AD-A273 124

AL-TR-1991-0078

ARMSTRONG LABORATORY

COCKPIT AUTOMATION TECHNOLOGY CSERIAC-CAT JULY 1989 - DEC 1990: FINAL REPORT

Trudy S. Abrams
Cindy D. Martin
Carl E. Orr
Thomas A. Hinson

UNIVERSITY OF DAYTON RESEARCH INSTITUTE
300 COLLEGE PARK
DAYTON, OHIO 45469-0150

JUNE 1991

Approved for public release; distribution is unlimited.

AIR FORCE SYSTEMS COMMAND
WRIGHT-PATTERSON AIR FORCE BASE, OHIO 45433-6573

NOTICES

When US Government drawings, specifications, or other data are used for any purpose other than a definitely related Government procurement operation, the Government thereby incurs no responsibility nor any obligation whatsoever, and the fact that the Government may have formulated, furnished, or in any way supplied the said drawings, specifications, or other data, is not to be regarded by implication or otherwise, as in any manner licensing the holder or any other person or corporation, or conveying any rights or permission to manufacture, use, or sell any patented invention that may in any way be related thereto.

Please do not request copies of this report from the Armstrong Aerospace Medical Research Laboratory. Additional copies may be purchased from:

National Technical Information Service
5285 Port Royal Road
Springfield, Virginia 22161

Federal Government agencies and their contractors registered with the Defense Technical Information Center should direct requests for copies of this report to:

Defense Technical Information Center
Cameron Station
Alexandria, Virginia 22314

TECHNICAL REVIEW AND APPROVAL

AL-TR-1991-0078

This report has been reviewed by the Office of Public Affairs (PA) and is releasable to the National Technical Information Service (NTIS). At NTIS, it will be available to the general public, including foreign nations.

This technical report has been reviewed and is approved for publication.

FOR THE COMMANDER

KENNETH R. BOFF
Acting Division Chief
Human Engineering Division
Armstrong Laboratory

REPORT DOCUMENTATION PAGE

Form Approved
OMB No 0704-0188

1. AGENCY USE ONLY *(Leave blank)*	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	June 1991	Final, Jul 89 to Dec 90

4. TITLE AND SUBTITLE
Cockpit Automation Technology CSERIAC-CAT JUL 89 - DEC 90:
Final Report (U)

5. FUNDING NUMBERS
PE 62202F
PR 7184
TA 12
WU 22
C DLA900-88-D0393

6. AUTHOR(S)
Trudy S. Abrams, Cindy D. Martin, Carl E. Orr, and
Thomas A. Hinson

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
University of Dayton Research Institute
300 College Park
Dayton, OH 45469-0150

8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
AL/CFHD
Wright-Patterson AFB, OH 45415-6573

10. SPONSORING/MONITORING AGENCY REPORT NUMBER
AL-TR-1991-0078

11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution is unlimited

12b. DISTRIBUTION CODE
A

13. ABSTRACT *(Maximum 200 words)*
This report covers the 18-month contract period during which time CSERIAC served as a beta site for setting up, evaluating and managing the Boeing-developed CAT software tools, and for facilitating their use by the cockpit design community. A brief description of the overall task is given, followed by a chronological summary of accomplishments within subject areas of general management, configuration control, development of proficiency and training, technology transfer, the library of documentation, and a related effort -- the AAMRL/HEG CAT Library and Database. The longest section is a detailed critique and evaluation of the CAT Methodology and the software tools. Finally, recommendations vis-a-vis equipment needs, technical personnel and management, and technology transfer and training are listed. Two significant documents are provided in entirety as appendices: The Configuration Control Plan, and a template form of the Procedures Notebook which guides the user through the analyses processes linked by the Methodology and served by the software tools.

14. SUBJECT TERMS
Cockpits; Automation; Cockpit Automation Technology; CAD; Design; Mission Scenario; Workload Analyses; Beta Site; CAD Software.

15. NUMBER OF PAGES
94

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
Unclassified	Unclassified	Unclassified	UL

CONTENTS

1. BACKGROUND

In the early 1980's the Air Force began an extensive program in Cockpit Automation Technology (CAT) aimed at improving crew station design through improvement of the engineering design process. This program focused on incorporating computer aids into the design process, particularly analysis tools which could help determine how automation technology should be used to alleviate pilot task and attention overload. During Phase 1 the CAT concept was studied and refined. In Phase 2 the CAT design process was developed and applied, and development of a cockpit automation design support system was undertaken.

Phases 2 and 3 were begun in the late 1980's, the major role being played by Boeing Advanced Systems in Seattle. Objectives were to further develop the CAT design process methodology and support systems, and to include mission, cockpit, task and function allocation analyses software tools as one segment. As development progressed at Boeing, Air Force Advanced Development Program Office (ADPO) personnel saw the advantages of having a "close-by" beta site where the tools could be tested, evaluated, and maintained by personnel who were connected directly to neither the Air Force nor to Boeing. Furthermore, the site could develop as the tools themselves developed, so that after final acceptance of this CAT segment, the site and its technical personnel, now knowledgeable in the use of the tools and their applications, could become the vehicle for transferring this technology to the crew station design community.

The Crew System Ergonomics Information Analysis Center (CSERIAC), managed by the University of Dayton Research Institute (UDRI) and located at the Human Engineering Division of the Armstrong Aerospace Medical Research Laboratory (AAMRL/HE) at Wright-Patterson Air Force Base, undertook this role. Defense Logistics Agency Contract Number DLA900-88-D-0393, Task 01, was issued on 6 July 1989 by the Defense Electronics Supply Center (DESC) to the University of Dayton for a contract period of 18 months. [5.1.] The first delivery (from Boeing) of CAT hardware and software occurred five months later, in December. During the next eight months, it became evident that, due to circumstances largely beyond the control of both the Government and the University, satisfactory completion of all task items by the contract end date was either not possible or not desirable, and an amendment to the task descriptions was requested and granted. This final report summarizes the technical work done under the amended contract.

1.1. General Task Description

CSERIAC's broad responsibilities were (1) to host, operate and maintain the Boeing-developed CAT tools and their related commercial products and databases; (2) to evaluate and critique these software tools; and (3) to transfer this technology (the use of these tools) to the design community-- by giving demonstrations of its capabilities, running training workshops, and providing independent analyses services. [5.1.]

1.2. Boeing-Delivered Resources

The hardware component of Boeing's Early Designer's Computer-Aided Design System (DCADS) Delivery in October 1989 that was received by CSERIAC consists basically of one DEC super-mini (VAX 8250), one Silicon-Graphics workstation (IRIS 4D/50G), one DEC graphics workstation (VAXstation II/GPX), and standard peripherals for those systems (disk and tape drives, controllers, terminals, networking hardware, etc.). A complete listing of these items appears in the hardware inventory prepared by CSERIAC in March 1990. [5.2.] In accordance with AAMRL practice, the component systems were given node names-- the VAX 8250 is known as MERLIN, the IRIS 4D/50G as CATBIRD, and the VAXstation II/GPX is called WREN.

The software, some of which was delivered the following December, consisted of the VAX VMS operating system and the standard software utilities, languages, editor, etc., and the IRIX operating system (UNIX for the IRIS workstation) ; graphics software; networking software; word-processing software; the commercial products integral to CAT (the CAD package I-DEAS, the DBMS package Ingres, and the specialized mission decomposition program MDTOOL); and the CAT tools developed by Boeing. A complete listing of these items appears in the software inventory prepared in February 1990. [5.2.]

The manuals provided by the commercial vendors (DEC, Silicon Graphics, Ingres, and SDRC for I-DEAS) were the only documentation accompanying the hardware and software, since MDTOOL (by Merit Technology) and the Boeing tools were still under development. A listing of these items, likewise, is given in the documentation inventory prepared in February 1990. [5.2.]

In addition to delivering the hardware, software and documentation that comprised their Early DCADS Delivery, Boeing technical personnel helped install the hardware and software systems and provided a training course from 4-15 December 1989. [5.3.]

1.3. AF-Supplied Resources

Some hardware, software and accompanying documentation came to CSERIAC directly from the Government-- for example, the Tektronix printer and rasterizer, Wollongong network software, various cables, etc. The inventories listed above include these items although their origin is not specified. [5.2.]

The Government also supplied an office (Room 4 in Building 196 at WPAFB Area B) that was to be used as a computer room/demonstration room/training center/library, and some technical services for wiring, air-conditioning, etc.

1.4. CSERIAC Resources

As called for in the Statement of Work, CSERIAC provided staffing for this Special Task. In addition to administrative support from UDRI and the CSERIAC Associate Director and clerical staff as necessary, the designated CSERIAC-CAT team consisted of four technical personnel. These were a full-time Task Manager, a full-time Systems Manager, a half-time Human Factors Engineer Crew System Analyst, and a part-time Software Engineer. UDRI also loaned surplus furniture to augment the Government furnishings in the CAT Room.

2. SUMMARY OF ACCOMPLISHMENTS

2.1. General Management

During the first and second quarters of this contract period, in anticipation of the delivery of the CAT hardware and software systems from Boeing, general plans were formulated and key personnel were hired and briefed on the project. [5.4.]

At the beginning of the third quarter, following the Boeing training course in December 1989, the computer equipment was moved and reconfigured several times between Room 8 (the CSERIAC general offices) and the CAT Room in attempts to establish an adequate work space. Difficulty controlling the temperature in the CAT Room and vulnerability to lightning and power surges were evident from the beginning and addressed continually by CSERIAC. On 20 August 1990 Government personnel installed a drop-out relay and during the following week they replaced a lower window with an air-conditioning unit. [5.4.]

Several basic procedures for facilitating and controlling the use of the CAT Room and CAT tools by other than CSERIAC personnel were put in place early on. User Accounts were installed on all systems, and a Scheduling Calendar and Activities Log Notebook (for documenting use by non-CSERIAC designers and engineers) were instituted. [5.4.]

A working meeting between a few Government and CSERIAC personnel, preliminary to a formal Kick-Off, was held on 11 January 1990 at which an outline describing the status of CAT equipment and CSERIAC activities and goals was presented and discussed. Thirteen people attended the Kick-Off on 9 February. A top-level early version management chart was presented and discussed, goals were clarified, and areas of particular concern were noted. Three action items were identified: (1) compilation of inventories for current in-house software, hardware and documentation; (2) delivery of a schedule chart showing milestones for the entire CAT Special Task; and (3) establishment of configuration control procedures, methods, and tools. [5.4.]

An inventory of CAT software was delivered to the CAT ADPO on 22 February 1990; inventories for hardware and documentation followed on 30 March. The first of several editions of a CAT Management Plan Schedule Chart (PERT Diagram) and accompanying Task Timeline (Gantt Chart) were delivered to the CAT ADPO and other Government personnel at about the same time (6 March). The task of controlling, documenting and tracking both hardware and software configuration changes was analyzed, methods and procedures were defined, and a Macintosh database management system was identified within which a configuration control database could be built, maintained easily, and accessed by appropriate management personnel both at CSERIAC and at AAMRL/HE. [5.4.]

Also in mid February 1990, initial contact and good rapport was established with the Deputy Project Manager for CAT at Boeing in Seattle. This rapport continued throughout the contract period with excellent cooperation demonstrated continually, not only between the two prime Points of Contact (the Boeing Deputy Project Manager and the CSERIAC Task Manager), but in all contacts between Boeing and CSERIAC technical personnel. Several drafts of an Associate Contractor's Agreement were exchanged between respective contracts offices during the following months. A formal document was signed by both parties in November, though the relationship had been adequately served, informally, from the beginning. [5.4., 5.5.]

The first of several discussions concerning the status of the current project and the need to extend and expand its objectives took place in May of 1990. Directly afterwards a memo proposing personnel allocation and funding for an additional year of effort was delivered to the CAT ADPO. At the same time, CSERIAC-CAT management personnel drafted the first of several documents suggesting amendments to the original Statement of Work that were more consistent with the direction and time-frame of the project as it had actually developed and was expected to develop in the future. Later versions of this document formed the basis of a request to DESC suggesting details for a Contract Modification. This request noted that the realities of working with a developmental prototype conflicted with fulfilling several tasks delineated in the original SOW, whose objectives would, in fact, be best served after final versions of the CAT tools were released. This Contract Modification was granted by DESC in late November. [5.1., 5.4.]

In summary, the CSERIAC-CAT general management goals were to fulfill the requirements of the Special Task contract by (1) establishing a cohesive team of technical personnel and facilitating their acquisition of expertise in the function and use of the CAT software; (2) establishing procedures and aids for continued management of CAT at CSERIAC, including configuration control and support for the use of CAT by the technical design community; (3) establishing a working relationship with the developers of the CAT tools; and (4) evaluating and critiquing the CAT software in terms of its usability and applicability insofar as possible, given its stage of development. All of these goals have been met. [5.1., 5.4.]

2.2. Configuration Control

The hardware and software systems delivered in October and December of 1989 were configured initially to accommodate the training course. A truly workable configuration that allowed for multi-user access and file transfer between the component systems was not instituted until early March when a new Systems Manager assumed full-time duties. The month of March was extremely busy and productive; several hardware failures were detected and corrected, and several software problems were solved. File transfer capabilities between MERLIN, WREN and CATBIRD were established, and protected user accounts on all systems were set up and tested. Additionally, as noted above, inventories of all hardware, software and documentation items were produced and delivered to the CAT ADPO in February and March. [5.4.]

Also in March, directory listings for each of the three systems were printed out and sent to Boeing in efforts to determine optimum configuration for all the software. Boeing analysts quickly confirmed that the configurations that had been hastily set up for the training course were inadequate for practical use and, working with the CSERIAC-CAT Systems Manager, were helpful in suggesting changes. [5.4.]

A review of options concerning hardware sites and configurations, along with projections of current and future disk space needs, made clustering the two VAX systems imperative. All user accounts and both VAX operating systems were placed on MERLIN disk packs; only paging files and the I-DEAS CAD/CAM software were left on WREN's three RD disk drives. Unusable hardware (such as an RA-81 drive not usable on MERLIN without a new bus controller) were turned over to AAMRL/HE. Setting up the rooted directories and the printer and batch queues in the new environment, the main subtasks associated with clustering the VAXes, turned out to be a bit more involved than expected but were successfully accomplished. [5.4.]

Networking the two VAXes to the IRIS workstation with WIN/TCP, the Wollongong TCP/IP network software, had been accomplished earlier but had to be repeated because of changes in disks and disk drive names associated with the new cluster environment. This also turned out to be somewhat problematic due to incompatibilities between the WIN/TCP and the VAX 5.3-1 O/S, but, again, was successfully accomplished by early summer. During the last quarter of the contract period (September-December 1990) all AAMRL computers were configured for Internet access, with concomitant changes in all node addresses. This caused some disruption in our local network and cluster, and quite a lot of rebuilding was necessary yet again. [5.4.]

Hardware failures occurred fairly regularly, though not excessively. On average, one or two were dealt with each quarter. Maintenance personnel from the appropriate vendors (DEC or Silicon Graphics) responded quickly; in most instances faulty components were replaced under existing support contracts. [5.4.]

Operating system software upgrades were installed as they were acquired. From early March until the end of December 1990, upgraded VAX/VMS operating systems had been installed for MERLIN and WREN three times, and upgraded IRIX operating systems for CATBIRD had likewise been installed three times. A complete system generation with reinstallation of all products was done once for each of the two operating systems. [5.4.]

There were several important updates to applications software as well, with most of the activity occurring in the spring. Updates to commercial packages (Ingres, MDTOOL and I-DEAS) were regularly received, but only those evaluated and implemented by Boeing were installed as working versions. MDTOOL version 3.05 was installed by Merit Technology personnel on 12 June. That, together with the companion upgrade to the Boeing software which was delivered soon after, became our first operating baseline and was dubbed CAT β-1 (Beta-1). The Boeing tape included some changes to the CASS modules and to IATOOL, two new versions of NMT (one compatible with the new format for the flight data recorder file and the other compatible with the old format of that file), and some database files compatible with the new MDTOOL. I-DEAS 4.1, Ingres 6.2, and the VAX/VMS 5.3-1 and IRIX 3.2 operating systems are the other basic components of CAT β-1. Towards the end of the year Boeing sent a considerable number of data files compatible with MDTOOL 3.08, around which we are expecting to build the next update of the CAT tools, CAT β-2. [5.4.]

