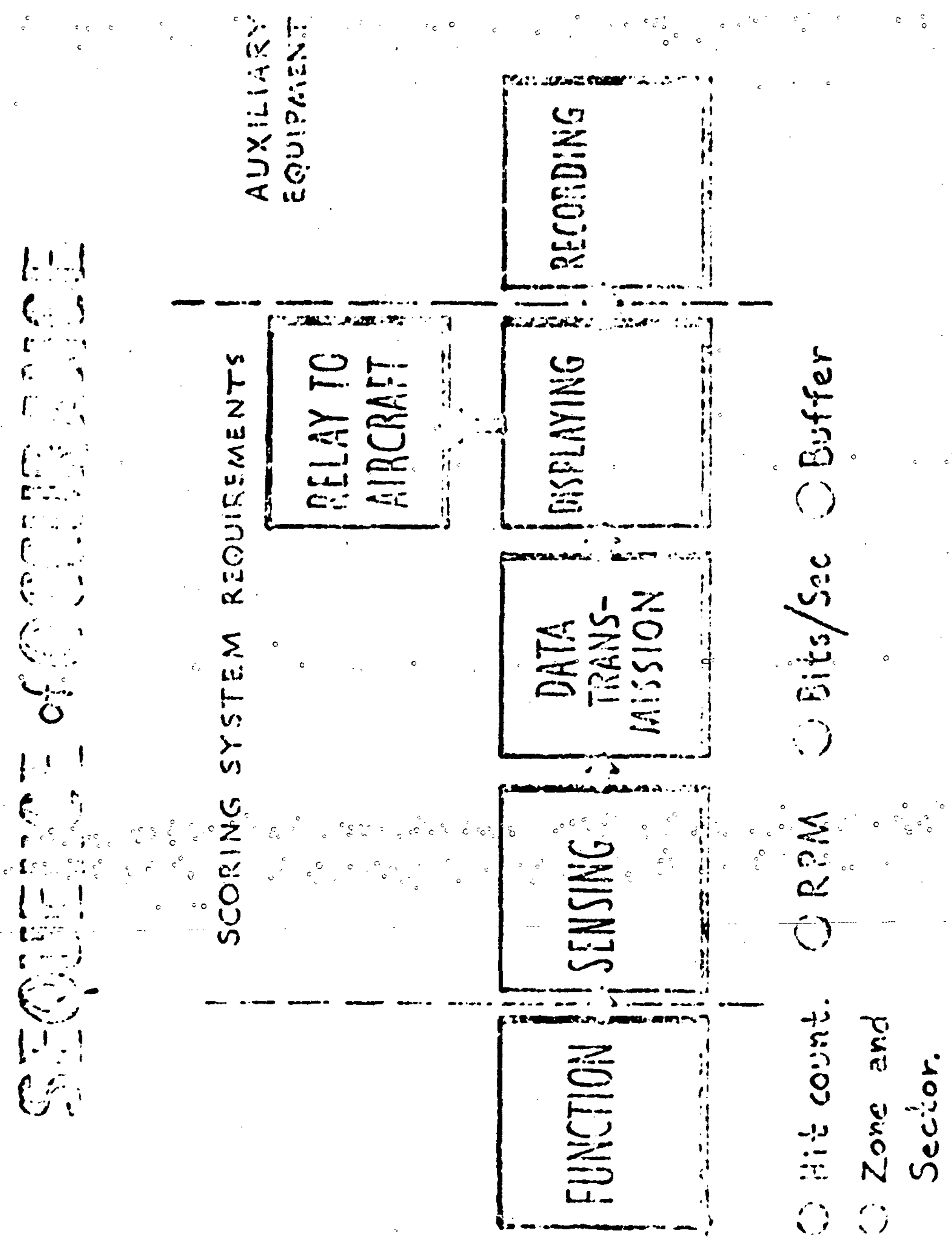
UNIT TRAINING



SCORING SYSTEM FUNCTIONS
HIERARCHY of IMPORTANCE

LEVEL 1	SENSING HITS	SCORING ○ HITS VERSUS ROUNDS FIRED ○ AIMING POINT	DISPLAYING
LEVEL 2	MISS DISTANCE r/θ BY ZONE		
LEVEL 3	DATA TRANSFORMATION ○ SORTING OF ORDNANCE ○ SORTING OF FIRING A/C	DATA TRANSMISSION ○ RATE ○ METHOD ○ FORMAT	DATA RECORDING ○ INFORMATION STORAGE & RETRIEVAL


STUDY OBJECTIVE
REQUIREMENT
DEVELOP SPECIFICATION


SCORING SYSTEM REQUIREMENTS
AUXILIARY EQUIPMENT
FUNCTION
SENSING
DATA TRANSMISSION
RELAY TO AIRCRAFT
DISPLAYING
RECORDING
Hit count.
Zone and Sector.
RPM
Bits/Sec
Buffer

