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ABSTRACT

The annotated bibliography presents technical reports and other publications on research conducted by the Advanced Systems Division. The materials cover the period March 1973-December 1974. Also included are reports published prior to March 1973 which were approved for public release during this period. The bibliography supplements the Annotated Bibliography of the Advanced Systems Division Reports (1950-1972). The citations are arranged chronologically by year and alphabetically by author within the year. The subjects covered include the following: guides, handbooks, and summaries; human resources engineering; simulation techniques; professional training; aircrew training and evaluation; technical training and evaluation; job performance aids; and training and learning. The indexes include an author, category, and abstract number index; a subject index; and a technical report index. Except for journal articles, microfiche and reproduced paper copies of the annotated materials may be purchased from the National Technical Information Service (NTIS), Springfield, Virginia 22161. (Author/EC)

AFHRL-TR-75-12

AIR FORCE

HUMAN RESOURCES

LABORATORY

ANNOTATED BIBLIOGRAPHY OF THE ADVANCED SYSTEMS DIVISION REPORTS (1973 – 1974)

Compiled by

Helen E. Lebkisher

ADVANCED SYSTEMS DIVISION
Wright-Patterson Air Force Base, Ohio 45433

August 1975

Iterim Report for Period March 1973 – December 1974

AIR FORCE SYSTEMS COMMAND
BROOKS AIR FORCE BASE, TEXAS 78235

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This bibliography was submitted by Advanced Systems Division, Air Force Human Resources Laboratory, Wright-Patterson Air Force Base, Ohio 45433, under project 1710, with Hq Air Force Human Resources Laboratory (AFSC), Brooks Air Force Base, Texas 78235.

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This technical report has been reviewed and is approved.

GORDON A. ECKSTRAND, Director
Advanced Systems Division

Approved for publication.

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Commander

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This bibliography presents an unclassifed, unlimited, annotated bibliography of technical reports and other publications on research conducted by the Advanced Systems Division, Air Force Human Resources Laboratory (AFHRL). The cited references cover the period March 1973 through December 1974. Also included are references of reports published prior to March 1973 which were approved for public release during this period. This report supplements Annotated Bibliography of the Advanced Systems Division Reports (1950–1972), AFHRL-TR-72-43, March 1973, AD-760 114.

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PREFACE

The Advanced Systems Division contributes to the development of advanced Air Force systems and operations through research and development on training equipment engineering, training, performance evaluation, job performance aids, and the relationship of human resources to the system development process. Provides technical assistance in these areas in support of studies, analyses, development planning activities, acquisition, test, evaluation, modification or operation of aerospace systems and related equipment.

This report presents an unclassified, unlimited, annotated bibliography of technical reports and other publications on research conducted by the Advanced Systems Division, Air Force Human Resources Laboratory (AFHRL). The cited references cover the period March 1973 through December 1974. Also included are references of reports published prior to March 1973 which were approved for public release during this period. This report supplements Annotated Bibliography of the Advanced Systems Division Reports (1950-1972), AFHRL-TR-72-43, March 1973, AD-760 114. The citations in this bibliography are arranged chronologically by year and alphabetically by author within the year. Three indexes are included: (1) the Author, Category, and Abstract Number Index, (2) the Subject Index, and (3) the Technical Report Index.

Dr. Ross L. Morgan assigned the abstracts to the various categories.

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ANNOTATED BIBLIOGRAPHY OF THE
ADVANCED SYSTEMS DIVISION REPORTS
(1973 - 1974)

ABSTRACTS FOR 1969

1. A'Hearn, F., Daniel, J.N., Enright, C.S., Giggey, F.W., Torr, D.V., & Zappala, A.G. The System Life Cycle: A Defense Weapon System Scenario Simulation Model. AFHRL-TR-69-10, April 1969. AD-878 577.

   In order to provide a learning aid with which students in the Defense Weapon System Management Center could gain experience in a wide variety of decisions in various interrelated functional areas throughout a weapon system life cycle, a simulation model was formulated. This simulation consists of a life cycle scenario for a fictitious "Conqueror" surface to surface missile system, with manual and computer assisted student exercises at 35 critical decision points. These exercises cover the full range of functional areas and program phasing, and are keyed to material and decision techniques covered in concurrent classroom instruction. The student receives a "school solution," in terms of the next increment of the scenario, at the conclusion of each exercise. The scenario and exercise outlines have been completed. Recommendations for the preparation of detailed supporting material for each exercise and certain unique software are included so that the simulation may be used in the training of weapon system managers.

2. Askren, W.B., & Newton, R.R. Review and Analysis of Personnel Subsystem Test and Evaluation Literature. AFHRL-TR-68-7, January 1969. AD-859 300.

   This report reviews and analyzes 95 documents related to Personnel Subsystem Test and Evaluation. The reports are divided into two groups: (1) system tests and (2) related research material. Each report is abstracted and then analyzed further in terms of 11 categories: a. Scope and Relation to Personnel Subsystem Elements; b. Test Objectives; c. Data Requirements and Test Criteria; d. Data Collection Methodology; e. Support Requirements; f. Reducing and Analyzing Data; g. Significant Test Results; h. Communicating and Using Test Results; i. Factors in Planning a Test Program; j. Factors in Conducting a Test Program; k. Other Problems.

3. Potempa, K.W. A Catalog of Human-Factors Techniques for Testing New Systems. AFHRL-TR-68-15, February 1969. AD-854 482.

   This report contains 16 human-factors testing techniques contributed by a number of Air Force and contractor personnel. While limited in

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The above reports, which were published in 1969, were released to the general public in 1973.

number, it covers a broad segment of the human-factors testing spectrum. For example, the techniques presented range from those used during the design and fabrication through those used in field and operational system testing. This catalog was developed as a prototype to determine its usefulness to human-factors personnel as a reference source for human-factors testing devices and techniques. If this prototype finds acceptance, a more comprehensive catalog may be developed. The comprehensive catalog would serve two purposes. First, it would present information about techniques that have not previously been published. Second, it would present in one source most of the techniques currently being used in human-factors testing.

ABSTRACTS FOR 1971

4. Mays, J.A. The Development and Evaluation of a Ultra-High Resolution Television System. AFHRL-TR-71-1, February 1971. AD-885 826.

   The report describes the development of a Ultra-High Resolution television system, capable of operating at 2047 or 1023 lines/30 frames per second, and the evaluation of the television system with three high-resolution vidicons. The report describes the electronic circuitry developed, in particular the extremely wideband video preamplifier and video processor. The evaluation phase of the program includes data concerning the performance of the television system and the three vidicons. The evaluation found that the television system is capable of operating at the proposed 2047 and 1023 TV lines/30 frames per second and meets the design goal of 90 MHz video bandwidth. The evaluation of the three vidicons included: (1) the RCA type 4586, (2) the General Electrodynamics type 1347-001 one inch electrostatic deflection, electrostatic focus vidicons employing an additional magnetic focus coil for improved resolution, and (3) a GE type Z7940 1-1/2 inch electrostatic deflection, magnetic focus (FPS) vidicon. Each of the vidicons was found to have both good and bad qualities, the use of any one of them would have to be based upon the requirements of the system. The conclusion reached by examination of the resultant data supports the belief that television systems employing very wide bandwidth and high scan rates are quite possible and will result in a substantial advancement in the state-of-the-art of simulation.

5. Nagler, A.H., & Mazurkewitz, A.R. Wide Angle, Infinite Depth-of-Field, Optical Pickup for Visual Simulation. AFHRL-TR-71-41, November 1971. AD-892 433.

   During Phase I of the program, a study was undertaken to establish the most favorable approach toward producing a wide-angle, infinite depth-

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The above reports, which were published in 1971, were released to the general public in 1973.

of-field, inclined-image plane viewing probe for purposes of simulation. The second phase involved fabrication, test and evaluation of an engineering feasibility model of such a device. This report describes both phases of the program. Previous optical pickups for flight simulators were limited by slant range focus at close approaches to a model. Obtaining closer approaches has important size, cost and versatility advantages in making simulator terrain models and support equipment. Phase I study results indicated the feasibility of producing a 140° circular field pickup with full pitch capability and a close approach 4.1 mm. A preliminary but realistic design was developed and evaluated. The design approach was confirmed by photographing a runway model with a modified 110° probe. Other concepts examined that had promise of improving resolution were dual sensor outputs and dual relays. Component trade-offs, simplifications, and techniques were sufficiently developed for the design and fabrication phase of the program to proceed directly. The Phase II design, fabrication and test program resulted in an engineering model that essentially met all of the design goals of the program. The probe system was evaluated numerically and photographically, working to an altitude of 0.2 inches. It has full functional operation in a static form and can readily be reworked to dynamic operation if desired.

