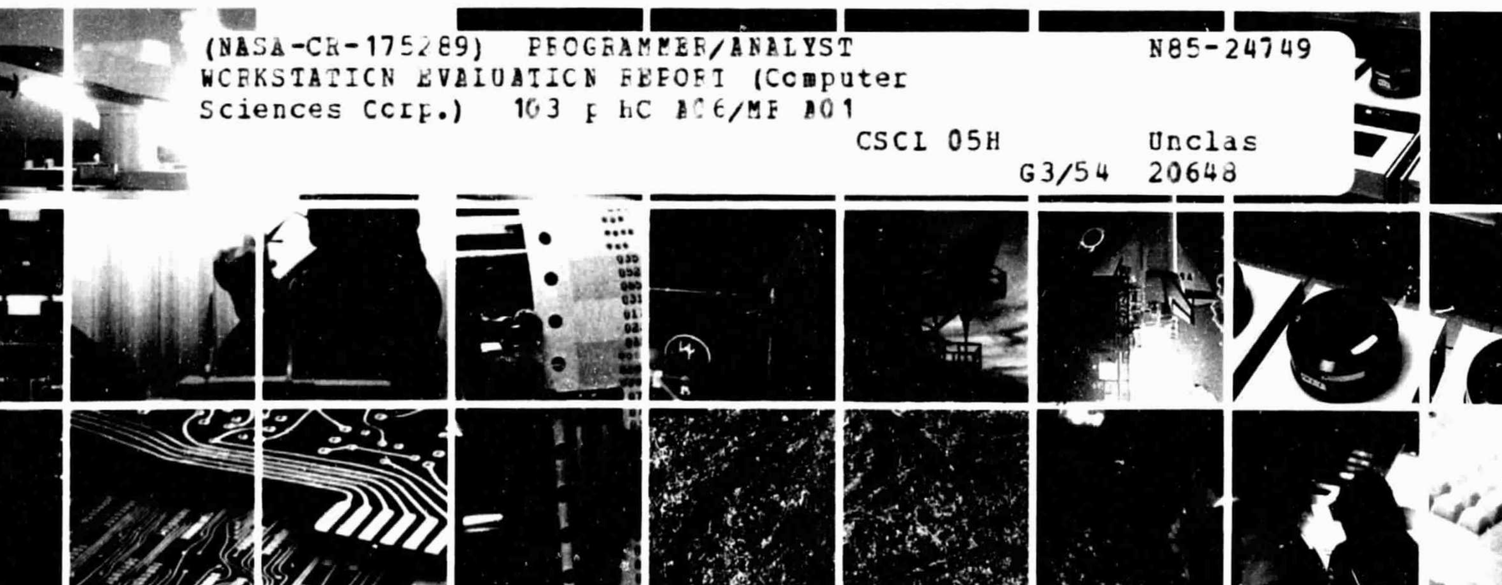
CSC/TM-84/6138

PROGRAMMER/ANALYST WORKSTATION EVALUATION REPORT

Prepared for
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
Goddard Space Flight Center
Greenbelt, Maryland

CONTRACT NAS 5-27888
Task Assignment 802

NOVEMBER 1984



(NASA-CR-175289) PROGRAMMER/ANALYST WORKSTATION EVALUATION REPORT (Computer Sciences Corp.) 103 p HC A06/MF A01 CSCL 05H
N85-24749
Unclas
G3/54 20648

CSC

COMPUTER SCIENCES CORPORATION

CSC/TM-84/6138

PROGRAMMER/ANALYST WORKSTATION EVALUATION REPORT

Prepared for

GODDARD SPACE FLIGHT CENTER

By

COMPUTER SCIENCES CORPORATION

Under

Contract NAS 5-27888
Task Assignment 802

Prepared by:

Rakesh Mital 11/28/84
R. Mital Date

R. Berg
C. Brown
D. Card
S. Cheuvront
V. Church
T. Clark
B. Hardie
M. Kim
K. Koerner
J. Langston
J. Page

Approved by:

Thomas L. Jolad for K. Koerner 11/29/84
K. Koerner Date
Operations Manager

G. H. Mahler 11/29/84
G. Mahler Date
Functional Area Manager

Accepted by:

Anthony Maione 12/17/84
A. Maione Date
Section Head Code 532.1
System Planning
and Requirements

ABSTRACT

This document presents the methodology and results of the programmer/analyst workstation evaluation undertaken at Computer Sciences Corporation under Task Assignment 80200.

TABLE OF CONTENTS

TABLE OF CONTENTS (Cont'd)

Section 5 (Cont'd)

LIST OF ILLUSTRATIONS

Figure

LIST OF TABLES

Table

SECTION 1 - INTRODUCTION

This report documents an investigation and evaluation of the use of automated tools to support programmers and analysts during the software development life cycle. It also presents the results of this evaluation and makes recommendations for future activities in this area. The work was performed by Computer Sciences Corporation (CSC) under the direction of the National Aeronautics and Space Administration (NASA).

1.1 BACKGROUND AND PURPOSE OF THE EVALUATION

Both CSC and NASA are striving for improvements in the quality and productivity of software development efforts. In the past, very few automated tools have been available to support software requirements analysis and design. Recently, however, some tools have appeared on the market. The hypothesis is that the use of such tools would provide significant productivity and quality improvements during the requirements analysis and design phases of software development. Furthermore, improvements during these phases would, in turn, produce improvements in quality and productivity over the entire system life cycle.

As a first step, CSC and NASA studied commercially available products through an industry survey. Next, a 90-day evaluation of two commercial products by programmers and analysts was undertaken to determine which tool is the best to support programmers and analysts through life cycle development. Finally, a tool was selected for full implementation on the PACOR/GRO project, where complete analysis of software statistics over the system life cycle will determine whether or not quality and productivity improvements have actually occurred.

1.2 REPORT ORGANIZATION

This report is organized into six sections and six appendixes. Section 2 discusses the background of the evaluation and includes a description of desired features as well as the evaluation approach. Section 3 presents the results of the industry survey of currently available commercial products. Section 4 documents the configuration of workstations installed for the in-house evaluation and CSC's activities during the evaluation. Section 5 contains the results of the evaluation and discusses some individual areas of interest. Section 6 summarizes the key findings from the evaluation and makes both short- and long-term recommendations for using automated tools.

Appendix A shows the questionnaire used to record user responses. Appendix B contains the requirements analysis problems used in the control problem workshop. Appendixes C and D provide a log of hardware/software problem report summaries and evaluator suggestions. Appendixes E and F present recommendations from PACOR/GRO and PC&A to the Source Selection Board.

SECTION 2 - BACKGROUND OF THE PROGRAMMER/ANALYST WORKSTATION EVALUATION

CSC has established a structured software development methodology, summarized in Digital System Development Methodology (DSDM[1]). Part of CSC's commitment to DSDM involves the use of programmer/analyst workstations to allow this methodology to be followed easily so that programmers and analysts can concentrate on technical solutions to problems.

Automated tools can replace the current mode of using paper models for data flow diagrams, data dictionaries, function specifications, structure charts, and so on. To support the interactive process of analysis and design, the workstation must be able to supply information graphically as well as in text form. Given the iterative nature of analysis and design, automation and simplification of the process of generating and refining paper models will probably increase efficiency.

2.1 DESIRED FEATURES OF THE WORKSTATION

To best support DSDM during software development, the analysis and design tools need to automate the basic steps of this methodology. The automated tools ultimately selected should be able to

- Implement the DeMarco structured analysis methodology, providing the programmer/analyst with the capabilities to interactively
  - Create and modify data flow diagrams--The system should be able to insert and delete graphic symbols for processes, data flows, data stores, data sources, and data sinks.

[1]Version 2.0, copyright March 1984. DSDM is a trademark of Computer Sciences Corporation.

Views of the data flow diagram should be displayed at the scale requested by the designer.

- Create an analysis data dictionary automatically derived from the data flow diagrams--For every modification to a data flow diagram, the system must update the related information in the data dictionary or prompt the designer for further information.

- Create and modify process descriptions--When a low-level process is defined or modified in a data flow diagram, the designer should be prompted for the process description. The system should provide a standard format for the description and support the use of English text or decision trees.

- Create and modify data structure charts--The system should ensure correspondence between the data dictionary and the structure charts and should prompt the designer to correct suspected inconsistencies.

● Implement the Yourdon structured design methodolgy, providing the capabilities to interactively

  - Create and modify the structure charts used to evaluate designs--All valid graphic symbols should be supported. A preliminary structure chart should be created directly from the results of the structured analysis process, if desired.

  - Create and maintain a structured design data dictionary--Any changes to either the structure chart or the data flow diagrams should result in prompts for needed changes to the dictionary. The design data dictionary can be integrated with the analysis data dictionary.

- Describe a module's design, including a standard format for a prolog in text and a process flow in program design language (PDL)--These module descriptions should be correlated with the generated structure charts.
- Construct a template for a unit test matrix based on the module design

- Implement the workstation on a microcomputer--A basic concept for the programmer/analyst workstation is to be able to implement the tools and techniques of DSDM on a microcomputer workstation. For requirements analysis and design, use of a microcomputer is judged to be more advantageous for CSC than use of terminals connected to a central host computer. The microcomputer provides the capabilities to

  - Maintain a similar development environment regardless of the project's host computer--This should reduce training efforts and learning-curve costs from one project to the other
  - Make the tool available on different projects without adding the cost of conversion
  - Ensure access at all times--The project host computer availability is not an issue. The microcomputer workstation can be available 24 hours a day, 7 days a week. Downtime or unavailability of a customer's mainframe should not be a concern during the early stages of development.

- Maintain information in a standard format from one project to another--A project's design is thus maintained on a data base and can be accessed for use on another project. The products of each phase should be standard and should not require conversion, nor should one have to be concerned with the availability of another computer.

2.2 APPROACH TO THE WORKSTATION EVALUATION

CSC determined that a multiphased approach to implementing the workstation was the most effective plan. A multiphased approach allows the most thorough evaluation and helps ensure a successful implementation. The three phases are (1) industry survey, (2) in-house evaluation, and (3) full implementation. Table 2-1 summarizes this plan.

2.2.1 INDUSTRY SURVEY

Phase 1 consisted of a two-level screening of commercially available products. This survey phase began with attending conferences, reviewing current literature on the subject, and consulting with technical experts to obtain a list of feasible sources. Initial screening consisted of telephone discussions and written correspondence. After the initial screening, products that met the following key criteria were considered further: requirements analysis tools, design tools, and microcomputer implementation.

The second-level screening consisted of vendor demonstrations. The following features were sought and evaluated in this second-level screening of workstation products:

- User friendliness
- Graphic and textual data manipulation
- Interactive requirements analysis tools
- Interactive design tools

Table 2-1. Summary of Implementation Approach

PHASE	CRITERIA FOR EVALUATION	METHODOLOGY
1. INDUSTRY SURVEY — 90-DAY DURATION		
STEP 1—INITIAL SCREENING OF PRODUCTS FULFILLING BASIC CONCEPTS	AVAILABLE REQUIREMENTS ANALYSIS TOOLS AVAILABLE DESIGN TOOLS MICROCOMPUTER IMPLEMENTATION OF TOOLS	CONFERENCE PARTICIPATION LITERATURE REVIEW TECHNICAL EXPERTS
STEP 2—PRODUCTS WITH SUFFICIENT BENEFITS FOR IN-HOUSE EVALUATION	75% OF DESIRED FEATURES SUPPORTED	EVALUATION DURING VENDOR DEMONSTRATION OF PRODUCT
2. IN-HOUSE EVALUATION — 90-DAY DURATION		
STEP 1—TECHNICAL PERSONNEL USE TOOLS TO PRODUCE PRODUCTS	IMPROVED EASE FOR PRODUCING PRODUCTS OF DEVELOPMENT METHODOLOGY QUALITY OF PRODUCTS	USAGE OF TOOLS QUESTIONNAIRES GENERAL ASSESSMENTS COMPARISON OF PRODUCTS
STEP 2—DIVISION TEAM EVALUATES BENEFITS	QUALITY OF PRODUCTS COST EFFECTIVENESS OF PRODUCTS	STUDY OF QUESTIONNAIRES AND TRENDS ASSESSMENT OF QUALITY OF PRODUCTS
3. FULL IMPLEMENTATION — 32-MONTH DURATION ON THE PACOR/GRO PROJECT		
STEP 1—EVALUATION OF STATISTICS AT COMPLETION OF EACH PHASE OF DEVELOPMENT: REQUIREMENTS ANALYSIS, DESIGN, EACH BUILD, AND SYSTEM TEST	IMPROVED QUALITY OF PRODUCT REDUCED COST REDUCED TIME TO PRODUCE PRODUCTS	COMPARISON TO STATISTICS FROM PROJECTS IN SIMILAR ENVIRONMENT QUESTIONNAIRES TO TECHNICAL USERS AND MANAGERS
STEP 2—EVALUATION OF OVERALL PROJECT STATISTICS AT COMPLETION	OVERALL LIFE-CYCLE PRODUCTIVITY IMPROVED QUALITY OF PRODUCT	COMPARISON TO STATISTICS AND COSTS FROM OTHER PROJECTS CUSTOMER SATISFACTION WITH PRODUCT ASSESSMENT OF DOCUMENTATION QUALITY AND COSTS

9809(34*)b)/84

- Usability as a development terminal on the host computer
- Library capability to support software requirements and design tools
- Management support tools
- Workstation networking capabilities
- Microcomputer implementation

The end product of the phase 1 industry survey was a recommendation of two qualified products for more comprehensive evaluation by CSC. The criterion for being considered "qualified" was that more than three-fourths of the desired features be available. In addition, during the phase 1 industry survey, initial discussions were conducted with qualified vendors regarding the possibility of CSC or vendor modifications to the product to meet CSC needs.

2.2.2 IN-HOUSE EVALUATION

Phase 2 consisted of a 90-day in-house evaluation of qualified products; this is the phase whose activities were conducted under Task 802. During the evaluation, the tools were used to produce technical analysis and design products for ongoing software development projects.

The evaluation was conducted by two teams of System Sciences Division personnel, funded by NASA. The Division level team evaluated workstation usage across the Division and the Corporation. This team consisted of representatives of project management, project control, product assurance, software engineering, and system engineering. It was responsible for assessing the overall results of using the tools, comparing cost effectiveness, presenting results to NASA and CSC managers, and negotiating with vendors.