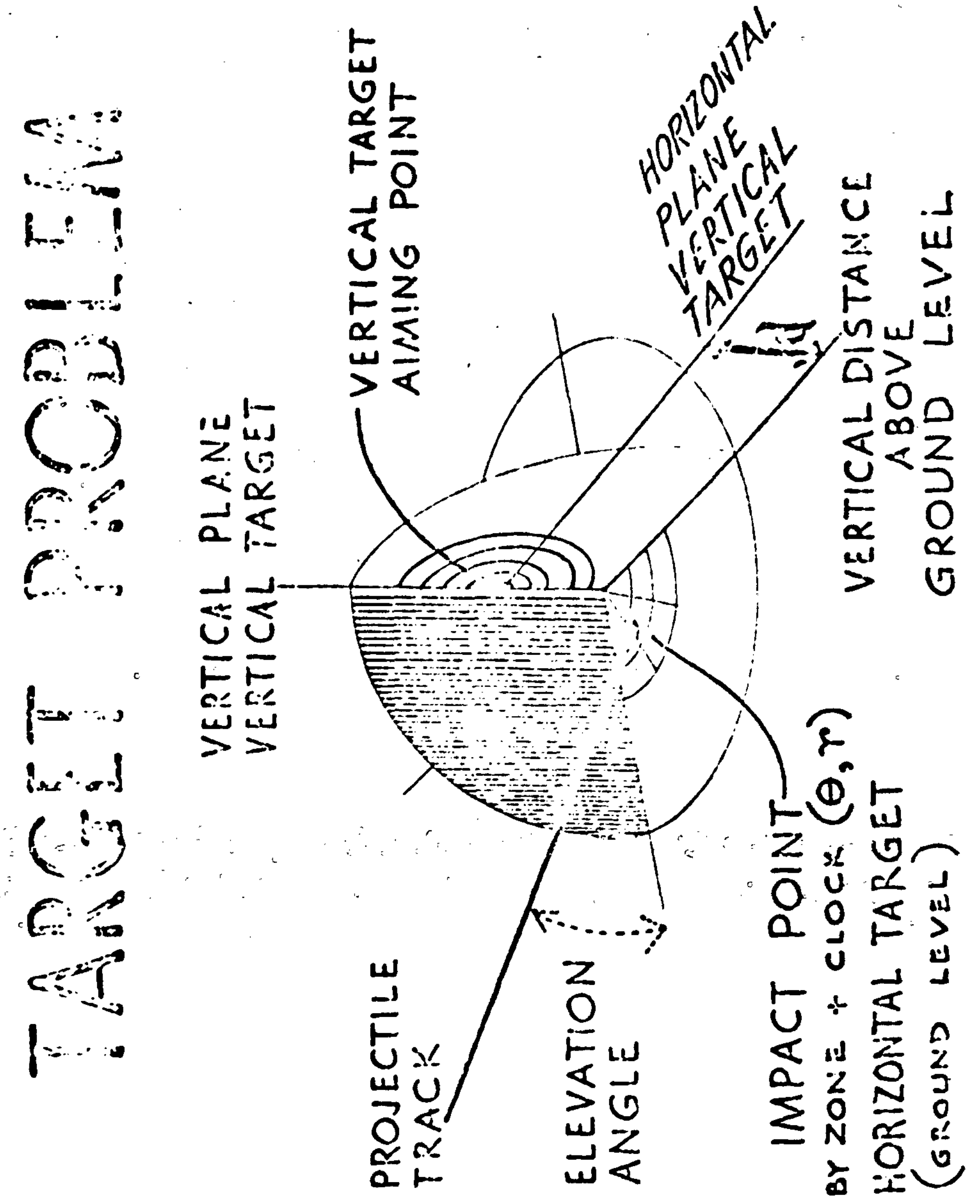
WORK ACCOMPLISHED during TASK 2

CRITICAL PARAMETERS & FUNCTIONAL DESIGN REQUIREMENTS have been established for each SUB SYSTEM:

- TARGETS
  - INDIVIDUAL TRAINING
  - UNIT TRAINING
- SENSING
- DATA CONVERSION
- DATA TRANSMISSION
  - TARGET TO CONTROL
  - CONTROL TO AIRCRAFT
- DISPLAY
  - CONTROL
  - AIRCRAFT
- RECORDING

TARGET COVERAGE

- ASSUMES A POINT OF AIM ± 45° FORWARD DIRECTION + GROUND IMPACT (AREA) FOR INDIVIDUAL TRAINING
- ASSUMES A SIMULATED REALISTIC TARGET UP TO 360° FOR POINT WEAPONS + 360° GROUND IMPACT FOR AREA WEAPONS FOR UNIT TRAINING
- ASSUMES 0° to 80° DIVE ANGLE FOR ALL TARGETS


TARGET PROBLEM
VERTICAL PLANE VERTICAL TARGET
VERTICAL TARGET AIMING POINT
HORIZONTAL PLANE VERTICAL TARGET
VERTICAL DISTANCE ABOVE GROUND LEVEL
PROJECTILE TRACK
ELEVATION ANGLE
IMPACT POINT BY ZONE + CLOCK (θ, r)
HORIZONTAL TARGET (GROUND LEVEL)

TARGETS for INDIVIDUAL and UNIT training

ROUNT	TYPE	ORDNANCE SELECTION
[illegible] :	REALISTIC	POINT WEAPONS → [illegible] ETC
		AREA WEAPONS → PERSONNEL ETC
INDIVIDUAL:	POINT OF AIM	POINT WEAPONS → VERTICAL PLANE SCORING
		AREA WEAPONS → HORIZONTAL PLANE SCORING

- RECOMMEND SEPARATION of POINT and AREA WEAPON TARGETS for INDIVIDUAL TRAINING AS WELL AS UNIT TRAINING
- 4 AREA WEAPON AIMING POINT TARGETS + 2 POINT WEAPON AIMING POINT TARGETS per RANGE (IT)

SENSING PLANE + AREA

REQUESTED

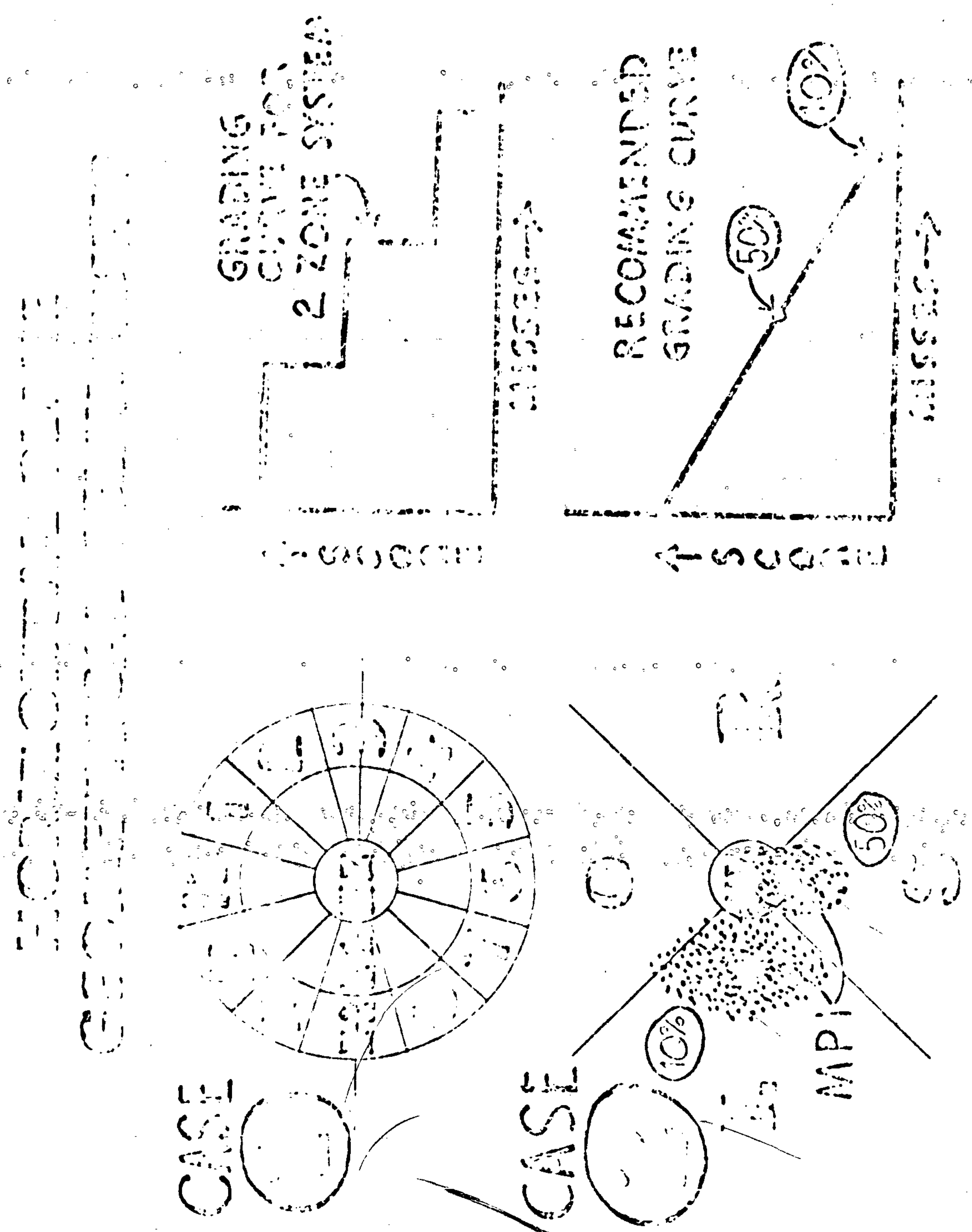
(1)