Beginning in the spring and continuing through to early December, considerable effort was spent in the pursuit of providing and maintaining support agreements (licensing) with various hardware and software vendors. These vendors include Ingres, Merit Technology (for MDTOOL), SDRC (for I-DEAS), Tektronix, Hewlett-Packard, Wollongong (for TCP/IP), Interleaf (for the Tech Pub S/W), Precision Visuals (for the DI-3000 Graphics S/W), Microsystems (for Mass-11 Word Proc S/W), and, of course, DEC and Silicon Graphics. Itemized lists, including model numbers and pricing information, were delivered to the CAT ADPO as the information was collected and organized. Additionally, several times during the year, the CSERIAC-CAT Systems Manager alerted the CAT PO in writing (or E-Mail) to potential problems or needs with respect to both hardware and software that should be considered for optimum continuous support of the CAT systems. [5.4.]

A preliminary schema for the configuration control database (called CATCON) was designed and installed in FoxBASE+/Mac, a Macintosh-platform multi-user version of a DBMS owned by CSERIAC. Besides its touted speed and other state-of-the-art features, this DBMS was chosen because PC versions of FoxBASE can network with the Mac versions, allowing maximum access. Preliminary descriptions and plans for developing this database were presented at the kick-off meeting in early February and a first-draft schema (listing field names, data types, and descriptions of contents) was included in the fourth CAT Quarterly Technical and Configuration Control Reports covering April-June. [5.4.] A formal (written) Configuration Control Plan including more detailed descriptions along with projections of content and use was delivered to the CAT ADPO on 20 November and is included in the Appendices as Section 6.1. [5.6.]

2.3. Development of Proficiency and Training

Establishing expertise in the use of the CAT tools has been a major and continual thrust at CSERIAC. Paralleling this effort has been the development of training concepts, methods and aids, since that which is learned by CSERIAC-CAT will subsequently be taught by CSERIAC-CAT. Exposure to the basic components and concepts of the Boeing CAT program began before the actual training course in December 1989, though no hands-on experience was possible before delivery and configuration of the hardware and software. After the training course, and after a working environment and stable multi-user configuration was achieved, progress in these areas increased dramatically. By early February the CSERIAC-CAT Analyst had exercised all of the tools on both graphics workstations from the single user account active at that time. On-line procedural documentation was generated for each module, so that lessons learned while acquiring proficiency could be used in critiquing the tools, developing training concepts and materials, and transferring the technology-- applying CAT to the cockpit design process. [5.4.]

Hands-on exercising of the tools was slowed during the early spring due to the large amount of system reconfiguration. However, a short review of CAT capabilities was given to HSD/YAH and WRDC/KTC personnel, and progress was made in analyzing possibilities and developing strategy for the first formal proficiency demonstration. The F-16C cockpit was selected as the subject for this demonstration, and some relevant material was acquired-- (hard copy) F-16 scenarios from HSD/YAH, and a tape from Boeing containing several directly relevant input files. [5.4.]

Throughout the contract period, as the CSERIAC-CAT Analyst concentrated on developing proficiency in using the CAT modules, the Systems Manager's main thrust was increasing his general knowledge of the hardware and software systems under his care and in computer graphics, particularly CAD/CAM. In practice, each of these CSERIAC-CAT team members served as the other's main "back-up," lending depth to team expertise.

During the second half of 1990 all efforts in developing proficiency, developing materials which could be used for demonstration and training later on, and analyzing the limitations or bugs in the CAT software were specifically tuned to preparations for the formal demonstration of CSERIAC-CAT proficiency and CAT capabilities. An Organizational Plan and Agenda for the demonstration was delivered to the CAT ADPO on 5 September. Subsequent meetings, both intra-CSERIAC and between CSERIAC-CAT people and CAT ADPO personnel, helped develop a somewhat realistic engineering design problem as the focus of the demonstration. CAT ADPO personnel and personnel of HSD/YH were particularly helpful in supplying technical guidance for developing the Air-to-Ground (A/G) mission scenario and generating the event time line. Other ASD technical personnel, and technical personnel at Merit Technology and at Boeing, also helped in various ways towards preparation of this example design problem for the demonstration. [5.4.]

The formal "Demonstration of CAT Software Tool Capability and CSERIAC-CAT Proficiency Using an Engineering Cockpit Design Problem" was given on 19 December in the CAT Room at CSERIAC. A total of 10 people attended. On 30 October, seven weeks before the demonstration, a draft narrative of the engineering design problem was delivered to the CAT ADPO. A revised (and final) version was delivered on 18 November. Additionally, as an offshoot of the successful year-long effort to document procedures used in applying CAT to design problems in general (an integral part of our Training and Technology Transfer efforts), the CSERIAC-CAT Analyst, with team cooperation, produced a 94-page document which describes, specifically for the example design problem used in this demonstration, the analyses steps, results, and recommendations for design changes; notes bugs and limitations of the CAT tools encountered; and includes 67 pages of appendices containing sample output and descriptions specific to this problem and these analyses. [5.4., 5.7]

On the day following the formal demonstration, a Workshop Plan was delivered to the CAT ADPO. Actual presentation of a training workshop during this year (a requirement of the original Statement of Work), was deemed unwise largely because of the current developmental state of the CAT software, so that SOW item was amended appropriately. The final distribution version of CAT software is not expected from Boeing until the end of 1991; evaluation of it and the building of support files (databases and CAD data sets) will take some time after that. For these reasons, the thrust of this Workshop Plan was preliminary and offered very basic and theoretical options in scope, time-frame, design, and course content. [5.4., 5.8.]

2.4. Technology Transfer

Areas of concern at CSERIAC-CAT have all along been seen as interdependent and intertwined. That is, we have acknowledged that management of the special task, configuration control and systems management, development of proficiency and training, and transfer of the CAT technology to the engineering design community are interrelated and that the categories exist mainly for administrative and reporting purposes, often with no clear-cut boundaries between them. Consequently, we have never treated them linearly; technology transfer strategies-- indeed, marketing strategies in addition-- have been considered from the very beginning as parallel concerns along with the development of proficiency and training methods/procedures, even though we have been working entirely with a pre-release version of the technology.

At the end of February 1990, in response to a request from AAMRL/HED, a user account was set up for an LTSI analyst so that the CAT modules, particularly MDTOOL, could be exercised with "real-world" data. Soon afterwards, user accounts were set up for personnel of ASD/ENECH, ASD/ENECH-CSEF, and CAE-Link so that they could investigate the use of CAT in redesigning the C130-J cockpit. A User Activity Log in the form of a loose-leaf notebook with preprinted forms was instituted to keep track of activity, and the standard AFSC Form 2685 implemented to receive requests for, and maintain records of, access to the CAT computers. [5.4.]

Several informal demonstrations have been given, with CAT ADPO approval, to industry and USAF groups investigating the potential of using CAT in crew station design. R&D personnel from the Ford Motor Company visited CSERIAC in mid May of 1990. Two personnel of AFHRL/LR were given a short demonstration in July. In August, MDTOOL was demonstrated for several members of HSD/YAH(NSBIT), and the Branch Chief of AAMRL/BBE. And in mid October, personnel of NTI and of Fighter Command International attended a demonstration of MDTOOL and discussed CSERIAC capabilities for database maintenance and design. Informal demonstrations have been given, as requested by the CAT ADPO, for various AAMRL/HEX personnel. [5.4.]

SABER Lab personnel have borrowed copies of MDTOOL and related files to support their own separate efforts. Likewise, ASD/ENECH and CAE-Link personnel have continued to exercise MDTOOL for other projects; in October and November they evaluated KC-135 Air-to-Air (A/A) scenarios provided by Boeing in the hopes of applying them to a redesign effort for that aircraft. Another ASD/ENECC engineer and a WL/KTC engineer have also continually exercised MDTOOL, with technical support from CSERIAC-CAT. [5.4.]

The Procedures Notebook represents a long-term effort and a significant accomplishment. It evolved as an integrated attempt by the CSERIAC-CAT Analyst to address issues in providing guidance and documentation during actual applications of CAT, in developing aids for training and technology transfer, and in documenting the analyses performed for the engineering design example used in the formal demonstration. It parallels the Designer's Electronic Notebook (DEN) being developed by Boeing as part of CAT and serves similar functions. At CSERIAC, each "template" version of the Procedures Notebook will serve to guide the analyst and designer through the use of the CAT tools during the analyses process. When the analysis is complete, the Notebook serves as a tracking mechanism for shifting to alternative designs and further analyses, and for documenting an acceptable design change. Design engineers using CAT β-2I (Beta-2 Interim) at CSERIAC to investigate specific problems have been provided with template versions of the Procedures Notebook. [Section 6.2.] We plan continual improvement and further evolution of this particular aid to using CAT. [5.4., 5.9.]

Another aspect of the transfer of CAT technology to the user community is its marketing. Early on, during the kick-off meeting on 9 February 1990 and in follow-up informal meetings, a good idea (originating with a member of AAMRL/HEG) for helping to organize the marketing of CAT at CSERIAC via a "CAT Product Inventory Data Base" was discussed. The database would help to define CSERIAC's role in distributing services and "hard" products-- promotional or explanatory documents, software and data files (CAT, or CAT-related), specifications for commercial hardware and software needed to run CAT, etc. Customer tracking would be another function of the database, so that profiles of customer activity within and outside of the DoD would be available. Although this database has not developed beyond the idea stage during this contract period, its potential is recognized and further development is planned.

2.5. Library of Documentation

A library of CAT documentation, each item of which is directly related to a particular piece of CAT hardware or software, is maintained in the CSERIAC office or CSERIAC-CAT Room. No technical documentation that is specific to the Boeing-developed CAT tools has been delivered yet, of course, but current versions of user's manuals and installation instructions for all commercial products are available. A few second-source textbooks (on Ingres, for example) are also in the CSERIAC CAT Library. Each piece of documentation will eventually be represented in the configuration control database (CATCON), in the record for the hardware or software item to which that documentation relates. Eventually, each will be tagged with a suitable control/ownership code. [5.2., 5.4., 5.6.]

2.6. Related Effort: AAMRL/HEG CAT Library & Database

An additional accomplishment, not specified in the SOW but seen as contributing to the overall objectives of CAT, was the establishment of a bibliographic database and library for literature on Cockpit Automation Technology (CAT). The library itself is currently located at AAMRL/HEG. CSERIAC performed an extensive bibliographic search to help identify relevant documents, then helped acquire those designated by HEG personnel. [5.4.]

The database uses the Ingres Database Management System that supports the CAT software tools and is mounted on MERLIN, the VAX 8250. CSERIAC-CAT team members with expertise in database design helped determine requirements and specifications. The database schema was installed in late summer and has the name HE_CAT_LIBRARY_DB.

HEG personnel were provided with field descriptions and given a training session (using their own computer terminals to access MERLIN) in August. [5.4.]

Though not fully developed, this related project is seen as a valuable asset to the overall CAT mission. It provides a "close-by," highly selective and highly relevant bibliography and library of technical literature on Cockpit Automation Technology, within easy reach of the designers and engineers who need it.

3. CRITIQUES AND EVALUATIONS

As previously stated, an important general goal was to evaluate and critique the CAT software in terms of its usability and applicability, given its prototype stage of development. Attention was given to this objective during all interactions and exercising of the CAT tools, but comprehensive evaluations and documentation thereof were actually accomplished during the development of the formal "Demonstration of CAT Software Tool Capability and CSERIAC-CAT Proficiency Using an Engineering Cockpit Design Problem". [5.7.]

3.1. The CAT Methodology

The overall objective of the Air Force's CAT Program is to "develop and demonstrate a totally integrated crew system design and evaluation process applicable to manned military flight vehicles". To meet this objective, Boeing Advanced Systems, for their part, developed a structure for this integrated process (the Methodology) and complemented it with the Designer's Computer Aided Design System (DCADS), the CAT software tools.

The Boeing-developed CAT Methodology is depicted in $IDEF_0$ format as a two-level flow structure where the top level consists of function blocks and the second level consists of procedures specific to each function block that must be performed to obtain the necessary input for the next function block. Boeing has developed groups of function blocks for each of four processes (sometimes called "phases" or "stages" in the Boeing documentation)-- Analysis, Design, Test & Evaluation, and ILS & Safety-- within each of the four weapon system development phases of the Department of Defense major systems acquisition process (MSAP). These four weapon system development phases are: Concept Definition, Demonstration/Validation, Full Scale Development, and Test & Evaluation. The Boeing CAT Methodology, thus, is encompassed within a matrix of 16 different groups of top-level function blocks (See Figure 1).

The group of function blocks within the Demonstration/Validation column (phase) and Analyses row (process) appeared to be the most appropriate for the feasibility-study type of analyses most likely to occur at CSERIAC-CAT in the future, and for those needed in the example problem of the CSERIAC-CAT formal demonstration. Although not all of the top-level function blocks were executed or reviewed for that particular problem, the complete list for that cell of the Methodology structure is as follows:

DEMONSTRATION/VALIDATION Column, ANALYSIS Row:

DA01. Develop Human Engineering Plan;
DA02. Conduct Mission and System Analysis;
DA03. Characterize Mission;
DA04. Define Baseline Crew Station;
DA05. Generate Control/Display Catalog;
DA06. Perform Function Analysis;
DA07. Attach Tasks to Procedures;
DA08. Perform Procedure Analysis;
DA09. Perform Reach Analysis;
DA10. Perform Internal Vision Analysis;
DA11. Perform External Vision Analysis;
DA12. Perform Workload Analysis;
DA13. Perform Information Analysis;
DA14. Review Configuration and Rework or Accept;
DA15. Perform Critical Task Analysis;
DA16. Review Go-Ahead for Evaluation;
DA17. Perform Function Analysis;
DA18. Evaluate Design Solution Candidates;
DA19. Define Control and Display Requirements;
DA20. Define Operational Procedures;
DA21. Establish Equipment Requirements;
DA22. Document Human Engineering Results.

The CAT Methodology provides a logical framework in which to establish procedures for performing human engineering analysis of crew station design. For the demonstration design problem, the procedures attached to the function blocks considered were thorough in addressing all possible areas of analysis. However, the methodology failed to provide help in determining whether or not certain procedures might actually need to be performed at all in a particular analysis, why, or which procedures might most readily be shed. The Methodology also fails to identify a starting point for the analyses and to indicate what resources are required to obtain specific analytical output that might be desired.

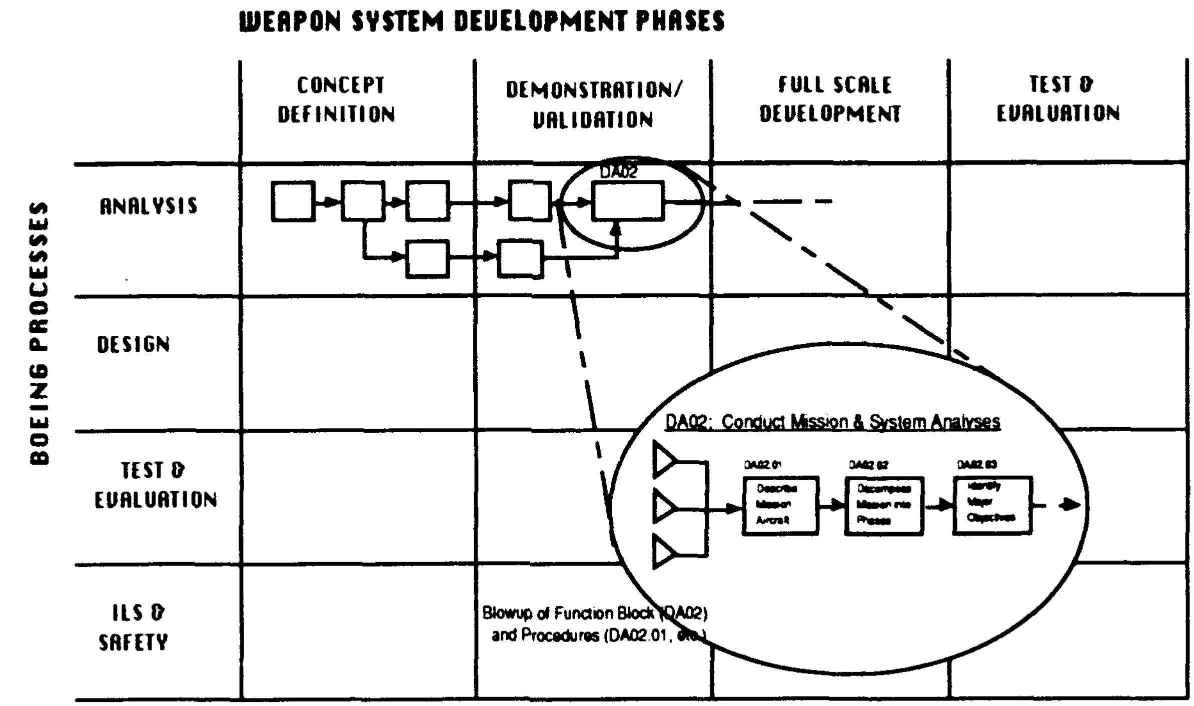

Figure 1.