The second team consisted of programmers and analysts representing six projects or areas. They were responsible for using the analysis and design tools of the workstation and evaluating the effectiveness of the tools to support DSDM.

2.2.3 FULL IMPLEMENTATION

Phase 3, the last step, consists of configuring the workstations and the tools for use on a specific project. The project to be studied is PACOR/GRO, a 32-month software development project for a data capture system, work on which started in October 1984. During this period, the effectiveness of workstations will be assessed in a product-oriented, software development environment.

Complete implementation can provide valid and reliable metrics for the entire software development life cycle. These metrics can then be used to determine whether the workstations truly improve both productivity and quality. Results will be compiled at the end of each development phase (requirements analysis, design, and each build and system test) and at the end of the project. The quality of the product, customer satisfaction with the product, management and technical personnel's satisfaction with the workstation, and cost considerations will be evaluated in the overall assessment of the workstation. Future implementation on other projects will be based on the results of these evaluations.

SECTION 3 - RESULTS OF INDUSTRY SURVEY

Phase 1 consisted of a two-level screening of commercially available products. Level 1 screening consisted of telephone discussions and written correspondence. Level 2 consisted of vendor demonstrations.

3.1 LEVEL 1: INITIAL SCREENING

During the initial screening, CSC found that most commercially available products support code generation and report writing. Products or tools that support the development methodology of analysis and design are fairly new. Many companies indicate that they are pursuing development of these tools on a microcomputer; however, relatively few products are available and supported today. Initially, eight vendors were contacted whose products are currently available in this area. These eight products and their current status as analysis and design tools are listed below.

Product	Status
Yourdon	• Not available • Being developed for IBM PC • Earliest demonstration in January 1985
Tektronix	• Available for BETA test site • LSI or VAX based
PROMOD (GEI)	• U.S. availability unknown • IBM PC/XT or VAX based
Excelerator (Index Technology)	• Available for IBM PC/XT
CASE 2000 (NASTEC)	• Available on CTEC 8086

Product	Status
Boeing Argus	• Package and nonsupported source available • New enhanced and supported product available in January 1985
Symbolics	• Available on Symbolics 3600 • No requirements analysis tools
SOFTOOL CCC and PE	• Configuration control and programming environment tools • IBM PC implementation in late 1984 • Design environment tools in 1985

After the initial screening, the following four products met the key criteria of providing requirements analysis and design tools and microprocessor implementation (see Section 2.2.1):

- Tektronix
- PROMOD
- Excelerator
- CASE 2000

3.2 LEVEL 2: IDENTIFYING CANDIDATE PRODUCTS FOR FURTHER EVALUATION

The second level of the industry survey was to determine which products that met the basic criteria provided the most benefits. CSC had already decided that only an in-house evaluation could provide a sufficiently thorough analysis of benefits (Phase 2). However, further information was needed to determine and recommend which products provided sufficient improvements over the current development approach to warrant the costs associated with an in-house evaluation. CSC believed that vendor demonstrations could reveal the availability of the nine desired features (Section 2.2.1) at this level of the evaluation. Table 3-1 shows the desired features and CSC's evaluation of the availability of each

Table 3-1. Desired Features as Traced in Four Products

FEATURES	PRODUCTS			
	TEKTRONIX	PROMOD	EXCELERATOR*	CASE 2000*
USER FRIENDLINESS	◒	◒	●	○
GRAPHIC AND TEXTUAL DATA MANIPULATION	●	●	●	●
CAPABLE INTERACTIVE REQUIREMENTS ANALYSIS TOOLS	●	●	●	●
CAPABLE INTERACTIVE DESIGN TOOLS	○	○	●	◒
USABILITY AS A DEVELOPMENT TERMINAL ON HOST	●	●	●	●
LIBRARY CAPABILITY TO SUPPORT SOFTWARE REQUIREMENTS AND DESIGN TOOLS	◒	◒	●	●
MANAGEMENT SUPPORT TOOLS	○	◒	◒	●
WORKSTATION NETWORKING CAPABILITIES	●	○	○	●
MICROCOMPUTER IMPLEMENTATION	●	●	●	●

9809(34*b)/84

○ FEATURE NOT CURRENTLY AVAILABLE.
◒ FEATURE PARTIALLY AVAILABLE.
● FEATURE AVAILABLE.

*PRODUCT MEETS CRITERIA FOR PHASE 2 IN-HOUSE EVALUATION.

feature for each product. The following subsections summarize each of the four products.

3.2.1 TEKTRONIX

The Tektronix workstation provides color graphics and joystick control and is an LSI- or VAX-based system. It received a 2-week evaluation in the Division facility. The system was developed by Tektronix for their in-house use and is now being prepared for commercial availability. The system will be available for Beta test-site use.

Several software problems exist with the Tektronix system. Because it does not yet support the generation of structure charts, CSC determined that the use of Tektronix at this point was premature. In addition, it provided less than 75 percent of the desired features: it was not user friendly, did not actually support DSDM methodology, and did not contain management tools.

3.2.2 PROMOD

PROMOD is an automated tool for requirements analysis and design produced by GEI in West Germany. Requirements analysis is performed using DeMarco data flow diagrams, and design follows Modula II methods.

Its major disadvantage is that it imposes a strict adherence to the methodologies, which constrains the use of the tool for large projects due to the inherent lack of flexibility. In addition, the graphics interface is poor: the size of an individual diagram is constrained to be the amount that can be drawn on a cathode ray tube (CRT) screen, and modification of diagrams is cumbersome. Finally, PROMOD is not currently available in the United States.

The major advantage of PROMOD is the depth and completeness of its analysis function. No other product currently reviewed has PROMOD's capabilities to analyze a leveled set of data flow diagrams with minispecifications and a data dictionary. PROMOD can produce detailed reports on the internal consistency of data flow diagrams.

Overall, PROMOD failed to meet CSC's criterion of providing 75 percent of the desired features. The design tools were so difficult to use that CSC deemed it not useful for our purposes. The interface was rated only partially user friendly. It could not currently be networked to other workstations to provide an automatic central project data base. CSC thus decided that further evaluation of this product was premature and not cost effective.

3.2.3 EXCELERATOR

The Index Technology Excelerator runs on an IBM PC/XT with special graphic boards and a mouse interface. It produces good data flow diagrams and structure charts. The Excelerator's mouse interface is very user friendly and allows panning and zooming. The Excelerator advertises the following capabilities: (1) a graphic facility for data flow diagrams, structure charts, data model diagrams, presentation graphs, and documentation graphs; (2) a dictionary maintaining all system information in one place; (3) a screen-painting facility to develop prototypes and user interfaces; (4) a report formatter; and (5) a documentation facility of word processing, documentation specification, and production.

The Excelerator has been commercially available since May 1984. It provides more than 80 percent of the desired features for the workstation. Because it runs on an IBM PC/XT, many management support tools are available, although they are not an integrated part of the Excelerator system.

The main drawback of the Excelerator is its inability to support the networking of workstations. Thus, no central project data base can be maintained automatically for simultaneous users. This condition needs further consideration in CSC's evaluation. The Excelerator will provide this capability in a future release when IBM announces its networking strategy.

3.2.4 CASE 2000

The NASTEC CASE 2000 is a software development life cycle workstation implemented on the CTEC 8086. It is a powerful system with tools supporting all phases of development and the integration of tools for project management. The CASE 2000 advertises development tools, including structured design, structured programming, a requirements analysis data dictionary, a requirements analyzer, change control, and quality reviewer. It presents a life cycle manager that features cost/schedule estimating, task assignment and releases, and methodology/project data base and status reporting. In addition, the CASE 2000 provides several communications protocols, compilers, editors, and word processors. It permits networking of up to 16 workstations.

The primary limitation of the CASE 2000 is that it is relatively difficult to learn to use. It is more powerful, however, and thus may be worth the learning curve. The CASE 2000 was not rated as user friendly, and there were some limitations with drawing structure charts. It has, however, over 80 percent of the desired features and is considered worthwhile for further evaluation.

SECTION 4 - IN-HOUSE EVALUATION

No single commercially available product met all of CSC's requirements. However, two products provide over 80 percent of the capabilities determined to be advantageous for requirements analysis and design: the Index Technology Excelerator and the NASTEC CASE 2000. During this evaluation, the use of these products on a day-to-day basis allowed a valid assessment of benefits and drawbacks in the real world.

4.1 WORKSTATION CONFIGURATION

Two systems were installed in CSC's Silver Spring facility for the 90-day evaluation from July 30, 1984, until October 30, 1984.

4.1.1 EXCELERATOR

The Excelerator is designed to run on an IBM PC/XT. This is a very popular computer and widely available from a number of sources. It features an Intel 8088 microprocessor running at 4.77 megahertz. This is a design with a 16-bit internal data path and an 8-bit external data path. The standard operating system allows the software to address up to 640 kilobytes of random access memory. A high-resolution IBM monochrome green monitor is required. Index Technology offers a high-resolution graphics interface as part of their package, which provides a bit-mapped screen with 640- by 352-pixel resolution. An asynchronous serial interface and a Centronics-compatible parallel interface is provided. The computer provides a 5-1/4-inch floppy disk drive with a storage capacity of 360 kilobytes and a 10-megabyte Winchester hard disk. A mechanical mouse is provided for moving the cursor on the screen. Many standard parallel printers are supported.

Two Index Technology Excelerator systems were used on IBM PC/XTs. A mouse interface, a high-resolution graphics board, and Microsoft Word software were included with the Excelerator package. The Excelerator software can draw data flow diagrams and structure charts and can build a data dictionary. An Epson FX-100 printer was connected to each workstation.

4.1.2 CASE 2000

The CASE 2000 system consists of hardware developed by Convergence Technologies and software developed by NASTEC Corporation. A typical configuration contains an Integrated Work Station (IWS) master station and up to 15 IWS cluster stations. The master station supports a printer, external communications line, and a mass storage device. These are all accessible from any of the cluster stations. In addition, each cluster station can support its own printer, communications line, and mass storage device.

Each workstation (i.e., either a master station or a cluster station) consists of a 16-bit Intel 8086 microprocessor with a clock speed of 5 megahertz, a 15-inch green display screen that can be tilted and swiveled for user comfort, and a 103-key detached electronic keyboard. The cluster stations contain 512 kilobytes of local user random access memory; the master station contains 768 kilobytes. The high-resolution character-mapped green screen displays 34 lines by 132 characters; each character is contained in a 10-by-15-pixel cell. An RS 422 channel, operating at 307 kilobaud, ties the cluster stations to the master station.

The mass storage device contains an 8-inch, single-sided, double-density floppy disk drive with a storage capacity of one-half megabyte and a Winchester fixed disk drive with an unformatted capacity of 40 megabytes. Additional mass storage units may be attached to the master station or the cluster stations. For cluster-station-attached mass storage devices, only the cluster station to which they are attached has access to the mass storage device.

The configuration supplied for this evaluation consisted of one master station, two cluster stations, a half-megabyte floppy/33-megabyte hard disk mass storage system, and a high-quality dot matrix printer.

Software supplied with the system consisted of the CTOS (Convergent Technologies Operating System), BASE (Basic Application for Software Engineering), and DesignAid software, the last two developed by NASTEC. CTOS is a real-time, message-based, event-driven, multiprogramming operating system. The master station provides file system and queue management resources for all stations in the cluster.

4.2 WORKSTATION EVALUATORS

The evaluators consisted of two teams: one at the Division level and the other consisting of individuals from various CSC groups.

4.2.1 DIVISION EVALUATION TEAM

The 12-member Division evaluation team consisted of project managers, Division directors of product assurance and project control, system engineers, and software engineers. It met every 2 weeks to discuss activities and also met informally with vendors as needed to discuss activities, problems, or recommendations. The Division team reviewed input from users and the products of the various tools.

4.2.2 TECHNICAL EVALUATION TEAM

The technical team included representatives from Spacelab, PACOR/GRO, PC&A, the Bilateration Ranging Transponder System (BRTS) Scheduling Subsystem, the Network Control Center and the Operations Support Computing Facility (the last two as participants in the control problem workshop), and the Technical Publications Department. Each area appointed one coordinator.

4.2.2.1 Technical Coordinators

Technical coordinators met every 2 weeks to discuss the status of evaluation activities. During these meetings, problems and suggestions were discussed. Use of and access to workstation resources were also scheduled.

4.2.2.2 Workstation Users

Thirty-four users participated in the evaluation. These programmers and analysts used the workstations to perform their day-to-day jobs in the area of analysis and design. The users met every 2 weeks to provide feedback to the Division team and to the vendors. These meetings provided a forum for informal communication.

4.3 EVALUATION METHODS

Various methods were used to obtain objective results in the evaluation. The following activities were performed:

- Questionnaires were given every 30 days to all users (Section 5.1).
- A requirements analysis control problem workshop was conducted using the tools (Section 5.2).
- Desired detailed features were compared (Section 5.3).
- Individual projects provided their recommendations (Section 5.4).
- The Division evaluation team provided recommendations based on their area of expertise (Section 5.5).

- Hardware/software problem reports were maintained (Appendix C).
- Evaluator suggestions were recorded (Appendix D).

SECTION 5 - RESULTS OF IN-HOUSE EVALUATION

During the 3-month trial period, the Index Technology Excelerator and NASTEC CASE 2000 workstations were made available to a wide variety of users. The trial period was divided into three segments, and the reaction of users to each workstation during each time segment was surveyed.

5.1 QUESTIONNAIRE RESULTS AND TRENDS

Users provided their reactions via the questionnaire shown in Appendix A. The questions on this form deal with user background, specific workstation capabilities, overall effectiveness, and the manner in which workstations were used.

Table 5-1 summarizes the number of responses to the surveys for each workstation. The tabulations and statistics reported in this section combine data from all three surveys. However, only the latest evaluation of each workstation from each participant was used in this analysis.

Table 5-1. Survey Response

Data Group	Total Respondents	Respondents Using	
		Excelerator	CASE 2000
Survey 1	19	12	16
Survey 2	23	15	18
Survey 3	13	7	10
Combined Survey	34	22	29

NOTE: Combined survey includes only the latest evaluation of each workstation from participants in any of the three surveys.