ABSTRACTS FOR 1973

6. Askren, W.B., Korkan, K.D., & Watts, G.W. Human Resources Sensitivity to System Design Tradeoff Alternatives: Feasibility Test With Jet Engine Data. AFHRL-TR-73-21, November 1973. AD-776 775.

The feasibility of developing Design Option Decision Trees to a level of detail which shows hardward involved in "on-aircraft" maintenance, and the feasibility of measuring the sensitivity of human resources data to design tradeoff problems depicted in these Trees were investigated. The approach included expanding a portion of an earlier developed aircraft jet engine Tree, selecting tradeoff problems from the expanded Tree for sensitivity analysis, and collecting psychometric data from experienced jet engine mechanics regarding this sensitivity. Five Design Option Decision Trees were developed for turbofan jet engines. Eight turbofan problems were evaluated for affect on human resources. The factors of training and experience, and amount of troubleshooting time are affected by choice of design option in six of the eight tradeoff problems. Ease of maintenance is affected in five problems, and complexity of tools and equipment is affected in two problems. Crew size and job specialty are each affected in one problem.

7. Askren, W.B. Analysis of Air Force Institute of Technology Course #475 "Laboratory Management of R&D." AFHRL-TR-73-27, August 1973. AD-767 197.

The Air Force Institute of Technology Course #475, "Laboratory Management of Research and Development" was analyzed to determine if such a course is needed, what form it should take, and what subjects should be included in the curriculum. The analysis also provides other supplementary data. It was found that Laboratory Commanders are in favor of retaining the course but believe it should be changed. The study recommends that the course be continued reoriented to training the new laboratory scientist/engineer regarding the duties of his job, that the course be shortened to a maximum of 15 days using 21 priority subject matter topics, and that a Laboratory Project Engineer Handbook be developed to supplement the course. The study also recommends that a DOL Course Advisory Group be established to monitor the course content and objectives. This analysis applies to Course 475 as it was taught through June 1972. The course was revised subsequent to that date based partially on the findings of this study. Inquiries concerning the current AFIT/SL Course 475 content and method of instruction should be addressed to the Chief, Continuing Education Division, AFIT School of Systems and Logistics, Wright-Patterson Air Force Base, Ohio 45433.

8. Askren, W.B. Human Resources and Personnel Cost Data in System Design Tradeoffs; and How to Increase Design Engineer Use of Human Data. Professional paper presented at the 81st Annual Convention of the American Psychological Association, Montreal, Quebec, Canada, 27-31 August 1973. AFHRL-TR-73-46, October 1973. AD-770 737.

A number of studies performed over a period of several years regarding the use of human resources and personnel cost data in system design tradeoffs were analyzed and the results integrated. Five questions were posed and answered. What are system design tradeoffs? What are human resources data? Why should military psychologists be interested in system design tradeoffs and human resources data? How much effect do system design tradeoffs have on human resources and personnel cost? And, what does this have to do with increasing engineer use of human data in design activities? The following conclusions were derived. Tradeoffs are a significant part of the weapon system design process. The choice of design alternative in a tradeoff study would, in many cases, substantially affect the human resources of the organization using the product of the design. It is feasible to use data describing these human resources in design tradeoffs. This use could lead to development of products which make less demand on those resources. Viewing system as a human decision process involving choice points and options, gives the psychologist an orientation toward design which allows him to more effectively work with the engineer.

9. Gum, D.R. Modeling of the Human Force and Motion-Sensing Mechanisms. AFHRL-TR-72-54, June 1973. AD-766 444.

The purpose of the study was: to investigate human force and motion-sensing mechanisms; to develop models for, the prominent or potentially artificially stimulatable mechanisms; to implement them on an analog computer; and to investigate their responses to various force and motion-forcing functions. Models were implemented and tested for a semicircular canal, the otolith, head motion muscle spindle sensing, and body seat pressure sensing. The relative magnitude of the sensed force and motion through the various mechanisms has not been possible to assess because the action of some mechanism transducers, i.e., the Pacinian receptors, and the processing of the information received from the various receptors is not well understood. However, tests of the models have demonstrated the relative time delays between applied force and perceived force for the various mechanisms, showing that both the muscle spindle and pressure-sensing mechanisms perceive an applied force much more rapidly than the vestibular system. Also, the long adaptation phenomenon associated with the semicircular canals which seems to degrade their usefulness in flight and the rapid adaptation phenomenon associated with the pressure sensors which makes them important sensors for consideration in the design of motion systems have been shown through model testing.

10. Joyce, R.P., Chenzoff, A.P., Mulligan, J.F., & Mallory, W.J. Fully Proceduralized Job Performance Aids: Draft Military Specification for Organizational and Intermediate Maintenance. AFHRL-TR-73-43(I), December 1973. AD-775 702.

This volume supplies a model for specifications for the preparation of Fully Proceduralized Job Performance Aids for the maintenance of Air Force equipment. The model reflects the research findings of the Air Force Human Resources Laboratory and other Department of Defense agencies concerning maintenance data. It has the unique feature of requiring that a task analysis yielding certain intermediate products necessary for the development of this type of data be prepared in a standard format and submitted for review by the Procuring Agency. These intermediate products include items such as an Annotated Task Identification Matrix, a Test Equipment and Tool Use Form, and a Generalized Task List, as well as step description worksheets and level of detail requirements. The aids to be developed from these specifications are for the organizational and intermediate maintenance functions: adjust, align, calibrate, checkout/troubleshooting, clean, dissassemble/assemble, inspect, lubricate, operate, remove/install, repair, and service. The specification, covers all content, writing, illustration, and format requirements for Job Guide Manuals and Fully Proceduralized Troubleshooting Aids. It includes comprehensive quality assurance provisions and an approved verb list.

11. Joyce, R.P., Chenzoff, A.P., Mulligan, J.F., & Mallory, W.J. Fully Proceduralized Job Performance Aids: Handbook for JPA Developers. AFHRL-TR-73-43(II), December 1973. AD-775 705.

This volume provides guidance for the development of Fully Proceduralized Job Performance Aids (JPAs) for the organizational and intermediate maintenance of Air Force equipment. It contains detailed instructions to the contractor for preparing fully proceduralized JPAs in accordance with the Draft Specification (Volume I of this technical report). It includes instructions for performing the behavioral task analysis, for development of the Job Guides and Fully Proceduralized Troubleshooting Aids (FPTAs), and for insuring quality and accuracy assurance. The very important validation and verfication activities are also thoroughly discussed. Personnel types and qualifications required for efficient development of JPAs are also included. In addition, this volume presents a strategy and guidance for developing supervised practice exercise designed to produce the skills required for preparing fully proceduralized JPAs.

12. Joyce, R.P., Chenzoff, A.P., Mulligan, J.F., & Mallory, W.J. Fully Proceduralized Job Performance Aids: Handbook for JPA Managers and Training Specialists. AFHRL-TR-73-43(III), December 1973. AD-775 706.

This report provides guidance for the Air Force Data Managers charged with the responsibility for the procurement of Fully Proceduralized Job Performance Aids (JPAs). It provides guidelines, suggested procedures, and checklists for use by data managers in the review and assessment of the subproducts, intermediate products, and JPAs produced in accordance with the draft specification contained in Volume I of the Technical Report. It also provides guidance to Air Force Training Specialists in development of training coordinated with JPAs, and in specifying the appropriate JPA/training trade-off for new equipment systems.

13. Knoop, P.A., & Welde, W.L. Automated Pilot Performance Assessment in the T-37: A Feasibility Study. AFHRL-TR-72-6, April 1973. AD-766 446.