3.1.1. Applicability to Design Process

To perform the analyses for the demonstration problem, and for future analyses, a procedures notebook was developed to keep records of the software tools accessed, required inputs, outputs, file naming for traceability, lessons learned, and results leading to design documentation and specifications. This notebook complements the CAT Methodology developed by Boeing and maintains a record of the analyses activities for traceability and for providing any information necessary for documentation. Though somewhat cumbersome in its current paper format, it serves an important function by providing a prototype and guide for future crew station design activities. [5.9.]

Given the structure of the Boeing CAT Methodology and that the example design problem analysis was to be performed within the Dem/Val phase, the procedures notebook was divided into sections corresponding to the top-level functions, the procedures for each of those functions were then listed and specific information was entered for each procedure. This worked well for the demonstration design problem. [5.7.] The CAT Methodology did provide a logical structure for execution of the analysis process. The most noteworthy problem in applying the CAT Methodology to the design process is the lack of feedback loops for iterative processes. The current CAT Methodology is uni-directional and will not accommodate parallel or iterative processes.

3.1.2. Relationship to the CAT Software Tools

The software tools (DCADS) may be used to obtain output files leading to products for several procedures of the top-level functions in the CAT Methodology. Those that support the top-level functions for the example design problem are given below:

- DA02. Conduct Mission and System Analysis - Mission Decomposition Tool (MDTOOL);
- DA03. Characterize Mission - MDTOOL;
- DA04. Define Baseline Crew Station - Cockpit Instrument Panel Layout Program (CIPLP);
- DA05. Generate Control/Display Catalog - CIPLP;
- DA06. Perform Function Analysis - Network Management Tool (NMT);
- DA07. Attach Tasks to Procedures - NMT;
- DA08. Perform Procedure Analysis - NMT;
- DA09. Perform Reach Analysis - Operator Assessment of Reach (OAR);
- DA10. Perform Internal Vision Analysis - Display Legibility Analysis (DLA);
- DA11. Perform External Vision Analysis - E-VISION;
- DA12. Perform Workload Analysis - Procedure Execution Time (PET), Mission Scenario Analysis (MSA), Mission Procedure Execution (MPE), Mission Time-Line Analysis (MTA), Mission Task Time Performance (MTP), Function Analysis Report (FAR);
- DA13. Perform Information Analysis - Information Analysis Tool (IATOOL);
- DA17. Perform Function Analysis - NMT;
- DA18. Evaluate Design Solution Candidates - Survivability Measures and Methods Technique (SUMMET);

There is a very close relationship between the CAT Methodology and CAT Software tools. Although the CAT Methodology theoretically allows for performing procedures in any medium, it is apparent that most procedures are described with specific software tools in mind. For example, when performing Procedure Analysis, the user is required to "Attach

Procedures to Functions." This references a menu option specific to the NMT, and is not as meaningful if the user is performing this procedure in another medium (such as pencil and paper), or in a different software environment.

3.2. Software Baseline Version, CAT β-1

As described in Sections 1 and 2, the early DCADS hardware and software which was delivered to CSERIAC-CAT December 1989 together with the software update of June 1990 (MDTOOL 3.05 and some of the Boeing-developed software interacting with it) became the CSERIAC-CAT baseline configuration which we called CAT β-1. Critique and evaluation of this version, therefore, should be interpreted acknowledging the fact that both MDTOOL and the Boeing software were still in developmental phases at this time.

3.2.1. Relationship to the CAT Methodology

Relationship of the CAT software tools to the Methodology is best described by noting the functionality of each tool as implementation of a particular part of the Methodology. The Mission Decomposition Tool (**MDTOOL**) allows one to graphically plan a mission, decompose it into analyses subsets or phases, and analyze it phase by phase. It can generate planned and perspective view maps based on Defense Mapping Agency (DMA) Digital Terrain Elevation Data (DTED) and Digital Feature Analysis Data (DFAD); set up and display complete mission scenarios, including terrain, flight path, FEBA, and threat parameters; evaluate mission scenarios for threat exposure, terrain masking, and terrain following; and generate an event timeline (flight data recorder file). After an event timeline is generated, the user may add or delete events, tailoring the timeline further to represent more realistically the sequence of events in the true scenario. MDTOOL supports the following top-level functions of the Methodology: Conduct Mission and System Analyses, and Characterize the Mission.

For the demonstration problem, **MDTOOL** was used to describe a scenario and the objectives, strategies, and performance criteria for the critical mission element, and to create the scenario by specifying gaming regions, threats, targets, flight profile, and flight path. After all specifications were made, the mission was executed and a flight data recorder file generated. The flight data recorder file was edited to include appropriate events. MDTOOL relates well with the CAT Methodology. It allows for a great level of detail in mission specifications and is able to capture each of the procedures in the Methodology that relate to conducting mission and system analyses and characterizing the mission.

The Cockpit Instrument Panel Layout Program (**CIPLP**) helps the operator set up the layout of the cockpit using three entities. First, a panel is defined as a mounting surface and the user can enter up to 99 panels, specifying the orientation of each with three orthogonal reference points. Secondly, a module is defined as a grouping of controls and up to 199 modules can reside on each panel. The five inputs necessary to specify each module are width, height, local x-y coordinates, and tilt angle. And thirdly, each module can contain 99 control/indicators. To define a control/indicator the following are necessary: type (alphanumeric code given to a category of controls and indicators), local x-y coordinates (relative displacements of the control/indicator centers versus the module lower left corner point), and complexity score (a numerical value indicative of how complex it is to operate a control/indicator). CIPLP supports the following top-level functions: Define Baseline and Redesigned Crew Station, and Generate Control/Display Catalog.

Although **CIPLP** provides a means for creating or editing the cockpit geometry file that is necessary for further analysis, it is not instrumental in its relationship to the CAT Methodology. We found that the procedures established by the CAT Methodology are easily accomplished and more directly facilitated by editing an existing Cockpit Configuration Control file using the EDT editor available on the VAXstation II/GPX Workstation.

The External Vision Analysis program (**E-VISION**) provides the user with a total vision envelope of unobstructed vision from within the cockpit. It plots monocular vision from the design eye point (Aitoff or rectangular grids). A total vision envelope is shown from -180 degrees to 180 degrees in azimuth and -90 degrees to 90 degrees in elevation. E-VISION supports the external vision analysis top-level function of the Methodology. It directly relates to this part of the Methodology and is able to produce all appropriate output for the external vision analysis function.

The CAT Automated Software System (**CASS**) is comprised of a number of Boeing-developed programs that allow the user to perform workload and anthropometric analyses after the event timeline has been prepared using NMT and the cockpit geometry has been specified and formatted using CCC. CASS encompasses the following software tools:

NMT, CCC, DLA, MCOS, OAR, PET, MSA, MPE, MTA, FAR, MTP, PLTGGP, and C-SAINT.

The first of these, **NMT** (Network Management Tool) interacts with the user to develop and apply functions, procedures, and tasks to the mission event timeline contained in the flight data recorder file. NMT thus aids the analyst in elaborating the event timeline generated by MDTOOL into a complete timeline description of crew member activity down to the elementary task level. It supports the following top-level functions of the Methodology: Perform Function Analysis, Perform Procedure Analysis, and Attach Tasks to Procedures.

NMT was used to create an event-function-procedure-task treenet structure from the event timeline of the flight data recorder file for the demonstration problem. This treenet structure is a direct result of performing the function, procedure and task analyses required by the Methodology at this point. By creating this treenet structure, mission specific data for this function block is in a format that is usable for further workload and information analyses. NMT provides an excellent means for organizing and archiving this kind of data.

The second in the CASS group of programs listed above, **CCC** (Cockpit Configuration Control) uses the output from the CIPLP program (named, conveniently, *.cccin file) as its input, reformats this data into a report format that is both usable by the other workload and anthropometric software and readable by the user. This program does not relate directly to the CAT Methodology but is an intermediate program that must be run in order to obtain output from other software tools that do relate directly to the CAT Methodology.

DLA, the Display Legibility Analysis program , analyzes the specified panels of the cockpit to determine the character height of legends and displayed characters necessary to insure legibility from the eye reference point. The program calculates the physical height of a required marking to make it subtend a specified visual angle at the eye of an observer seated at a specified location in the cockpit. DLA simulates realistic head motion in looking at a display using a link-man model of the operator's head, neck, and shoulders. This program supports only one of the twelve procedures for the Internal Vision Analysis top-level function of the Methodology.

MCOS is the Monte Carlo Operator Sample generator that creates simulations of human operators to determine whether cockpit controls under consideration can be reached by a specified population. Each operator is defined by 12 standard anthropometric measures. Operator samples can be generated from population statistics or user input of actual measurements from a known sample. MCOS is an optional program that can be run prior to performing Reach Analysis and therefore indirectly supports this top-level function.

OAR (Operator Assessment of Reach) performs a reach analysis for a specified number of operators on each control of every selected panel in the CCC geometry database file. Each operator is placed at the design eye reference point and the resulting seat reference point is saved. The operator, then placed at his seat reference point, is made to reach toward each control. OAR accumulates and reports successful and unsuccessful reach attempts for each control. Positioning of the operator and constraints placed on the test depend on the operator's clothing and restraint conditions. OAR can perform a head clearance for each operator if requested. The program defines four reach zones: Z1, non-straining reach with shoulder harness; Z2, straining reach against shoulder harness; Z3, non-straining reach with only a waist harness; and Z4, full straining reach while restrained at the waist. It calculates and gives the percent of the sample that can reach each control within the constraints of each of the four zones. OAR directly supports the procedures for performing the Reach Analysis top-level function of the CAT Methodology.

The following CAT software tools support the Workload Analysis top-level function:

(1) **PET** (Procedure Execution Time) calculates the workload characteristics for isolated procedures (manual and visual only) and provides a quick calculation of procedure durations.

(2) **MSA** (Mission Scenario Analysis) lists the timeline, frequency of use statistics for the devices, and reformats the timeline for Mission Procedure Evaluation.

(3) **MPE** (Mission Procedure Evaluation) calculates workload statistics for each procedure in the timeline and prepares the data for MTA, FAR and MTP (Mission Time-Line Analysis, Function Analysis Report, and Mission Task-Time Probability).

(4) **MTA** (Mission Time-Line Analysis) sums the MPE-generated workload data by time interval, identifies workload peaks and contributions, reports overall workload statistics, and prepares workload plots.

(5) **FAR** (Function Analysis Report) produces workload reports focusing on functions rather than procedures.

(6) **MTP** (Mission Task-Time Probability) uses an alternate workload measure to look at probability of activity in a channel each second of the timeline, identifies workload peaks and contributions, reports overall workload statistics, and prepares workload plots.
(7) **PLTGGP** (Plot via General Graphics Package Format) displays MTA or MTP workload plot files in 2D or 3D.
(8) **C-SAINT** (Customized Systems Analysis of Integrated Networks of Tasks) generates a summary report of the amount of time the pilot is rushed, the amount of time the pilot is busy, the number of procedures the pilot is behind, and the number of procedures the pilot skipped. Both average and peak values are reported.

Using the output of these software tools, a well-rounded workload analysis can be performed which directly relates to procedures of the CAT Methodology functions.

The Function Allocation Tool (**FALTOOL**) is an adaptation of the commercial software called SUMMET (Survivability Measures and Methods of Evaluation Technique). This tool is a general purpose trade-off study and decision aid. The user identifies a decision structure, the program evaluates the proposals against the criteria, and rankings are calculated as output. This adaptation of SUMMET is limited to resolving candidate decisions for the function allocation process established in the CAT Methodology.

The Information Analysis Tool (**IATOOL**) is an application of the database management system Ingres that creates a mission-dependent and cockpit configuration-dependent timeline of information requirements at the pilot/vehicle interface. At this point in CSERIAC-CAT evaluation of the Boeing tools, IATOOL has not yet been reviewed adequately enough to determine its relationship to the CAT Methodology Information Analysis top-level function.

3.2.2. User Interface(s)

MDTOOL version 3.05 is installed on the Silicon Graphics IRIS 4D/50G called CATBIRD which operates with UNIX. It is menu-driven with mouse control. All options are clear to the point of being self-explanatory and consistent, making this CAT software tool very user-friendly. However, the user must be careful to save any edited files prior to exiting a menu. It is very easy to lose valuable files because MDTOOL exits menus without prompting for a save.

The **CIPLP** delivered in June 1990 runs on the VAXstation II/GPX called WREN (with VAX/VMS O/S). It is menu-driven with selections made from the keyboard. CIPLP is called from its own directory and run separately from the CAT Analysis Software System (CASS) which comprises the workload and anthropometric analyses. CIPLP's display interface is primitive but the meaning of each prompt is clear, making it easy to use.

E-Vision is an I-DEAS (CAD) Boeing-developed application running on the VAXstation II/GPX. It is, for the most part, command driven with keyboard entries. Use of E-Vision requires a knowledge of I-DEAS and a general familiarity with CAD. Some of the prompts are a little obscure; most are adequately user-friendly.

NMT also runs on the VAXstation II/GPX. It currently uses the VAX Window System with selections made by mouse. Although displayed character strings are small and somewhat difficult to read, the NMT window is filled with usable information. Error messages are informative and the user is forewarned of system crashes and prompted for saving files. All of this makes NMT highly user friendly. Unfortunately, NMT databases and treenet files can be quite large, leading to lengthy waits of up to 15 minutes for the user while files are being read. Also, there is a large delay between mouse selection and screen response, apparently a function of the windowing system. This can be a cause of great frustration and increased error.

The **CASS** group of programs are also installed on the VAXstation II/GPX. When CASS is invoked, NMT, CCC, Workload Software, and Anthropometric Software become available as menu options. The menu format is very user friendly in that it displays to the user which software programs need input from others. It is also easy to move through the different menu layers to find and run desired programs.

SUMMET, likewise, runs on the VAXstation II/GPX and is menu driven with selections made from the keyboard. The CAT β-1 version is difficult to use because it requires operating in two windows, and once the user presses <Return> for the second window he/she cannot return to the first and must start over again to see it. A user must also be familiar with the way SUMMET works, especially insofar as understanding the menu selections, which are cryptic. Improvements made to SUMMET since the June 1990 delivery supposedly address most, if not all, of these user-interface issues, and these improvements are expected to be evident in the next version of CAT software delivered to CSERIAC.

IATOOL is also on the VAXstation II/GPX. As previously mentioned, IATOOL is an application of the Ingres database management system. It is menu-driven with selections made from the keyboard. Like SUMMET, several improvements have been made since its June 1990 delivery making it more usable and meaningful, and full testing and critique of this program is best reserved for a subsequent report period.

3.2.3. Bugs and Technical Limitations of Software

In **MDTOOL** 3.05 we have identified the following bugs and technical limitations:

(1) The UNIX *vi editor* is not adequate for general use as a word processor. Its commands are cryptic, cumbersome and difficult to memorize.
(2) There are no provisions for aircraft weapon sensor and weapon load specifications.
(3) Only single seat aircraft are accommodated, limiting usage. (Work-arounds are possible but cumbersome by creating event timelines for each player in the cockpit.)
(4) Large map areas (or linked map cells) are too slow to work with since MDTOOL redraws or initializes the map area after each menu selection.
(5) There is no file name cited when errors and memory dumps occur, making it difficult to locate, diagnose, and fix problems.
(6) The user cannot create realistic special maneuvers, e.g., pop-ups. MDTOOL does not model these correctly.
(7) Threats are not affiliated with a particular side. That is, threats see everything as "foe" so that aircraft are subject to attack by "friendly fire".
(8) The algorithms for the holding pattern option are incorrect.
(9) Entering negative g values is difficult. Whereas "negative g" values are intuitively thought of as positive numbers, MDTOOL requires a negative number. If working from an existing menu, the negative sign already exists and the numeric value can be entered. But if the sign in the prompt is deleted, it cannot be re-entered.
(10) The 6 DOF aero model does not work properly. (The program will run, but the resulting output aero parameters are incorrect.)