5.1.1 EVALUATOR HISTORY

Survey organizers attempted to include the widest possible range of potential users. Figure 5-1 shows the distribution

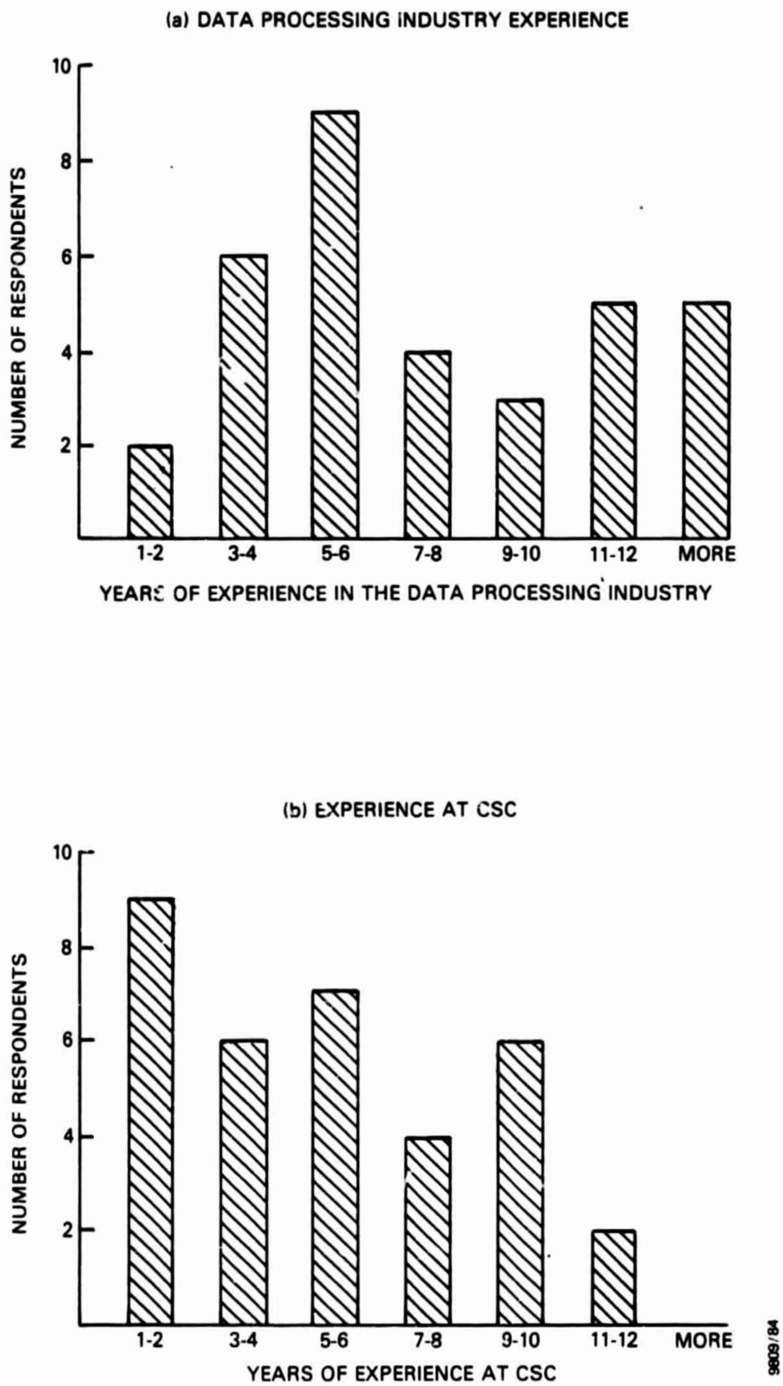


Figure 5-1. Experience of Respondents

of industry and CSC experience among survey respondents. A broad range of experience in terms of years of experience is represented for both attributes. However, Table 5-2 indicates that many professional roles are not represented in the sample obtained from the surveys. Survey respondents have been primarily programmers and analysts. Consequently, the surveys cannot provide much information about how well the workstations would support other professional roles.

Table 5-2. Roles of Respondents

Work Role	Excelerator	CASE 2000
Division Evaluator	0	0
Analyst	11	15
Programmer	8	10
Quality Assurance	0	1
Software Manager	2	2
Project Manager	0	0
Support	1	1
TOTAL	22	29

Survey organizers did not assign specific problems or times for workstation use. Participants in the evaluation effort generally attempted to apply the workstations to an ongoing task. Figure 5-2 shows the distribution of contact times with each workstation. Relatively few users of either the Excelerator or the CASE 2000 achieved more than 20 hours of contact time. Table 5-3 reports the level of familiarity that users estimated themselves to have attained.

Only one (Excelerator) user claimed to have become "knowledgeable" about a workstation during the 3-month evaluation period. Otherwise, users of the two workstations attained

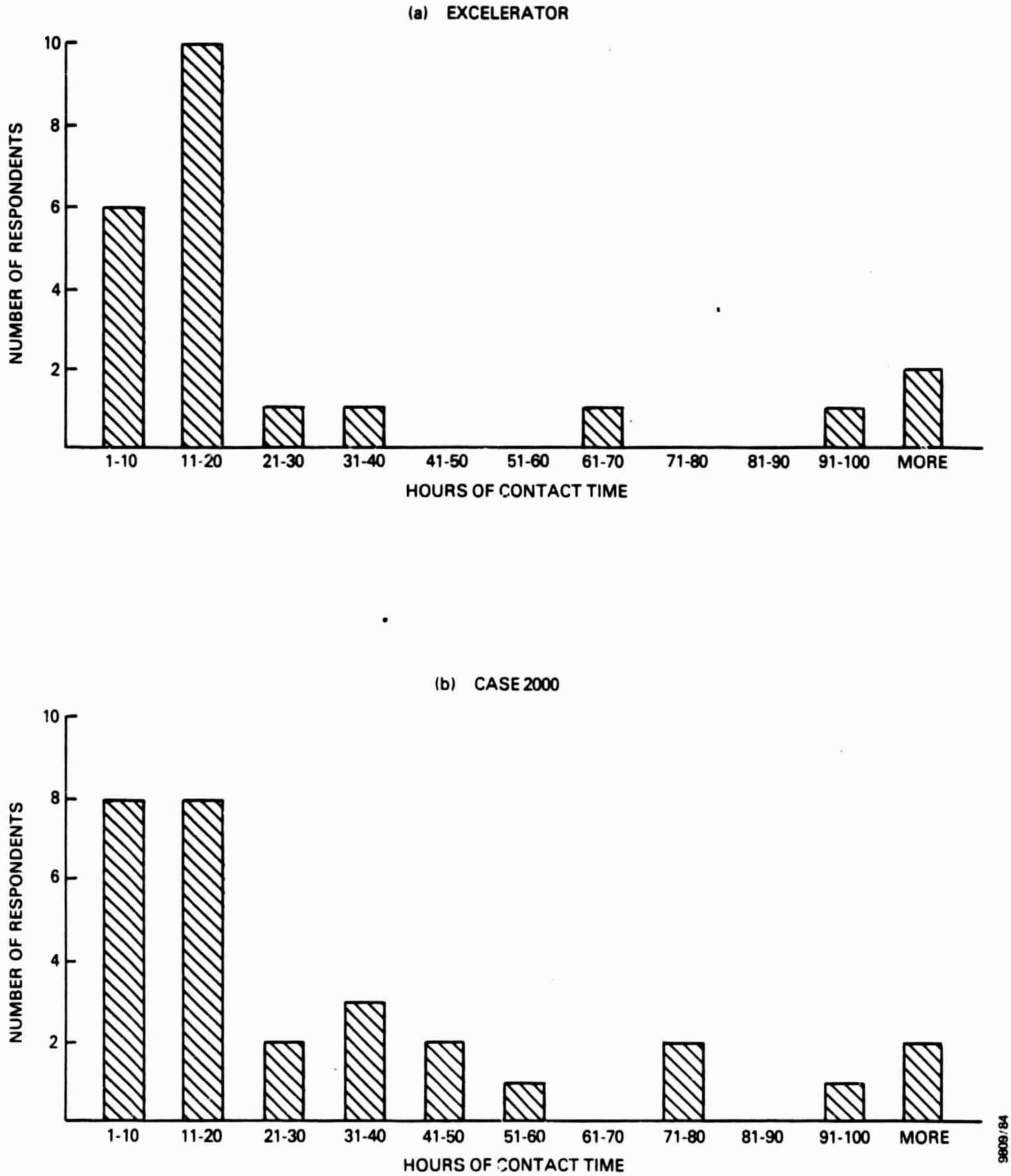


Figure 5-2. Exposure to Workstations

comparable levels of familiarity. However, a higher proportion of CASE 2000 users reported more than 20 hours of contact time.

Table 5-3. Familiarity With Workstations

Level of Familiarity	Excelerator	CASE 2000
Not Very Familiar	6	7
Somewhat Familiar	10	14
Familiar	5	8
Knowledgeable	1	0
TOTAL	22	29

5.1.2 TOOL CAPABILITIES

Survey respondents rated 13 specific tool capabilities as well as the overall effectiveness of each workstation. Table 5-4 summarizes the respondent's evaluations of these specific tool capabilities. The Excelerator was rated significantly higher for ease of learning and user friendliness. No substantial differences exist between the two workstations with respect to ratings of requirements analysis and design capabilities. Quality assurance and project management capabilities were not fully explored by survey respondents. Users frequently complained of the lack of capabilities for verifying the consistency of requirements and design. Consequently, most survey respondents did not rate these capabilities.

Survey respondents judged both workstations to be improvements over existing manual procedures, as shown in

Table 5-4. Evaluation of Workstation Capabilities

Capability	Median Rating[a] Excel-erator	Median Rating[a] CASE 2000	Responses[b] Excel-erator	Responses[b] CASE 2000
Graphics Support	4	4	21	27
Easy to Learn	4[c]	2	22	28
Fast Response	3	4	21	28
DSDM Req Analysis	3	3	19	23
Data Flow Diagrams	3	3	21	23
DSDM Design	3	3	14	13
Structure Charts	3	4	12	9
Data Dictionary	4	3	16	16
User Friendliness	4[c]	2	22	28
Project Management	-	3[d]	0	3
Quality Assurance	3	3	2	5
Check Requirements	4	3	6	11
Check Design	3	3	4	7
TOTAL RATING	41	37		

[a]Rating: 5 = good, 1 = poor.

[b]Responses other than not applicable (N/A) or missing.

[c]Probability < 0.05 that this difference in ratings is due to chance.

[d]Value not included in total rating because capability was not rated for both workstations.

Table 5-5. However, those individuals who exercised both systems generally stated a preference for the Excelerator. A significant proportion of respondents rated the Excelerator positively with respect to all three key attributes: quality of product, time to produce, and effort to generate (see Table 5-5). The CASE 2000 received significant positive ratings for quality and effort only. This may be due to the substantially greater learning time required for operation of the CASE 2000 (see also Section 5.1.1).

Table 5-5 shows that the ratings of the Excelerator tend to increase with increased contact, whereas those of the CASE 2000 tend to decrease. This suggests that some of the apparent attractions of the CASE 2000 weaken as the user becomes more familiar with the hardware. On the other hand, the inadequacy of the Excelerator printer was cited frequently by its users as a detriment to quality.

5.1.3 WORKSTATION USAGE

The two workstations appear to have been subjected to the same types of usage. Table 5-4 demonstrates that the same capabilities were exercised on both the Excelerator and CASE 2000. Table 5-6 shows that the same types and proportions of activities were performed on both workstations. Therefore, any differences in workstation ratings are not likely to be due to differences in workstation usage.

Table 5-7 shows that users of both systems generally worked from previously developed sketches or drafts. Somewhat different results might have been obtained from this evaluation if participants had begun using the workstations at the beginning of their projects.

Table 5-5. Evaluation of Overall Effectiveness

IMPROVES QUALITY?

Workstation	Contact	Yes	No	% Yes	Total % Yes
Excelerator	Low	4	2	67	83[a]
	High	6	0	100	
CASE 2000	Low	6	0	100	93[a]
	High	8	1	89	

REDUCES TIME?

Workstation	Contact	Yes	No	% Yes	Total % Yes
Excelerator	Low	6	1	86	92[a]
	High	5	0	100	
CASE 2000	Low	5	1	83	71
	High	5	3	63	

REDUCES EFFORT?

Workstation	Contact	Yes	No	% Yes	Total % Yes
Excelerator	Low	6	1	86	92[a]
	High	5	0	100	
CASE 2000	Low	6	0	100	85[a]
	High	5	2	71	

[a]Probability < 0.05 that this percentage is the result of random selection between YES/NO.

Table 5-6. Type of Activity

Workstation	Draw Diagrams	Organize Data
Excelerator	14	10
CASE 2000	18	15

Table 5-7. Form of Input

Workstation	Drafts	Sketches	Notes	Mixture
Excelerator	6	6	2	3
CASE 2000	8	6	5	3

The proportion of different input forms is, however, about the same for the two workstations. Thus, this factor probably did not affect the relative workstation ratings.

5.1.4 SUMMARY OF RESULTS

Most of the survey respondents were programmers or analysts, and the workstation features most completely explored were those supporting the development of requirements analysis and design documentation (i.e., graphics, data dictionaries, and word processing). Conclusions based on this survey must therefore be confined to how well the workstations support programmers/analysts in these activities. Two separate questions must be answered: How well does each workstation support the structured requirements analysis and design methodologies? How well does that workstation support fit into the existing requirements/design development environment? The survey results provide guidance on answering both questions.

Overall, most survey respondents judged the capabilities of the Excelerator to be superior. Although the Excelerator was rated significantly higher in terms of ease of learning and user friendliness, the two systems were not rated very differently in terms of support for requirements analysis and design. Both systems appeared to offer improvements with respect to the key attributes of quality, time, and effort. However, a high percentage of respondents rated the Excelerator as likely to be more beneficial.

The ease of integrating either workstation into an existing requirements/design environment depends on its match to that environment. The Excelerator and CASE 2000 are optimized for different environments. The former targets the environment in which many unrelated, small- to medium-scale requirements/design problems are being solved simultaneously. The latter targets the environment in which the solution to a single large requirements/design problem is developed over a relatively long period of time.

The Excelerator's ease of learning and operation (via a mouse) makes the system cost effective in those situations in which one or two individuals spend a few months producing a formal requirements/design specification (possibly based on input from a larger team). These individuals spend the rest of their time on other activities (e.g., mathematical analysis or programming). The provision for individual diskettes allows the system to be shared by many users with different problems. Furthermore, the computer can be used to run other software when no requirements/design activity is in progress.