Research was conducted to develop a capability for quantification and assessment of in-flight pilot performance for utilization in Undergraduate Pilot Training (UPT). This feasibility effort was directed to overcoming the disadvantages of the traditional subjective rating of a pilot trainee's performance by the instructor pilot. This was accomplished through the development of an automated, objective performance measurement system that possesses the characteristics of reliability, validity, and sensitivity. A T-37B was instrumented to digitally record 24 flight and engine parameters. An extensive computer software system was developed with which to reduce, calibrate, and

analyze the recorded data from the lazy 8 and barrel roll maneuvers, and compute performance measures. Criterion values for the two maneuvers were developed by utilizing task analysis data, narrative descriptions, and recorded in-flight maneuver performance of a highly qualified Air Training Command instructor pilot. Utilizing recorded data from 16 students and 4 instructors, experimental performance measures were derived through an interative analytic approach. Study results indicated that lazy 8 performance assessment can be accomplished using the flight parameters of roll angle, pitch angle, and airspeed in a single summary error measure. Barrel roll measuremnt is dependent upon roll and pitch angle, acceleration (g force), and roll rate. A definite relationship between roll and pitch was determined to be critical to measurement. Discussions of measurement validation methods, debriefing plots, a sampling rate study, instrumentation techniques, and problem areas are provided.

14. Knoop, P.A. Advanced Instructional Provisions and Automated Performance Measurement. Human Factors, 15(6), 583-597, December 1973.

An advanced simulation research system is being developed to support experiements oriented toward quantifying the effect on transfer of training of alternative training and simulation techniques. Included in the system is sophisticated training research software which automates most of the functions traditionally performed by flight simulator instructors or operators. Also under development are techniques for automatically assessing pilot proficiency in the simulator and in the operational aircraft. Recent feasibility studies in performance measurement resulted in identification of necessary flight variables for assessing proficiency on two undergraduate pilot training maneuvers; established alternative approaches to developing measurement techniques on a broader scale; applied existing technology to develop an in-flight data acquisition system for the T-37 aircraft; and raised (or, more correctly, reraised) issues regarding standardization in instruction and rating procedures.

15. Lintz, L.M., Loy, S.L., Brock, G.R., & Potempa, K.W. Predicting Maintenance Task Difficulty and Personnel Skill Requirements Based on Design Parameters of Avionics Subsystems. AFHRL-TR-72-75, August 1973. AD-768 415.

The relationships among subsystem design characteristics, personnel skill characteristics, personnel skill characteristics, and job performance were investigated for avionics subsystems. A list of design characteristics was estiablished, based on expert opinions of avionics engineers, Air Force supervisors, and instructors. Functional loops and line replaceable units were selected from ten subsystems representing navigation, flight control, communications, and fire control subsystems. Experienced maintenance supervisors identified high skill

and low skill maintenance personnel. The same supervisors associated performance times and error probabilities with these personnel for three maintenance tasks - an easy task, a difficult task, and a complete functional checkout task. Supervisors also rated each task on a scale difficulty. Both stepwise regressions and factor analysis were used to derive equations for predicting performance time, error probability, and task difficulty from design characteristics. Similar analyses derived equations relating performance time and errors to personnel characteristics. Multiple correlation coefficients were from 0.50 to 0.93. Personnel factors of Experience, Aptitude, Breadth of Skills, Motivation, Training, Time in Grade, and Non-AF Technical Education were identified. Equipment design factors of Checkout Complexity, Checkout Information, Length of Checkout, Accessibility, Equipment Complexity, and Test Equipment and Adjustments are associated with performance times and errors.

16. Mays, J.A., & Irish, K.M. The Development and Evaluation of an Optimized Video Output From a Wide Angle Optical Probe. AFHRL-TR-73-22, December 1973. AD-774 577.

This report describes a two-phase program to develop an optimized video output from a wide angle optical probe. Phase I of the program presents data resulting from radiometric and photometric studies of model paints, textures and illumination sources; performance data resulting from tests conducted on the wide angle optical probe; and a preliminary system design. Phase II of the program dealt with system development and evaluation. The report describes the detailed design of the high resolution 2-inch vidicon camera, including particular emphasis on the wideband video preamplifier and video processing electronics. The evaluation phase of the program includes data concerning the performance of the television system, and the performance of the integrated system including the optical probe, magnifying image intensifier and ultra high resolution 2-inch vidicon camera. The conclusion reached by examination of the resultant data supports the belief that a truly optimized video output from a wide angle optical probe has been achieved.

17. Mitchell, R.L., Lucero, A.B., & Harrison, R.E. Simulation of High-Resolution Radar Displays of City Complexes. AFHRL-TR-73-11, August 1973. AD-768 413.

The modeling and simulation techniques capable of generating large-scale high-resolution radar displays of cultural features are investigated. Specific features include power transmission towers, buildings, railroads, bridges, storage tanks, streets, rivers, and natural terrain. In addition, the general background-type of return is also discussed. The problem of real-time simulation is assessed. The techniques have been applied to simulate radar images of a 2.25 x 2.25 mile area of North Long Beach, California, to a resolution of 20 feet.

18. Schumacher, S.P. Development of a Technical Data File on the Design and Use of Instructional Systems. AFHRL-TR-73-41, December 1973. AD-775 149.

This report describes the development of a technical data file concerned with the technology of Instructional System Development suitable for a variety of users. The file was prepared in a way amenable to later computerized storage and retrieval. General information sources and indexes of highly probable relevant content were reviewed with key words and relevant specialty journals covering the period 1950 to 1973 were searched. Abstracts of articles providing opinion, new methodology, evaluative summary and literature review were of a summarizing descriptive nature. Abstracts of articles reporting sampling studies, correlational analysis, and experimental data were prepared more comprehensively so that they might often be used in lieu of the article. A common format was used with a bibliographic/indexing information page and an evaluation checklist being included. The principal results of the effort are as follows: (1) a paper file of 2,693 abstracts, (2) a card file of titles, (3) a coordinate index, (4) a comprehensive key word index and bibliography, and (5) MT/ST tapes of 1,950 of the abstracts. Incidental to the development, comprehensive guidelines for abstracting this type of literature and a compendium of author-noted research-and-development needs were prepared.

19. Valverde, H.H. A Review of Flight Simulator Transfer of Training Studies. Human Factors, 15(6), 510-523, December 1973.

Often operational equipment is considered to be the most effective and valid training equipment. However, this is not true in every instance. In fact, sometimes it may be undesirable to use real equipment for training if suitable simulators are available. For example, the use of operational equipment has several disadvantages which include (1) high costs, (2) limitation on practice of varied aspects of tasks, and (3) safety hazards. Practical decisions in the use of training devices depend upon compromises between economic and training objectives. A trainer need not duplicate operational equipment to have training value. Technical reports pertaining to flight simulator transfer of training studies available from the Defense Documentation Center are reviewed.

ABSTRACTS FOR 1974

20. Askren, W.B., and Korkan, K.D. Design Option Decision Tree: A Method for Schematic Analysis of a Design Problem and Integration of Human Factors Data. In Proceedings of Human Factors Society 18th Annual Meeting, Huntsville, Alabama, October 1974.

A Design Option Decision Tree (DODT) is a graphic means of showing the design options available at each decision point in the design pro-

cess. Several examples of DODTs for aircraft design problems are shown. The procedures for developing a DODT are described. A proposed method for use of the DODT to resolve a design problem is presented. This method includes evaluating the design options in the Tree for impact on the system, and tracing paths through the Tree as dictated by specific design goals. The use of human factors data as one of the evaluation parameters is illustrated. The paper concludes with a discussion of other uses of a DODT.

21. Askren, W.B. Preview of the Special Issue of Human Factors on "Human Resources as Criteria for System Design and Organization Planning." In Proceedings of Human Factors Society 18th Annual Meeting, Huntsville, Alabama, October 1974.

    A preview of a special issue of the Human Factors journal is presented. The issue will be published in early 1975 on the topic, "Human Resources as Criteria for System Design and Organization Planning." The theme of the special issue, and the content of each of the articles is described.