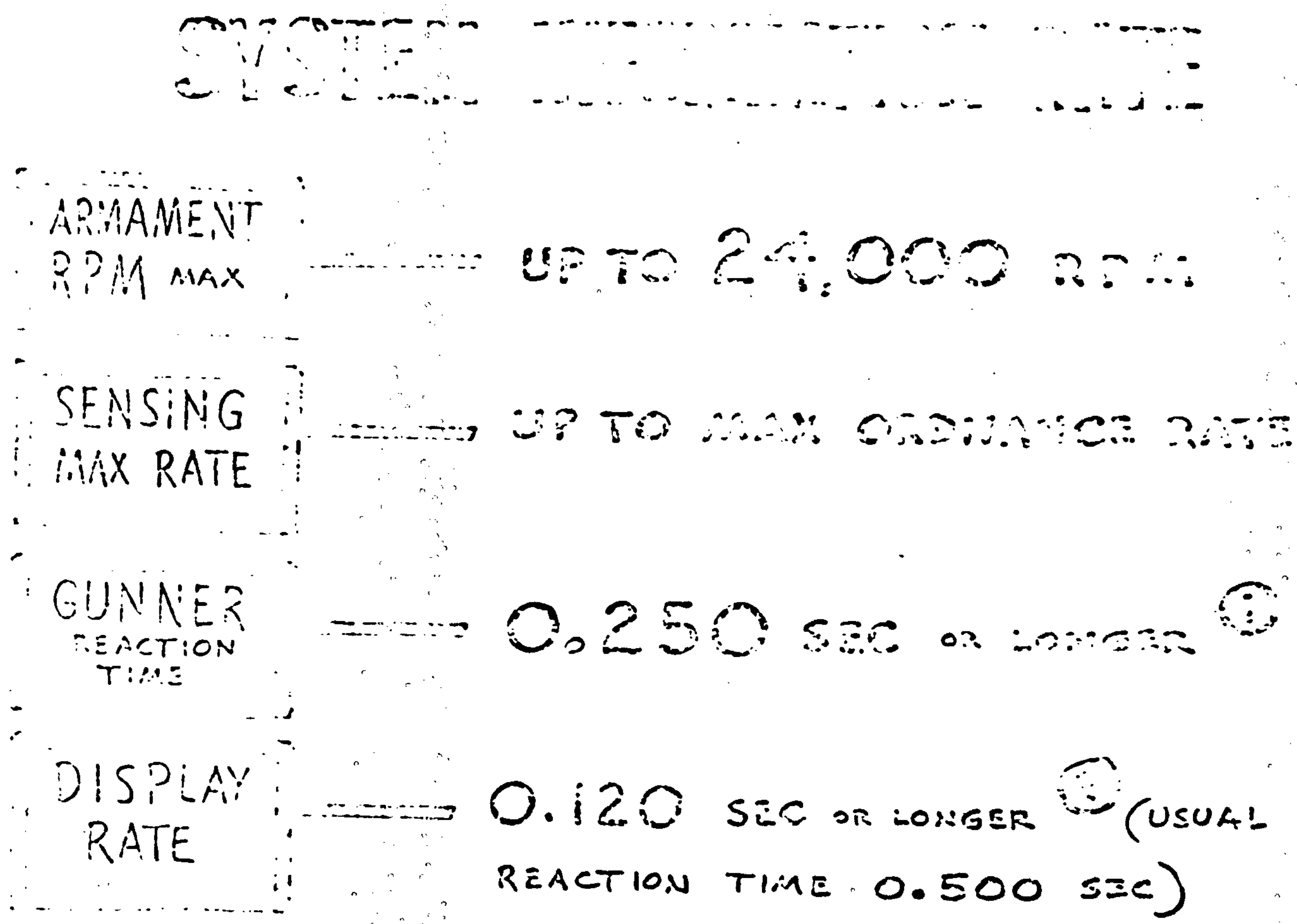
- POINT WEAPONS — HIT AREA + OVER-SHORT; L-R
- AREA WEAPONS — HIT AREA + CLOCK for MPI + 2 ZONES

[illegible]DED

(2)

- POINT WEAPONS — VERTICAL PLANE; HIT AREA + OVER-SHORT; L-R
- AREA WEAPONS — HORIZONTAL PLANE; HIT AREA + OVER-SHORT; L-R