The CASE 2000's central disk and data dictionary support the situation in which many individuals are working on different aspects of the same requirements/design problem. This system simplifies configuration management for large projects. The additional cost imposed by the lengthy training and phase-in period are recovered during the relatively long development period; function keys move the user through the system faster than does a mouse. Furthermore, the function keys can be programmed to satisfy project-specific needs. However, "difficult to learn" implies "easy to forget," so this system is not suited to non-full-time users. The overall higher rating, lower cost, and potential for other uses suggests that the Excelerator is preferable to the CASE 2000 except for large projects.

5.2 CONTROL PROBLEM WORKSHOP

A 2-week structured analysis workshop was conducted during the evaluation period. Section 5.2.1 describes the workshop activities, and results are presented in Section 5.2.2.

5.2.1 WORKSHOP ACTIVITIES

Eight software analysts were selected to use the workstations for defining the software requirements for a control problem. Two members of CSC's Division evaluation team selected the problem, directed the efforts of the analysts, evaluated the results, and collected the analysts' personal evaluations of the control problem exercise and the workstations.

The analysts were selected by the CSC managers of two major NASA/CSC projects--the Network Control Center and the Operations Support Computing Facility. All the analysts were currently performing analysis efforts on their projects and would be able to use what they learned from the exercise in the near term. One of the analysts had prior experience using both workstations. None of the others had any such experience. All analysts had prior experience using the structured analysis method (DeMarco, Gaines, Sarson) supported by both workstations. However, none of the analysts were experts in the method.

The Division evaluation team elected to establish three control groups for the exercise. One group (two analysts) would use the Excelerator workstation; another group (three analysts) would use the CASE 2000 workstation; and a third group (three analysts) would use manual methods to solve the problem, but would have access to a sophisticated word processor to build and maintain text. The word processor given to the third group was that provided on the CASE 2000 workstation. This group was not given access to the CASE 2000 graphics support capabilities.

The control problem exercise spanned 2 weeks (10 business days). The analysts were assigned to the exercise on a half-time basis, i.e., from 1:00 p.m. to 5:00 p.m. on each of the 10 business days. The day-to-day scenario was as follows:

<u>Day 1</u>. The Division evaluation team conducted a 4-hour seminar on the analysis method to be used during the exercise. The analysts were assigned to the three groups. The groups were structured so that the average experience of each group was even. Each group was told to function as an analysis team, i.e., only one integrated set of analysis products was to be produced by each group. The analysts were given a training problem to be used during the next 4 days while learning how to use the workstations. (The training problem is presented in Appendix B.)

<u>Day 2</u>. The Excelerator and CASE 2000 groups were given hands-on instruction on using the workstations. The instructions were given by vendor representatives and experienced CSC users of the workstations. The Excelerator instruction period lasted about 2 hours, whereas the CASE 2000 instruction period lasted all afternoon (4 hours). The Excelerator group began using their workstations to solve the training problem.

<u>Day 3</u>. The word processor group was given about 2 hours of instruction on using the word processor assigned to them. The CASE 2000 group used their workstations for the remaining 2 hours. The Excelerator group used their workstations for 4 hours.

<u>Day 4</u>. All three groups were given 4 hours' access to the workstations for the training problem. The CASE 2000 and word processor groups had to share their workstations since they were using the same equipment.

Day 5. All three groups were given 3 hours' access to the workstations for the training problem. During the last hour of the day, the analysts and the Division evaluation team met to discuss problems and to review the control problem to be used during the next week. (The control problem is presented in Appendix B.) Two experienced users of the workstations also attended the meeting to help solve problems reported by the analysts. The Division evaluation team gave each analyst a copy of the control problem and explained the intent of the problem.

Days 6-7. The workstations were assigned to the three analyst groups for 4 hours each day. The Division evaluation team talked to the analysts while they were using the workstations to identify the problems the analysts were experiencing in using the workstations or understanding the control problem. Other experienced users of the workstations helped the analysts solve problems they were having with the workstations. The Division evaluation team answered all questions relevant to the control problem itself. At the end of day 7, each group provided a "first cut" of their control problem solutions to the Division evaluation team for inspection.

Day 8. During the morning, the Division evaluation team inspected the control problem solutions provided by the three analyst groups. The activities of the control group on this day were similar to those of the preceding two days, with one exception. The Division evaluation team met with each group separately to inform the analysts of problems in their solutions that had to be corrected. In addition, one of the requirements in the original problem was intentionally changed. The intent of these two actions by the evaluation team was to simulate two realistic situations: changing analysis products to bring them in line with standards and responding to requirements changes. This also forced the analysts to use the workstations to change the products built on the workstations.

Day 9. The activities of this day were basically the same as those on days 6 and 7.

Day 10. The activities of this day were similar to those of the preceding 4 days, except that only 3 hours were spent using the workstations. During the last hour of the afternoon, the analysts and the Division evaluation team met to review the results of the entire exercise. Each group provided a copy of their analysts' products to the Division evaluation team. The analysts were asked for an initial assessment of the exercise in terms of the value of the workstations and also the value of the training received in the analysis method. All analysts agreed that automated support noticeably improved productivity and quality. In addition, all agreed that their understanding and appreciation of the analysis method used was significantly increased. The analysts were then directed to prepare an informal report detailing their assessment of the workstations. They were given one week to prepare this report.

5.2.2 CONTROL PROBLEM RESULTS

All three teams completed the control problem on time. Each team produced a credible set of documentation that was of sufficient quality to be used in an informal review. The team personnel felt that use of the workstations provided a noticeable increase in productivity, but there is no quantitative data to support this observation. The team personnel also felt that the use of any automation aid (e.g., the word processing software of the word processing team) was helpful in increasing the ease of modification and technical quality of the products.

The overall ranking of the workstations from control problem data was as follows:

Rank	System
1	CASE 2000
2	Excelerator
3	Word processing software

The difference between the top and bottom in terms of work product results and user satisfaction was not great and could not be the basis for a recommendation of one product over the other. Additionally, an inability to show a clear superiority of work products between the full workstation use and just the word processor points up the need to continue to analyze these workstations under more realistic work conditions.

The following sections present more detailed results for each control problem team.

5.2.2.1 CASE 2000

The CASE 2000 team generally felt that the workstation with the DesignAid product was very helpful in performing the requirements analysis problem. The team suggested the following improvements to make the CASE 2000 even more useful:

- Capability to draw curved lines on data flow diagrams
- Capability to include text from supplemented files that describes a data dictionary entry in the data dictionary report
- Capability to have invisible sources and sinks for data flows
- A better printer for final copies of printouts

- Capability to use multiple lines for data flow names on data flow diagrams
- Capability to "auto-define" items in the data dictionary from a data flow diagram
- More generalized report generation capabilities

The most undesirable features of the CASE 2000 were the difficulty in learning to use the system and the poor user interface, especially in the complexity of key sequences necessary to accomplish certain functions.

5.2.2.2 Excelerator

The Excelerator team was less impressed with their workstation, although they felt that, with suitable enhancements, the workstation would definitely help an analyst. Major desired improvements were as follows:

- More control over the data dictionary report writer
- Addition of cross-references between the data dictionary and data flow diagrams
- Capability to print the additional text portion of a description form
- Capability to move labels on data flow diagrams without retyping them
- Less sensitive mouse for performing certain operations
- Capability to have invisible sources and sinks for data flows
- Having the display match the printed output for data flow diagrams (what you see is what you get)

This team felt that the user interface for the Excelerator was good, although one member experienced problems with the mouse when trying to manipulate user labels.

5.2.2.3 Manual

This group drew data flow diagrams by hand and used the CASE 2000 word processor to generate the data dictionary and function specifications. For a problem of this size, their products were as good as those generated using the full capabilities of the workstation. For a much larger problem (one more typical of what CSC might do on a contract), this would likely not be the case. All members of the group felt that the use of the word processor improved the quality of their products and their ability to maintain those products. Their recommendations for improvement were in the area of increasing automation support. Specifically, they desired

- A toggle switch for insert-versus-overstrike mode in the word processor
- A sorting capability that is insensitive to alphabetic case
- The capability to sort entire paragraphs instead of merely lines (to keep extended definitions together)

5.3 COMPARISON OF FEATURES

A detailed comparison of features available on the Excelerator and the CASE 2000 to support requirements analysis and design was undertaken as a part of this evaluation. Section 5.3.1 outlines the approach used; Section 5.3.2 presents the results of the comparison; and Section 5.3.3 summarizes the conclusions.

5.3.1 APPROACH

Eight major categories of features were identified:

- Data flow diagrams
- Structure charts
- Data dictionary

- Function specifications
- Data flow diagram validation
- Structure chart validation
- Report/display generation
- General/other

The eight categories were assigned relative weights adding up to 100. Each major category was further divided into specific features. Each feature was assigned a weight of either 1 (desirable) or 2 (mandatory). Four groups who had used both the Excelerator and the CASE 2000 fairly extensively during the evaluation period were asked to assess the two systems feature by feature. This input was used to assign numerical scores for each feature on a scale of 0 to 5 (0 = not available, 1 = low, 5 = high).

A final score for each workstation was achieved as follows:

Let w_i = weight of ith feature in a major category (value = 1 or 2)

r_i = raw score for ith feature (range = 0 to 5)

W_j = weight of jth major category (ΣW_j = 100)

<u>Step 1</u>. For each feature, compute weighted score (s_i) as follows:

$$s_i = w_i \, r_i$$

<u>Step 2</u>. For each major category, compute overall raw score (R_j) as follows:

$$R_j = \frac{\sum s_i}{\sum w_i}$$

Step 3. For each major feature, compute overall weighted score (S_j) as follows:

$$S_j = W_j R_j$$

Step 4. Compute final scores for each workstation as follows:

$$\text{Final score} = \frac{\sum S_j}{\sum W_j} = \frac{\sum S_j}{100}$$

The range of final scores is 0 to 5.

5.3.2 RESULTS

Table 5-8 lists scores for individual features and shows the computation of overall raw scores for each major category. Table 5-9 shows the computation of final scores from overall raw scores. In summary, the Excelerator and the CASE 2000 scored as follows:

Excelerator	2.01/5.00
CASE 2000	2.82/5.00

5.3.3 CONCLUSION

Two conclusions emerge from the preceding analysis:

- Neither the Excelerator nor the CASE 2000 scored very high. This indicates that both systems lack many of the desired features.
- Feature for feature, the CASE 2000 is superior to the Excelerator.

Table 5-8. Computation of Overall Raw Scores (1 of 8)

DATA FLOW DIAGRAMS	WEIGHT (w_i)	EXCELERATOR		CASE 2000	
		RAW SCORE (r_i)	WEIGHTED SCORE (s_i)	RAW SCORE (r_i)	WEIGHTED SCORE (s_i)
ABLE TO DRAW USER-DEFINED SYMBOLS	1	0	0	3	3
ABLE TO MOVE SYMBOLS	2	3	6	3	6
FOR DATA FLOWS, ABLE TO DRAW: • LINES AT ARBITRARY ANGLES • CURVED LINES • LINES THROUGH ARBITRARY POINTS • DOUBLE ARROWED LINES	2	3	6	2	4
ABLE TO DRAW STUB DATA FLOWS	2	1	2	3	6
PERMITS A SINGLE DATA FLOW TO ENTER (EXIT) MULTIPLE PROCESS BUBBLES	2	1	2	3	6
SUPPORTS MULTIPLE LINE/ARROW FORMATS	1	0	0	4	4
PLACES RESTRICTIONS ON THE LENGTH, FORMAT, AND PLACEMENT OF LABELS	1	3	3	3	3
ABLE TO NUMBER PROCESS BUBBLES	2	4	8	4	8
CONTAINS ZOOMING/PANNING CAPABILITY	2	4	8	1	2
PRODUCES PRINTER OUTPUT IDENTICAL TO SCREEN DISPLAY	1	3	3	5	5
ABLE TO UNDO LAST UPDATE	1	2	2	3	3
ABLE TO SET UP A SKELETAL LOWER LEVEL DATA FLOW DIAGRAM FOR A PROCESS BUBBLE	1	2	2	0	0
ABLE TO DETERMINE/DISPLAY PARENT/CHILDREN OF A PROCESS BUBBLE	2	4	8	3	6
TOTAL	20		50		56
OVERALL RAW SCORE $\left(R = \frac{\Sigma s_i}{\Sigma w_i}\right)$			2.5		2.8

9809(34*)/84

Table 5-8. Computation of Overall Raw Scores (2 of 8)

STRUCTURE CHARTS	WEIGHT (w_i)	EXCELERATOR		CASE 2000	
		RAW SCORE (r_i)	WEIGHTED SCORE (s_i)	RAW SCORE (r_i)	WEIGHTED SCORE (s_i)
HAS USER-DEFINED SYMBOLS AVAILABLE	1	0	0	3	3
HAS SYMBOLS AVAILABLE FOR LEXICAL INCLUSION, OFF-PAGE CONNECTIONS, AND PREDEFINED UNITS	2	2	4	4	8
ABLE TO INCLUDE DATA INTERFACE TABLES ON STRUCTURE CHARTS	2	0	0	3	6
ABLE TO DEFINE NAMED DATA AND CONTROL COUPLES AND DIFFERENTIATE BETWEEN THE TWO	2	4	8	4	8
TOTAL	7		12		25
OVERALL RAW SCORE $\left(R = \frac{\Sigma s_i}{\Sigma w_i}\right)$			1.7		3.6

9809(34*)/84

Table 5-8. Computation of Overall Raw Scores (3 of 8)

DATA DICTIONARY	WEIGHT (w_i)	EXCELERATOR		CASE 2000	
		RAW SCORE (r_i)	WEIGHTED SCORE (s_i)	RAW SCORE (r_i)	WEIGHTED SCORE (s_i)
ABLE TO DEFINE COMPOSITE DATA ITEMS	2	3	6	3	6
ABLE TO USE PROSE ENGLISH OR GRAPHICS TO DESCRIBE AN OBJECT	2	3	6	2	4
ABLE TO AUTOMATICALLY GENERATE A SKELETAL ENTRY FOR ALL LABELED OBJECTS ON A DATA FLOW DIAGRAM	1	2	2	2	2
ABLE TO DEFINE ALIASES	1	5	5	5	5
PROMPTS FOR DEFINITION OF DATA ELEMENTS COMPRISING A COMPOSITE DATA ITEM	1	1	1	0	0
ABLE TO ENFORCE NAMING CONVENTIONS	1	0	0	0	0
TOTAL	8		20		17
OVERALL RAW SCORE $\left(R = \frac{\Sigma s_i}{\Sigma w_i}\right)$			2.5		2.1