22. Baran, H.A. Air Force Human Resources Laboratory Military Personnel Costing Conference. Proceedings of the AFHRL Military Personnel Costing Conference held 2-3 May 1973 at the Advanced Systems Division, Wright-Patterson AFB, Ohio. AFHRL-TR-74-106, December 1974.

    This conference was the initial step in an R&D project to develop and demonstrate a family of techniques to generate standard personnel cost data for use in: (a) weapon system design engineering; (b) weapon system life cycle support operations; and (c) personnel/manpower budgeting. It was organized to provide technical guidance in directing the efforts of this project. Representatives from various organizations within Air Force Headquarters, Tactical Air Command, Air Force Systems Command, Air Training Command, Air Force Logistics Command, and the US Naval Personnel Research Laboratory comprised the membership. The objectives were: (A) identify and summarize the various concepts and practices of personnel costing and how they relate to system engineering design, system support, and various command level personnel, manpower, and budgetary activities; (B) identify the "users" of personnel cost data, their present requirements and uses for it, and their desires for new types or formats of such data; (C) ascertain what has been accomplished by other agencies that could be adapted to satisfy in part/whole the requirements identified in objectives B and identify work currently in progress which might be applicable; and (D) summarize the most pressing research goals and requirements.

23. Connelly, E.M., Loental, D.G., Bourne, F.J., & Knoop, P.A. Computer-Aided Generation of Performance Measures for Man-Machine Systems. In Proceedings of Human Factors Society 18th Annual Meeting, Huntsville, Alabama, October 1974.

    The design, application, and evaluation of man-machine systems are limited by our ability to measure system performance in a reliable and

sensitive manner. Without adequate performance measures, there is no way to test system designs, to plan and execute training systems, or to effectively evaluate operational systems. Typically, measures are manually produced by selecting a set of candidate performance measures which are subsequently tested for reliability and validity. Since the measurement value of a given candidate measure is not known until these tests are complete, this process, which may be an iterative process, can be both time consuming and costly. Also, since only a few candidate measures can be investigated manually, there is a high probability that superior measures are not even considered. Automating at least some of the manual operations required can result in improved performance measures in less time and at lower cost. The performance measurement generating processor described in this paper accepts demonstration data representing various levels of performance, and under user control, analyzes the data to provide candidate performance measures. The processor also conducts validation tests and orders candidate measures according to their measurement value. Output from the FORTRAN IV processor includes results from validation tests and specifications for objective performance measures.

24. Connelly, E.M., Bourne, F.J., Loental, D.G., & Knoop, P.A. Computer-Aided Techniques for Providing Operator Performance Measures. AFHRL-TR-74-87, December 1974.

This report documents the theory, structure, and implementation of a performance measurement processor (written in FORTRAN IV) that can accept performance demonstration data representing various levels of operator's skill and, under user control, analyze data to provide candidate performance measures and validation test results. The processor accepts two types of information: (1) sample performance data on magnetic tape and (2) user information reflecting knowledge about features of the performance that are considered to be important to measurement. The sample performance data input is smoothed by the processor in order to remove or reduce noise factors in accordance with information provided by the user. Criterion performance functions are, optionally, provided by the user or are computed by the processor using skilled performers' data. The processor then develops a discrete representation of continuous performance data based on observed deviations from the criterion functions. This discrete representation, in turn, is used to model each performance using state-space techniques. The processor operates on the state-space model to compute vectors which form generators of various conceivable measure spaces. Candidate performance measures are then generated by operating on the vectors with multiple regression algorithms. Empirical validation tests of several types are applied to the candidate measures for assessment of their validity-likelihood. The processor can be applied to measurement problems where the human operator working with his equipment obtains demonstrations of various levels of performance. These potential applications include those situations where criterion performance cannot

be quantitatively predefined and/or the existing definitions are ambiguous. Demonstration of some portions of the processor was accomplished using limited flight demonstration data from an instrumented T-37B aircraft for five undergraduate pilot training (UPT) maneuvers: (1) Barrel Roll, (2) Lazy 8, (3) Cloverleaf, (4) Split S, and (5) Normal Landing.

25. Connelly, E.M., Bourne, F.J., Loental, D.G., Migliaccio, J.S., Burchick, D.S., & Knoop, P.A. Candidate T-37 Pilot Performance Measures for Five Contact Maneuvers. AFHRL-TR-74-88, December 1974.

The objective of this program was to develop candidate pilot performance measures for five undergraduate pilot training (UPT) contact training maneuvers flown in the T-37B aircraft. The work included development and application of a method of analyzing operator performance tasks for purposes of identifying candidate measures. This resulted in sectoring of each T-37B maneuver into functional segments, wherein the dominant measurement variables are consistent, and task segments, wherein the relationships among the dominant measurement variables are consistent. Several types of measures were then defined which, collectively, satisfy measurement needs over all task segments. Specific candidate measurement formulae were developed for each segment in accordance with the analysis results. Computer programs (FORTRAM IV) were developed and implemented to: (1) smooth, print out, and plot data recorded on-board a T-37B aircraft; (2) automatically detect task segment boundaries; (3) compute criterion function from skilled performer's data; (4) compute measures specified at run-time by the user; and (5) perform and print results of several empirical validation tests of the candidate measures for subsequent researcher analysis.

26. Foley, J.P. Evaluating Maintenance Performance: An Analysis. AFHRL-TR-74-57(I), October 1974. AD-A004 761.

Late in 1962, the writer prepared a paper entitled Performance Testing: Testing for What is Real (Foley, 1963). This was followed by a Bibliography on Maintenance Personnel Performance Measurement by Askren (1963) and work on a draft of an annotated bibliography by Porterfield in the same year. All of these efforts indicated that there was probably a lack of job realism in the formal measuring devices used to ascertain the training success and promotion potential of maintenance personnel. They also indicated that although a rather extensive technology had been developed for paper and pencil testing, no well-structured technology or guidance existed for the development and administration of job performance tests. These preliminary works and findings indicated a requirement for exploratory development concerning job performance tests for maintenance. To avoid duplication in such an exploratory development program, the approach was to tap the wealth of existing, but scattered, sources of available hard data concerning job performance measurements, to structure these data as they applied to the measurement of ability to

perform electronic maintenance tasks, to analyze them in relation to current Air Force practice and to make recommendations for the development and tryout of effective job performance measurements for Air Force electronic maintenance. Paper and pencil testing procedures are used almost exclusively for determining which personnel are slected for training, for determining student progress while in training and for determining the promotion eligibility of personnel assigned to field maintenance units. A number of studies are cited which indicate that low correlations were obtained by comparing job task performance tests to paper and pencil theory tests and to job knowledge tests. Several studies also are cited which indicate that the traditional theory content, found in most electronic maintenance training programs, does not contribute a great deal to the ability to perform electronic maintenance tasks. A full application of the modern technology for technical training development would solve the course content problem. This technology requires a systems approach to training program development in which training objectives are based on a complete job task identification and analysis. Criterion referenced Job Task Performance Tests (JTPT) are required to determine if training objectives are achieved. However, a serious gap remains in this technology since adequate guidance is not available for the development of JTPT. As a result of this analysis, it was recommended that comprehensive exploratory and advanced development efforts concerning Air Force maintenance should be established and funded. These programs should systematically and comprehensively identify and solve problems concerning maintenance practice in the field and problems concerning the selection and training of maintenance personnel. A necessary first effort should be to gather and study hard data on how well maintenance men can perform the key tasks of their jobs. Also, based on the results of this analysis a contractual effort was initiated to develop criterion referenced JTPT for electronic maintenance tasks. This effort was followed by an attempt to develop both graphic and video symbolic substitutes of improved empirical validity. The results of these efforts are reported in Volumes II, III, and IV of this series of documents.

27. Foley, W.L. High-Speed Rotating Mirror System for Wide-Angle Image Projection. AFHRL-TR-74-42, June 1974. AD-A001 629.