Overall, our criticism of the current **CIPLP** is that it is labor-intensive to use. The extent of this limitation is dependent upon the extent of the analysis being performed. If the entire control/display suite is being analyzed, it is more efficient to create the "*.cccin" file using the EDT Editor available on the VAXstation II/GPX than by responding to each of the prompts in CIPLP. A major limitation leading to user frustration is being unable to abort from one selection to return to a previous menu. This may cause the user to abort the program entirely (CTRL/C) and start from the beginning. There were, however, no bugs found in the CIPLP version delivered in June 1990.

For **NMT** we have the following critical comments:

(1) The mouse is ignored during string edit, which prohibits the user from aborting to the previous selection.
(2) The program's prompting for prefixes to file names has no meaning for the user and no apparent use, leading to confusion. (Boeing has improved this feature in later versions.)
(3) There are errors in the routine "Attach Functions to Events." This could only be executed by locating nodes by number. When NMT searches the treenet for the next function, it does not find the associated function in the event_function database; NMT clears the last selection and the database is reset at the beginning of the file.
(4) The routine "Initiate Task Creation:" is too restrictive in requirements for the treenet name. It will not function unless "cockpit" forms the first seven letters of the name.

No bugs or technical limitations were found in **CCC**.

For our example design problem, performing geometric analysis (reach or vision) was not a requirement. Therefore, none of the associated CAT software tools (**DLA, MCOS, OAR**) were used to test design problem files. However, demonstration data provided by Boeing was used to test both reach and vision analysis. All programs were found to function; no bugs were detected. Limitations will be determined when the software has been applied more widely to include realistic data.

We were unable to run **PET** because the calling routine could not find the appropriate input file. There may be some incompatibility between CSERIAC-CAT's file-naming convention and this version of PET. The next version of the CASS software tools resolves this problem by generating the file under the right name in NMT.

MSA was run successfully for the example demonstration problem and appears to have no bugs or technical limitations.

MPE software calculates workload statistics for each procedure in the timeline, performs link analysis, predicts task and procedure complexity, and provides procedure execution times. Procedure execution times are calculated from pre-defined dwell and transit times for each channel. The inadequacy or limitation that ensues from using a theoretical method to predict procedure execution time is that individual tasks of a procedure are generally not all performed sequentially. Many tasks would be performed in parallel-- that is, simultaneously or overlapping. MPE attempts to accommodate this by calculating a time root sum of squares value (TRSS), an artificial method of combining the time required in each channel to get a total time which is somewhere between pure sequential and pure simultaneous execution. Therefore, the degree of validity of the output procedure execution times is dependent on how accurately the dwell and transit times were defined, and how closely TRSS was able to simulate task overlap. No bugs were found in MPE.

MTA output identifies the procedures (by number) that cause workload peaks. The reports were difficult to interpret because the user must cross reference other output reports to identify the actual procedure that is being performed and to determine what the "God's Eye" view of the situation is-- that is, why the pilot is performing this procedure. There was no difficulty in running the program, however.

MTP ran well and we report no bugs or limitations.

In order to run **PLTGGP**, the DI3000 (Precision Visuals) software must be installed on the VAXstation II/GPX, and the terminal print logicals must be set up appropriately. DI3000 is not installed at this time so no workload plots were obtained. We can therefore not evaluate this program for bugs or limitations.

FAR output was unobtainable at the time we tested this program and we cannot report on its performance.

No bugs were found in **C-SAINT**, but the output was not useful for the demonstration example problem. C-SAINT is best used to determine an overall summary of the amount of time the pilot is rushed or busy, the number of procedures the pilot is behind, and the number of procedures skipped. However, it seems more efficient and more direct to use the output of MPE and MTA to identify problem procedures that may be amended.

As mentioned, **IATOOL** is a Boeing application of the database management system Ingres. During the time the example demonstration problem was being developed, Ingres was not fully accessible to the analyst. In addition, Boeing engineers have since improved the usability and applicability of this software. For these reasons, and also because of time constraints and the limited nature of our first design problem which did not require the use of IATOOL, full exercising of Ingres and testing of the Boeing databases developed within it will be performed after delivery of the CAT β-2 Interim version.

Since June 1990 but after major testing of the software in preparation for our demonstration, Boeing also upgraded its adaptation of **SUMMET**, the software tool used for decision making in the Function Allocation analysis. Because of time constraints and the practicality of waiting to do in-depth testing until after receipt of the upgraded version, and, again, because our demonstration problem did not require a trade-off study, SUMMET was not tested for limitations. However, SUMMET, like some of the software mentioned above, has been exercised with Boeing demonstration data without uncovering any bugs.

In summary, it should be noted that many of the software problems encountered in CAT β-1 have been addressed since delivery of that baseline version, and that more concentrated testing and evaluation of the software is expected during 1991.

4. RECOMMENDATIONS

CSERIAC-CAT has kept records in all areas of managing and implementing CAT during this period of its development. Using these records of our experience with CAT, we expect to be able to make an increasing number of recommendations for future management of the program and for the transfer of this technology to the cockpit design community.

4.1. Equipment Needs: HW & SW

4.1.1. Hardware

With the current hardware configuration of the Silicon Graphics Iris 4D/50G, the DEC VAXstation II/GPX and the DEC VAX 8250, evolution of the CSERIAC CAT facility into a training and analysis center for CAT tools supporting more than a few problems concurrently would require at least two hardware upgrades.

- One recommendation is to increase disk capacity for the Silicon Graphics IRIS workstation.
- The second is to improve tape backup capacity for the VAX systems.
- Additionally, one should address the issue of memory capacity for the VAX 8250.

For CAT usage as it exists now, the current **Silicon Graphics IRIS 4D/50G** system is adequate for the current MDTOOL package applied to a single analysis. Where the system proves inadequate is in hosting multiple analyses with more users working different problems (e.g. fighter, cargo, and bomber cockpits all being analyzed). The basic problem, as noted above, is inadequate disk space on the current workstation. The workstation is essentially a stand alone configuration. It communicates with the VAXes over the network but it is not practical to store files and directories on the Silicon Graphics except on the local disk. Disks for the 4D series come in 380 Mbyte, 780 Mbyte, and 1.2 Gbyte sizes (retail prices approximately $3500, $5000, and $7500, respectively).

- In order to support a group of MDTOOL users on the current 4D/50G system, disk storage must be added. If disk size is increased for the workstation by adding one of the larger capacity disk drives (780 Mbyte or more), the existing 380 Mbyte disk could be used on another Armstrong Laboratory IRIS 4D workstation.

- However, we recommend considering a broader perspective. The general problem of impending obsolescence should be addressed, particularly for the IRIS.

The 4D/50G system is a RISC based cpu with 380 Mbyte SCSI disk and a "low density" cartridge tape graphics workstation. Silicon Graphics no longer includes this model in their current product line but has retained the single RISC based cpu systems as a personal IRIS set of products (4D/20, 4D/25 and 4D/35) and a line of parallel processing systems known as "power series" products (4D/310 and up). They are currently offering an upgrade option to customers wishing to convert obsolete 4D systems to the low end of the power series (4D/310). This offer expires June 30, 1991. WRDC has a requirements contract in place to take advantage of this upgrade for the Silicon Graphics systems at WPAFB.

If funding is available there are practical reasons for such an upgrade. The older systems will continue to become more expensive to maintain and eventually become incompatible and unsupported by Silicon Graphics. The current 4D/50G system is not part of the incrementally upgradable line of the SG power series which can be easily upgraded by adding cpus, memory, etc. as more powerful, faster machines are required for new applications. (All models in the power series are basically the same with just more processors and/or memory.) Silicon Graphics is currently improving the power series with firmware, hardware, and software as part of normally provided system maintenance. Other 4D systems are essentially frozen at their current capacities.

The current CAT software also requires **VAX computers**, and some of it specifically requires a VAX GPX graphics workstation. It is possible (but not practical in our environment) to have large capacity disk storage on the DEC workstation, so a second VAX system at another location must be networked or clustered with it. Disk capacity must be large enough to conduct separate analyses and the system must contain enough memory to accommodate applications and third party (commercial) software. The current VAX 8250 contains only 8 Mbytes of memory and this is the lower limit for critical software such as the current Ingres database management system. In fact, if the Ingres software is updated we may not be able to host the new version without additional memory.

A major activity on the CAT VAXes is user and system backups. The amount of software on the system is large and, as users are added, a significant amount of the remaining disk capacity will be used up. Eventually, backing up the system on the TU81 tape drive of the

VAX 8250 may take 8 hours or more. This is not efficient and a better backup system is recommended, particularly to support CAT training. For the current VAX system, the controller and drive for an 8 mm backup would allow for fewer backup tapes and fewer hands-on backup procedures.

Again, one must consider the cost of obsolescence. DEC bases hardware and software maintenance price structure on the original retail value of the hardware. Yearly inflation increases maintenance costs. This creates a peculiar situation. As the hardware evolves and models in the product line are replaced with better and faster machines, it can become impractical to continue to run, or to upgrade, older DEC computers. Furthermore, Digital equipment requires that brand new licenses be obtained for all software on upgraded models of their computers. It should also be noted that third party software vendors follow DEC's lead in their pricing policies for yearly maintenance.

- It may be technically and financially feasible to replace the VAX 8250 with a VAXstation III system.

The software and hardware maintenance costs and license fees are less for the lower-end cpu and large capacity disk storage would still be possible. Performance of a lower-end cpu is rapidly downgraded if too many interactive or batch sessions are required, but since, currently, many users do not need to be logged in at the same time, this might not be a problem. CSERIAC will investigate the relative merits of substituting a newer, lower-end VAX for the VAX 8250.

- If the current configuration is maintained, however, we recommend at least more memory and an improved back-up system for the VAX 8250.

4.1.2. Software

In addition to maintaining appropriate versions of the operating systems software, commercial products like Ingres, MDTOOL and I-DEAS, and the Boeing-developed CAT tools, CSERIAC strongly recommends the purchase of two types of software products which are not currently part of CAT, improvement of the Boeing support software (besides the programs themselves), and consideration of additional system tools. Discussed below are Computer-Aided Software Engineering (CASE) tools, and MCAD libraries or standard tools for the creation or modification of cockpit geometries. Improvement of the Boeing-developed databases and other Boeing input files would also add to CSERIAC capability, and the purchase of some less-critical, but very useful general system management tools is also recommended.

A set of appropriate **CASE tools** would help CSERIAC fulfill its aim in developing as a training and analysis center for CAT in a multi-user, multi-project environment. Key questions in the support of multiple projects is how much of each set of files must be duplicated for each user account and which files are better left in common areas accessed by all users. Furthermore, some projects will require additions and modifications to data bases used to describe or represent parameters of the aircraft and human performance. For those, it is necessary to provide local or user specific copies of some files. That is, data appropriate for fighter missions is not necessarily the same as that for refueling missions.

Similarly, mission, aircraft, and analysis specific data within a single project or belonging to unrelated projects must be controlled and managed. CASE can greatly ease the burden of version control and help to prevent confusion and mistakes.

For VAX systems DEC markets a product called VAXset which includes LSE/SCA (Language-Sensitive Editor/Source Code Analyser), CMS (Code Management System), MMS (Module Management System), and other elements. On the Silicon Graphics system there is the RCS (Revision Control System) and the *make* utility. These systems perform audit histories of changes, support multiple versions for text, source code and data, and also perform various library functions.

LSE/SCA is present on the CSERIAC-CAT VAXes but the most useful of the other CASE tools (CMS and MMS) are not. Without these, a number of records must be maintained manually (i.e. with editors) which identify the contents and purposes of each of the various versions of files created on the system. It takes a good deal of diligence to prevent confusion, mixups and other problems. CASE tools automatically keep track of a lot of useful information in such an environment. For the CSERIAC-CAT Silicon Graphics IRIS workstation, the two most useful CASE tools are RCS and the *make* utility, which we do have, and we will implement additional version control by writing shell scripts.

- Continued use of these products is recommended.

- In support of CSERIAC's growing capability as a training and analysis center for CAT, we recommend adding other tools from the DEC CASE package, in particular CMS and MMS.

While a fair amount of experience with the CAT software tools has been gained at CSERIAC, there is a serious lack of general **MCAD tools and data files** to support the MCAD programs. Methods are being devised for the addition of information and descriptions to the CAT data bases for missions, human factors, evaluation criteria, etc. But no part of the CAT software directly supports these data enhancements and no programs, tools or documentation currently exist to manipulate the basic information on which all the CAT analyses are based.

As configured, the CAT software is lacking straightforward or efficient means for the creation or modification of cockpit geometries. To date, all analyses have used previously created cockpit geometry files. The CIPLP program allows manual entry of geometric elements of a cockpit one point at a time and the I-DEAS CAD/CAM system can be used to manipulate geometric elements. But no specific library of cockpit parts such as displays and controls has yet been provided, and no procedures to manipulate and assemble parts are currently part of the CAT software. Assembling a cockpit from scratch is a major undertaking which is not well-supported by current CAT software.

Furthermore, there are no documented guidelines and no established procedures for modifying existing parts of the cockpit geometry. This would be simpler than designing a complete new cockpit, but issues of data formats and the availability of data files must still be addressed and procedures for conversion of CAD data must be developed.

And finally, there is the problem of supporting a realistic iterative design process. Analysis using the CAT tools has been demonstrated in a "single-pass" run of a posed problem, but a designer is likely to need a matrix of results for a range of some design factor, or want to iterate a design through multiple passes, altering the design on each pass based on the results of analysis. This is difficult with the current software and the simplest method at present is to edit the geometry file directly, that is, by altering the list of numbers representing coordinates and identifiers.

- We therefore strongly recommend acquiring interfaces to manipulate the cockpit geometry graphically in support of the CAT analysis tools, and the establishment of a robust library of CAD shapes and other CAD data files.

- We note also, as above, the need for enhancing the other **(Boeing-developed) databases** that interact with the CAT tools (e.g., event, event_function, function_procedure). Better definition of the data requirements, and better descriptions of their structure and functions are needed. Also lacking are documented procedures for updating and maintaining these databases, and explanations about what happens when elements of the database are edited.

- **Other Boeing-developed input files** such as those involved in workload prediction and cockpit configuration control also need review and improvement. During preparation of the demonstration design problem, for example, some of the output from the workload analysis created concern for the validity of the input data and the algorithms used.

- Besides the acquisition of CASE and MCAD software and improvement of the databases and other input files, we recommend acquiring some general **system management tools**. SPM (System Performance Management), Disk Defragmentors, and, to a lesser degree, RSM (Remote System Manager) are those worthy of consideration.

Additionally, we note that although specific CAT software tools were developed to support specific procedures in the CAT Methodology, implementation of the Methodology was not meant to be limited only to the use of those tools.

- It is recommended that other software sources be sought for possible adaptation to the CAT process. Software may exist that is easier to use, more powerful, or lower in cost, thus allowing for growth and flexibility as technology grows.

4.2. Technical Personnel and Task Management

Because of the late delivery of CAT equipment and software and the protracted period of assembling appropriate personnel, the biggest priority at the beginning of 1990 was task start-up-- developing a cohesive and efficient CSERIAC-CAT team, configuring the equipment in a productive work environment, implementing management procedures and configuration control, familiarizing key technical personnel with CAT tools and objectives, establishing liaison and working relationships with Boeing and with the CAT ADPO, and, of course, completing the requirements of the contract itself, especially with respect to deliverables. Having accomplished all of this, we see the next contract period as one in which priority shifts from start-up to full-scale development of CSERIAC-CAT capabilities. As such, we see the need to maintain and to continue increasing accomplishments in the above areas while extending technical capabilities specific to the CAT Methodology and the use of the CAT tools.

- We recommend a continuing "core" CSERIAC-CAT team of individuals who would perform the principal roles of Task Manager, Systems Manager, and Cockpit Design Engineer. All three will support analysis activities for user agencies.

- In addition, this team would rely, as required, on other CSERIAC staff for support in administration and management, development and implementation of training courses and workshops, the writing of manuals and other documentation, and the development of CAT tools or CAT management support databases.

- We further recommend that subject matter experts in operations and tactics, and especially those with piloting experience (both fighter and transport) be identified as potential resources.

4.3. Technology Transfer and Training

We note that transferring CAT technology to the cockpit design community encompasses issues of general demonstrations in CAT capabilities, training in its use, in-depth and specific demonstrations given in conjunction with analyses support, and promotion and marketing of the technology. While recognizing that these issues merit individual attention and have been-- and will continue to be-- addressed individually, we view them primarily within the context of technology transfer.