9809(34*)/84

Table 5-8. Computation of Overall Raw Scores (4 of 8)

FUNCTION SPECIFICATIONS	WEIGHT (w_i)	EXCELERATOR		CASE 2000	
		RAW SCORE (r_i)	WEIGHTED SCORE (s_i)	RAW SCORE (r_i)	WEIGHTED SCORE (s_i)
ABLE TO WRITE FUNCTION SPECIFICATIONS USING PROSE ENGLISH, STRUCTURED ENGLISH, DECISION TREES, DECISION TABLES, FREE FORMAT (INCLUDING GRAPHIC SYMBOLS)	2	3	6	5	10
TOTAL	2		6		10
OVERALL RAW SCORE $\left(R = \frac{\Sigma s_i}{\Sigma w_i}\right)$			3.0		5.0

9809(34*)/84

Table 5-8. Computation of Overall Raw Scores (5 of 8)

DATA FLOW DIAGRAM VALIDATION	WEIGHT (w_i)	EXCELERATOR		CASE 2000	
		RAW SCORE (r_i)	WEIGHTED SCORE (s_i)	RAW SCORE (r_i)	WEIGHTED SCORE (s_i)
VERIFIES THAT ALL ELEMENTS OF THE DATA FLOW DIAGRAM ARE DEFINED IN THE DATA DICTIONARY	2	4	8	5	10
VERIFIES THAT NO FUNCTIONS OR DATA STORES ARE DIVINE SOURCES OR BLOCK HOLES	1	0	0	0	0
VERIFIES THAT ALL OBJECTS ARE LABELED	2	2	4	5	10
VERIFIES THAT ALL FUNCTIONS ARE EXPANDED INTO EITHER DATA FLOW DIAGRAMS OR FUNCTION SPECIFICATIONS	2	0	0	0	0
IF A BUBBLE IS EXPANDED INTO A DATA FLOW DIAGRAM: • DO THE NAME AND NUMBER OF THE BUBBLE AND DATA FLOW DIAGRAM MATCH? • DO THE DATA FLOWS ON THE PARENT AND CHILD MATCH?	2	2	4	2	4
IF THERE IS A FUNCTION SPECIFICATION FOR A BUBBLE: • DO THE NAME AND NUMBER OF THE BUBBLE AND SPECIFICATION MATCH? • ARE ALL THE DATA FLOWS ENTERING OR EXITING THE BUBBLE USED IN THE SPECIFICATION?	1	2	2	0	0
PERMITS A FUNCTION SPECIFICATION TO BE DEFINED FOR A BUBBLE THAT IS EXPANDED INTO A DATA FLOW DIAGRAM	1	5	5	5	5
ABLE TO DETERMINE IF SOMETHING IN THE DICTIONARY IS NOT DEFINED ANYWHERE	1	0	0	3	3
TOTAL	12		23		32
OVERALL RAW SCORE $\left(R = \frac{\Sigma s_i}{\Sigma w_i}\right)$			1.9		2.7

9809(34*)/84

Table 5-8. Computation of Overall Raw Scores (6 of 8)

STRUCTURE CHART VALIDATION	WEIGHT (w_i)	EXCELERATOR		CASE 2000	
		RAW SCORE (r_i)	WEIGHTED SCORE (s_i)	RAW SCORE (r_i)	WEIGHTED SCORE (s_i)
ABLE TO IDENTIFY UNITS WITH SAME (DIFFERENT) NAMES AND DIFFERENT (SAME) FUNCTION	2	0	0	1	2
ABLE TO RESTRICT MAXIMUM FANOUT FROM A UNIT	1	0	0	0	0
TOTAL	3		0		2
OVERALL RAW SCORE $\left(R = \frac{\Sigma s_i}{\Sigma w_i}\right)$			0.0		0.7

9809(34*a)/84

Table 5-8. Computation of Overall Raw Scores (7 of 8)

REPORT/DISPLAY GENERATION	WEIGHT (w_i)	EXCELERATOR		CASE 2000	
		RAW SCORE (r_i)	WEIGHTED SCORE (s_i)	RAW SCORE (r_i)	WEIGHTED SCORE (s_i)
ABLE TO PRINT/DISPLAY DATA FLOW DIAGRAMS, FUNCTION SPECIFICATIONS, DICTIONARY CONTENTS	2	2	4	3	6
HAS A GENERALIZED QUERY CAPABILITY TO SELECT ITEMS FOR PRINT/DISPLAY	1	1	1	4	4
ABLE TO CHOOSE WHICH ATTRIBUTES OF AN OBJECT ARE TO BE REPORTED	1	3	3	4	4
ABLE TO SELECT DICTIONARY ENTRIES FOR WHICH DEFINITIONS ARE MISSING OR TO BE SUPPLIED	1	0	0	3	3
MAINTAINS/DISPLAYS DATE/TIME OF LAST UPDATE FOR EACH ENTRY IN THE DICTIONARY	2	0	0	4	8
LISTS DICTIONARY ENTRIES UPDATED SINCE A SPECIFIED DATE/TIME	1	0	0	4	4
SELECTS REPORT DESTINATION (PRINTER/DISPLAY)	2	5	10	5	10
PRODUCES REPORTS OF SUFFICIENT QUALITY TO INCLUDE IN CSC DOCUMENTS	2	3	6	3	6
HAS A GENERALIZED REPORT GENERATOR CAPABILITY	1	3	3	3	3
ABLE TO PRODUCE AN INTEGRATED DOCUMENT BY SPECIFYING A TABLE OF CONTENTS OR PRINT LIST	1	3	3	3	3
PRINTS/DISPLAYS STRUCTURE CHARTS WITHOUT DATA FLOWS, DATA COUPLES, INTERFACE TABLES, etc.	2	0	0	0	0
PRINTS/DISPLAYS THE FIRST n LEVELS OF A STRUCTURE CHART	1	2	2	2	2
TOTAL	17		32		53
OVERALL RAW SCORE $\left(R = \frac{\Sigma s_i}{\Sigma w_i}\right)$			1.9		3.1

9809(34*a)/84

Table 5-8. Computation of Overall Raw Scores (8 of 8)

GENERAL/OTHER	WEIGHT (w_i)	EXCELERATOR		CASE 2000	
		RAW SCORE (r_i)	WEIGHTED SCORE (s_i)	RAW SCORE (r_i)	WEIGHTED SCORE (s_i)
SUPPORTS SHARED DATA BASE IN MULTIUSER ENVIRONMENT	2	0	0	5	10
PROVIDES CONCURRENT ACCESS TO DIFFERENT VERSIONS OF THE DATA BASE	1	0	0	0	0
PROVIDES ACCESS PROTECTION FOR CONFIGURED DATA BASE OR PORTIONS THEREOF	2	1	2	4	8
ABLE TO BACK UP AND RESTORE DATA BASES	2	5	10	5	10
SUPPORTS INTEGRATED GRAPHICS AND WORD PROCESSING	1	0	0	5	5
ABLE TO EMULATE USER INTERFACE OF TARGET SYSTEM	1	2	2	0	0
PROVIDES REAL-TIME VALIDATION	1	1	1	1	1
ABLE TO TURN SPECIFIC VALIDATION OPTIONS ON OR OFF	2	1	2	0	0
SUPPORTS SPLIT SCREENS/WINDOWS	1	0	0	3	3
HAS A MOUSE-CONTROLLED CURSOR	1	5	5	0	0
IS MENU DRIVEN	1	5	5	2	2
ABLE TO LAY OUT DATA FLOW DIAGRAMS	1	0	0	0	0
ALLOWS USERS TO SELECT UPPER/LOWERCASE SENSITIVITY	1	0	0	4	4
ABLE TO DEFINE LEARN KEYS OR MACROS	1	0	0	3	3
SUPPORTS CONTEXT SENSITIVE HELP	2	2	4	3	6
ALLOWS THE WORKSTATION TO BE USED AS A GENERAL-PURPOSE MICROCOMPUTER	2	5	10	3	6
TOTAL	22		41		58
OVERALL RAW SCORE $\left(R = \frac{\Sigma s_i}{\Sigma w_i}\right)$			1.9		2.6

9809(34*a)/84

Table 5-9. Computation of Final Scores

MAJOR CATEGORY	WEIGHT (W_j)	OVERALL RAW SCORE (R_j)		OVERALL WEIGHTED SCORE (S_j)	
		EXCELERATOR	CASE 2000	EXCELERATOR	CASE 2000
DATA FLOW DIAGRAMS	15	2.5	2.8	37.5	42.0
STRUCTURE CHARTS	15	1.7	3.6	25.5	54.0
DATA DICTIONARY	15	2.5	2.1	37.5	31.5
FUNCTION SPECIFICATIONS	5	3.0	5.0	15.0	25.0
DATA FLOW DIAGRAM VALIDATION	15	1.9	2.7	28.5	40.5
STRUCTURE CHART VALIDATION	5	0.0	0.7	0 0	3.5
REPORT/DISPLAY GENERATION	15	1.9	3.1	28.5	46.5
GENERAL/OTHER	15	1.9	2.6	28.5	39.0
TOTAL	100			201	282
FINAL SCORE $\left(= \frac{\Sigma S_j}{\Sigma W_j} \right)$				2.01	2.82

9809(34*b)/84

5.4 WORKSTATION USAGE DURING THE EVALUATION PHASE

5.4.1 SPACELAB

Two Spacelab project teams were used to develop data flow diagrams and their associated data dictionaries and functional specifications for the Spacelab Input Processing System (SIPS). Each team consisted of four programmer/analysts with varying levels of skill and a balanced skill mix.

The work was performed over a 2-month period (August through September 1984), with participants spending an average of approximately 25 percent of their time on this activity. This includes the time required for training and familiarization.

Weekly technical review meetings were held to discuss and critique requirements analysis products developed to date. Thus, the final products evolved through numerous iterative analysis cycles, much as they would in an actual software development environment. The meetings also coordinated efforts between the two teams, and work assignments to team members were made at that time. Input to the workstation evaluation process was provided by having each participant periodically complete survey questionnaires and attend biweekly user group meetings.

All participants found the workstations to be an improvement over the manual approach and the quality of products from both workstations to be good. The CASE 2000 team required a longer time for training and learning before participants became fully productive. The Excelerator was felt to be significantly easier to use. However, even for a small effort such as this, the availability of a centralized data base on the CASE 2000 was found to be useful. The manual merging of files across workstations was considered tedious and errorprone on the Excelerator. Both workstation systems were felt to be weak in data dictionary and validation support.

5.4.2 PACOR/GRO

The PACOR/GRO project is the target project for the first in-depth, product-oriented, long-term use of the programmer/analyst workstation. During the first 2 months of the evaluation period, the PACOR/GRO project began as a small task to develop software requirements for the PACOR/GRO software system. This task required a preliminary delivery of the Software Requirements Specification on a Programmer/Analyst Workstation on September 28, 1984. The PACOR/GRO project officially began on October 1, 1984.

The PACOR/GRO development team's use of the workstation reflected the small size and nondedicated nature of its original staff and the immediacy of its deliverable. Their experience with the workstation can be divided into four sequential phases:

- Familiarization with the CASE 2000
- Familiarization with the Excelerator
- Product development and delivery on the Excelerator
- Product development on the CASE 2000

The familiarization with the CASE 2000 took place over a 3-week period. This process consisted of attending vendor classes, taking the tutorial, and independent experimentation. Three members of the PACOR/GRO task participated.

The familiarization with the Excelerator took place over a 1-week period and consisted of the tutorial and independent experimentation. Three members of the PACOR/GRO task participated.

At this point, the preliminary PACOR/GRO Software Requirements Specification was developed on the Excelerator system. This effort consisted of the development of data flow diagrams, process descriptions, a data dictionary, and text. Intermediate products were reviewed with the customer. At the end of the task, a 75-page document produced directly from the output of the Excelerator was delivered to the customer. The quality of this delivery was high, and the experience with the Excelerator product positive. Four members of the PACOR/GRO development team participated in this full-time effort over a 5-week period.

Immediately following the initial delivery, and coincident with the formal start of the PACOR/GRO project, the material was transported to the CASE 2000 from the Excelerator with assistance from NASTEC personnel. A two-workstation configuration was made available exclusively to the PACOR/GRO team. Onsite technical assistance was provided for the first week. The PACOR/GRO team, now augmented to six, continued the structural analysis activity on the CASE 2000. Intermediate products were reviewed with the customer. The experience with the CASE 2000 was extremely positive.

As more staff members were added to the project, the perceived advantages of the CASE 2000 centralized data base increased. The data dictionary for the rudimentary Software Requirements Specification had already exceeded the floppy disk on the Excelerator; this limitation did not exist on the CASE 2000. The ability of the CASE 2000 to mix text and graphics was a tremendous advantage in document production. Overall, it appears to be a more flexible, sophisticated tool than the Excelerator.

The PACOR/GRO project's experience with both workstations is positive. The CASE 2000 is, however, more suited to PACOR/GRO project needs.

5.4.3 PC&A

PC&A personnel used both workstation systems to support five different software development activities ranging from concept evaluation to preliminary design and prototyping. Although the evaluation period was inconveniently timed for some efforts, several deliverable items were produced (in part) with the workstations, and considerable information was derived from their use.

Task members of the graphics assessment task were trained on both systems to investigate interactive graphics techniques and potential. This task is responsible for advising on needed graphics capabilities in the flight dynamics environment. Task personnel were primarily interested in editing and displaying and in interaction methods on the workstations; they did not investigate the mechanized formalisms provided by these systems.

The CASE 2000 system was used by the Software Engineering Laboratory (SEL) data base task personnel to perform and document a data flow analysis of an existing data collection/validation process. Although limitations of the data dictionary and constraints of conforming to certain rules precluded the use of the design aid software, the data flow diagram capabilities of the system were exercised during a moderately rigorous create/review/correct editing process; the data flow diagrams were used in an informational memorandum delivered to GSFC.

Both workstation systems were used by Design Metrics task personnel in recasting the requirements specification for an Earth Radiation Budget Satellite (ERBS) control utility into a more rigorous form. This effort involved a restructuring of text-and-formula specifications in a composite model of data flows, entity-relationship descriptions, and state models to capture all aspects of the utility. Task personnel were required to make extensive use of the analytical and graphic capabilities of the workstations.

The Attitude Determination Error Analysis System (ADEAS) task is presently in the preliminary design phase for this support software system. Task personnel were trained on both workstations and have made some investigations into capabilities. More extensive use would have been made, but the evaluation period conflicted with ADEAS design phase activities.