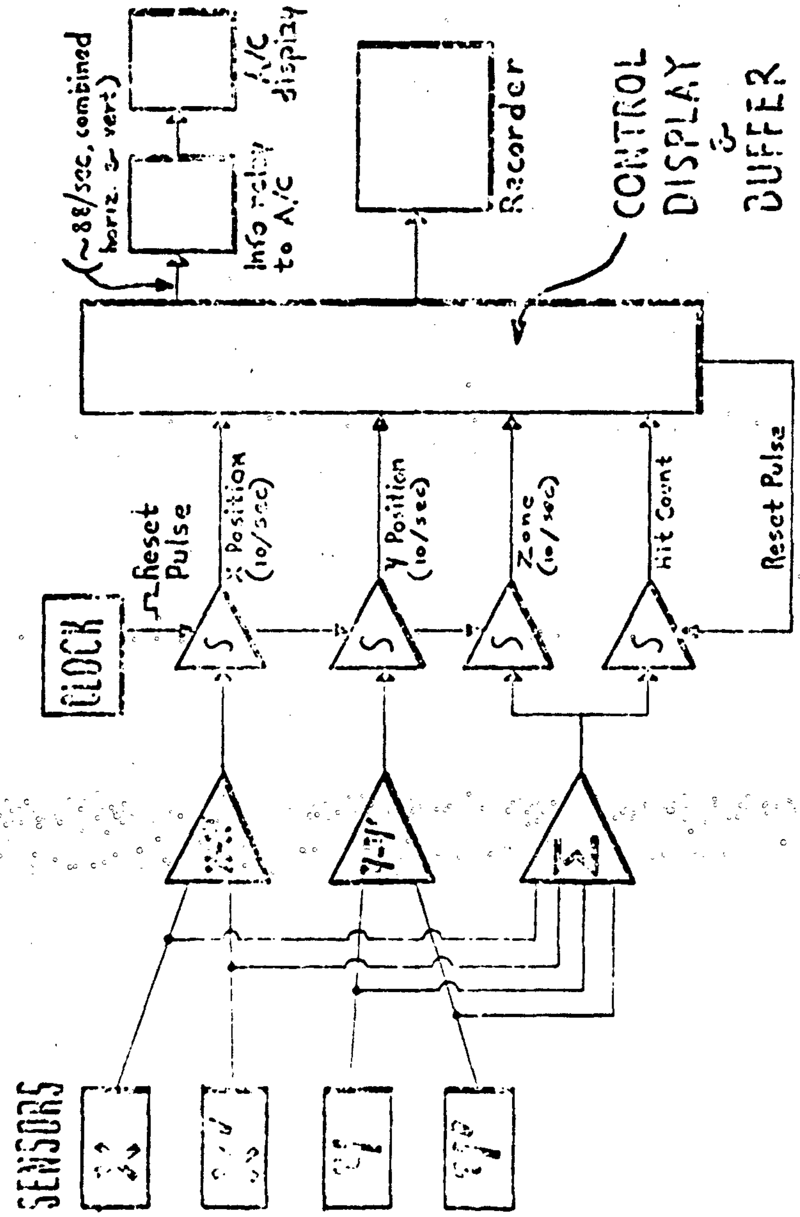

2 ZONE SYSTEM
RECOMMENDED
GRADING CURVE
50%
10%
CASE
CASE
MPI



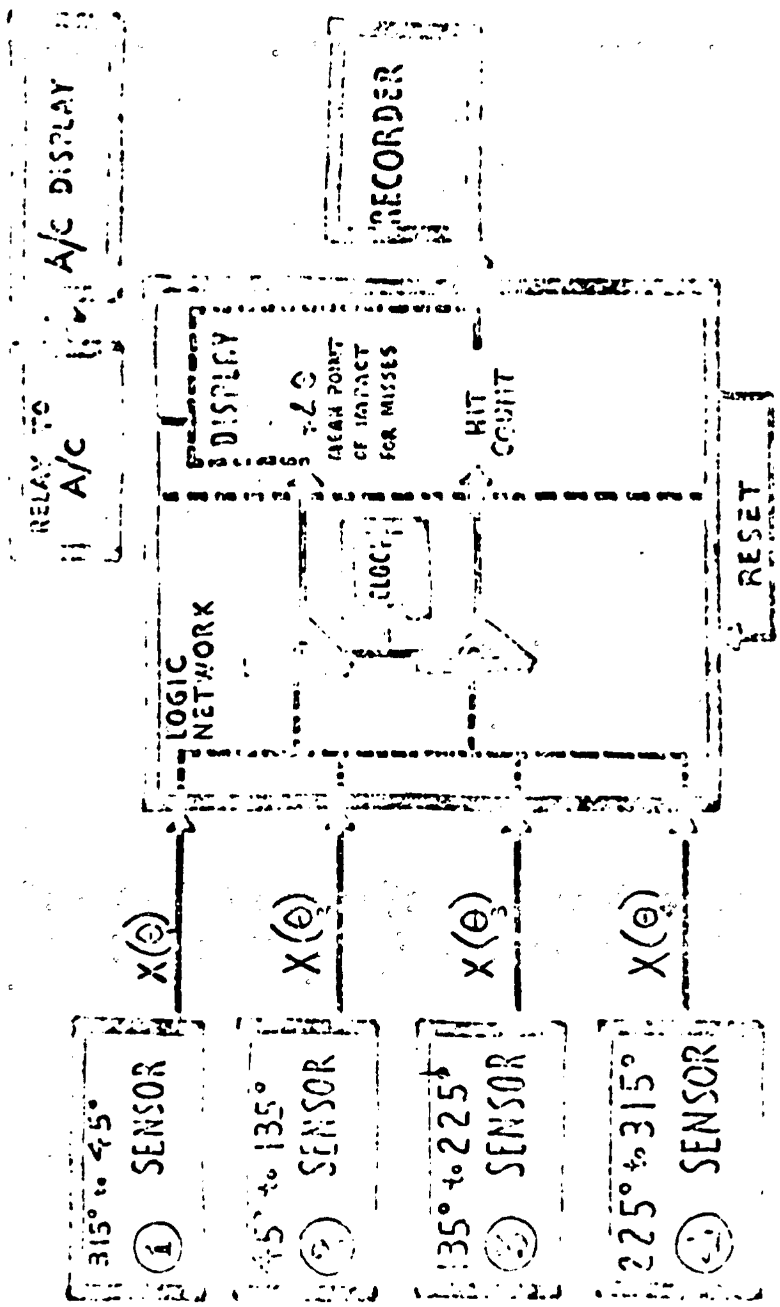
(1) SLOWEST INFORMATION RATE IN SYSTEM

(2) FASTEST SINGLE FUNCTION/DISPLAY RATE FOR USABLE INFORMATION (FASTER DISPLAYS WILL BE INTEGRATED BY OBSERVER)

EXAMPLE OF A CONCEPTUAL INFORMATION FLOW DIAGRAM



EXAMPLE OF AN ALTERNATE FLOW DIAGRAM



TASK 3

REVIEW of DOCUMENTS and PERTINANT INFORMATION.

REVIEW of MANUFACTURERS SPECIFICATIONS.

ANALYSIS of EACH SYSTEM VS AAQRSS REQUIREMENTS (TAB IX)

ANTICIPATED PROBLEM AREAS

COST EFFECTIVENESS - DUE TO LACK OF A PRECISE METHOD FOR MEASUREMENT OF PROFICIENCY

CURRENT UNIT TRAINING IN THE U.S. PROVIDES VERY LITTLE TO MEASURE EFFECTIVENESS AGAINST

LACK OF INFORMATION FROM SOME SYSTEM MANUFACTURERS

IDENTIFIED CRITERIA TO BE USED IN COST EFFECTIVENESS ANALYSIS

- SPEED & ACCURACY of SCORING SYSTEMS & METHODS; CURRENT & PROJECTED VS INITIAL & CONTINUING INVESTMENTS.
- REDUCTION IN RANGE PERSONNEL & SERVICES REQUIRED FOR SCORING
- PROJECTED REDUCTION IN TIME & MATERIAL CONSUMED IN ANNUAL OR PERIODIC UNIT REQUALIFICATION
- TIME & COST of TRAINING INDIVIDUALS & UNITS TO PRESCRIBED LEVELS OF PROFICIENCY

NAVTRADEVCEN 69-C-0178-1

AGENDA

THIRD TECHNICAL REPORTING CONFERENCE

23-24 September 1969

Contract N61339-69-C-0178

ARMED AIRCRAFT QUALIFICATION RANGE SCORING SYSTEM

I PROGRAM PLAN

Purpose of Meeting

Program Schedule

II ACCOMPLISHMENTS DURING THE REPORT PERIOD

A. Completion of Task 4 (Trade-Off Summaries)

B. Initiation of Task 5 (Draft Performance Specification)

C. Initiation of Task 7 (Draft Concept Formulation Report)

III PROBLEM AREAS

A. Input Data for Cost Effectiveness

B. Lack of Information for Some System Manufacturers

IV WORK YET TO BE ACCOMPLISHED

Complete Tasks 5, 6, & 7

V WORK STATUS

Approximately 75% of the Study Effort has been accomplished.