Although **demonstrations** were given throughout the year to government and potential users, they were limited in content to the current version of the CAT Methodology and software. Besides improving content, developing the demonstrations into two distinct types would be useful.

- Development of a general overview demonstration for management is recommended that would give a brief description of the CAT Methodology and tools and would summarize their capabilities.

- A second type of demonstration for users would give more details by presenting an example application of the Methodology and software within the context of a real design problem.

By continuing and expanding CSERIAC's role in **analyses support**, the overall objectives of technology transfer as well as training and promotion will be served. The old maxim that "satisfied customers are the best means of advertising" is true.

- We recommend enhancing team expertise in CAT and cockpit design, and making much more use of CSERIAC (and UDRI) resources in human factors engineering, so that we can promote and carry out our role as expert consultants in the design process.

The **Procedures Notebook** that was created for managing and implementing the demonstration design problem paralleled and complemented the procedures of the Dem/Val Phase of the Weapon Systems Design Process and the analysis stage of the CAT Methodology and was instrumental in completing the design problem. [5.9., 6.2.]

- It is recommended that a second generation Procedures Notebook be developed that corresponds to the Designer's Electronic Notebook (DEN) currently under development by Boeing. By expanding the Procedures Notebook and its use, better manageability and traceability will be obtained.

Besides the promotion and marketing advantages gained by demonstrating CAT to potential users and by using it to help analyze real world design problems, advertising in trade magazines and journals, writing technical articles for publication in the GATEWAY and other periodicals, presenting papers at technical conferences, and featuring CAT at trade shows and symposia are all possibilities within the scope of CSERIAC experience and capabilities.

- We therefore recommend establishing a regular **program of promotion and marketing** once the final CAT release is functional and adequate documentation has been developed.

Formal **workshops** in the use of CAT have already been identified by the CAT ADPO as important avenues of technology transfer. Again, development of adequate documentation in the form of user's manuals and/or procedures notebooks is an important prerequisite. We have noted the possibility of different types of workshops in our Workshop Plan [5.8.], and we see the possibility of distinguishing types of workshops differently later on when CAT is fully developed. General workshops offered periodically to the broad community of crew station design engineers is one obvious category. Specialized workshops offered on-site to companies or organizations embarking on major design projects or groups of projects is another possible category. We see both types as major efforts on CSERIAC's part.

- We recommend emphasis on periodic workshops as major avenues of technology transfer once the final CAT version is operational.

5. REFERENCES

5.1. **Statement of Work**, Contract DLA900-88-D-0393, 5 July 1989; issued to the University of Dayton, by Defense Electronics Supply Center, Contract Specialist: PSC/ S. Robbins.

5.2. **Inventories** (T. Abrams to CAT ADPO), 1. CAT Software Inventory, 22 February 1990; 2. CAT Inventories, Hardware and Documentation, 30 March 1990.

5.3. **Evaluation of [Boeing] CAT Training** (CSERIAC Program Office to Phil Kulwicki, AAMRL/HEX-CAT), 22 December 1990.

5.4. **Quarterly Reports**, Technical and Configuration Control (UDRI CSERIAC-CAT to AAMRL/HEX-CAT Program Office), 1. July-September 1989; 2. October-December 1989; 3. January-March 1990; 4. April-June 1990; 5. July-September 1990; 6. October-December 1990.

5.5. **Associate Contractor Agreement Between The University of Dayton and The Boeing Company Acting Through Boeing Military Airplanes**, signed by D.E. Bjornson (Boeing), 20 November 1990, and R.P. Boehmer (Univ of Dayton), 27 November 1990.

5.6. **Configuration Control Plan** (CSERIAC-CAT to AAMRL/HEX-CAT Program Office), 20 November 1990.

5.7. **"Demonstration of CAT Software Tool Capability and CSERIAC-CAT Proficiency Using an Engineering Cockpit Design Problem"**, C. Martin, T. Abrams, C. Orr, December 1990.

5.8. **Workshop Plan** (CSERIAC-CAT to AAMRL/HEX-CAT Program Office), 20 December 1990.

5.9. **Procedures (Project Name)**, C. Martin, December 1990.

6. APPENDICES

6.1. Configuration Control Plan

(Original in memo form, CSERIAC letterhead)

To: AAMRL/HEX-CAT Program Office 20 November 1990
Lt./Col. R. Collins, Mr. P. Kulwicki

From: CSERIAC-CAT
T. Abrams, C. Orr

CONFIGURATION CONTROL PLAN

Contents:

1. Introduction and Overview

According to MIL-STD-480B, configuration control has to do with *changes*-- proposal, justification, evaluation, coordination, approval or disapproval and implementation thereof, to approved baselines. Configuration control of the CAT hardware, software and documentation at CSERIAC must be established, however, with the objectives, time frame, and relationships (or dependencies) of this special task in mind. For this contract period, CSERIAC is acting as a beta site for the evaluation and testing of software under development. All software and hardware acquired by CSERIAC and incorporated into the CAT system comes from the prime developer, The Boeing Company Military Airplanes Division, through the CAT ADPO. CSERIAC, therefore, must play a predominantly reactive role-- to incorporate, test, keep track of, and evaluate what we are given. During the period of this special task, no significant hardware or software changes will be initiated by CSERIAC.

Current hardware may be classified as belonging to or interfacing with three (sub)systems-- a DEC VAX 8250 computer (called MERLIN), a DEC GPX graphics workstation (called WREN), and a Silicon Graphics IRIS graphics workstation (called CATBIRD).

Current software may be classified in two dimensions-- the first as "belonging to" one of the three hardware systems listed above, and the second as either (1) systems software including operating systems, editors, programming languages, etc.; (2) interface software for networking, clustering, and/or other communications; (3) third party applications such as Ingres, I-DEAS, and MDTOOL; or (4) Boeing-developed applications or tools.

2. Establishment of Baseline Configuration

2.1. Hardware

The baseline configuration for hardware was established early in 1990, with equipment included in the Early DCADS Delivery. Because of limited disk space, and to suit the CAT tools' requirements for transferring files between the IRIS and VAX equipment, MERLIN and WREN were clustered, and the two workstations (WREN and CATBIRD) were networked. Besides the primary terminals on each workstation, another terminal is connected through a terminal server to MERLIN, WREN, and two other AAMRL VAX computers, FALCON and EAGLE.

Baseline hardware configuration will provide color graphics printing capability from either CATBIRD or WREN by means of one Tektronix printer. (Another contractor has responsibility for providing the necessary cable.) Additionally, an LN03 printer is available to any terminal through MERLIN.

Specific descriptions for each hardware component-- manufacturers, model numbers, licensing/support information, etc.-- exist now as hard copy lists and will be available from the configuration control database once it is populated. (The database, *Catcon,* is described below in Section 4).

2.2 Software

Baseline software configuration centers on the June 1990 version of the CAT Analysis Software (dubbed CAT ß-1), MDTOOL version 3.05, I-DEAS 4.3, Ingres 6.2, and the VAX/VMS 5.3-1 and IRIX 3.2 operating systems. Specific descriptions for each software component, likewise, exist now as hard copy lists and will be available from the configuration control database, Catcon.

2.3 Documentation

CSERIAC has no technical documentation as yet that is specific to the current (ß-1) Boeing-developed CAT tools, though a few early User's Manuals (1987, 1988) are on hand and do provide some insight into the development strategy and objectives. These publications, along with all documentation for systems, interface or third party applications software, and all hardware documentation, have been catalogued on inventory lists and are kept in the CSERIAC CAT Room library. Each piece of documentation will be represented in Catcon, in the record for the hardware or software item to which that documentation relates. This library system may be developed further if necessary, by tagging each copy of each item with decimal codes, e.g.

3. Inventories of Configuration Items

Inventories have been prepared for all hardware and software items, and for all documentation (Feb 1990, Mar 1990). The data in these inventories will be updated and entered into Catcon.

4. Control Method: Configuration Control Database

The heart of CSERIAC's configuration control plan for CAT hardware, software and documentation is *Catcon*, a Macintosh database using the FoxBASE+/Mac database management system. FoxBASE is a current leader in microcomputer database management systems, particularly in terms of speed, flexibility, and the capability of handling large amounts of text-type data. It has the attractive feature of being produced in both Mac and PC versions, and (with appropriate hardware and software support) a FoxBASE database can be accessed from both Macs and PCs networked together, if that is desirable. CSERIAC currently owns the multi-user Mac version which can be used by individual Macintosh computers or by a network of Macintoshes.

The first version of the database schema has been designed and installed. There are twenty-two fields, described below. Population of the database (entering the data described in sections 2 and 3 above) will take place during the next support period and is expected to be complete by mid 1991.

CSERIAC Configuration Control Database, Catcon

	Field Name	Data Type	Explanation of Contents
1.	**recno**	numeric	record number, the unique record key
2.	**curr**	logical	a "yes" or "no" condition to indicate "current" or "not current," respectively
3.	**name**	character	full name of unit (RA-81, IRIS-4D, MDTool)
4.	**model**	character	model or version number
5.	**functn**	character	functional description (Disk Drive, Graphics Workstation CPU, DBMS, eg)
6.	**mfgr**	character	name of manufacturer (Digital Equipment Corp, Silicon Graphics, Merit Technology, eg)
7.	**mfgrcon**	character	manufacturer's POC, address and phone number
8.	**mfgid**	character	manufacturer's serial or registration number
9.	**govid**	character	government identification or code
10.	**swtyp**	character	software type (System, Commercial Application Program, Special Development, eg) (only for records concerning software)
11.	**hwsuppl**	character	hardware supplies: complete names of all needed. Refers to *secondary* supplies or materials such as tape cartridges, cables, print wheels, etc. (only for records concerning hardware)
12.	**daterec**	date	date received

	Field Name	Data Type	Explanation of Contents
13.	**dateon**	date	date installed
14.	**dateoff**	date	date removed (for items where curr=yes, this field should be blank)
15.	**pendson**	character	"depends on"... the names of *other primary* pieces (of HW or SW) necessary to make *this* piece (of HW or SW) functional
16.	**pendents**	character	"dependents"... the names of *other primary* pieces (of HW or SW) which depend on this piece to make them functional
17.	**spfeat**	memo	special features, refers to manufacturer-installed options, such as internal hard drive size, RAM size, etc.
18.	**instal**	memo	distribution information (installation instructions, distribution tapes or disks, etc.): name, identification codes (if any), and location of
19.	**othrdoc**	memo	relevant documentation, *other than distribution* instructions: name, identification codes (if any), location of
20.	**licenscurr**	memo	current licensing or support agreement information: name of owner, date purchased, cost, time period valid, expiration date, terms (if relevant), POC for extending, etc.
21.	**licenshist**	memo	licensing or support agreement history, same information as above
22.	**failhist**	memo	failure and resolution histories: date and problem, how it was resolved, for each incident

Each record in the database will represent a unique piece of hardware or software, excluding duplicates for software items. Once populated, the database will be updated whenever new items are received by CSERIAC or changes to the configuration occur. The CSERIAC-CAT Task Manager and Systems Manager will share responsibility for maintaining the database and keeping it current. A comprehensive and concise User's Manual for Catcon will be produced after the database has been populated and tested (probably during the second half of 1991). Likewise, output forms will be designed to user specifications so that printouts supplying particular information or a particular aspect of the data can be produced quickly. The design of the database is amenable to change, should use of this prototype indicate the need for new types of information and/or new fields.

The current database design (that is, the fields and definitions of their content) and some examples of selecting records sharing particular data entries indicate that configuration control can be maintained easily. It will be possible at any time to produce a printout that describes the current hardware or software configuration, or both, by selecting those records that have the field **curr** filled with "yes." Or, for example, in tending to licensing needs, all items distributed by a particular manufacturer and in current use may be selected via the fields **curr** and **mfgr** and then a listing of those items, with whatever information is necessary, can be printed out.

During the next contract/support period, two other "files" (or adjunct databases) will be designed and implemented as special aids for the Systems Manager. One will contain a schedule and record of system backups, and one will keep track of user accounts and user files, including backups. Backup schedules and procedures will be determined according to available hardware and to need as use of the CAT tools increases, and these schedules and procedures will be available for reference.

5. Evaluation

An important element among the objectives of this special task is *evaluation* of the configuration items. Although this means primarily with regard to the functionality of the CAT software, CSERIAC-CAT expects also to provide evaluation and recommendation with regard to the configuration itself. With increased use, data will be collected on the accessibility and human factors aspects of both hardware and software configuration. The ease of transferring files, the need for on-line directives and messages or better menus, the relative merits of one workstation over another (including reliability and frequency-of-repair, for example) are a few of the areas for which data will be gathered. Recommendations for reconfiguring the systems, for the purchase of different or additional hardware or software support packages (editors, compilers, communications and file transfer protocols, etc.) will be made as appropriate.

Copies:

Maj. P. Irish
D. Stafford
L. Howell
C. Martin

6.2. Procedures Notebook (Template Form)

PROCEDURES NOTEBOOK

(PROJECT NAME)

(AUTHORS)

(DATE)

(PERFORMING ORGANIZATION)

(PERFORMED FOR)

TOP LEVEL FUNCTIONAL FLOW BLOCKS OF THE CAT METHODOLOGY FOR THE DEM/VAL PHASE OF THE WSDP AND ANALYSIS PROCESS

The purpose of the Demonstration and Validation Phase is to expand the definition of candidate concepts through extensive analyses of alternatives and to develop concepts from functional baseline systems to the stage where prototype construction would be possible. The Dem/Val Phase will normally result in a full, updated system specification for the weapon system, as well as critical item development specifications for major subsystems and items of equipment or software.

Key crew system design decisions which should be resolved by the end of the Dem/Val Phase include crew station geometry, identification of control and display equipment, control and display arrangement, preliminary panel layouts, preliminary display formats and control logic, and escape and life support preliminary designs.

The following CAT Methodology top-level functional flow blocks were developed to provide a structured and quantitative process that would allow a designer to match aircrew needs with evolving technologies within the Dem/Val Phase of the Weapon Systems Design Process (WSDP) and the Analysis Process of the CAT Methodology. These top-level functional flows are broken down further into specific procedures and computer software has been developed to support these procedures.

DA01. Develop Human Engineering Plan
DA02. Conduct Mission and System Analysis
DA03. Characterize Mission
DA04. Define Baseline Crew Station
DA05. Generate Control/Display Catalog
DA06. Perform Function Analysis
DA07. Attach Tasks to Procedures
DA08. Perform Procedure Analysis
DA09. Perform Reach Analysis
DA10. Perform Internal Vision Analysis
DA11. Perform External Vision Analysis
DA12. Perform Workload Analysis
DA13. Perform Information Analysis
DA14. Review Configuration (Rework or Accept)
DA15. Perform Critical Task Analysis
DA16. Review Go-Ahead for Evaluation
DA17. Perform Function Allocation Analysis
DA18. Evaluate Design Solution Candidates
DA19. Define Control and Display Requirements
DA20. Define Operational Procedures
DA21. Establish Equipment Requirements
DA22. Document Human Engineering Results

DA01. PROCEDURES FOR DEVELOPING THE HUMAN ENGINEERING PLAN

DA01.1 Identify CAT Methodology Tailoring Requirements

a. **CSERIAC Support Capabilities:** Given a cockpit engineering design problem, CSERIAC will determine what top-level procedures of the CAT methodology will be implemented for obtaining supporting analysis, results, and providing recommendations.

b. **Design Problem Effort:**

DA01.2 Define Subcontractor Human Engineering Requirements

a. **CSERIAC Support Capabilities:** CSERIAC will determine what operational experience will be required to support the completion of the selected top-level tasks.

b. **Design Problem Effort:**

DA01.3 Define Human Engineering System Analysis Tasks

a. **CSERIAC Support Capabilities:** Given a proposed cockpit design or redesign effort, CSERIAC will recommend specific system analysis tasks required to obtain viable results for basing human engineering system design recommendations.

b. **Design Problem Effort:**

DA01.4 Define Human Engineering Detail Design Tasks

a. **CSERIAC Support Capabilities:** N/A to CSERIAC support capabilities.

b. **Design Problem Effort:**

DA01.5 Define Human Engineering Procedure Development Tasks

a. **CSERIAC Support Capabilities:** CSERIAC will define the necessary procedures to be developed for recommended design changes.

b. **Design Problem Effort:**

DA01.6 Define Human Engineering Test & Evaluation Tasks

a. **CSERIAC Support Capabilities:** N/A to CSERIAC support capabilities.

b. **Design Problem Effort:**

DA01.7 Identify Human Engineering Deliverable Products

a. **CSERIAC Support Capabilities:** CSERIAC will provide final documentation of results and cockpit design recommendations of the analyses performed to be included in the Human Engineering Deliverable Product documentation.

b. **Design Problem Effort:**

DA01.8 Determine Level of Effort for the Human Engineering Tasks

a. **CSERIAC Support Capabilities:** N/A to CSERIAC support capabilities.

b. **Design Problem Effort:**

DA01.9 Develop Human Engineering Program Schedule

a. **CSERIAC Support Capabilities:** N/A to CSERIAC support capabilities.

b. **Design Problem Effort:**

DA01.10 Document Human Engineering Program Plan

a. **CSERIAC Support Capabilities:** N/A to CSERIAC support capabilities.

b. **Design Problem Effort:**

DA02.PROCEDURES FOR CONDUCTION MISSION AND SYSTEM ANALYSIS

Explanations and examples appear in this section for clarification.