Task personnel on the Flight Dynamics Analysis System (FDAS) task (with some overlap with the ADEAS and Design Metrics activities) attempted to use the workstation systems to prototype screen-sequencing user interfaces. The FDAS requirements specification effort is using an operational specifications approach to which such a prototype would be well suited. Neither workstation system, unfortunately, provided adequate capabilities for a full-scale prototype effort. The attempt was abandoned.

In addition to these specific projects, a number of other PC&A personnel made minor use of the workstation systems out of curiosity and discussed their findings with persons more directly involved.

5.4.4 BRTS SCHEDULING SUBSYSTEM (BSS)

The BRTS Scheduling Subsystem (BSS) was well into the preliminary design phase of the software development cycle. The Preliminary Design Review (PDR) was postponed 3 weeks to allow task members to produce some of the design products on the workstations and at the same time to assist in evaluating the workstations. Originally, the plan was to produce the same output on both machines, but insufficient time prohibited this. Because the CASE 2000 was flexible enough to allow users to define their own symbols, it was selected as the tool best suited to BSS needs.

An attempt was made to produce data flow diagrams and the accompanying data dictionary. The limited data flow concept on the CASE 2000 did not support current standards incorporated into our design. Current solutions were not satisfactory and would have increased the clutter of the data flow diagrams. Entering the data dictionary would have been tedious and would not have improved upon an in-house product already in use. It was then decided to produce structure charts, interface tables, and the accompanying data dictionary at the workstation. The process was tedious initially, but improved with experience. Use of function keys and creation of symbol files also helped.

Task members did not spend much time on the Excelerator but did enough to determine that its main advantage over the CASE 2000 was its user friendliness.

5.4.5 TECHNICAL PUBLICATIONS

The Technical Publications Department's graphics supervisor was chosen to use and evaluate the workstations. The evaluation consisted of preparing some routine types of artwork that are presently prepared in the traditional pen-and-ink/type-pasteup method, which involves two distinct functions as well as two individuals with vastly different skills. Four types of art were created: an organization chart, data flow diagrams (two), a structure chart, and a milestone chart. An evaluation of the workstations' capabilities follows.

- CASE 2000--In general, the CASE 2000 was found to be fast and easy to use. Graphics were fairly easy to enter and modify. However, standard-size symbols were too small for type size. Correcting curved portions of symbols was tedious and often required replacement of entire symbols.

Simple milestone charts were easily drawn but space for type could be a problem on more complex charts. In addition, the maximum timespan on a milestone chart is restricted to 28 months unless months are stacked or changed to one-character designations. As a self-training tool, the CASE 2000 tutorial is inadequate and confusing, and, according to a NASTEC representative, inaccurate in places.

- Excelerator--The menu-driven Excelerator was in some respects easier to use than the CASE 2000 because the user continually receives prompts. Furthermore, the use of a mouse makes cursor movement faster. However, on the Excelerator, no means exist for drawing a line unless it is a connection between two symbols. Also, type is very condensed and difficult to read and not centered vertically within the symbol. Overall, the major drawback of the Excelerator is that it is far less flexible in freehand drawing than is the CASE 2000.

5.5 DIVISION EVALUATION

This section presents the Division evaluation team's assessment of available tools. Section 5.5.1 details the tool evaluation; Section 5.5.2 addresses performance and configuration considerations, including an estimation of PACOR/GRO sizing requirements; and Section 5.5.3 presents cost data for the CASE 2000 and the Excelerator.

5.5.1 EVALUATION OF TOOLS

5.5.1.1 Requirements Analysis

The Excelerator, the CASE 2000, and sophisticated word processors are all valuable aids for requirements analysis and represent major improvements over purely manual methods. For projects on which the analysis team is small (one to three persons), all three tools will have equal value. For projects with a medium-sized analysis team (three to five persons), the Excelerator and CASE 2000 workstations would probably be much better than a word processor alone. For projects with large analysis teams (more than five analysts), the CASE 2000 would probably be superior to the Excelerator, primarily because of the availability of the controllable, shared data base on the CASE 2000.

When the evaluation effort began, we expected to see improved technical quality in the analysis products. We were not sure if productivity would also improve. The results, however, seemed to indicate a noticeable improvement in both quality and productivity.

The most important capabilities offered by the Excelerator and CASE 2000 workstations relate to the preparation, maintenance, validation, and control of data flow diagrams and data dictionaries. Both workstations offer similar capabilities. Both can be used to prepare data flow diagrams and data dictionary entries. Preparing data flow diagrams was easier to learn and use on the Excelerator than on the CASE 2000 workstation. The Excelerator is more flexible in terms of the structure and length of data dictionary entries than the CASE 2000.

Both workstations provide adequate capabilities in maintaining data flow diagrams and data dictionaries. The ease of maintenance seemed to be the major factor that improved the quality of the analysis products. With automated support, users are far more willing to change the products to improve technical quality than if they had to rely only on manual methods. With automated tools, users seem to view their analysis products with less ego and thus are less likely to resist making changes to the products.

Both workstations offer limited validation capabilities for data flow diagrams and data dictionary entries. The CASE 2000 validation capabilities are better than those offered by the Excelerator. Validation capabilities are just as important as those for preparing and maintaining data flow diagrams and data dictionaries. This is the area in which improvement is most needed on both workstations.

The Excelerator has very limited capabilities for controlling the content of analysis products. The CASE 2000 has a much better control capability; however, it should be further improved. Although each project using the CASE 2000 can have its own controlled data base of data flow diagrams and data dictionary, only one data base can be active at any one time at all active terminals. What is needed is a capability to designate, by active terminal, which data base will be accessed from the terminal. This would allow multiple projects to use a cluster of terminals concurrently. This capability would also allow individual analysts to prepare interim data flow diagrams and data dictionary entries more quickly, without having to constantly worry about naming conflicts with other analysts using the workstation. Thus, the analysts could negotiate name changes among themselves after they have completed their interim analysis products.

Either workstation, or a word processor, is far better than purely manual methods. Improved quality and productivity in requirements analysis will occur if the analysts on a project have ready access to such tools.

5.5.1.2 Design

The Excelerator and CASE 2000 workstations are valuable aids for system design efforts and represent major improvements over purely manual methods. Either workstation would be suitable for small to medium system design teams (up to six designers). For large system design teams (more than six designers), the CASE 2000 workstation would probably be superior, primarily because of the availability of a controllable, shared data base on this workstation.

Although we did not study the value of a word processor in design efforts, it is felt that productivity and quality would also improve if the system design team were to have ready access to word processors. However, the increased quality and productivity probably would not be as great as with the Excelerator or CASE 2000 workstations. Word processors would be very useful in managing a design data dictionary. On one recent project, a word processor proved very useful in detecting duplicate and incorrectly named units on structure charts.

The most important capabilities offered by the Excelerator and CASE 2000 workstations relative to design efforts deal with the preparation, maintenance, and control of structure charts and design data dictionaries. Both workstations provide adequate capabilities in preparing and maintaining structure charts and data dictionaries. The Excelerator is easier to learn and use than the CASE 2000. The CASE 2000 workstation offers an automatic means of controlling structure chart and data dictionary content, whereas the Excelerator's control capabilities depended on manual procedures. However, the CASE 2000 has the same control deficiencies, as described in Section 5.5.1.1.

Neither workstation provided adequate structure chart validation capabilities. At best, the workstations could only detect when a unit interface item (a data or control couple) was not defined in the data dictionary. The validation capabilities need to be strengthened considerably, especially those related to detecting inconsistencies in interfaces between calling and called units (modules).

Both workstations treated the products of analysis and design as two independent sets of products. The value of the workstations would be considerably increased if they could transform data flow diagrams into structure charts. Neither workstation offers such a capability, in even a limited fashion. If such a capability existed, a designer could use the computer-generated structure charts as a check on the designer's structure charts. Such a capability would not be easy to provide and would probably require the designer to provide some guidance to the workstation software. This capability may, however, be worth the potential development cost.

5.5.1.3 Development Life Cycle

Other than analysis and design capabilities, the Excelerator provides no features to ease the preparation of other life cycle products. The Excelerator is, however, based on a quality word processor, Microsoft Word. This word processor is easy to use and is one of the most sophisticated available on any computer. It could thus be useful in generating most of the technical documentation prepared during the development life cycle, e.g., user guides, test plans and procedures, and technical reports.

Because the Excelerator runs on an IBM PC, the PC itself could be used to generate unit prologs, PDL, and code. If the PC were linked to a mainframe computer, the code could be shipped to the host computer for testing. Compilers exist on the PC for most coding languages used in NASA software products. Compilation errors could thus be eliminated before the code is shipped to the host computer. Some limited unit testing could also be done on the PC. These extended capabilities would, however, require the purchase of additional hardware and software.

Because the CASE 2000 workstation is based on Convergent Technology workstations, it is designed to provide the host computer interface specified above. Language compilers for most NASA coding languages can also be purchased for the workstation. The CASE 2000 also offers a sophisticated word processor with many capabilities similar to those provided by Microsoft Word on the PC. Thus, both workstations could be extended to provide useful tools needed during software implementation.

With no additional investment, both workstations provide a good word processing capability for documentation produced throughout the development life cycle. With some additional investment, both could also provide support for software implementation efforts.

5.5.1.4 Quality Assurance

The quality of most products produced while using the workstations was noticeably higher than was experienced on other projects using purely manual methods. This quality improvement applied both to products that had not yet been reviewed by quality assurance personnel and to those changed to correct quality problems detected by quality assurance personnel. The probable reason for these improvements was the ease with which users could make changes in their products. They were more likely to take the time to make voluntary changes that improved quality and were less likely to debate the merits of quality problems detected by quality assurance personnel. The users simply appeared to have less ego invested in their products.

In the past, quality assurance personnel checked development products in hardcopy form. Ideally, in an automated environment offered by workstations, quality assurance personnel would use the workstations to check product quality and thus would not need hardcopy versions of the products. It is not yet clear, however, how this would actually occur. Hardcopy versions of the products existing on the workstations must still be used for quality inspections. If, however, workstations provided an easy way to annotate the products, the reliance on hardcopy output could be reduced significantly.

The workstations should provide an easy way to access the information data base created by the workstation software. Quality problems that often go unnoticed become obvious when information is sorted or looked at in a different way. The workstations should therefore provide tools that could be used as building blocks for viewing, sorting, and otherwise restructuring a workstation's information data base.

5.5.1.5 Project Management

Based on presentations by Index Technology, the Excelerator currently has no implemented project management capabilities. However, a review of early requirements statements indicates that the company understands the need for an integrated project management capability. As Index Technology further develops their requirements, a careful review should be made to bias the implementation toward management of systems development projects.

Although numerous project management packages are available for the IBM PC, no package has yet interfaced with the Excelerator. Ideally, project management and project performance tools should be integrated through a common data base. It is unlikely that a vendor other than Index Technology could produce such an integrated set of tools.

A version of the Life Cycle Manager was reviewed during presentations made by NASTEC in August. The Life Cycle Manager appears to be designed toward assisting the planning of small efforts, and as such has limited flexibility. Although some of the concepts are sound (especially a common data base of completed events), it does not permit scheduling of dependencies nor lend itself to performance measurement. The current reports are inadequate both in content and organization. Extensive work would be necessary to use the Life Cycle Manager as a tool for managing systems development projects.

5.5.2 PERFORMANCE AND CONFIGURATION CONSIDERATIONS

Sections 5.5.2.1 and 5.5.2.2 outline the performance and configuration considerations for the Excelerator and the CASE 2000, respectively.

5.5.2.1 Excelerator

As delivered, Index Technology assumes that you have an IBM PC/XT with an IBM keyboard, the IBM monochrome monitor, and an asynchronous communications serial interface. To this, Index Technology adds the Tecmar multifunction board with 128 kilobytes of additional random access memory, a serial and parallel I/O port, the Tecmar high-resolution graphics board, a Microsoft mouse, the Excelerator software, and Microsoft Word word processing software. A dot matrix printer or plotter must also be added. The product supports such printers as the Epson FX-100, the IDS Prism printer, the IBM graphics printer, and the Toshiba P1351 printer. In a comparative test, all of these printers printed a standard flow chart in from 7-1/2 to 8-1/2 minutes. The Excelerator also supports plotters such as the HP 7475A, which took 8 minutes to print the standard test diagram. For significantly faster printout, a QMS Laser Graphics printer may be used. This printed the standard diagram in 1 minute. From a performance perspective, printout speed is very significant, because the product is designed such that print spooling is not supported. Thus, the system cannot be used for anything else until a requested printout is finished printing. This is judged to be a severe limitation on the performance of the system.

Because the Excelerator, in its current form, is a single station system, it presents significant problems for use on large projects. Other than copying files to a floppy disk and loading them onto a second system, there is no way for two users to work from the same data base at the same time. No easy merging of files is supported. At some later time, Index Technology plans to support multiple systems interfaced through a local area network, however, this is not presently available.

For improved operating performance, the Excelerator can now be installed on an IBM PC/AT. This system uses an Intel 80286 microprocessor, which is a true 16-bit CPU with an internal and external 16-bit data bus. For internal calculations, a factor of three improvement over an IBM PC/XT has been reported. The printout speed limitations mentioned previously still exist with this configuration.

5.5.2.2 CASE 2000

The CASE 2000 system (Section 4.1.1) consists of a series of clustered workstations, each with its own 16-bit microprocessor running at 5 megahertz. Local memory of half a megabyte is used at each station for local program processing. Each station has a copy of the operating system for local execution. Very high performance at each station results from this architecture because each user has his/her own powerful CPU and one-half megabyte of local memory. Each station handles its own keyboard scanning and screen refresh and display. Communications with the 33-megabyte Winchester hard disk or the one-half-megabyte floppy disk are over the 307-kilobaud RS 422 channel. The hard disk has an average access time of 50 milliseconds. Track-to-track access time is 19 milliseconds. The instantaneous transfer rate is almost one-half megabyte per second. The floppy disk has an average access time of 260 milliseconds. Track-to-track access time is 8 milliseconds, and the transfer rate is 62.5 kilobytes per second.

Files are printed from a print spooler. The workstations can be performing other functions while a file is printing. The printer can operate at up to 780 characters per second (CPS) in draft mode. However, in a slower letter quality graphics mode and a letter-quality text mode, output suitable for formal reports can be produced. System and application software consumes 8 megabytes of storage space on the 33-megabyte Winchester disk, leaving about 25 megabytes for user files.