The design and fabrication of visual display systems with a wide field-of-view and high resolution, as is required for pilot training simulators, is a formidable problem. Individual displays must be carefully fabricated and mosaicked together so the resulting system maintains continuity and resolution over the total display field. While such systems have been successfully developed, the optical components can be large and expensive, and alignment is a formidable problem where several

channels are required. Methods were investigated for wide angle deflection of a laser beam at rates compatable with standard video processing. The effort consisted of investigation and design of a magnetic suspension and rotation device for achieving scan rates in excess of 3,000 revolutions per second. Two design ("Q" coil and differential pickup) approaches were investigated and measurements were made of rotational rates and acceleration verses input drive power. Stability was investigated under short term conditions for different rotor configurations, and special measures were undertaken to minimize drift of the supported body. One of the designs, namely the differential pickup type, appears worthy of further investigation and testing.

28. Hicks, V.B., & Tetmeyer, D.C. Simulating Maintenance Manning for New Weapon Systems: Data Base Management Programs. AFHRL-TR-74-97(IV), December 1974. AD-A011 989.

The Air Force Human Resources Laboratory, in conjunction with Headquarters Air Force System Command and the Aeronautical Systems Division, has developed and implemented a new method for determining and evaluating the maintenance manning required for new weapon systems. Key features of the new approach are: 1. Manning requirements are determined by dynamic simulation of maintenance work to support specific operational scenarios. The number of people needed to support the same aircraft and flying hour program varies greatly with basing and deployment, mission types, and sortie length. 2. Manning is based on required availability, not just on the sum of manhours worked. While worktime is a major consideration, equipment does not break on schedule and combat aircraft cannot always fly on a schedule that provides an even workload. 3. Maintenance frequencies and job requirements for a new system are extrapolated from Air Force experience with similar equipment, adjusted for differences in design and environment. The total time a man is tied up on a job is explicitly modeled, not just "wrench turning" time. 4. Output is in a format compatible with the Air Force Manpower Authorization System. This approach provides more realistic and useable estimates of manning requirements and focuses on how both a contractor's design and Air Force procedures contribute to maintenance cost. As soon as the new aircraft configuration can be defined, comparable equipment and design differences are identified at subsystem level. Maintenance data on comparable equipment is processed through a series of specially designed programs. These data are the basis for developing initial estimates of frequency, time, and resources for each maintenance task when modified by the judgement of experienced maintenance technicians and project engineers. The logistics and operational concepts basing, maintenance organization and flying schedules are developed in detail for various scenarios and set down in explicit form for input to the simulation. The simulation attempts to generate the specified missions in the computer. Aircraft are turned and maintenance accomplished as they break or need service according to the task data specified in the input. Manning

levels in the various work centers are constrained on successive runs until further reduction prevents the necessary number of missions from getting off. Computer programs used in the final stage of the maintenance manpower simulation modeling process integrate direct work center manning output from a number of simulation runs; add supervision, overhead requirements, and standard element manning; and apply appropriate grade spread criteria. The output is a complete basic authorization document for maintenance manning, compatible with Air Force manpower authorization procedures. The program may be exercised to obtain manning for any proposed flying rate with the simulated range and has an option for adjusting existing equations with new data representing updated or alternative conditions. The series of COBOL and FORTRAN computer programs described in this volume was developed to permit a Logistics Composite Model (LCOM) maintenance data base to be constructed in simplified format with all the data describing a single task contained on one punch card or magnetic file record. The programs translate the task data into the necessary LCOM inputs and incorporate a number of useful diagnostic checks which eliminate the more frequently encountered data preparation errors. Use of these programs implifies data base development, update, and control. They are currently in operation on the Aeronautical Systems Division's CDC 6600 computer. The methodology and models have been successfully applied on the A-10 program and are being considered for implementation on other aeronautical systems in or entering development. Work is underway in conjunction with Air Force Logistics Command to incorporate this methodology into a system for total logistics trade-offs and life cycle costing.

29. Irish, K.M., & Orszulak, J.H. Visual Simulation Video Processing Techniques. AFHRL-TR-74-76, December 1974. AD-A009 640.

This report describes a two-phase program to further the development of visual simulation video processing techniques as applied to a wide angle optical probe/TV camera. Phase I of the program included the study of applicable wide-angle display techniques, study of additional processing of the probe's video signal for proper mating to a display, study of color visual requirements, and a review of state-of-the-art separation techniques for TV cameras. Phase II of the program dealt with the construction of a video matrix generator to provide the necessary electronic processing to mate the optical probe/TV camera system to applicable wide angle displays. The conclusions reached were that a matrix of display elements is necessary for a compact and realistic wide-angle display, and a colc TV camera could be developed using present technology to mate with the Farrand wide-angle optical probe.

30. Joyce, R.P., & Chenzoff, A.P. Improving Job Performance Aids Through Condensation, Dual-Level Presentation, Promotion of Learning and Entry by Malfunction Symptoms. AFHRL-TR-74-12, March 1972. AD-781 757.

This report describes the research effort that attempted to simplify and condense the presentation of Job Performance Aid (JPA) data. It also describes a method of presenting technical data to both experienced and inexperienced personnel in one JPA format. Such factors as text limitations, illustration criteria, layout restrictions, and physical size of the manuals were found to contribute to the excessive bulk of the JPAs. Controls were developed for each of the influencing factors. Dual-level presentation of technical data was also studied. This portion of the study identified the types of information required, and not required by experienced technicians. The original JPA sample was reformatted, incorporating both condensation principles and dual-level presentation factors. The application of condensation principles resulted in a decrease from 104 pages in the original 4" x 8" size to 18 pages in the larger 8 1/4" x 10 3/4" size, and information was provided for both experienced and inexperienced personnel. The sample JPAs were then evaluated by novice and experienced mechanics. The condensed, dual-level JPAs provided proper information to both experienced and inexperienced personnel and were well received. A third aspect of this study concerned troubleshooting. A review of the goals of fully proceduralized troubleshooting was accomplished, and possible changes in goals were suggested. A possible way to enter a troubleshooting procedure utilizing known failure symptoms was developed and discussed.

31. Maher, F.A., & York, M.L. Simulating Maintenance Manning for New Weapon Systems: Maintenance Manpower Management During Weapon System Development. AFHRL-TR-74-97(I), December 1974. AD-A011 986.

The Air Force Human Resources Laboratory, in conjunction with Headquarters Air Force Systems Command and the Aeronautical Systems Division, has developed and implemented a new method for determining and evaluating the maintenance manning required for new weapon systems. Key features of the new approach are: 1. Manning requirements are determined by dynamic simulation of maintenance work to support specific operational scenarios. The number of people needed to support the same aircraft and flying hour program varies greatly with basing and deployment, mission types, and sortie length. 2. Manning is based on required availability, not just on the sum of man-hours worked. While worktime is a major consideration, equipment does not break on a schedule and combat aircraft cannot always fly on a schedule that provides an even workload. 3. Maintenance frequencies and job requirements for a new system are extrapolated from Air Force experience with similar equipment, adjusted for differences in design and environment. The total time a man is tied up on a job is explicitly modeled, not just "wrench turning" time. 4. Output is in a format compatible with the Air Force manpower authorization system.

This approach provides more realistic and useable estimates of manning requirements and focuses on how both a contractor's design and Air Force operational procedures contribute to maintenance cost. As soon as the new aircraft configuration can be defined, comparable equipment and design differences are identified at subsystem level. Maintenance data on comparable equipment is processed through a series of specially designed programs. These data are the basis for developing initial estimates of the frequency, time, and resources for each maintenance task when modified by the judgement of experienced maintenance technicians and project engineers. The logistics and operational concepts, basing maintenance organization, and flying schedules are developed in detail for various scenarios and set down in explicit form for input to the simulation. The simulation attempts to generate the specified missions in the computer. Aircraft are turned and maintenance accomplished as they break or need service according to the task data specified in the input. Manning levels in the various work centers are constrained on successive runs until further reduction prevents the necessary number of missions from getting off. The results of various simulation runs are integrated in a final series of computer programs that computes manning in each work center for any flying program within the simulated range, adds authorized overhead, adjusts for grade level limitations, and produces a complete basic authorization document for maintenance manning in the required format. The methodology and models have been successfully applied on the A-10 program and are being considered for implementation on other aeronautical systems in or entering development. Work is underway in conjunction with Air Force Logistics Command to incorporate this methodology into a system for total logistics trade offs and life cycle costing.