DA02.1 Describe Mission and Aircraft

a. CAT Software Tool - MDTOOL
b. Inputs - from subject matter experts with operational experience, human engineering document, and Weapon System Requirements document
c. Output - mission synopsis text file, "*.syn"
d. Design Problem Input - *Document all resources used as inputs for describing the mission and aircraft, for example, 'The mission scenario was obtained from Mr. John Doe (WPAFB). The document reference is 'Tanker Avionics/Aircrew Complement Evaluation (TAACE), Volume III: Mission Scenario,' TR #AFWAL-TR-80-3030, May 1980, AD A088036. Additional scenario clarification was obtained from Col Bob Cat (WPAFB).*

e. Design Problem Output - *Identify location of output if it is in paper format or specify the filename that was created while using the CAT software tool. For example, in this procedure MDTOOL is used and the output file created to document the description of the mission and aircraft might be 'KC135.syn'*

f. Design Problem % Complete - *Determine the level of completion after entering any new data to this procedure block, i.e. 100%.*

g. Design Problem Notes - *This is a good place to identify any bugs or limitations in the CAT software, lessons learned, or peculiarities of implementing this procedure. For example: '8 Apr 91: While editing with the vi editor, the user must include a hard return after each line, otherwise, MDTOOL will not be able to read the text file created.'*

DA02.2 Decompose Mission into Phases and Segments

a. CAT Software Tool - MDTOOL
b. Inputs - from subject matter experts with operational experience
c. Output - documented information for input into the mission objective file
d. Design Problem Input - *Example: 'Time-line information on phases and segments provided by Col Bob Cat (WPAFB) from data he collected and pilot interviews.'*

e. Design Problem Output - *Example: 'KC135.obj'*

f. Design Problem % Complete - *Example: 90%*
g. Design Problem Notes -

DA02.3 Identify Major Objectives for Each Segment

a. CAT Software Tool - MDTOOL
b. Inputs - from subject matter experts with operational experience and documentation from procedure DA02.2
c. Output - mission objectives text file, "*.obj"
d. Design Problem Input - *Example: same as DA02.1d*
e. Design Problem Output - *Example: KC135.obj*
f. Design Problem % Complete - *Example: 90%*
g. Design Problem Notes -

DA02.4 Define Performance Measures for Objectives Within Each Segment

a. CAT Software Tool - MDTOOL
b. Inputs - from subject matter experts with operational experience
c. Output - mission performance text file, "*.pfm"
d. Design Problem Input -
e. Design Problem Output -
f. Design Problem % Complete - *Example: 0%*
g. Design Problem Notes - *Example: 10 Apr 91: Chose not to complete this procedure due to its inapplicability*

DA02.5 Set Criterion Levels for Each Performance Measure for Each Segment

a. CAT Software Tool - MDTOOL
b. Inputs - from subject matter experts with operational experience and output of procedure 4
c. Output - documented in mission performance text file, "*.pfm"
d. Design Problem Input -
e. Design Problem Output -
f. Design Problem % Complete - *Example: 0%*
g. Design Problem Notes - *Example: see procedure DA02.4g*

DA02.6 Documentation of the Bugs and Limitations of MDTOOL Version : *(fill in Version #)*

The user should identify all the bugs and limitations incurred during the implementation of the above procedures.

DA03. PROCEDURES FOR CHARACTERIZING THE MISSION

DA03.1 Produce/Obtain Maps of Scenario Area

a. CAT Software Tool - MDTOOL
b. Inputs - DMA, DFADS, DTED databases
c. Outputs - specified gaming region
d. Design Problem Inputs -

e. Design Problem Outputs -

f. Design Problem % Complete -
g. Design Problem Notes -

DA03.2 Determine Target Locations

a. CAT Software Tool - MDTOOL
b. Inputs - from mission synopsis specifications and subject matter expert
c. Outputs - target/threat file that includes target parameters, along with location of targets for a given mission scenario
d. Design Problem Inputs -

e. Design Problem Outputs -

f. Design Problem % Complete -
g. Design Problem Notes -

DA03.3 Determine Threat Locations

a. CAT Software Tool - MDTOOL
b. Inputs - from mission synopsis specifications and subject matter expert
c. Outputs - target/threat file that includes threat parameters, along with location of threats for a given mission scenario
d. Design Problem Inputs -

e. Design Problem Outputs -

f. Design Problem % Complete -
g. Design Problem Notes -

DA03.4 Determine Flight Profile/Flight Path

a. CAT Software Tool - MDTOOL
b. Inputs - from mission synopsis specifications and subject matter expert
c. Outputs - flight path file that includes: airframe, engine, airspeed, altitude, and g limit parameters, along with waypoint locations - "*.wpt"
d. Design Problem Inputs -

e. Design Problem Outputs -

f. Design Problem % Complete -
g. Design Problem Notes -

DA03.5 Generate Mission Timeline

a. CAT Software Tool - MDTOOL
b. Inputs - Mission scenario file as was developed by procedure DA03.1 through DA03.4 completion. All of these outputs are saved to one scenario file, "*.scn," that is called for mission execution in order to generate the mission timeline.
c. Outputs - flight data recorder file, "*.fdr"
d. Design Problem Inputs -

e. Design Problem Outputs -

f. Design Problem % Complete -
g. Design Problem Notes -

DA03.6 Insert Events into Time-line

a. CAT Software Tool - MDTOOL
b. Inputs - From the Event databases available in the current release of MDTOOL, and from subject matter experts to clarify what realistic events would occur for the given mission scenario.
c. Outputs - an edited flight data recorder file, "*.fdr"
d. Design Problem Inputs -

e. Design Problem Outputs -

f. Design Problem % Complete -
g. Design Problem Notes -

DA03.7 Documentation of the Bugs and Limitations of MDTOOL Version: *(fill in Version #)*

DA04. PROCEDURES FOR DEFINING BASELINE CREW STATION

DA04.1 Select Existing Baseline Crew Station

a. CAT Software Tool - N/A
b. Inputs - From weapon system description document, operational experience, mission and system requirements database, mission scenario database, and/or crew station design reports and drawings.
c. Outputs - documentation of existing crew station
d. Design Problem Inputs -
e. Design Problem Outputs -
f. Design Problem % Complete -
g. Design Problem Notes -

DA04.2 Identify Avionics Performance Characteristics

a. CAT Software Tool - N/A
b. Inputs - from weapon system description document, operational experience, mission and system requirements database, mission scenario database, and/or crew station design reports and drawings
c. Outputs - documentation of avionics performance characteristics
d. Design Problem Inputs -
e. Design Problem Outputs -
f. Design Problem % Complete -
g. Design Problem Notes -

DA04.3 Identify Vehicle Performance Characteristics

a. CAT Software Tool - N/A
b. Inputs - from weapon system description document, operational experience, mission and system requirements database, mission scenario database, and/or crew station design reports and drawings
c. Outputs - documentation of vehicle performance characteristics to be used in MDTOOL airframe and engine parameter specifications
d. Design Problem Inputs -
e. Design Problem Outputs -
f. Design Problem % Complete -
g. Demo Notes -

DA04.4 Identify Weapons Performance Characteristics

a. CAT Software Tool - N/A
b. Inputs - from weapon system description document, operational experience, mission and system requirements database, mission scenario database, and/or crew station design reports and drawings.
c. Outputs - documentation of weapons performance characteristics
d. Design Problem Inputs -

e. Design Problem Outputs -
f. Design Problem % Complete -
g. Design Problem Notes -

DA04.5 Identify Required Changes to Baseline Crew Station

a. CAT Software Tool - N/A
b. Inputs - From avionics, vehicle, and weapons performance characteristics specification in procedures DA04.2 through DA04.3, determine required changes in baseline crew station.
c. Outputs - Specification and documentation of required changes in cockpit controls/displays, operating procedures, and crew station geometry.
d. Design Problem Inputs -

e. Design Problem Outputs -

f. Design Problem % Complete -
g. Design Problem Notes -

DA04.6 Define Baseline Crew Station Control and Display Suite

a. CAT Software Tool - N/A
b. Inputs - From procedure DA04.5.
c. Outputs - Documentation and specification of control/display suite which will be input into the cockpit geometry file in CIPLP, to output a "*.ccc" file.
d. Design Problem Inputs -

e. Design Problem Outputs -

f. Design Problem % Complete -
g. Design Problem Notes -

DA04.7 Define Baseline Crew Station Operating Procedures

a. CAT Software Tool - N/A
b. Inputs - from procedure DA04.5
c. Outputs - Documentation of baseline crew station operating procedures for the baseline, proposed redesign, or for the entire cockpit control/display suite for new design proposals.
d. Design Problem Inputs -

e. Design Problem Outputs -

f. Design Problem % Complete -
g. Design Problem Notes -

DA04.8 Define Baseline Crew Station Geometry

a. CAT Software Tools - CIPLP
b. Inputs - from procedure DA04.6
c. Outputs - Documentation/specification of baseline crew station geometry and the "*.ccc" cockpit geometry, cockpit configuration control file.
d. Design Problem Inputs -

e. Design Problem Outputs -
f. Design Problem % Complete -
g. Design Problem Notes -

DA05.PROCEDURES FOR GENERATING CONTROL/DISPLAY CATALOG

DA05.1 Define/Update Controls and Display (Indicator) Type Lists

a. CAT Software Tools - CIPLP
b. Inputs - from baseline crew station definition outputs, and avionics design team
c. Outputs - documentation of updated control/indicator lists, edited "*.ccc" file
d. Design Problem Inputs -

e. Design Problem Outputs -

f. Design Problem % Complete -
g. Design Problem Notes -

DA05.2 Assess Complexity and Workload for Each C/D Type

a. CAT Software Tools - N/A
b. Inputs - from subject matter experts
c. Outputs - documentation of updated control/display (indicator) complexity and workload scores, edited "*.ccc" file
d. Design Problem Inputs -

e. Design Problem Outputs -

f. Design Problem % Complete -
g. Design Problem Notes -

DA05.3 Assess Operator Error Likelihood for Each C/D Type

a. CAT Software Tools - N/A
b. Inputs - from subject matter experts
c. Outputs - documentation of updated control/indicator error likelihood, edited "*.ccc" file
d. Design Problem Inputs -

e. Design Problem Outputs -

f. Design Problem % Complete -
g. Design Problem Notes -

DA05.4 Estimate/Update Performance Time for Each C/D Type

a. CAT Software Tools - N/A
b. Inputs - from subject matter experts
c. Outputs -documentation of updated control/indicator error likelihood, edited "*.ccc" file
d. Design Problem Inputs -

e. Design Problem Outputs -

f. Design Problem % Complete -
g. Design Problem Notes -

DA06.PROCEDURES FOR PERFORMING FUNCTION ANALYSIS

DA06.1 Identify Functions for Each Event

a. CAT Software Tool - NMT
b. Inputs - from mission function database and subject matter experts
c. Outputs - specifications for the creation of an Event_Function treenet, "*_EF.tnet"
d. Design Problem Inputs -

e. Design Problem Outputs -

f. Design Problem % Complete -
g. Demo Notes -

DA06.2 Prioritize Functions for Each Event

a. CAT Software Tool - NMT
b. Inputs - from subject matter experts and procedure DA06.1
c. Outputs - specifications for editing the Event_Function treenet, "*_EF.tnet"
d. Design Problem Inputs -

e. Design Problem Outputs -

f. Design Problem % Complete -
g. Design Problem Notes -

DA06.3 Insert Functions into Timeline

a. CAT Software Tool - NMT
b. Inputs - from procedure DA06.1
c. Outputs - Event_Function treenet structure file, "*_EF.tnet"
d. Design Problem Inputs -

e. Design Problem Outputs -

f. Design Problem % Complete -
g. Design Problem Notes -

DA06.4 Documentation of the Bugs and Limitations of NMT Version: *(fill in Version #)*

DA07.PROCEDURES FOR ATTACHING TASKS TO PROCEDURES

DA07.1 Determine Controls needed for Each Procedure

a. CAT Software Tool - N/A
b. Inputs - "*.cccin" cockpit geometry file and subject matter expert
c. Outputs - specifications for a function_procedure_task treenet, "*_fpt.tnet"
d. Design Problem Inputs -

e. Design Problem Outputs -

f. Design Problem % Complete -
g. Design Problem Notes -

DA07.2 Determine Specific Display Elements and/or Formats Needed for Each Procedure

a. CAT Software Tool - N/A
b. Inputs - "*.ccc" cockpit geometry file and subject matter expert
c. Outputs - specifications for a function_procedure_task treenet, "*_fpt.tnet"
d. Design Problem Inputs -

e. Design Problem Outputs -

f. Design Problem % Complete -
g. Design Problem Notes -

DA07.3 Determine Cognitive and/or Perceptual Tasks Needed for Each Procedure

a. CAT Software Tool - N/A
b. Inputs - "*.ccc" cockpit geometry file and subject matter expert
c. Outputs - specifications for a function_procedure_task treenet, "*_fpt.tnet"
d. Design Problem Inputs -

e. Design Problem Outputs -

f. Design Problem % Complete -
g. Design Problem Notes -

DA07.4 Determine Multifunction C/D Sequence to Access Formats and Programmable Controls

a. CAT Software Tool - N/A
b. Inputs - "*.cccin" cockpit geometry file and subject matter expert.
c. Outputs - specification for task sequence for a given cockpit geometry to perform procedure
d. Design Problem Inputs -

e. Design Problem Outputs -

f. Design Problem % Complete -
g. Design Problem Notes -

DA07.5 Create Task for Device

a. CAT Software Tool - NMT
b. Inputs - specifications from procedure DA07.1
c. Outputs - an event_function_procedure_task treenet structure stating the verb to manipulate the specified control given the available cockpit geometry "*.cccin" file, "*_EFPT.tnet"
d. Design Problem Inputs -

e. Design Problem Outputs -

f. Design Problem % Complete -
g. Design Problem Notes -

DA07.6 Arrange Tasks in Sequence for Each Procedure

a. CAT Software Tool - N/A
b. Inputs - subject matter expert
c. Outputs - tasks specified in sequence
d. Design Problem Inputs -

e. Design Problem Outputs -

f. Design Problem % Complete -
g. Design Problem Notes -

DA07.7 Identify Alternate Task Sequences, If Applicable, for Each Procedure

a. CAT Software Tool - N/A
b. Inputs -
c. Outputs -
d. Design Problem Inputs -

e. Design Problem Outputs -

f. Design Problem % Complete -
g. Design Problem Notes -

DA07.8 Eliminate Task Redundancies

a. CAT Software Tool - NMT
b. Inputs - subject matter expert and/or CSERIAC-CAT Analyst
c. Outputs - edited "*_EFPT.tnet"
d. Design Problem Inputs -

e. Design Problem Outputs -

f. Design Problem % Complete -
g. Design Problem Notes -

DA07.9 Delete Tasks Which Would be Shed by the Pilot

a. CAT Software Tool - NMT
b. Inputs - subject matter expert and/or CSERIAC-CAT Analyst
c. Outputs - edited "*_EFPT.tnet"
d. Design Problem Inputs -

e. Design Problem Outputs -

f. Design Problem % Complete -
g. Design Problem Notes -

DA07.10 Documentation of the Bugs and Limitations of NMT Version: *(fill in Version #)*