The configuration can grow to a maximum of 16 stations simply by adding the cluster stations and necessary communication I/O cards. System mass storage can grow to 100 megabytes. For large development systems, a Convergent Technologies Megaframe master processor can be used. This configuration will support up to 64 users and 10 gigabytes of online storage. NASTEC uses the Megaframe as its development system but has not as yet placed any in the field.

5.5.3 DATA BASE SIZING AND BACKUP

The PACOR/GRO project intends to use the programmer/analyst workstation for every posible technical document. Arrangements have been made with the Technical Publications Department for assistance in formatting, online editing, and reproduction from the output of the workstations. The size estimates given in Table 5-10 are based on a comparison of comparable documents from the Space Telescope Data Capture Facility and extrapolation from the portions of documents that are already on the workstations.

Data base size estimates for the Spacelab project are shown in Table 5-11. They were derived by extrapolating the PACOR/GRO estimate to the total page count for Spacelab documentation.

Should online storage become scarce on a project, the following strategies should be considered.

Table 5-10. PACOR/GRO Documentation Size Estimates

DOCUMENT		EST. PAGES	DISK SPACE REQUIRED (MEGABYTES)					
			TEXT	GRAPHICS/ DFDs	SPECS	STRUCTURE CHARTS	DATA DICTIONARY	TOTAL
SOFTWARE REQUIREMENTS SPECIFICATION (SRS)		500	0.2	0.2	0.5	0	2.0	2.9
FUNCTIONAL DESIGN DOCUMENT (FDD)		200	0.4	0.2	0.2	0	0	0.8
PRELIMINARY DESIGN DOCUMENT		500	0.2	0.2	0.2	0.2	2.0	1.0
ACCEPTANCE CRITERIA		100	0.4	0	0	0	0	0.4
SOFTWARE TEST PLAN		200	0.8	0	0	0	0	0.8
DETAILED DESIGN DOCUMENT		2000	0.8	0.3	2.0	0.5	4.0	7.6
USER'S GUIDE		500	2.0	0	0	0	0	2.0
SYSTEM PERFORMANCE ANALYSIS		30	0.12	0	0	0	0	0.12
MODEL DOCUMENTATION		100	0.4	0.1	0	0	0	0.5
DATA BASE DEFINITION		60	0.24	0	0	0	0	0.24
RELEASE TEST PLAN AND PROCEDURES		700	2.8	0	0	0	0	2.8
BUILD TEST PLANS AND PROCEDURES (BUILDS 1 AND 2)		300	1.2	0	0	0	0	1.2
MODEL RESULTS AND PERFORMANCE ANALYSIS REPORT (BUILDS 1 AND 2 AND FINAL)		50	0.2	0	0	0	0	0.2
SYSTEM PROGRAMMER'S GUIDE		200	0.8	0	0	0	0	0.8
RELEASE TEST RESULTS		150	0.6	0	0	0	0	0.6
BUILD TEST RESULTS (BUILDS 1 AND 2)		100	0.4	0	0	0	0	0.4
TOTAL	PAGES	5690						
	MEGABYTES		9.76	1.0	2.9	0.7	8.0	22.36

9809(34*b)/84

Table 5-11. Spacelab Documentation Size Estimates

Document	Pages
Requirements	3,000
• Baseline Requirements	
• Hardware Specifications	
• Interface Control	
Design	
• Functional Design	2,100
• Preliminary Design	
• Detailed Design	
Implementation	
• Operations Reference Manual	5,500
• Programmer's Reference Manual	
• User's Guide	
• GINA Reference Manual	
Test	
• Test Plans	1,700
• Test Procedures	
TOTAL	12,300

Total Disk Space Required $= \frac{12,300}{5,690} \times 22.36$

$= 48.33$ megabytes

First, on both the CASE 2000 and the Excelerator, online data base files can be backed up onto offline storage media. Since on most projects documents are developed sequentially, many may be in progress simultaneously but would not all be changing at the same time. Strategies can thus be developed that allow for static documents and multiple copies of changing documents to be backed up separately and appropriately (in addition to periodic backups to protect against loss of online data due to disk failures) and restored online as and when needed, thereby providing online storage space relief. Backing up of files can be handled in two ways:

- Individual files can be backed up on 0.5-megabyte (unformatted) floppy disks. For very large files or where an entire volume has to be saved at one time, this can be a time-consuming procedure.
- Both the CASE 2000 and the Excelerator (IBM PC/XT) support a variety of standard communications protocols/emulators. The workstation(s) can thus be linked to a mainframe computer and relatively inactive files down-loaded for backup purposes. Obviously, this option is subject to the availability of a mainframe computer.

A second strategy to be considered is that online storage capacity can be expanded on the CASE 2000. Up to 120 megabytes of shared disk space can be configured on the master workstation. Furthermore, up to three additional 40-megabyte disks can be added to each cluster station. The latter would, however, be accessible only from the workstation to which they are attached.

Although the IBM PC/XT can accommodate disk capacities higher than 10 megabytes, the Excelerator cannot access the additional disk space. Excelerator workstations are, therefore, currently limited to 10 megabytes of online storage.

5.5.4 EVALUATION OF COSTS

The cost figures presented here are list prices as of the summer of 1984. All of the CASE 2000 products must be purchased from NASTEC. For the Excelerator product, the basic computer hardware, an IBM PC/XT, can be purchased by the user from any source desired. To that is added the Index Technology Excelerator product.

Excelerator

The Excelerator model evaluated for this study ran on an IBM PC/XT configured as required with an IBM monochrome monitor and the high-resolution graphics card, a multifunction card, a mouse, and Excelerator software from Index Technology. Because the user supplies the basic computer system and a printer, the prices may vary depending on the current supply channels. For a typical configuration with a moderate-speed printer, the outside hardware would cost about $6000. To this must be added $9500 for the Excelerator package, for a total system price of $15,500. This would provide the user with a system with a 360-kilobyte floppy disk drive, a 10-megabyte (unformatted) Winchester hard disk, and a 160-CPS printer. Index Technology has a discount schedule for volume purchases. For example, the price is reduced by $500 for the second through fifth purchases. If the Excelerator were to be installed on an IBM PC/AT for improved performance, the price would be about $1100 more than for the IBM PC/XT. This would provide a 1.2-megabyte floppy disk drive and a 20-megabyte Winchester hard disk. Additional improvements in performance could be obtained by installing a faster laser printer, at an additional cost of about $7000 per workstation.

CASE 2000

The costs of the CASE 2000 vary depending on the configuration purchased. For a configuration of eight workstations, a one-half megabyte floppy disk, a 40-megabyte (unformatted) Winchester hard disk, and a 780-CPS printer with system and DesignAid software, the total purchase price is $133,000. This provides a burdened price of $16,700 per workstation. Additional workstations can be added for the price of the station, additional memory, software license, and communications card when necessary. NASTEC, like Index Technology, has a discount schedule for volume purchases. Depending on the volume purchased, cluster stations can be added for $11,100.

Comparison of Costs

In general, the cost per workstation for the Excelerator is the cost of one workstation multiplied by the number of workstations (minus volume discounts). For the CASE 2000, the centralized data base architecture makes the cost-per-workstation computation very sensitive to the number of workstations (even excluding volume discounts) because the costs of the mass storage device(s) and printer(s) are prorated over the number of workstations. Thus, a direct cost comparison between the two is difficult except for specific configurations.

For single-workstation configurations, the Excelerator is significantly cheaper than the CASE 2000. As the number of workstations increases, this cost advantage decreases, reaching a break-even point at about nine workstations. Beyond this number, the CASE 2000 offers a cost advantage.

SECTION 6 - CONCLUSIONS AND RECOMMENDATIONS

The following conclusions have been drawn from the results of the programmer/analyst workstation evaluation presented in Section 5:

- The workstations have a beneficial effect on productivity during the requirements analysis and design phases of a software development effort. This is found to be true even in the absence of graphics tools (i.e., with word processors only).

- The workstations also have a positive effect on the quality of requirements analysis and design products. It is felt that this improvement in quality would further improve overall life-cycle productivity due to a potential reduction in testing and maintenance efforts.

- The Excelerator is easier to learn and use than the CASE 2000.

- Feature for feature, the CASE 2000 is more powerful than the Excelerator. However, neither system is even close to being perfect. In particular, both systems provide limited validation and data dictionary support.

It should be noted that the tools under consideration are still in their infancy. With advances in the state of the art of "intelligent" systems, both the Excelerator and the CASE 2000 (as well as others) are expected to become increasingly powerful tools to support requirements analysis and design efforts.

- The CASE 2000 architecture (specifically, the centralized data base) lends itself to ease of configuration control and better analyst communication. The importance of this factor is felt to increase with project size and complexity.

- The Excelerator appears to be better suited to environments in which one or more small problems are being worked on by a few people over relatively short periods of time.

- The CASE 2000 appears to be better suited to environments in which a single large and complex problem is being worked on by many people over relatively longer periods of time.

Based on these conclusions, specific recommendations are presented in the following categories:

- Overall recommendations
- Recommendations for the PACOR/GRO project
- Recommendations for other project usage
- Long-term recommendations

<u>Overall Recommendations</u>

Overall recommendations are as follows:

- The use of programmer/analyst workstations on software development projects is strongly recommended.

- In the absence of such workstations, the use of word processors and other limited-capability tools (e.g., DFDraw, DBASE II, etc.) should be considered.

- Neither the Excelerator nor the CASE 2000 is clearly superior to the other. Both, however, offer significant advantages over our current manual mode of analysis and design.

<u>Recommendations for the PACOR/GRO Project</u>

The CASE 2000 is recommended for use on the PACOR/GRO project. This is a medium-sized, end-item deliverable, 32-month software development effort. It is envisioned that, during the requirements analysis and design phases, 10 to 20 programmers and analysts will be involved and that

8 workstations will be used. The recommendation is based on the following:

- The CASE 2000 centralized data base, which offers ease of configuration control and improved analyst communication
- Comparable costs for an eight-workstation system
- Current PACOR/GRO work available on the CASE 2000
- Preference of PACOR/GRO personnel for the CASE 2000

PACOR/GRO personnel's recommendations are included as Appendix E. These recommendations were presented to and accepted by CSC's internal source selection board.

Recommendations for Other Projects

This evaluation clearly establishes the benefits of using programmer/analyst workstations on software development projects. Which workstation is most suitable for a project depends, in large part, on the project goals and environment.

The PC&A task's recommendations are included as Appendix E. The source selection board determined that the Excelerator should be made available to the PC&A and Network Control Center projects. This recommendation was based on the following:

- The questionnaire showed the Excelerator to be preferred
- Ease of use of the Excelerator
- Low costs for those projects with IBM PC/XTs
- Preference of PC&A personnel for the Excelerator

Long-Term Recommendations

Because both the Excelerator and the CASE 2000 need improvements before either could be considered perfect and because neither is clearly superior to the other, the following recommendations are made:

- Avoid locking ourselves into one or the other system at this time
- Continue to evaluate both the Excelerator and the CASE 2000 by using them on different software development projects
- Continue to evaluate new products as they become available
- Continue to influence companies to extend their products in areas that are underdeveloped and that are needed
- For those areas that companies are not willing to pursue on their own, enter into agreements that permit modifications and additions to standard products

APPENDIX A - PROGRAMMER/ANALYST WORKSTATION QUESTIONNAIRE

9809

PROGRAMMER/ANALYST WORKSTATION

Evaluator Name:________________________ **Date:**________________

Tool (Circle one): a) Excelerator b) Case 2000

SECTION 1 · TOOL CAPABILITIES

Please respond as honestly as possible to the following questions. In areas that need improvement please provide suggestions in the comments area so that vendors may evaluate enhancements. NA means not available or not applicable or not observed:

Do you find this tool:		Low				High	On what experience do you base your assessment?				
							Reading	Observation of Others	Tutorial	Slight Use	Extensive Use
1. Provides Effective Graphics Support?	NA	1	2	3	4	5					
2. Is Easy to Learn to Use?	NA	1	2	3	4	5					
3. Provides Sufficiently Fast Response Time?	NA	1	2	3	4	5					
4. Supports DSDM/Project Requirements Analysis Methodology?	NA	1	2	3	4	5					
5. Produces Quality Data Flow Diagram?	NA	1	2	3	4	5					
6. Supports DSDM/Project Design Methodology?	NA	1	2	3	4	5					
7. Produces Quality Structure Charts?	NA	1	2	3	4	5					
8. Assists in the Generation and Maintenance of Data Dictionary Entries?	NA	1	2	3	4	5					
9. User Friendly (Operator Interface)?	NA	1	2	3	4	5					
10. Provides Additional Project Management Tools?	NA	1	2	3	4	5					
11. Provides QA Support?	NA	1	2	3	4	5					
12. Provides Consistency Checking of Requirements Analysis Products?	NA	1	2	3	4	5					
13. Provides Consistency Checking of Design Products?	NA	1	2	3	4	5					

SECTION 2 - GENERAL COMMENTS

1. Name 5 aspects of this tool you **like**:

   (Highest Importance) A.

   B.

   C.

   D.

   (Lowest) E.

2. Name 5 aspects of this tool you **dislike**:

   (Highest Dislike) A.

   B.

   C.

   D.

   (Lowest Dislike) E.

3. Do you find this tool has assisted you in improving the quality of the product? (Consider "quality" as attributes [e.g., freedom from errors] that enhance the product's value in later development stages. Feel free to record your definition of quality in this context.)

   Yes / No / Can't Tell

4. Do you find the tool has improved the speed at which you generate products? (Consider both elapsed [calendar] time and work rate.)

   Elapsed Time: Faster/ Slower / Can't Tell

   Work Rate: Faster/ Slower / Can't Tell

5. General Evaluation of Product:

SECTION 3 - EVALUATOR'S HISTORY

1. Degree you consider yourself familiar with using the product (circle one):

   a) Not Very b) Familiar With Some Aspects c) Familiar d) Knowledgeable

2. Circle all areas of product you have used:

	Indicate your degree of familiarity with the associated technique:			
	Used Extensively	Used Casually	Studied, but no actual use	Not Familiar
a) Data Flow Diagram				
b) Data Dictionary				
c) Structure Charts				
d) Word Processor				
e) Other Graphics				
f) Language Compilers				
g) Project Management Tools				

3. Circle the role you think is most applicable to you:

   a) Division Evaluator

   b) Analyst

   c) Programmer

   d) QA

   e) S/W Manager

   f) Project Manager

   g) Support Personnel

4. Years of Experience in Industry: ______________

   With CSC: ______________

5. Length of time you have used tool: ____________

   (Estimate total hours or days @ hours per day [average].)