32. Miller, R.B. A Method for Determining Task Strategies. AFHRL-TR-74-26, May 1974. AD-783 847.

This study is an extension of task analysis methodology. The concept of strategic principles or task strategies implicit in the job activities of highly proficient performers is examined with the intent of improving training. The goal is to identify or invent such strategies, as appropriate, and then proceed with training encouraging use of them. A set of 25 information processing functions is described along with examples of strategic principles and training implications. Certain other strategic principles not readily interpretable in information processing terms are presented also. An analytic procedure for determining and/or devising strategies is provided and suggestions on the teaching and learning of strategies are summarized.

33. Moody, W.D., Nichols, S.R., & Tetmeyer, D.C. Simulating the Maintenance Manning Required for New Weapon Systems: Vol V - Manpower Programs. AFHRL-TR-74-97(V), December 1974. AD-A011 990.

The Air Force Human Resources Laboratory, in conjunction with Headquarters Air Force Systems Command and the Aeronautical Systems Division, has developed and implemented a new method for determing and evaluating the maintenance manning required for new weapon systems. Key features

of the new approach are: 1. Manning requirements are determined by dynamic simulation of maintenance work to support specific operational scenarios. The number of people needed to support the same aircraft and flying hour program varies greatly with basing and deployment, mission types, and sortie length. 2. Manning is based on required availability, not just on the sum of manhours worked. While worktime is a major consideration, equipment does not break on schedule and combat aircraft cannot always fly on a schedule that provides an even workload. 3. Maintenance frequencies and job requirements for a new system are extrapolated from Air Force experience with similar equipment, adjusted for differences in design and environment. The total time a man is tied up on a job is explicity modeled, not just "wrench turning" time. 4. Output is in a format compatible with the Air Force Manpower Authorization System. This approach provides more realistic and usable estimates of manning requirements and focuses on how both a contractor's design and Air Force procedures contribute to maintenance cost. As soon as the new aircraft configuration can be defined, comparable equipment and design differences are identified at subsystem level. Maintenance data on comparable equipment is processed through a series of specially designed programs. These data are the basis for developing initial estimates of the frequency, time, and resources for each maintenance task when modified by the judgement of experienced maintenance technicians and project engineers. The logistics and operational concepts basing, maintenance organization and flying schedules are developed in detail for various scenarios and set down in explicit form for input to the simulation. The simulation attempts to generate the specified missions in the computer. Aircraft are turned and maintenance accomplished as they break or need service according to the task data specified in the input. Manning levels in the various work centers are constrained on successive runs until further reduction prevents the necessary number of missions from getting off. The pair of computer programs documented in this volume are used in the final stage of the maintenance manpower simulation modeling process. They integrate direct work center manning output from a number of simulation runs; add supervision, overhead requirements, and standard element manning; and apply appropriate grade spread criteria. The output is a complete basic authorization document for maintenance manning, compatable with Air Force manpower authorization procedures. The program may be exercised to obtain manning for any proposed flying rate within the simulated range, and has an option for adjusting existing equations with new data representing updated or alternative conditions. The methodology and models have been successfully applied on the A-10 program and are being considered for implementation on other aeronautical systems in or entering development. Work is underway in conjunction with Air Force Logistics Command to incorporate this methodology into a system for total logistics tradeoffs and life cycle costing.

34. Mullen, P.A., & Joyce, R.P. Demonstration of Fully Proceduralized Job Performance Aids and Matching Training. AFHRL-TR-74-69, August 1974. AD-A002 147.

Sixteen airmen with no background in electronics were given four weeks of job-oriented training and then observed as they performed maintenance while using fully proceduralized job performance aids (FPJPAs). Half of the airmen had the high aptitude usually required for training in electronics. The other half had significantly lower aptitudes. There is some evidence that most of the airmen were below average in reading ability. This effort had two purposes. One was to provide interested military and civilian personnel a preview of the maintenance performance of minimally trained airmen using FPJPAs. Another was to shake-down or debug the FPJPAs and the matching training program prior to a major experimental comparison of alternative types of technical data and training for maintenance. The airmen were observed by the experimenter and a continually changing group of interested observers as they performed 14 maintenance tasks on a Doppler Radar set (AN/APN-147) and its Computer (AN/ASN-35). Ten of the problems involved troubleshooting, two involved removal and replacement of hardware and two involved soldering. With an average of 1.5 "assists" per troubleshooting problem, the airmen were able to solve the problems in average times (for various problems) ranging from 18 to 59 minutes. The 90 "assists" were needed because of reading errors (52), misuse of multimeter (20), lack of manual dexterity (6), misuse of oscilloscope (5), and miscellaneous errors (7). On the troubleshooting tasks, the high aptitude trainees scored consistently better than the medium aptitude trainees in both time and number of assists; however neither of these differences were statistically significant. The high aptitude group was able to complete 10 of their 30 problems without an assist while the medium aptitude group completed only two problems without an assist. On the remove and replace tasks, both groups proceeded smoothly and, with one exception, without error. In the soldering tasks, the medium aptitude group was slower but their products were of higher quality than the high aptitude group. Although the airmen did not exhibit the errorless performance that had been desired, their performance should be considered as at least promising. Causes for many of their deficiencies were identified and can be corrected. In general, the presence of the high-ranking observers seemed to disturb and slow the performance of the airmen. Also, it should be noted that no baseline is available to compare the performance of these airmen with the performance of conventionally trained airmen using conventional technical data. A training program about two weeks longer than the four week course used in this demonstration will be necessary to achieve satisfactory performance of maintenance tasks, including troubleshooting, while using FPJPAs. The FPJPAs must be completely verified to insure clarity and accuracy. Although personnel with high aptitude for electronic maintenance probably will out perform those with lower aptitude, satisfactory maintenance performance probably can be obtained from personnel of either high or medium aptitude if they are provided with job-oriented training and FPJPAs.

35. Pieper, W.J., Pinkus, A.L., & Thomas, D.L. Computer Generated Troubleshooting Trees: Application and Tryout. AFHRL-TR-74-20(I), November 1974. AD-A004 634.

This report describes the results of a project to refine and test a procedure for developing troubleshooting trees by computer. In an earlier project conducted by NASA, a computer program and data preparation procedures were developed. However, the program and procedures were not fully tested. In this project, the procedures and program were refined, adapted, and tested. They were tested by using them to develop troubleshooting trees for a moderately complex electronic system. The troubleshooting trees were then evaluated by inserting faults into the equipment and using the trees to isolate the faults. Although the trees did not lead to isolation of 100% of the faults, the results did indicate that development of troubleshooting trees by computer is feasible. However, further refinements of the process are required before it can be used operationally. Additional information on the development and use of the computer program is given in AFHRL-TR-74-20(II).

36. Pieper, W.J., & Pinkus, A.L. Computer Generated Troubleshooting Trees: The Program. AFHRL-TR-74-20(II), July 1974. AD-785 139.

This volume describes the development, use, and tryout of a computer program to prepare troubleshooting trees by computer. The program inputs information on the system data flow, component reliabilities, and costs of available tests. An iterative process is then used to select the most efficient sequence of tests to isolate all possible faults. This is accomplished by computing an index of information gained per unit cost (IGUC) for each test. The test with the highest IGUC is selected as the first test in the tree. The IGUCs are then recomputed for the remaining tests and the test with the highest IGUC is added as the next step in the tree. The process is continued until a tree is developed which will isolate all faults in the system. The procedures and program were tested by using them to develop troubleshooting trees for a 300 component electronic system. The troubleshooting trees developed were tested by using them to isolate faults inserted into the equipment. Although the trees did not lead to isolation of 100% of the faults, the results did indicate that computer development of troubleshooting trees by computer is feasible. However, further refinements of the process are required before it can be used operationally.

37. Potter, N.R., & Dieterly, D.L. Methods for Predicting and Assessing the Impact of Technology on Human Resources Parameters: Report of the Literature. AFHRL-TR-74-71, August 1974. AD-A000 051.