CA-251-69
RMD:bat
14 October 1969

To: Department of the Navy
Naval Training Device Center
Orlando, Florida 32813

Attention: Mr. K. W. Peterson, Code 371
Project Engineer
Army Participation Group

Reference: Contract N61339-69-C-0178
(Armed Aircraft Qualification Range
Scoring System Study)

Subject: Third Technical Reporting Conference, (TRC)
23 - 24 September 1969

1. The third Technical Reporting Conference for the Armed Aircraft Qualification Range Scoring System Study was conducted at the Contractor's facility at Los Angeles, California, on 23 24 September 1969. The following personnel were in attendance:

Mr. Paul S. Walker	Army Participation Group, NTDC Code 381
Mr. K. W. Peterson	Project Engineer, NTDC Code 371
Captain Robert N. Franklin	U. S. Army Armor School, Weapons Dept. Fort Knox, Kentucky
Mr. John P. Ford	Booz-Allen Applied Research, Los Angeles
Mr. Wally Brondstatter	Del Mar Engineering Labs., Los Angeles
Mr. John M. Hammond	Del Mar Engineering Labs., Los Angeles
Mr. O. B. Lolraugh	Del Mar Engineering Labs., Los Angeles

2. Attached as Enclosure 1 is the Technical Reporting Conference Agenda covering topics which were discussed. The initial portion of the conference consisted of a presentation by the Contractor of all agenda items. Following this, Government representatives reviewed and prepared informal questions on all data prepared by the Contractor during the report period. The final portion of the conference included a review of the Government representatives'

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comments and a critique of the Contractor's accomplishments, approval of his approaches to the various study problems and answers by the Contractor to all questions generated by the Government's representatives. Item I of the Agenda reviewed the purpose of the conference and summarized all that had been accomplished prior to the commencement of this reporting period. The program schedule was reviewed and reasons for a four weeks' slippage in the contract schedule were discussed. It was mutually agreed between Contractor and Government Representatives to submit to the Contracting Officer a letter request for an extension of one month to the contract schedule. Agenda Item II, "Accomplishments During the Report Period", was divided into three sub-items. Sub-item "A" concerned completion of Task 4, "Candidate System Trade-Off Summaries"; sub-item "B" concerned the initiation of Task 5, "Preparation of the Ultimate Scoring System Performance Specification", and sub-item "C" represented a summary of progress to date on "The Concept Formulation Report", Task 7.

3. Included herewith as Enclosure 2 is a summary of the Contractor's Task 4 activities and accomplishments. It was concluded that the Contractor's efforts and methods used in the scoring system trade-off analysis were acceptable, and that the ratings assigned each of the sixteen candidate hardware systems were appropriate to essential functional system requirements. The system awarded the highest score meets less than 50% of the essential requirements for an idealized range scoring system.

4. A draft specification for the idealized range scoring system was presented by the Contractor (Task 5). The specification includes all the essential functional scoring system requirements which were developed during Tasks 1 and 2. Government representatives expressed satisfaction with the scope, content, and format of the draft specification, suggesting, however, that a more specific delineation of system characteristics be incorporated. The Contractor agreed to incorporate the suggestions made during the critique portion of the conference. A copy of the draft specification is attached herewith as Enclosure 3. The preparation of a cost effectiveness study is required to complete Task 5. Since neither operational nor specific hardware acquisition cost data is available, a cost model was constructed and presented at the conference. It was agreed that this model should be used in the Contractor's cost effectiveness effort. This model and other rationale is provided as Enclosure 4.

5. The Contractor initiated work on Task 7, ("The Concept Formulation Report"), during the report period, but this obviously cannot be finalized until all study tasks are completed. A copy of this draft report is furnished herewith as Enclosure 5. It was mutually agreed that NTDC would not furnish a "Foreword" to this report and consequently will be omitted by the Contractor.

Naval Training Device Center
Attn: Mr. K. W. Peterson, Code 371

CA-251-69
14 October 1969
-3-

6. It was reported by the Contractor that the problem areas reported during the Second Technical Reporting Conference still exist, namely, lack of data for a complete cost effectiveness effort and lack of complete information from scoring system manufacturers. It was also reported by the Contractor that approximately 75% of the study effort was complete. Work yet to be accomplished includes completion of Tasks 5, 6, and 7.

7. This report is furnished to comply with the requirements set forth in Section "C", Item 2d of the reference contract; submittal of this report satisfies completion of Item 2 of the reference contract.

DEL MAR ENGINEERING LABORATORIES

R. E. Denney
Administrative Assistant

Enclosures: As Noted

APPENDIX H

DEVELOPMENTAL ENGINEERING

1. Purpose. The purpose of this report is to determine the amount and type of development engineering effort and an estimated cost to update all candidate "off-the-shelf" scoring systems to meet the idealized system's functional requirements. This determination is limited to state-of-the-art technology and the development will not require invention or scientific advances to achieve.

2. General. In study tasks 3 and 4 it was ascertained that each of the candidate "off-the-shelf" scoring systems were functionally inadequate and none met all the requirements of the idealized system specification. Attached as Tables 2 through 17 are individual developmental estimates for each candidate system showing elapsed development time and cost of the effort required to optimize each approach as well as estimated recurring maintenance and operations expenses.

3. Cost Estimating Methodology. To develop a method of estimating additional development and estimated production costs for candidate systems without attempting to forecast individual company development costs, a standardized method of cost estimating was used.

A new percentage figure was derived for each candidate system by taking the weighted score for each system less the points for the airborne data link, and data recording capabilities, as these would have to be developed by each candidate system manufacturer.

A development ratio factor was then generated by using the inverse square of the percentage figure.

All candidates who had a new percentage figure of below 50% were eliminated on the basis of excessive development, this also tended to eliminate unsuitable systems.

Development ratio factors then ranged from a low of 1.4 to a high of 2.78.

Times factor of 20 is the ratio of production to development cost, based on previous hardware development experience.

Development costs were then estimated as:

Existing production costs times 20 times development ratio factor.

Production costs were then estimated as:

$$\frac{\text{Development cost}}{20} + \text{original production cost.}$$

Table 1 shows cost estimation data generated during costing effort.

Development costs were amortized over 20 systems for 10 years for the cost analysis.

Candidate 3 was not included in the cost estimates due to lack of any pricing data.

Candidates 12 and 15 were eliminated on the basis that a pure hit panel system would be unsuitable for development due to the large scoring areas involved, and replacement costs.