SECTION 4 - MODES OF USE

1. In using the workstation, did you work primarily from:

    a) relatively complete drafts (of figures and text);

    b) rough drafts (not complete enough to give to Tech. Pubs.);

    c) notes and imagination (designing on-line).

   (If several modes, please describe your pattern of use):

2. Did you make more or fewer iterations of the create/hardcopy/markup than you would without the workstation (how often did you get a clean copy?).

    a) more often b) about the same c) less often d) can't tell

3. Are you using the workstation primarily to:

    a) draw diagrams b) [illegible]ze data c) both d) not sure?

APPENDIX B - CONTROL PROBLEM WORKSHOP PROBLEMS

APPENDIX B - CONTROL PROBLEM WORKSHOP PROBLEMS

B.1 TRAINING PROBLEM

Develop a set of leveled data flow diagrams and a data dictionary for the following problem. If you have time, start to develop function specifications for low-level function bubbles in your data flows.

A customer would like a simple message switch with the following characteristics:

The switch accepts messages. A message consists of at least a destination terminal identifier and a message text. The destination terminal identifier indicates to which of two destination terminals (T1 and T2) the message should be sent. The message text is a character string.

Messages are sent from a single sender terminal, which is different from the two destination terminals. The sender terminal must be able to build a message in the format stated above. A destination terminal must be able to extract the message text from a message.

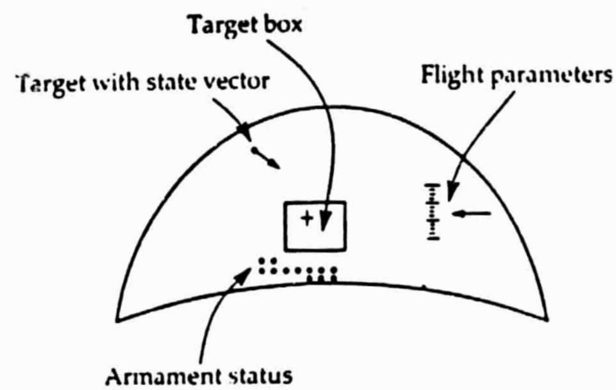
The switch acts as a buffer for the messages that are sent from the sender terminal to the destination terminals. Each destination terminal can receive only one message at a time from the buffer.

The switch should try to keep the destination terminals as busy as possible. Thus, the buffer should not be handled in a strict first-in-first-out (FIFO) manner. For example, if T1 is busy, and there are two messages in the buffer for T1 and one message for T2, the message for T2 should be sent regardless of the order in which the message arrived. However, the FIFO order should be preserved for each terminal.

The sender and terminals should be viewed as communicating with a source and sink external to the problem domain. The messages sent and received should be archived so that a time-stamped history of events can be constructed at a future time.

B.2 CONTROL PROBLEM

The Navy would like to buy a Heads-Up Display (HUD) subsystem for their A2D2 night/day/pursuit/support/attack/reconnaissance/fighter/bomber aircraft. They have released an PFP that contains well over 100,000 pages of detailed requirements covering all phases of the project, which we have summarized here. The pilot will view a display similar to that shown below:



Pilot's view of a typical heads-up display (HUD)

The object of this display is to provide sufficient information content with low complexity. The correct scenario is for the pilot to fly the aircraft so that the selected target falls within the target box; firing during that time ensures a hit. Assuming that the pilot has selected a trainable gun (that is, one that may be aimed automatically within a few degrees), the cursor inside the box points to where the gun is currently aimed. In addition, depending upon the target range and type of armament selected, the target box will vary in size, indicating the effective radius of the weapon; as the aircraft gets closer to the target, the box grows in size. The display also provides a presentation of critical flight parameters, such as altitude and angle of attack, plus a summary of the armament status. Furthermore, an arrow is superimposed on top of the selected target; this not only assures the pilot that the correct target is being tracked, but also presents the predicted target direction of flight.

Since the A2D2 has been around for a considerable length of time, the HUD will have to fit into an existing framework of subsystems in the aircraft. Knowing how important the external interfaces of a system are, we depart from our summary format and reproduce the full text of the interface specifications contained in the Navy's 100,000+ pages.

The other subsystems that the HUD must interface will include the following:

- ARMAMENT-SUBSYSTEM — Controls weapon resources and targeting
- NAVIGATION-SUBSYSTEM — Includes all flight avionics equipment for aircraft guidance and control
- TARGET-RADAR-SUBSYSTEM — Acquires and tracks target vehicles

Brief, wasn't it? No mincing of words in the Navy. To expand on the Navy's interface specification slightly, we should add that the Navy has other contractors ready, willing, and able to modify their subsystems (for a small fee) to provide you, within reason, with any information that you need to perform your job. You can further assume that it is definitely your job to specify whatever interface data you need.

In reviewing the rest of the material in the RFP, we could not find much more information of a technical nature that seemed pertinent to the HUD, with the exception of a paragraph in the middle of page 78,483, which we reproduce here for your edification:

> "The pilot sees a display consisting of flight parameters, a target box with an aiming point, the actual target with state vector, and armament status. During the target engagement, these elements will change at arbitrary times, forcing an immediate update of the display. The pilot may terminate the HUD processing upon command."

APPENDIX C - HARDWARE/SOFTWARE PROBLEM REPORT SUMMARY

APPENDIX C - HARDWARE/SOFTWARE PROBLEM REPORT SUMMARY

Hardware and software problems encountered during the evaluation period were logged and also reported to the vendors. Table C-1 summarizes the total number of problems reported as well as the number fixed, either by a new software release or a service call. Sections C.1 and C.2 list the reported problems for Excelerator and the CASE 2000, respectively.

Table C-1. Hardware/Software Problem Statistics

	Software		Hardware	
Product	Number of Problems Reported	Number of Problems Fixed	Number of Problems Reported	Number of Problems Fixed
Excelerator	7	1	6*	6*
CASE 2000	6	3	1	1

*All six problems were related to the malfunctioning TECMAR board.

C.1 EXCELERATOR

The following software and hardware problems were reported by users of the Excelerator.

Software

- Data flow diagrams print: While printing a data flow diagram, a partial page is printed, then the system pauses and the remainder of the page is printed. When printing is resumed after the pause, two rows of pixels are repeated on the printout.
- Restore function: If long and short project names are different and the short name is used, the restore succeeds but the user (a) must enter

two carriage returns before the restore operation begins and (b) cannot get out of the restore function without rebooting the system.

- Spooled print files not deleted: The spooled print file is not deleted after the file has been printed; the user must manually delete it using a Disk Operating System (DOS) command.

- External entity description: When describing an external entity and an ID of 11 characters is entered, a blank line is inserted in the external entity, then the ID. This causes the ID to run into the label in the box.

- Word processor: When exiting the Microsoft Word word processor, the system halts (fixed by a subsequent release).

- Name changed: When selecting the describe command and then pointing to a data flow box, the name of the data flow on the graph changed from 'captured-nondigital-data' to 'ca'.

- Print problem: Only half of a data flow diagram was printed.

Hardware

The following problems were fixed after the multifunctioning TECMAR board was replaced. (The TECMAR multifunction board contains 256KB of random access memory, an RS-232 serial port, a parallel port, and a clock/calendar.)

- Workstation hung: After a cold start, the workstation hung while running the system self-test routine, and a memory error message was displayed.

- Mouse inoperable: The Microsoft's mouse died in the middle of a graphics session.

- Load problem: The Excelerator software could not load the DOS COMMAND processor.
- Backup failed: The system went down during a project backup operation.
- Access problem: Upon starting the Excelerator, neither the GRAPHICS nor the XLDICTIONARY submenus could be accessed.
- Clock inoperable: The internal clock/calendar could not be reset.

C.2 CASE 2000

The following software and hardware problems were reported by users of the CASE 2000.

Software

- Horizontal lines drawn by using CODE+CURSOR are darker than vertical lines.
- If a specification of the form '@NAMEFILE' is entered in response to the report prompt 'Object/Relation NAME:', the DesignAid generates a report for the first object only and declares all other objects undefined.
- User Validation: If the DesignAid is activated by CNTL+SHIFT+D, it fails to perform user validation and allows the invalid user to access the DesignAid.
- Numerous data base access errors were encountered during interactive inquiry/update (fixed by a subsequent release).
- DesignAid error messages disappear from screen before they can be read (fixed by a subsequent release).

- Concurrent DesignAid validation from two workstations destroys file pointers (fixed by a subsequent release).

Hardware

- Symbol key does not work (fixed by NASTEC via a service call).

APPENDIX D - EVALUATOR SUGGESTIONS

APPENDIX D - EVALUATOR SUGGESTIONS

Over the evaluation period, users of the programmer/analyst workstations were encouraged to provide suggestions for system improvements. The suggestions received address three specific areas: software, hardware, and documentation. Sections D.1 and D.2 list evaluator suggestions for the Excelerator and the CASE 2000, respectively.

D.1 EXCELERATOR

The following suggestions were received from users of the Excelerator.

Software

- Allow validation of data flow diagrams across levels.
- Allow for loose arrows in data flow diagrams.
- Maintain user labels during a move object operation.
- Allow for more flexibility in labeling and connecting objects.
- Allow for user-defined objects.
- Allow for word processing capabilities while manipulating text in the graphics mode.
- Enhance the print screen utility so as to be able to predict what the finished graphic product will look like on the printed page.
- Allow for moving more than one graphic object at a time.
- Allow for a user-label option in a presentation graph.

- Enhance the system to (a) free the workstation while printing a graphics file and (b) delete a spooled graphics print file from the disk after the file has been printed.
- Allow for more elaborate constructs in the data dictionary (e.g., OR, XOR, variable number of entries in a repeat group).
- Timestamp the data dictionary entries to enhance the merging process of data dictionary entries.
- Allow for a more elaborate scheme than the data flow, record, item structure currently provide.
- Allow for a shared data base among different workstations.

Hardware

- Provide for a faster and better quality printer.

Documentation

- Enhance the user guide and the tutorial.

D.2 CASE 2000

The following suggestions were received from users of the CASE 2000.

Software

- Enhance the man-machine interface to provide a higher degree of user friendliness:
  - Enhance keyboard interface so as to reduce number of keystrokes required for an operation
  - Provide mouse control
  - Make system more menu driven

- Allow for automatic connections between objects instead of requiring users to specify the exact points (on the objects) to be connected.
- Allow for loose arrows in data flow diagrams.
- Enhance the DesignAid to support multiple dictionaries.
- Enhance the report-generating utility to generate better formatted reports.
- Allow a valid graphic symbol for the off-page connector.
- Allow for more elaborate constructs in the data dictionary (e.g., OR, XOR, variable number of entries in repeat groups).
- Enhance move and copy operations to perform the functions automatically instead of through MARK/BOUND.
- Allow for moving of more than one object along with connectors.
- Allow more space in the description field of the object definition menu.
- Allow validation of data flow diagrams across levels.
- Enhance DesignAid to recognize processes that are black holes or divine entities.

Hardware

- None

Documentation

- Enhance the reference manuals and tutorials. They are often incorrect and do not describe all the available capabilities.

APPENDIX E - PACOR/GRO PROJECT RECOMMENDATIONS TO THE SOURCE SELECTION BOARD

APPENDIX E - PACOR/GRO PROJECT RECOMMENDATIONS TO THE SOURCE SELECTION BOARD

1. Either CASE 2000 or Excelerator is preferable to manual approach
2. Both have a long way to go
3. CASE 2000 preferable for PACOR/GRO project
   - CASE 2000 centralized data base is a big advantage; gives more flexible and sophisticated reports; makes CM possible
   - Excelerator merge is unsophisticated, complicated, and errorprone; PACOR/GRO project is already at diskette limit for data dictionary
   - CASE 2000 quasi-programmable; at first is more difficult to learn; later more powerful; help is readily available
   - CASE 2000 more flexible; features can be tailored to generate the product you want; graphics can be moved and sized to specific need
   - CASE 2000 word processor avialable in all products; Excelerator cannot mix text and graphics

APPENDIX F - PC&A TASK RECOMMENDATIONS TO THE SOURCE SELECTION BOARD

CSC COMPUTER SCIENCES CORPORATION

INTEROFFICE CORRESPONDENCE

to: Source Selection Committe
from: G. Page
mail code/ext:
date: October 18, 1984
ref:
subject: Workstation Recommendation

Recommendation: Select the Excelerator Programmer/Analyst Workstation

The following factors are the basis for the recommendation.

1. The Excelerator is easier to learn and easier to use, i.e., it is fun to use.

   Benefits:

   - It will be accepted more quickly
   - It will minimize phase-in, learning, training
   - Therefore, it will improve productivity

2. The Excelerator, which uses an IBM PC, provides greater hardware flexibility and usability in other contexts.

   Benefits:

   - The IBM PCs could be used for other functions in slow periods.
   - The Index Technologies' product could be replaced by a future, better IBM PC-compatible product
   - The Index Technologies' product could be replaced by upgrading or trading for an IBM PC/G or PC/GX when the appropriate software is available, assuming it is a better product.

3. The Excelerator uses a newer technology.

   Benefit:

   - Evolutionary enhancement and growth of capability to satisfy our needs is more likely

4. Even though the Case 2000 has been in the field for a longer period of time, conceptually, the Case 2000 does not adequately address the problem we want to solve, i.e., it does not help the programmer/analyst enough.

   Penalties:

   - Satisfactory evolutionary enhancement and growth of capability to satisfy our needs is not likely.
   - It will not become significantly easier to learn or use.

5. Most users judge the overall capability of Excelerator to be better. However, they feel that either one would offer improvements in productivity, quality, and reliability.

Benefit:

- There will be improvements in productivity, quality, and reliability because a useful tool has been provided. However, the improvements from using the Case 2000 will not be as great (because of 1 above) nor will they escalate significantly (because of 4 above). In addition, there may be a detrimental antagonistic attitude from those who participated in the evaluation if Case 2000 is chosen (because of 1 above).

Penalty:

- By deciding to use Case 2000, there will be little opportunity to cost-effectively upgrade to a newer, better product (because of 2 above).

Recommendation: Select the Excelerator Programmer/Analyst Workstation

GP:gsp
Copy: M. Plett