DA08.PROCEDURES FOR PERFORMING PROCEDURES ANLAYSIS

DA08.1 Identify Applicable Procedures

a. CAT Software Tool - NMT
b. Inputs - from Function_Procedure database and subject matter expert
c. Outputs - specification for an Event_Function_Procedure treenet, "*_EFP.tnet"
d. Design Problem Inputs -

e. Design Problem Outputs -

f. Design Problem % Complete -
g. Design Problem Notes -

DA08.2 Identify Procedure Criticality Relative to Function and Associated Event

a. CAT Software Tool - N/A
b. Inputs - from subject matter expert
c. Outputs - procedure criticality specification
d. Design Problem Inputs -

e. Design Problem Outputs -

f. Design Problem % Complete -
g. Design Problem Notes -

DA08.3 Attach Procedures to Functions

a. CAT Software Tool - NMT
b. Inputs - outputs from procedure DA08.1 and "*_ef.tnet"
c. Outputs - "*_efp.tnet"
d. Design Problem Inputs -

e. Design Problem Outputs -

f. Design Problem % Complete -
g. Design Problem Notes -

DA08.4 Assess Mission Context for Each Procedure

a. CAT Software Tool - NMT
b. Inputs subject matter expert and/or CSERIAC-CAT Analyst
c. Outputs - edited "*_efp.tnet"
d. Design Problem Inputs -

e. Design Problem Outputs -

f. Design Problem % Complete -
g. Design Problem Notes -

DA08.5 Relocate Procedures Which Would be Time-Shifted by the Pilot

a. CAT Software Tool - NMT
b. Inputs - subject matter expert and/or CSERIAC-CAT Analyst
c. Outputs - edited "*_EFP.tnet"
d. Design Problem Inputs -

e. Design Problem Outputs -

f. Design Problem % Complete -
g. Design Problem Notes -

DA08.6 Documentation of the Bugs and Limitations of NMT Version: *(fill in Version #)*

DA09. PROCEDURES FOR PERFORMING REACH ANALYSIS

DA09.1 Identify Reference Anthropometric Database

a. CAT Software Tool - MCOS
b. Inputs -
c. Outputs -
d. Design Problem Inputs -

e. Design Problem Outputs -

f. Design Problem % Complete -
g. Design Problem Notes -

DA09.2 Establish Criterion Percentiles

a. CAT Software Tool -
b. Inputs -
c. Outputs -
d. Design Problem Inputs -

e. Design Problem Outputs -

f. Design Problem % Complete -
g. Design Problem Notes -

DA09.3 Calculate Functional Reach with Harness Locked

a. CAT Software Tool - OAR
b. Inputs -
c. Outputs -
d. Design Problem Inputs -

e. Design Problem Outputs -

f. Design Problem % Complete -
g. Design Problem Notes -

DA09.4 Calculate Maximum Functional Reach with Harness Locked

a. CAT Software Tool - OAR
b. Inputs -
c. Outputs -
d. Design Problem Inputs -

e. Design Problem Outputs -

f. Design Problem % Complete -
g. Design Prblem Notes -

DA09.5 <u>Calculate Functional Reach with Harness Unlocked</u>

a. CAT Software Tool - OAR
b. Inputs -
c. Outputs -
d. Design Problem Inputs -

e. Design Problem Outputs -

f. Design Problem % Complete -
g. Design Problem Notes -

DA09.6 <u>Compare Actual Reaches with User Population Norms</u>

a. CAT Software Tool - OAR
b. Inputs -
c. Outputs -
d. Design Problem Inputs -

e. Design Problem Outputs -

f. Design Problem % Complete -
g. Design Problem Notes -

DA09.7 <u>Review Mission Requirements for Out-of-Tolerance Items</u>

a. CAT Software Tool - N/A
b. Inputs -
c. Outputs -
d. Desin Problem Inputs -

e. Design Problem Outputs -

f. Design Problem % Complete -
g. Design Problem Notes -

DA09.8 <u>Prepare List of Non-Compliant Items</u>

a. CAT Software Tool - N/A
b. Inputs -
c. Outputs -
d. Design Problem Inputs -

e. Design Problem Outputs -

f. Design Problem % Complete -
g. Design Problem Notes -

DA09.9 Compile Report

a. CAT Software Tool - N/A
b. Inputs -
c. Outputs -
d. Design Problem Inputs -

e. Design Problem Outputs -

f. Design Problem % Complete -
g. Design Problem Notes -

DA09.10 Documentation of Bugs and Limitations of MCOS and OAR Version: *(fill in Version #)*

DA10.PROCEDURES FOR PERFORMING INTERNAL VISION ANALYSIS

DA10.1 Define Symbol/Character Size and Contrast Requirements

a. CAT Software Tool - N/A
b. Inputs -
c. Outputs -
d. Design Problem Inputs -

e. Design Problem Outputs -

f. Design Problem % Complete -
g. Design Problem Notes -

DA10.2 Define Phosphor Color and Persistence Requirements

a. CAT Software Tool - N/A
b. Inputs -
c. Outputs -
d. Design Problem Inputs -

e. Design Problem Outputs -

f. Design Problem % Complete -
g. Design Problem Notes -

DA10.3 Define Image Linearity, Jitter and Drift Requirements

a. CAT Software Tool - N/A
b. Inputs -
c. Outputs -
d. Design Problem Inputs -

e. Design Problem Outputs -

f. Design Problem % Complete -
g. Design Problem Notes -

DA10.4 Define Image Resolution and Accuracy Requirements

a. CAT Software Tool - DLA
b. Inputs -
c. Outputs -
d. Design Problem Inputs -

e. Design Problem Outputs -

f. Design Problem % Complete -
g. Design Problem Notes -

DA10.5 <u>Define Brightness, Uniformity and Adjustment Requirements</u>

a. CAT Software Tool - N/A
b. Inputs -
c. Outputs -
d. Design Problem Inputs -

e. Design Problem Outputs -

f. Design Problem % Complete -
g. Design Problem Notes -

DA10.6 <u>Define Night Vision Device Compatibility Requirements</u>

a. CAT Software Tool - N/A
b. Inputs -
c. Outputs -
d. Design Problem Inputs -

e. Design Problem Outputs -

f. Design Problem % Complete -
g. Design Problem Notes -

DA10.7 <u>Assess Vision Obstructions</u>

a. CAT Software Tool - E-VISION
b. Inputs -
c. Outputs -
d. Design Problem Inputs -

e. Design Problem Outputs -

f. Design Problem % Complete -
g. Design Problem Notes -

DA10.8 <u>Define Brightness and Brightness Range Requirements</u>

a. CAT Software Tool - N/A
b. Inputs -
c. Outputs -
d. Design Problem Inputs -

e. Design Problem Outputs -

f. Design Problem % Complete -
g. Design Problem Notes -

DA10.9 <u>Define Cockpit Lighting Color Requirements</u>

a. CAT Software Tool - N/A
b. Inputs -
c. Outputs -
d. Design Problem Inputs -

e. Design Problem Outputs -

f. Design Problem % Complete -
g. Design Problem Notes -

DA10.10 <u>Define Cockpit Labels and Legends Size and Color Requirements</u>

a. CAT Software Tool - DLA
b. Inputs -
c. Outputs -
d. Design Problem Inputs -

e. Design Problem Outputs -

f. Design Problem % Complete -
g. Design Problem Notes -

DA10.11 <u>Define Cockpit Signals Size, Color and Brightness Requirements</u>

a. CAT Software Tool - DLA
b. Inputs -
c. Outputs -
d. Design Problem Inputs -

e. Design Problem Outputs -

f. Design Problem % Complete -
g. Design Problem Notes -

DA10.12 <u>Document Internal Vision Analyses</u>

a. CAT Software Tool - N/A
b. Inputs -
c. Outputs -
d. Design Problem Inputs -

e. Design Problem Outputs -

f. Design Problem % Complete -
g. Design Problem Notes -

DA10.13 <u>Documentation of Bugs and Limitations of DLA and E-Vison Version: *(fill in Verson #)*</u>

DA11. PROCEDURES FOR PERFORMING EXTERNAL VISION ANALYSIS

DA11.1 Produce Total Vision Envelope Plots

a. CAT Software Tool - EVISION
b. Inputs -
c. Outputs -
d. Design Problem Inputs -

e. Design Problem Outputs -

f. Design Problem % Complete -
g. Design Problem Notes -

DA11.2 Produce Landing Approach Vision Plots

a. CAT Software Tool - EVISION
b. Inputs -
c. Outputs -
d. Design Problem Inputs -

e. Design Problem Outputs -

f. Design Problem % Complete -
g. Design Problem Notes -

DA11.3 Conduct Transparency Analyses

a. CAT Software Tool - N/A
b. Inputs -
c. Outputs -
d. Design Problem Inputs -

e. Design Problem Outputs -

f. Design Problem % Complete -
g. Design Problem Notes -

DA11.4 Assess Eye Protection Requirements

a. CAT Software Tool - N/A
b. Inputs -
c. Outputs -
d. Design Problem Inputs -

e. Design Problem Outputs -

f. Design Problem % Complete -
g. Design Problem Notes -

DA11.5 Compare Results with Requirements

a. CAT Software Tool - N/A
b. Inputs -
c. Outputs -
d. Design Problem Inputs -

e. Design Problem Outputs -

f. Design Problem % Complete -
g. Design Problem Notes -

DA11.6 Document Analyses and Results

a. CAT Software Tool - N/A
b. Inputs -
c. Outputs -
d. Design Problem Inputs -

e. Design Problem Outputs -

f. Design Problem % Complete -
g. Design Problem Notes -

DA11.7 Documentation of Bugs and Limitations of E-VISION Version: *(fill in Version #)*

DA12.PROCEDURES FOR PERFORMING WORKLOAD ANALYSIS

DA12.1 Establish Acceptable Levels of Workload

a. CAT Software Tool - CASS
b. Inputs - from CASS software tool specifications, subject matter experts, and possibly specifications made in the MDTOOL *.pfm file
c. Outputs - documentation of pre-established workload level criteria
d. Design Problem Inputs -

e. Design Problem Outputs -

f. Design Problem % Complete -
g. Design Problem Notes -

DA12.2 Determine Time to Complete Each Procedure

a. CAT Software Tool - MPE
b. Inputs - "*.ccc" cockpit geometry file and "*_nmt.msain" file created using NMT
c. Outputs -"*_mpe.report" for documentation of procedure execution times, "*_mpe.mtabin" input file for MTA, "*_mpe.farin2" input file for FAR
d. Design Problem Inputs -

e. Design Problem Outputs -

f. Design Problem % Complete -
g. Design Problem Notes -

DA12.3 Assess Time Available Versus Time Required

a. CAT Software Tool - MPE and "*_MPE.report" file for easiest look up
b. Inputs - from the "Procedure Initiation/Execution Time Summary" section of "*_MPE.report" output file of procedure DA12.2
c. Outputs - determination of which procedures will cause hang-ups because they take too long, given the time actually available
d. Design Problem Inputs -

e. Design Problem Outputs -

f. Design Problem % Complete -
g. Design Problem Notes -

DA12.4 Perform Link Analysis

a. CAT Software Tool - MPE
b. Inputs - *_MPE.report file
c. Outputs - documentation of suggested targets for automation or coupling of activities or information
d. Design Problem Inputs -

e. Design Problem Outputs -

f. Design Problem % Complete -
g. Design Problem Notes -

DA12.5 Identify Segments with Time Availability Problems

a. CAT Software Tool - MPE
b. Inputs - "*_mpe.report" results in procedure DA12.3
c. Outputs - documentation of procedures with time availability problems
d. Design Problem Inputs -

e. Design Problem Outputs -

f. Design Problem % Complete -
g. Design Problem Notes -

DA12.6 Evaluate Complexity of Pilot Activities

a. CAT Software Tool - MPE
b. Inputs - "Procedure Task Workload Report" from "*_MPE.Report" file
c. Outputs - documentation of the complexity of each of the tasks performed and for the complexity of the total procedure
d. Design Problem Inputs -

e. Design Problem Outputs -

f. Design Problem % Complete -
g. Design Problem Notes -

DA12.7 Evaluate Stress Factors Which Might Affect Workload

a. CAT Software Tool - N/A
b. Inputs -
c. Outputs -
d. Design Problem Inputs -

e. Design Problem Outputs -

f. Design Problem % Complete -
g. Design Problem Notes -

DA12.8 Identify Segments with Task Complexity Problems

a. CAT Software Tool - N/A
b. Inputs - output from Procedure DA12.6c
c. Outputs - documentation of the procedures with task complexity problems
d. Design Problem Inputs -

e. Design Problem Outputs -

f. Design Problem % Complete -
g. Design Problem Notes -

DA12.9 Identify Segments with Stress Problems

a. CAT Software Tool - N/A
b. Inputs - from procedure DA12.8c
c. Outputs -
d. Design Problem Inputs -

e. Design Problem Outputs -

f. Design Problem % Complete -
g. Design Problem Notes -

DA12.10 Integrate Estimates of Time, Complexity, and Stress Factors (and Workload)

a. CAT Software Tool - N/A
b. Inputs - outputs of Procedures DA12.5c, DA12.8c, DA12.9c, DA12.11c
c. Outputs - documentation of problem procedures and tasks for use in design recommendations, information analysis, and/or trade-off studies
d. Design Problem Inputs -

e. Design Problem Outputs -

f. Design Problem % Complete -
g. Design Problem Notes -

DA12.11 Identify Possible Workload Problems

a. CAT Software Tool - MTA
b. Inputs - "Problem Procedure Report" from "*_MTA.Report" file
c. Outputs - documentation of problem procedures based on channel workload
d. Design Problem Inputs -

e. Design Problem Outputs -

f. Design Problem % Complete -
g. Design Problem Notes -

DA12.12 Documentation of the Bugs and Limitations of CASS Version: *(fill in Version #)*

a.PET - is a quick way to get procedure durations. PET also calculates workload characteristics for isolated procedures.

b.MSA - provides the user with a listing of the time-line, and frequency of use statistics for devices (controls and displays) to give the analyst a heads up for possible control/display problem areas.

c.MPE - calculates workload statistics for each procedure in the time-line, performs link analysis, specifies task and procedure complexity, and provides procedure execution times.

d.MTA - sums the MPE generated workload data by time interval, identifies workload. peaks and contributions, reports overall workload statistics, and prepares workload plots.

e.MTP - provides an alternate workload measure: the probability of an activity in a channel each second of the time-line.

f.PLTGGP - generates 2D or 3D workload plots. To run this program, DI3000 must be installed on the MicroVAX II, and the GPX terminal print logicals must be set appropriately.

g.FAR - provides workload reports focusing on functions rather than procedures.

h.C-SAINT - generates a summary report of the amount of time the pilot is rushed, the amount of time the pilot is busy, the number of procedures the pilot is behind, and the number of procedures the pilot skipped.