Candidate No.	Modified Weighted Score	Modified %	Development Ratio	Existing Production Costs	Development Costs	Estimated Production Costs
4	40/77	52	2.63	$16,000	$840,000	$58,000
7	61/77	79	1.41	$25,000	$705,000	$60,250
8	60/77	78	1.45	$20,000	$580,000	$49,000
9	56/77	73	1.59	$30,000	$960,000	$78,000
13	50/77	65	1.93	$ 6,750	$255,000	$19,500
14	51/77	66	1.85	$11,000	$425,000	$32,250
15	39/77	50	2.78	$15,000	$830,000	$56,500

COST ESTIMATING DATA

TABLE 1

COST WORKSHEET

APPROACH NO. 1

ELECTRONIC SCORING SYSTEM, MODEL 800B

BABCOCK ELECTRONICS CORPORATION

This Electromagnetic Pulse-Doppler Scoring System was designed primarily for use with airborne targets and has been produced for the U. S. Army and Air Force. Although the scoring principles used in this system could satisfy a number of the functional requirements of the Armed Aircraft Qualification Range Scoring System, limitations in the following areas have been defined:

Scoring Radius: Limited to 50 feet

Accuracy: Adequate only with large caliber weapons

Two square feet radar cross section or more

Caliber/Type Weapon: No capability with 5.56 or 7.62mm

Vector: No vector information provided

Data Display: No real-time-hit, miss and vector data displayed

Malfunction/Damage Alarm: None

Development Cost Estimate $ N/A

Elapsed Development Time ________ Months

Exceptions: None

Note: Eliminated as candidate due to low functional performance.

System life cycle N/A years

ESTIMATES	
ITEM	COST
Production	N/A
Installation	N/A
Annual Maintenance	N/A
Annual Operation	N/A
Annual Spares	N/A

TABLE 2

COST WORKSHEET

APPROACH NO. 2

PERSONNEL TARGET SCORING SYSTEM

BABCOCK ELECTRONICS CORPORATION

This system which is under development for the U. S. Army is designed to sense misses of projectiles from flechette to 40mm in size and the point-of-impact for 40mm grenades surrounding a personnel type target. Application of this system to the functional requirements of the Armed Aircraft Qualification Range Scoring System leaves deficiencies in the following general areas:

Scoring Radius: Limited to 20 meters

Accuracy: Unstated (developmental system)

Caliber/Type Weapons: Limited to projectiles 5.56 to 40mm

Data Display: No real time display of hit-miss or vector data

Vector: No vector data provided

Malfunction/Damage Alarm: None

Development Cost Estimate $ N/A

Elapsed Development Time ______ Months

Exceptions: None

Note: Eliminated as candidate due to low functional performance and lack of cost information.

System Life Cycle N/A Years

ESTIMATES	
ITEM	COST
Production	N/A
Installation	N/A
Annual Maintenance	N/A
Annual Operation	N/A
Annual Spares	N/A

TABLE 3

COST WORKSHEET

APPROACH NO. 3

MISS DISTANCE ACOUSTIC DETECTOR

SFENA MODEL MAE 12B

This acoustic (amplitude) system was designed primarily for use with aerial targets and has been in use by the French Air Force and Army for several years. The principles of operation and scoring methods used are adaptable to the Armed Aircraft Qualification Range Scoring System but in many regards are not compatible with its functional requirements. The major diversions are as follows:

Scoring Rate: Not stated

Scoring Radius: Limited to 4.5m

Accuracy: Not stated

Caliber/Type Weapon: Used with 50 caliber and 30mm only (super-sonic)

Vector: No vector information provided

Number of Targets per System: Limited to 1 target per system

Simultaneous Multiple Type Weapons: Limited to 1 type of weapons

Development Cost Estimate $ N/A

Elapsed Development Time N/A Months

Exceptions: None

Note: Eliminated as candidate due to low functional performance and lack of cost data.

System Life Cycle N/A Years

ESTIMATES

ITEM	COST
Production	N/A
Installation	N/A
Annual Maintenance	N/A
Annual Operation	N/A
Annual Spares	N/A

TABLE 4

COST WORKSHEET

APPROACH NO. 4

RADAR SCORING SYSTEM MODEL RASCORE-S

SANDERS ASSOCIATES, INC.

This electromagnetic scoring system is designed for air-to-ground strafing use. It is based on the pulsed doppler radar principle, amplitude intensity. When applied to the functional requirements of the Armed Aircraft Qualification Range Scoring System, some significant diversions are observed and follow:

Scoring Radius: Limited to 20 feet

Caliber/Type Weapons: 7.62mm to 40mm only

Zone/Vector: Single Zone/no vector

Vert/Horiz Plane: Vertical only (point weapons)

Ammo Characteristics: Inert only

Data Trans Range: 1 mile

Dive Angle: Limited to between 5° and 15°

Approach Azimuth: 15° - 0° - 15°

Vulnerability: Due to bulk of sensing hardware, down range equipment must be protected.

Malfunction/Damage Alarm: None

Development Cost Estimate $ 840,000.00

Elapsed Development Time Est. 22 Months

Exceptions: None

System Life Cycle 10 Years

ESTIMATES	
ITEM	COST
Production	$58,000.00
Installation	3,500.00
Annual Maintenance	4,800.00
Annual Operation	8,000.00
Annual Spares	57,800.00

TABLE 5

COST WORKSHEET

APPROACH NO. 5

RADAR SCORING SYSTEM, MODEL RASCORE AP

SANDERS ASSOCIATES INC.

This electromagnetic scoring system was designed for use with a single personnel type target. It is based on the pulsed doppler radar principle, amplitude intensity. This system's characteristics, when applied to the functional requirements of the Armed Aircraft Qualification Range Scoring System are inconsistent in many respects. Major inconsistencies are as follows:

Scoring Radius: Limited to 4 meters

Caliber/Type Weapons: Limited to 5.56mm to 50 caliber

Zone Vector: No vector data provided

Horizontal/Vertical Plane: Half hemisphere only each plane

Data Display: No special display for real time readout

Approach Azimuth: 0° - 180°

Malfunction/Damage Alarm: None

MTBF: 100 hours

Development Cost Estimate $ N/A

Elapsed Development Time N/A Months

Exceptions: None

Note: Eliminated as candidate due to low functional performance.

System Life Cycle N/A Years

ESTIMATES	
ITEM	COST
Production	N/A
Installation	N/A
Annual Maintenance	N/A
Annual Operation	N/A
Annual Spares	N/A

TABLE 6

COST WORKSHEET

APPROACH NO. 6

RADAR SCORING SYSTEM, MODEL RASCORE-M

SANDERS ASSOCIATES, INC.

This electromagnetic scoring system was designed for use in either an air-to-air or a ground-to-air application. It gives continuous miss distance scale data and is based on the pulsed doppler correlation radar principle using pseudo-random coded phase reversal modulation techniques. Primary intended use is with missiles having a reasonable large radar cross section. The characteristics of this system when correlated with the functional requirements of the Armed Aircraft Qualification Range Scoring System reveals that some essential qualities are lacking, namely:

Scoring Rate: Approximately 860 RPM

Caliber/Type Weapon: Only missiles with 2 square feet radar reflectivity

Zone/Vector: No zone, no vector data

Malfunction/Damage Alarm: None

MTBF: 100 hours

Development Cost Estimate $ N/A

Elapsed Development Time N/A Months

Exceptions: None

Note: Eliminated as candidate due to low functional performance.