A research objective of the Air Force Human Resources Laboratory is the development of methods for defining the components of innovative technology and for measuring the effects of the incoming technology on Air

Force human resources. The human resource parameters of concern include manpower (e.g., numbers, job types, skill levels), training considerations, and cost data. Earlier investigations established the feasibility of using human resources data in design trade studies and of determining an graphically depicting the array of trade-off options available before inception of hardware design. The purpose of this review was to establish the current status of the methodology for forecasting and assessing technology and for quantizing human resource parameters with respect to the impact of incoming technologies. A search and critical analysis of the literature was undertaken to review the status of forecasting and assessing technology and of techniques for predicting the impact of technology on human resource parameters. The size of the literature base in the area of technological forecasting and technology assessment precluded the conduct of an exhaustive review. Rather, the determination was made that inclusion of selected references which described current methodologies in detail and which were judged as representative would better satisfy the objectives of the research effort. A total of 140 documents applicable to this effort were reviewed. Seventeen of these were identified as having major significance to the present effort. The review of the literature failed to provide solution to the problem of quantizing human resource parameters with respect to impact of incoming technologies. However, the use of a normative forecasting technique was strongly supported by the literature. In particular, a relevance tree approach was the technique viewed as amenable to the problem of successive identification of increasingly finer components in an organized, structured manner. The relevance tree procedure known as a Design Option Decision Tree was identified as practical for detailing a system to a level permitting the identification and assessment of human resource components for impact quantification.

38. Scheffler, F.L., DaPolito, F.J., McAdams, R.L., & Gee, M.J. Feasibility of Computer Processing of Technical Information on the Design of Instructional Systems. AFHRL-TR-73-40, January 1974. AD-778 073.

A study was made of the feasibility of a computer-based system to handle technical information pertinent to the design and use of instructional systems. The study took into account the information needs of both researchers and practitioners. Current and projected information needs of researchers and practitioners were determined from structured interviews. Ten available computer-based information storage and retrieval systems which could serve as a basis for such a technical system were investigated. Question-answering computer systems based on artificial intelligence concepts were reviewed and considered in terms of providing a perscriptive interactive system. It was concluded that practicable generalized semantic information retrieval systems would require further developments. The design and implementation of a natural language automated information retrieval system encompassing rudimentary features

of a prescriptive system is feasible, both in terms of the technical resource provided and its cost effectiveness. An on-line interactive retrieval system was designed, and a model data base of approximately 500 literature-derived comprehensive abstracts was implemented and tested to confirm the feasibility of the system.

39. Schumacher, S.P., Swezey, R.W., Pearlstein, R.B., & Valverde, H.H. Guidelines for Abstracting Technical Literature on Instructional System Development. AFHRL-TR-74-13, February 1974. AD-777 757.

Guidelines are presented for preparing abstracts of technical literature on instructional systems development (ISD). Although specifically developed for abstracting information during the preparation of a technical data file on ISD, the guidelines are sufficiently general to apply to other areas in which abstracts of technical literature are desired. For abstracting purposes, the literature was divided into two categories: (1) Type I and (2) Type II documents. The first category includes opinion articles, methodological developments, evaluative summaries, literature reviews, and bibliographies. The second category includes statistical sampling studies, correlational research, and research studies in which variables are manipulated. Both types of abstract are prepared on the same general form. A sample of the abstract form and examples of acompleted Type I and Type II abstracts are included. The sample form permits the most important characteristics of a document to be synthesized to facilitate the computerization of the technical data file.

40. Schumacher, S.P., Pearlstein, R.B., & Martin, P.W. A Comprehensive Key Work Index and Bibliography on Instructional System Development. AFHRL-TR-74-14, February 1974. AD-777 192.

This report provides a bibliographic listing of the 2,692 items selected and abstracted for a basic file of technical information on instructional system development. Both reports of pertinent original research as well as summarizing and discursive articles are included. The items date as far back as 1953 and represent a subset of articles within the general topic selected for special relevance. In addition, a comprehensive index according to over 600 key words is provided to assist the user in finding items of immediate interest.

41. Schumacher, S.P., & Wiltman, S. A Compendium of Research and Development Needs on Instructional System Development. AFHRL-TR-74-15, February 1974. AD-777 196.

This report provides a comprehensive listing of specific needs for research on instructional systems development, as identified and noted by the authors of 2,692 related articles. The articles from which the needs were taken had been selected and abstracted for a basic file of

technical information on instructional system development. Because the items date as far back as 1953 some, of course, may no longer be relevant but no attempt was made to reflect degree of current relevance in this listing. The needs are categorized and listed by principal system development activities and, in turn, by more specific subsidiary concerns.

42. Shriver, E.L., & Foley, J.P. Evaluating Maintenance Performance: The Development and Tryout of Criterion Referenced Job Task Performance Tests for Electronic Maintenance. AFHRL-TR-74-57(II), Part I, September 1974. AD-A004 845.

The previous Volume, AFHRL-TR-74-57(I), recommended the development of criterion referenced Job Task Performance Tests (JTPT) for typical electronic maintenance activities. This Volume reports the development of a battery of such tests together with an appropriate scoring scheme for reporting the results of administering them. The development of a Test Administrators Handbook also is described. This battery is considered to be a model for future criterion JTPT development and is intended for both formal training and field use. The battery includes separate tests for the following classes of job activities: (1) equipment checkout, (2) alignment/calibration, (3) removal/replacement, (4) soldering, (5) use of general and special test equipment, and (6) troubleshooting. The Doppler Radar, the AN/APN-147 and its computer the AN/ASN-35 were selected as a typical electronic system. This system was used as the test bed for this model battery. The soldering and general test equipment JPTP are applicable to all electronic technicians. The other tests of the battery apply to technicians concerned with this specific doppler radar system. Each class of activity for which JTPT were developed contains its individual mix of behaviors, but it is not mutually exclusive. There are dependencies among the classes. As a result a four level hierachy of dependencies can be stated: (1) checkout, removal/replacement, and soldering; (2) use of general and special test equipment; (3) alignment/calibration; and (4) troubleshooting. For example, troubleshooting may include all the activities mentioned before it. Due to the diverse character of the various mixes of behaviors involved in each class of maintenance activity, a single score report of test results would be meaningless. A profile of test results therefore was developed which provides for an individual cell for each test problem. The tests are structured so that each problem produces a product. The results for each problem is reported in terms of a go, no-go score. Either the test subject produces a satisfactory product or he does not. Where time is important, he must produce the satisfactory product in a specified time. Although process may be valuable as a diagnostic tool, it is not considered as an appropriate factor for scoring purposes. The hierachy of dependencies mentioned previously has implication for the order in which tests are

administered as well as for diagnostics. For example, since troubleshooting includes the use of test equipment and other activities in the hierachy, logic would dictate that administration of the tests for the sub-activities would precede the troubleshooting tests and that a test subject would not be permitted to take the troubleshooting tests until he had passed these other subtests. Due to the unavailability of a sufficient number of experienced test subjects at the time of the tryout of the JTPT battery, the tryout was not as extensive as planned. The limited tryout did indicate that the tests as developed are administratively feasible. There continued use, no doubt, would result in further modifications and polish. The report also includes a discussion of several implementation considerations and suggestions.

43. Shriver, E.L., Hayes, J.F., & Hufhand, W.R. Evaluating Maintenance Performance: Test Administrator's Manual and Test Subject's Instructions for Criterion Referenced Job Task Performance Tests for Electronic Maintenance. AFHRL-TR-74-57(II), Part II, January 1975. AD-A005 785.

The purpose of this document is to furnish a complete copy of the Test Subject's Instructions and the Test Administrator's Handbook for a battery of criterion referenced Job Task Performance Tests (JTPT) for electronic maintenance. Part I of Volume II of this series of documents, AFHRL-TR-74-57, reports and describes the development and tryout of this battery of tests.

44. Shriver, E.L., & Foley, J.P. Evaluating Maintenance Performance: The Development of Graphic Symbolic Substitutes for Criterion Referenced Job Task Performance Tests for Electronic Maintenance. AFHRL-TR-74-57(III), November 1974. AD-A005 296.