DA13.PROCEDURES FOR PERFORMING INFORMATION ANALYSIS

DA13.1 Identify Info Items for each Procedure

a. CAT Software Tool - NMT
b. Inputs -
c. Outputs -
d. Design Problem Inputs -

e. Design Problem Outputs -

f. Design Problem % Complete -
g. Design Problem Notes -

DA13.2 Insert Info Items into Timeline

a. CAT Software Tool - NMT
b. Inputs -
c. Outputs -
d. Design Problem Inputs -

e. Design Problem Outputs -

f. Design Problem % Complete -
g. Design Problem Notes -

DA13.3 Identify Information Related Problems

a. CAT Software Tool - N/A
b. Inputs -
c. Outputs -
d. Design Problem Inputs -

e. Design Problem Outputs -

f. Design Problem % Complete - 0%
g. Design Problem Notes -

DA13.4 Review System Functions and Modes/States

a. CAT Software Tool - N/A
b. Inputs -
c. Outputs -
d. Design Problem Inputs -

e. Design Problem Outputs -

f. Design Problem % Complete -
g. Design Problem Notes -

DA13.5 Identify Display Information Requirements

a. CAT Software Tool - N/A
b. Inputs -
c. Outputs -
d. Design Problem Inputs -

e. Design Problem Outputs -

f. Design Problem % Complete -
g. Design Problem Notes -

DA13.6 Identify Control Information Requirements

a. CAT Software Tool - N/A
b. Inputs -
c. Outputs -
d. Design Problem Inputs -

e. Design Problem Outputs -

f. Design Problem % Complete -
g. Design Problem Notes -

DA13.7 Compare Requirements with Information Availability

a. CAT Software Tool - IATOOL
b. Inputs -
c. Outputs -
d. Design Problem Inputs -

e. Design Problem Outputs -

f. Design Problem % Complete -
g. Design Problem Notes -

DA13.8 Prioritize Information per Mission Requirements

a. CAT Software Tool - N/A
b. Inputs -
c. Outputs -
d. Design Problem Inputs -

e. Design Problem Outputs -

f. Design Problem % Complete -
g. Design Problem Notes -

DA13.9 Assess System and Subsystem Mode Definitions

a. CAT Software Tool - N/A
b. Inputs -
c. Outputs -
d. Design Problem Inputs -

e. Design Problem Outputs -

f. Design Problem % Complete -
g. Design Problem Notes -

DA13.10 Assess Control Automation

a. CAT Software Tool - N/A
b. Inputs -
c. Outputs -
d. Design Problem Inputs -

e. Design Problem Outputs

f. Design Problem % Complete -
g. Design Problem Notes -

DA13.11 Assess Control Feedback Implementation and Requirements

a. CAT Software Tool - N/A
b. Inputs -
c. Outputs -
d. Design Problem Inputs -

e. Design Problem Outputs -

f. Design Problem % Complete -
g. Design Problem Notes -

DA13.12 Assess Degraded Control Modes Implementations and Requirements

a. CAT Software Tool - N/A
b. Inputs -
c. Outputs -
d. Design Problem Inputs -

e. Design Problem Outputs -

f. Design Problem % Complete -
g. Design Problem Notes -

DA13.13 Assess Display and Control Media

a. CAT Software Tool - N/A
b. Inputs -
c. Outputs -
d. Design Problem Inputs -

e. Design Problem Outputs -

f. Design Problem % Complete -
g. Design Problem Notes -

DA13.14 Assess Information Allocation to Devices

a. CAT Software Tool - N/A
b. Inputs -
c. Outputs -
d. Design Problem Inputs -

e. Design Problem Outputs -

f. Design Problem % Complete -
g. Design Problem Notes -

DA13.15 Assess Display Formatting and Symbology

a. CAT Software Tool - N/A
b. Inputs -
c. Outputs -
d. Design Problem Inputs -

e. Design Problem Outputs -

f. Design Problem % Complete -
g. Design Problem Notes -

DA13.16 Assess Information Display Processing

a. CAT Software Tool - N/A
b. Inputs -
c. Outputs -
d. Design Problem Inputs -

e. Design Problem Outputs -

f. Design Problem % Complete -
g. Design Problem Notes -

DA13.17 Assess Information Access Approaches

a. CAT Software Tool - N/A
b. Inputs -
c. Outputs -
d. Design Problen, Inputs -

e. Design Problem Outputs -

f. Design Problem % Complete -
g. Design Problem Notes -

DA13.18 Assess Control Feedback Presentation

a. CAT Software Tool - N/A
b. Inputs -
c. Outputs -
d. Design Problem Inputs -

e. Design Problem Outputs -

f. Design Problem % Complete -
g. Design Problem Notes -

DA13.19 Assess System Advisory Presentation

a. CAT Software Tool - N/A
b. Inputs -
c. Outputs -
d. Design Problem Inputs -

e. Design Problem Outputs -

f. Design Problem % Complete -
g. Design Problem Notes -

DA13.19 Documentation of Bugs and Limitations of IATOOL Version: *(fill in Version #)*

DA15. PROCEDURES FOR PERFORMING CRITICAL TASK ANALYSIS

DA15.1 Identify Critical Tasks

a. CAT Software Tool - N/A
b. Inputs -
c. Outputs -
d. Design Problem Inputs -

e. Design Problem Outputs -

f. Design Problem % Complete -
g. Design Problem Notes -

DA15.2 Define Procedure for Accomplishing Task

a. CAT Software Tool - N/A
b. Inputs -
c. Outputs -
d. Design Problem Inputs -

e. Design Problem Outputs -

f. Design Problem % Complete -
g. Design Problem Notes -

DA15.3 Identify Optional or Alternative Procedures

a. CAT Software Tool - N/A
b. Inputs -
c. Outputs -
d. Design Problem Inputs -

e. Design Problem Outputs -

f. Design Problem % Complete -
g. Design Problem Notes -

DA15.4 Define Pilot Performance Capability Limits

a. CAT Software Tool - N/A
b. Inputs -
c. Outputs -
d. Design Problem Inputs -

e. Design Problem Outputs -

f. Design Problem % Complete -
g. Design Problem Notes -

DA15.5 Define System Performance Capability Limits

a. CAT Software Tool - N/A
b. Inputs -
c. Outputs -
d. Design Problem Inputs -

e. Design Problem Outputs -

f. Design Problem % Complete -
g. Design Problem Notes -

DA15.6 Identify Actions Required by Critical Tasks

a. CAT Software Tool - N/A
b. Inputs -
c. Outputs -
d. Design Problem Inputs -

e. Design Problem Outputs -

f. Design Problem % Complete -
g. Design Problem Notes -

DA15.7 Identify Task Initiation Information

a. CAT Software Tool - N/A
b. Inputs -
c. Outputs -
d. Design Problem Inputs -

e. Design Problem Outputs -

f. Design Problem % Complete -
g. Design Problem Notes -

DA15.8 Identify Task Performance Feedback Information

a. CAT Software Tool - N/A
b. Inputs -
c. Outputs -
d. Design Problem Inputs -

e. Design Problem Outputs -

f. Design Problem % Complete -
g. Design Problem Notes -

DA15.9 Identify Operator Information Requirements

a. CAT Software Tool - N/A
b. Inputs -
c. Outputs -
d. Design Problem Inputs -

e. Design Problem Outputs -

f. Design Problem % Complete -
g. Design Problem Notes -

DA15.10 Identify Task Completion Criteria and Tolerances

a. CAT Software Tool - N/A
b. inputs -
c. Outputs -
d. Design Problem Inputs -

e. Design Problem Outputs -

f. Design Problem % Complete -
g. Design Problem Notes -

DA15.11 Identify Potential Performance Errors

a. CAT Software Tool - N/A
b. Inputs -
c. Outputs -
d. Design Problem Inputs -

e. Design Problem Outputs -

f. Design Problem % Complete -
g. Design Problem Notes -

DA15.12 Identify Potential Hazards

a. CAT Software Tool - N/A
b. Inputs -
c. Outputs -
d. Design Problem Inputs -

e. Design Problem Outputs -

f. Design Problem % Complete -
g. Design Problem Notes -

DA15.13 Document Critical Task Analysis

a. CAT Software Tool - N/A
b. Inputs -
c. Outputs -
d. Design Problem Inputs -

e. Design Problem Outputs -

f. Design Problem % Complete -
g. Design Problem Notes -

DA17.PROCEDURES FOR PERFORMING FUNCTION ALLOCATION ANALYSIS

DA17.1 Identify Possible Mission Performance Problems

a. CAT Software Tool - N/A
b. Inputs -
c. Outputs -
d. Design Problem Inputs -

e. Design Problem Outputs -

f. Design Problem % Complete -
g. Design Problem Notes -

DA17.2 ID and Prioritize Activities Within the Segments

a. CAT Software Tool - N/A
b. Inputs -
c. Outputs -
d. Design Problem Inputs -

e. Design Problem Outputs -

f. Design Problem % Complete -
g. Design Problem Notes -

DA17.3 Identify Problem Drivers

a. CAT Software Tool - N/A
b. Inputs -
c. Outputs -
d. Design Problem Inputs -

e. Design Problem Outputs -

f. Design Problem % Complete -
g. Design Problem Notes -

DA17.4 Automate Functions or Parts of Functions

a. CAT Software Tool - NMT
b. Inputs -
c. Outputs -
d. Design Problem Inputs -

e. Design Problem Outputs -

f. Design Problem % Complete -
g Design Problem Notes -

DA17.5 <u>Change Moding and/or Control Logic</u>

a. CAT Software Tool - N/A
b. Inputs -
c. Outputs -
d. Design Problem Inputs -

e. Design Problem Outputs -

f. Design Problem % Complete -
g. Design Problem Notes -

DA17.6 <u>Reduce Info Content of Displays; Redistribute Info Over Time</u>

a. CAT Software Tool - N/A
b. Inputs -
c. Outputs -
d. Design Problem Inputs -

e. Design Problem Outputs -

f. Design Problem % Complete -
g. Design Problem Notes -

DA17.7 <u>Increase System Power; Automate Remaining Pilot Tasks</u>

a. CAT Software Tool - N/A
b. Inputs -
c. Outputs -
d. Design Problem Inputs -

e. Design Problem Outputs -

f. Design Problem % Complete -
g. Design Problem Notes -

DA17.8 <u>Preprocess, Reformat, Fuse Info; Simplify Controls and/or Displays, Change Cuing</u>

a. CAT Software Tool - N/A
b. Inputs -
c. Outputs -
d. Design Problem Inputs -

e. Design Problem Outputs -

f. Design Problem % Complete -
g. Design Problem Notes -

DA17.9 Change Sensory or Control Modality

a. CAT Software Tool - N/A
b. Inputs -
c. Outputs -
d. Design Problem Inputs -

e. Design Problem Outputs -

f. Design Problem % Complete -
g. Design Problem Notes -

DA17.10 Reformat/Relocate Displays

a. CAT Software Tool - CIPLP
b. Inputs -
c. Outputs -
d. Design Problem Inputs -

e. Design Problem Outputs -

f. Design Problem % Complete -
g. Design Problem Notes -

DA17.11 Redesign/Relocate Controls

a. CAT Software Tool - CIPLP
b. Inputs -
c. Outputs -
d. Design Problem Inputs -

e. Design Problem Outputs -

f. Design Problem % Complete -
g. Design Problem Notes -

DA17.12 Allow Timeshifting of Tasks

a. CAT Software Tool - NMT
b. Inputs -
c. Outputs -
d. Design Problem Inputs -

e. Design Problem Outputs -

f. Design Problem % Complete -
g. Design Problem Notes -

DA17.13 Integrate and Resolve Candidate Changes

a. CAT Software Tool - N/A
b. Inputs -
c. Outputs -
d. Design Problem Inputs -

e. Design Problem Outputs -

f. Design Problem % Complete -
g. Design Problem Notes -

DA18. PROCEDURES FOR EVALUATING FUNCTION ALLOCATION CANDIDATES

DA18.1 Establish Evaluation Parameter

a. CAT Software Tool - SUMMET
b. Inputs -
c. Outputs -
d. Design Problem Inputs -

e. Design Problem Outputs -

f. Design Problem % Complete -
g. Design Problem Notes -

DA18.2 Develop Criteria for Each Parameter

a. CAT Software Tool - SUMMET
b. Inputs -
c. Outputs -
d. Design Problem Inputs -

e. Design Problem Outputs -

f. Design Problem % Complete -
g. Design Problem Notes -

DA18.3 Assign Weights to Evaluation Criteria

a. CAT Software Tool - SUMMET
b. Inputs -
c. Outputs -
d. Design Problem Inputs -

e. Design Problem Outputs -

f. Design Problem % Complete -
g. Design Problem Notes -

DA18.4 Evaluate Each Candidate on Each Evaluation Criterion

a. CAT Software Tool - SUMMET
b. Inputs -
c. Outputs -
d. Design Problem Inputs -

e. Design Problem Outputs -

f. Design Problem % Complete -
g. Design Problem Notes -

DA18.5 <u>Evaluate Relative Merits of Design Solution Candidates</u>

a. CAT Software Tool - SUMMET
b. Inputs -
c. Outputs -
d. Design Problem Inputs -

e. Design Problem Outputs -

f. Design Problem % Complete -
g. Design Problem Notes -

DA18.6 <u>Select Candidates for Implementation</u>

a. CAT Software Tool - SUMMET
b. Inputs -
c. Outputs -
d. Design Problem Inputs -

e. Design Problem Outputs -

f. Design Problem % Complete -
g. Design Problem Notes -

DA19. PROCEDURES FOR DEFINING CONTROL AND DISPLAY CONCEPT

DA19.1 Identify Controls and Displays to be Eliminated

a. CAT Software Tool - N/A
b. Inputs -
c. Outputs -
d. Design Problem Inputs -

e. Design Problem Outputs -

f. Design Problem % Complete -
g. Design Problem Notes -

DA19.2 Identify New Controls/Displays to be Created

a. CAT Software Tool - N/A
b. Inputs -
c. Outputs -
d. Design Problem Inputs -

e. Design Problem Outputs -

f. Design Problem % Complete -
g. Design Problem Notes -

DA19.3 Describe Display Format Info Elements

a. CAT Software Tool - N/A
b. Inputs -
c. Outputs -
d. Design Problem Inputs -

e. Design Problem Outputs -

f. Design Problem % Complete -
g. Design Problem Notes -

DA19.4 Describe Display Dynamics

a. CAT Software Tool - N/A
b. Inputs -
c. Outputs -
d. Design Problem Inputs -

e. Design Problem Outputs -

f. Design Problem % Complete -
g. Design Problem Notes -

DA19.5 Describe Data Fusion Requirements

a. CAT Software Tool - N/A
b. Inputs -
c. Outputs -
d. Design Problem Inputs -

e. Design Problem Outputs -

f. Design Problem % Complete -
g. Design Problem Notes -

DA19.6 Describe Control Response Characteristics

a. CAT Software Tool - N/A
b. Inputs -
c. Outputs -
d. Design Problem Inputs -

e. Design Problem Outputs -

f. Design Problem % Complete -
g. Design Problem Notes -

DA19.7 Describe System Response Time Requirements

a. CAT Software Tool - N/A
b. Inputs -
c. Outputs -
d. Design Problem Inputs -

e. Design Problem Outputs -

f. Design Problem % Complete -
g. Design Problem Notes -

DA20.PROCEDURES FOR FORMULATING OPERATIONAL GUIDELINES

DA20.1 Identify Existing Procedures to be Modified

a. CAT Software Tool - N/A
b. Inputs -
c. Outputs -
d. Design Problem Inputs -

e. Design Problem Outputs -

f. Design Problem % Complete -
g. Design Problem Notes -

DA20.2 Describe Modifications to Existing Procedures

a. CAT Software Tool - N/A
b. Inputs -
c. Outputs -
d. Design Problem Inputs -

e. Design Problem Outputs -

f. Design Problem % Complete -
g. Design Problem Notes -

DA20.3 Identify New Procedures to be Created

a. CAT Software Tool - N/A
b. Inputs -
c. Outputs -
d. Design Problem Inputs -

e. Design Problem Outputs -

f. Design Problem % Complete -
g. Design Problem Notes -

DA20.4 Describe New Procedures

a. CAT Software Tool - N/A
b. Inputs -
c. Outputs -
d. Design Problem Inputs -

e. Design Problem Outputs -

f. Design Problem % Complete -
g. Design Problem Notes -

DA20.5 <u>Identify Procedures to be Eliminated</u>

a. CAT Software Tool - N/A
b. Inputs -
c. Outputs -
d. Design Problem Inputs -

e. Design Problem Outputs -

f. Design Problem % Complete -
g. Design Problem Notes -

DA21.PROCEDURES FOR ESTABLISHING EQUIPMENT REQUIREMENTS

DA21.1 Identify Existing Equipment to be Modified

a. CAT Software Tool - N/A
b. Inputs -
c. Outputs -
d. Design Problem Inputs -

e. Design Problem Outputs -

f. Design Problem % Complete -
g. Design Problem Notes -

DA21.2 Describe Modifications to Existing Equipment

a. CAT Software Tool - N/A
b. Inputs -
c. Outputs -
d. Design Problem Inputs -

e. Design Problem Outputs -

f. Design Problem % Complete -
g. Design Problem Notes -

DA21.3 Identify New Equipment to be Acquired

a. CAT Software Tool - N/A
b. Inputs -
c. Outputs -
d. Design Problem Inputs -

e. Design Problem Outputs -

f. Design Problem % Complete -
g. Design Problem Notes -

DA21.4 Describe New Equipment

a. CAT Software Tool - N/A
b. Inputs -
c. Outputs -
d. Design Problem Inputs -

e. Design Problem Outputs -

f. Design Problem % Complete -
g. Design Problem Notes -

DA21.5 Identify Equipment to be Eliminated

a. CAT Software Tool - N/A
b. Inputs -
c. Outputs -
d. Design Problem Inputs -

e. Design Problem Outputs -

f. Design Problem % Complete -
g. Design Problem Notes -

☆U.S. Government Printing Office: 1992 – 648-069/40233