System Life Cycle N/A Years

ESTIMATES

ITEM	COST
Production	N/A
Installation	N/A
Annual Maintenance	N/A
Annual Operation	N/A
Annual Spares	N/A

TABLE 7

COST WORKSHEET

APPROACH NO. 7

ACOUSTIC SCORING SYSTEM, MODEL DA-3F

DEL MAR ENGINEERING LABORATORIES

This acoustic (amplitude) scoring system is in wide use by U. S. Navy and Air Force as an air-to-ground strafing/gunnery trainer. When comparing the operational characteristics of this system to the functional requirements of the Armed Aircraft Qualification Range Scoring System, the following inadequacies have been noted:

Scoring Rate: Presently limited to 10,000 RPM

Scoring Radius: Presently limited to 15m

Zone/Vector: No multiple zone - no vector data

No. of Targets per System: Limited to 1 f/simultaneous scoring

Simultaneous Multiple Type Weapons: One caliber/type at a time

MTBF: 700 hours

Data Recording: No provision for

Development Cost Estimate: $ 705,000

Elapsed Development Time 12 Months

Exceptions: None

System Life Cycle 10 Years

ESTIMATES

ITEM	COST
Production	$ 60,250
Installation	250
Annual Maintenance	2,400
Annual Operation	8,000
Annual Spares	22,025

TABLE 8

COST WORKSHEET

APPROACH NO. 8

ACOUSTIC SCORING SYSTEM, MODEL DA-3E

DEL MAR ENGINEERING LABORATORIES

This fixed accustic (amplitude) scoring system is in use at helicopter training school of the U. S. Army for air-to-ground gunnery qualification. A comparison of the operational characteristics of this system with the functional requirements of the Armed Aircraft Qualification Range Scoring System reveals that it meets all requirements except the following:

Scoring Rate: Up to 6000 RPM

Transmission Range: Up to 10,000M (Wire)

Data Display: No vector

MTBF: 700 hours

Zone/Vector: Partial vector (Combination of 2 or more sensors)

Development Cost Estimate $ 580,000

Elapsed Development Time 12-1/2 Months

Exceptions: None

System Life Cycle 10 Years

ESTIMATES	
ITEM	COST
Production	$49,000
Installation	5,750
Annual Maintenance	2,000
Annual Operation	8,000
Annual Spares	20,900

TABLE 9

COST WORKSHEET

APPROACH NO. 9

ACOUSTIC SCORING SYSTEM, MODEL DA-3/A

DEL MAR ENGINEERING LABORATORIES

This acoustic (amplitude) scoring system used by the U. S. Army for weapons system evaluation and possible training mission application. It was designed primarily for air-to-ground (helicopter) gunnery scorings. When comparing the operating characteristics of this system with the functional requirements of the Armed Aircraft Qualification Range Scoring System, limitations have been defined in the following areas:

Scoring Rate: 6000 RPM

Zone & Vector: No vector information data

Simultaneous Multi-Weapon: One type ammo at a time

MTBF: 700 hours

Malfunction/Damage Alarm: None

Development Cost Estimate $ 960,000

Elapsed Development Time Est. 19 Months

Exceptions: None

System Life Cycle 10 Years

ESTIMATES

ITEM	COST
Production	$78,000
Installation	250
Annual Maintenance	2,400
Annual Operation	8,000
Annual Spares	23,800

TABLE 10

COST WORKSHEET

APPROACH NO. 10

ACOUSTIC & VIBRATION SCORING SYSTEM DA-2

DEL MAR ENGINEERING LABORATORIES

This scoring system was designed to collect both hit and miss distance data from personnel type targets when fired on with small arms (5.56mm, 7.62mm and flechette) and to collect zones miss data when fired on by 40mm grenades.

Scoring Rate: 12,000 RPM-Hit, 6000 RPM-Miss, 500 RPM-Grenade

Scoring Radius: 0 - 2 meters

Caliber/Type Weapon: Small arms & 40mm Grenade

Transmission Range: 10,000 feet

Data Display: Computer inputs

MTBF: 500 hours

Attack Azimuth: Hit count panel: 0° - 60°

All others: 360°

Malfunction/Damage Alarm: None

Development Cost Estimate $ N/A

Elapsed Development Time N/A Months

Exceptions: None

Note: Eliminated as candidate due to low functional performance and lack of accurate cost information.

System Life Cycle N/A Years

ESTIMATES

ITEM	COST
Production	N/A
Installation	N/A
Annual Maintenance	N/A
Annual Operation	N/A
Annual Spares	N/A

TABLE 11

COST WORKSHEET

APPROACH NO. 11

HIT SENSITIVE PANEL TARGET SYSTEM, X3A109/1

DEL MAR ENGINEERING LABORATORIES

This hit panel type scoring system was designed primarily for use on tank gunnery ranges in both a stationary and mobile configurations. Comparing the characteristics and capabilities of this system to the functional requirements of the Armed Aircraft Qualification Range Scoring System, it is evident that the following areas are not fulfilled:

Scoring Rate: 60 RPM

Scoring Radius: Dependent on panel size

Zone/Vector: Neither is furnished

Data Transmission: Wire

Data Display: None

Dive Angle: 0 - 60°

Approach Azimuth: ± 60°

Malfunction/Damage Alarm: None

Development Cost Estimate $ N/A

Elapsed Development Time N/A Months

Exceptions: None

Note: Eliminated as candidate due to low functional performance and lack of production cost information.

System Life Cycle N/A Years

ESTIMATES

ITEM	COST
Production	N/A
Installation	N/A
Annual Maintenance	N/A
Annual Operation	N/A
Annual Spares	N/A

TABLE 12

COST WORKSHEET

APPROACH NO. 12

HIT PANEL SCORING SYSTEM, MODEL BT-14

SAAB AKTIEBOLAG (SWEDEN)

This hit panel type scoring system was designed for use by strafing aircraft during individual training. A comparison of this system's characteristics with the functional requirements of the Armed Aircraft Qualification Range Scoring System results in the following discrepancies:

Scoring Rate: 9000 RPM

Caliber/Type Weapon: 7.62 - 40mm

Zone/Vector: No zone, no vector

Scoring Radius: 20 feet

Data Transmission Range: 1000M (Wire)

Data Recording: No provisions

Portability: Fixed

Dive Angle: 10° - 30°

Approach Azimuth: ± 30

Malfunction/Damage Alarm: None

Development Cost Estimate $ N/A

Elapsed Development Time N/A Months

Exceptions: None

Note: Eliminated as candidate due to not being capable of meeting scoring radius requirements even with development.