An in-depth review of the literature reported in AFHRL-TR-74-57(I), of this series of documents strongly reiterated the fact that paper and pencil tests of job knowledge and electronic theory tests have very poor criterion-related or empirical validity with respect to the ability of electronic maintenance men for performing their job tasks. As a result, a battery of criterion referenced Job Task Performance Tests (JTPT) was developed and tried out and results were reported in AFHRL-TR-74-57(II). The battery included tests for the various job activities performed by electronic maintenance technicians such as checkout, align/adjust, remove/replace, soldering, use of general and special test equipment, and troubleshooting. Past experience with tests similar to these criterion referenced JTPT has indicated that even though criterion referenced JTPT were recognized as being superior by many training people, paper and pencil tests were substituted because they were more easily and cheaply developed and administered. The JTPT developed required the test subject to use actual equipment and they could only be administered to very small groups; in some cases, to only one subject.

Graphic symbolic substitutes would probably overcome these administrative problems. But such substitutes must have high empirical validity. Most previous attempts to develop such tests resulted in low validity. This volume describes another attempt to develop a battery of graphic symbolic substitutes of improved validity. A review of previous attempts resulted in a hypothesis that previous attempts had weaknesses in realism that could possibly be rectified. The successful accomplishment of most maintenance tasks must follow a main line procedure or strategy. But this main line usually is "cluttered" with distraction and subprocedures which interfere with the accomplishment of the main line procedure or strategy. For example, when troubleshooting, the technician must usually interrupt his strategy several times to set up his test equipment and to obtain check point information. Unless he is well organized and very persistent in following his strategy, he may lose track of his strategy. Even if he stays on the main line, he may gather faulty information from his test equipment which will prevent him from finding the trouble. Based on this rationale, it was concluded that previously developed symbolic tests such as the tab test did not provide such clutter. It was hypothesized that symbolic substitute tests could be developed that would retain a large amount of realistic task "clutter" and that such tests would have higher empirical validity than previously developed symbolic tests. In this effort, a battery of symbolic tests was developed including a companion symbolic test for each of the job activities for which a criterion referenced JTPT had previously been developed. Based on two limited validations, all of the graphic symbolic tests, with the exception of the symbolic test for soldering, indicated sufficient promise to justify further consideration and refinement. All of these promising symbolic tests should be given more extensive validations using larger numbers of experienced subjects. The validation of any such symbolic tests requires the administration of a companion JTPT as a validation criterion. As a result, a validation is an expensive process in terms of equipment and experienced manpower. The troubleshooting symbolic tests require the most extensive refinement. Several suggestions are made for improving their empirical validity.

45. Shriver, E.L., Hayes, J.F., & Hufhand, W.R. Evaluating Maintenance Performance: A Video Approach to Symbolic Testing of Electronics Maintenance Tasks. AFHRL-TR-74-57(IV), July 1974. AD-A005 297.

This volume reports an effort to use the video media as an approach for the preparation of a battery of symbolic tests that would be empirically valid substitutes for criterion referenced Job Task Performance Tests. The development and tryout of such criterion referenced tests and promising graphic symbolic substitute tests are reported in previous volumes. The graphic symbolic tests require the storage of a large amount of pictorial information which must be searched rapidly for display. At the time this video effort was started, no completely

satisfactory way had been found for rapidly searching and displaying such information. In addition, some dynamic displays would have been desirable for those graphic symbolics where as all of the original graphic pictorials are static. The anticipated results that the video media would provide satisfactory and economical solutions to these problems, did not materialize. From a testing point of view symbolic tests place the test subject in a passive, evaluative role of watching someone else perform each task. Success in this passive role does not insure his success in the active role of performing the same task. Also, the development costs of the video tests proved to be very high in terms of video equipment and test development time. To obtain video materials of acceptable quality, would require both quality video equipment and studio production facilities. As a result, it was recommended that video should not be further considered as a testing medium for performance analogues and that future efforts should be aimed at improving and refining graphic symbolic substitute tests.

46. Tetmeyer, D.C. Estimating and Controlling Manpower Requirements for New Systems: A Concept and Approach. AFHRL-TR-74-31, April 1974. AD-778 838.

The Air Force faces qualitative, quantitative and budgetary limitations on the number of personnel by AFSC that can be provided to maintain new weapon systems. A systems concept is proposed for manpower prediction and control during the development cycle, using automated data systems and simulation techniques. A plan is presented for a feasibility demonstration during validation phase on the A-X Tactical Aircraft.

47. Tetmeyer, D.C., & Moody, W.D. Simulating Maintenance Manning for New Weapon Systems: Building and Operating a Simulation Model. AFHRL-TR-74-97(II), December 1974.

The Air Force Human Resources Laboratory, in conjunction with Headquarters Air Force Systems Command and the Aeronautical Systems Division, has developed and implemented a new method for determining and evaluating the maintenance manning required for new weapon systems. Key features of the new approach are: 1. Manning requirements are determined by dynamic simulation of maintenance work to support specific operational scenarios. The number of people needed to support the same aircraft and flying hour program varies greatly with basing and deployment, mission types, and sortie length. 2. Manning is based on required availability, not just on the sum of manhours worked. While worktime is a major consideration, equipment does not break on schedule and combat aircraft cannot always fly on a schedule that provides an even workload. 3. Maintenance frequencies and job requirements for a new system are extrapolated from Air Force experience with similar equipment, adjusted for differences in design and environment. The total time a man is tied up on a job is explicitly modeled, not just "wrench turning" time. 4. Output is in a format compatible with the Air Force manpower authorization system. This approach provides more realistic and useable estimates of manning requirements and focuses on how both

a contractor's design and Air Force procedures contribute to maintenance cost. As soon as the new aircraft configuration can be defined, comparable equipment and design differences are identified at subsystem level. Maintenance data on comparable equipment are processed through a series of specially designed programs. These data are the basis for developing initial estimates of the frequency, time, and resources for each maintenance task when modified by the judgement of experienced maintenance technicians and project engineers. The logistics and operational concepts, basing, maintenance organization and flying schedules are developed in detail for various scenarios and set down in explicit form for input to the simulation. The simulation attempts to generate the specified missions in the computer. Aircraft are turned and maintenance accomplished as they break or need service according to the task data specified in the input. Manning levels in the various work centers are constrained on successive runs until further reduction prevents the necessary number of missions from getting off. The results of various simulation runs are integrated in a final series of computer programs that computes manning in each work center for any flying program within the simulated range, adds authorized overhead, adjusts for grade level limitations, and produces a complete basic authorization document for maintenance manning in the required format. The methodology and models have b en successfully applied on the A-10 program and are being considered for implementation on other aeronautical systems in or entering development. Work is underway in conjunction with Air Force Logistics Command to incorporate this methodology into a system for total logistics tradeoffs and life cycle costing. This volume describes the procedures to build a maintenance simulation data base for a new aircraft, to run it with the Logistics Composite Model (LCOM) computer program, and to use the results to predict the maintenance manning required for a new aircraft flying a specific operations scenario. Computer programming knowledge is not necessary to follow and apply this instruction. The procedures presented have been tested and used at the Aeronautical Systems Division of Air Force Systems Command in building and operating simulation models of A-10 and A7 aircraft.

48. Whalen, G.V., & Askren, W.B. Impact of Design Trade Studies on System Human Resources. AFHRL-TR-74-89, December 1974. AD-A009 639.

This study was undertaken to accomplish two objectives. The first objective was to identify and classify the characteristics of conceptual design trade studies that have high potential impact on human resource requirements of Air Force weapon systems. The approach used was a case history review and analysis of 129 F-15 aircraft design trade studies. The analysis indicated that the avionics system demonstrated the greatest potential impact on human resources. It was also found that trade studies dealing with design alternatives that

encompass widely different technologies have substantial impact on human resources. The types of human resources data (HRD) most influenced by alternative design options were maintenance task times and personnel costs. The second study objective was to determine the accuracy of using subjective estimates as a technique for deriving the HRD impact of trade study options. Using only engineering information for six avionics subsystems, from the conceptual design phase, Air Force maintenance technicians made subjective estimates of the impact of the designs on selected HRD items. It was found that technicians can make highly accurate estimates of the amount of time, the Air Force occupational specialty, the level of technical skill and the number of personnel needed to perform field maintenance tasks.

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