System Life Cycle N/A Years

ESTIMATES	
ITEM	COST
Production	N/A
Installation	N/A
Annual Maintenance	N/A
Annual Operation	N/A
Annual Spares	N/A

TABLE 13

COST WORKSHEET

APPROACH NO. 13

ACOUSTIC (AMPLITUDE) SCORING SYSTEM, MODEL BT-23

SAAB-LULCW (SWEDEN)

This acoustic (amplitude) scoring system was designed for use with aerial targets. A comparison of this system's characteristics with the functional requirements of the Armed Aircraft Qualification Range Scoring System results in the following discrepancies:

Scoring Rate: Up to 9000 RPM

Zone/Vector: No vector data obtained

Simultaneous Multiple Weapons: One type/caliber weapon at a time

MTBF: Not stated

Malfunction/Damage Alarm: None

Development Cost Estimate $ 255,000

Elapsed Development Time Est. 23 Months

Exceptions: None

System Life Cycle 10 Years

ESTIMATES

ITEM	COST
Production	$19,500
Installation	250
Annual Maintenance	2,400
Annual Operation	8,000
Annual Spares	17,950

TABLE 14

COST WORKSHEET

APPROACH NO. 14

ACOUSTIC (AMPLITUDE) SCORING SYSTEM, MODEL AS-100

AERONIC AB (SWEDEN)

This acoustic (amplitude) scoring system was designed for use with aerial targets. As in all acoustic (amplitude) scoring systems, a number of the requirements can be satisfied, but when the system's characteristics are compared to the functional requirements of the Armed Aircraft Qualification Range Scoring System, the following limitations are apparent:

Scoring Rate: 2000 RPM

Scoring Radius: 2 - 20M

Accuracy: < 90%

Zone/Vector: 12 zones - 4 sector under development

Scoring Charts: Supersonic only (no HE or subsonic)

MTBF: Not stated

Malfunction/Damage Alarm: None

No. of Targets per System: Limited to 1 target per system

Simultaneous Multiple Type Weapons: Limited to 1 type of weapon

Development Cost Estimate $ 425,000

Elapsed Development Time Est. 22 Months

Exceptions: None

System Life Cycle 10 Years

ESTIMATES

ITEM	COST
Production	$32,250
Installation	250
Annual Maintenance	2,400
Annual Operation	8,000
Annual Spares	19,225

TABLE 15

COST WORKSHEET

APPROACH NO. 15

ACOUSTIC (AMPLITUDE) SCORING SYSTEM MODEL MAE-14

SFENA (FRANCE)

This fixed acoustic scoring system was designed for air-to-ground gunnery scoring using the amplitude principle. It has been used by the French Air Force in aerial gunnery training. When comparing the characteristics of this system to the functional requirements of the Armed Aircraft Qualification Range Scoring System, the following essential elements are,

Scoring Rate: 8000 RPM

Scoring Radius: 10M

Zone/Vector: No vector data furnished

Type/Caliber: Up to 30mm

Simultaneous Multiple Type Weapons: One caliber at a time

Data Transmission: Wire only, no TM

Attack Azimuth: ± 20°

Dive Angle: 10 ± 5°

Malfunction/Damage Alarm: None

No. of Targets per System: Limited to 1 target

Data Recording: No provisions

Development Cost Estimate $ 830,000

Elapsed Development Time Est. 33 Months

Exceptions: None

System Life Cycle 10 Years

ESTIMATES

ITEM	COST
Production	$56,500
Installation	5,750
Annual Maintenance	2,400
Annual Operation	8,000
Annual Spares	21,650

TABLE 16

COST WORKSHEET

APPROACH NO. 16

HIT SKIN SCORING SYSTEM, MODEL VTS-RJM-1

JOANELL LABORATORIES INC.

This fixed hit scoring system was designed to be used in training tank gunnery techniques for the U. S. Army. When comparing the characteristics of this system to the functional requirements of the Armed Aircraft Qualification Range Scoring System, the following limitations are apparent:

Scoring Rate: 10,000 RPM

Scoring Radius: Limited to panel size

Zone/Vector: None provided

Data Transmission: 149/150 MHz TM

Display: No vector or miss

Malfunction/Damage Alarm: None

Miss Data: None

Development Cost Estimate $ N/A

Elapsed Development Time N/A Months

Exceptions: None

Note: Eliminated as candidate due to not being capable of meeting scoring radius requirements even with development.

System Life Cycle N/A Years

ESTIMATES	
ITEM	COST
Production	N/A
Installation	N/A
Annual Maintenance	N/A
Annual Operation	N/A
Annual Spares	N/A

TABLE 17

Naval Training Device Center, Orlando, Florida

NAVTRADEVCEN 69-C-0178-1 UNCLASSIFIED

AD________

REPORT ON RESULTS OF CONCEPT FORMULATION ACTIVITIES FOR AN ARMED AIRCRAFT QUALIFICATION RANGE SCORING SYSTEM. FINAL REPORT. 1969, 240 p, illus., 23 tables, 52 charts, 54 refs.

This study determined the technical feasibility and optimum design analysis for an Armed Aircraft Qualification Range Scoring System in accordance with Concept Formulation outlined in AMCR 70-30 and system requirements outlined in a Small Development Requirement (SDR).

After an intensive review and analysis of the SDR Requirements had been completed, a detailed investigation was conducted of all available "OFF-THE-SHELF" scoring systems. A "Trade-Off" analysis was made of the characteristics of each of these systems versus the requirements outlined for the optimum scoring system developed by the revised SDR. A cost effectiveness effort was completed, an Operational Specification was written, and a Concept Formulation Report was prepared. The report concluded than an off-the-shelf scoring system using acoustic sensing principles be further developed to meet the functional requirements of the optimum system in order to satisfy armed aircraft gunnery scoring requirements of the 1970 to 1975 time frame.

DESCRIPTORS

Scoring Systems

Naval Training Device Center, Orlando, Florida

NAVTRADEVCEN 69-C-0178-1 UNCLASSIFIED

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DESCRIPTORS

Scoring Systems

Naval Training Device Center, Orlando, Florida

NAVTRADEVCEN 69-C-0178-1 UNCLASSIFIED AD______

REPORT ON RESULTS OF CONCEPT FORMULATION ACTIVITIES FOR AN ARMED AIRCRAFT QUALIFICATION RANGE SCORING SYSTEM. FINAL REPORT. 1969, 240 p, 3 illus., 23 tables, 52 charts, 54 refs.

This study determined the technical feasibility and optimum design analysis for an Armed Aircraft Qualification Range Scoring System in accordance with Concept Formulation outlined in AMCP 70-30 and system requirements outlined in a Small Development Requirement (SDR).

After an intensive review and analysis of the SDR Requirements had been completed, a detailed investigation was conducted of all available "OFF-THE-SHELF" scoring systems. A "Trade-Off" analysis was made of the characteristics of each of these systems versus the requirements outlined for the optimum scoring system developed by the revised SDR. A cost effectiveness effort was completed, an Operational Specification was written, and a Concept Formulation Report was prepared. The report concluded than an off-the-shelf scoring system using acoustic sensing principles be further developed to meet the functional requirements of the optimum system in order to satisfy armed aircraft gunnery scoring requirements of the 1970 to 1975 time frame.

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Aerial gunnery
Gunnery training
Ranges (Facilities)
Instrumentation
Armed aircraft qualification range scoring system
Acoustic scoring system

Del Mar Engineering Laboratories
Los Angeles, Calif. and
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13. ABSTRACT
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