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Computer Science Research at Langley

*Proceedings of a workshop
held at Langley Research Center
November 2-5, 1981*

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Susan J. Voigt, *Editor*
Langley Research Center
Hampton, Virginia

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PREFACE

A Langley workshop to highlight ongoing research in computer science at the center and to identify additional areas for research was held November 2-5, 1981. It was organized by a steering committee representing five Langley directorates. Over 150 people attended the opening session, and between 40 and 75 people participated in each of nine discussion groups focused on various Langley computer application areas.

In planning for the workshop, a survey was conducted of the users of the Langley scientific computer complex, the business data system, the wind-tunnel data reduction systems, and microprocessors. Survey results, which indicated the application areas of the respondents and the computer science areas where users felt research could benefit their work, were used to plan the final program.

Areas of applied computer science research which are of particular benefit to Langley programs were identified during the workshop. These included graphics, numerical methods, database management, distributed computing, and programmer support systems and tools.

The contributions of the session chairmen in organizing the panel discussions and contributing to the session summaries are gratefully acknowledged.

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INTRODUCTION

Computers are sophisticated tools used and relied upon by many scientists and engineers at Langley Research Center in the performance of their research work. Computer science, a relatively new discipline underlying the effective use of computers, is the study of the principles of computation and data relationships. A growing interest in the discipline of computer science within NASA was evidenced by a 1981 NASA/ASEE summer study entitled Computer Science: Key to a Space Program Renaissance, which was cosponsored by several NASA Headquarters offices, Goddard Space Flight Center, and the University of Maryland. This study activity concluded that NASA needs an aggressive program in computer science in order to meet the needs of NASA missions in the future.

Concomitantly, an agency-wide planning activity was initiated in the fall of 1981 to develop plans for a NASA computer science research program. To aid in the development of a Langley plan, the Workshop on Computer Science Research was held in November 1981 to let the Langley computing community express their needs and desires for research in areas of computer science. This was an internal workshop for users of the various Langley computing facilities, both civil servants and contractors. (A key to the abbreviations for Langley research divisions and contractor organizations mentioned in this report is given in Appendix A.)

The workshop had four goals: (1) to highlight current research activities in computer science at LaRC, (2) to allow users to describe computer science research needs from the perspective of their applications, (3) to identify some specific areas of applied research with potential benefit to Langley, and (4) to nurture the computer science community at LaRC. These goals were met during the workshop, and a particular success was the interaction among people with common problems and interests from across the center. In fact, a key recommendation from the workshop was the continuation of such communication within subcommunities, through special-interest workshops, seminars, newsletters, and working committees.

The workshop was organized by a steering committee of nine representatives from the Aeronautics, Electronics, Space, Structures, and Management Operations Directorates. The workshop consisted of an opening session, which covered the background leading to the workshop and highlighted current Langley research in various computer science areas, and nine discussion groups which were held sequentially over a 3-day period. Each of these discussion sessions focused on a particular computer application area and was organized by the session chairman, who invited LaRC computer users to serve as panelists or speakers. The program for the workshop is given in Appendix B.

Prior to finalizing the program, the steering committee sent out a questionnaire to all LaRC computer users. The purpose of the survey was to identify the most common application areas around which to organize sessions. The questionnaire was sent to almost 1400 people, including the ACD Computer Bulletin mailing list, users of the BDSD administrative computer system, the microprocessor user community, users of the wind-tunnel data acquisition systems, and all LaRC research divisions. A copy of the questionnaire appears in Appendix C. Computer users were asked to indicate their computer application area(s) and then to relate these to areas of research in computer science which could benefit those application areas.

The results of the survey are given in figures 1 and 2, indicating the application areas of the respondents and the computer science areas where research effort would benefit. Organization of the workshop discussion groups was influenced by the

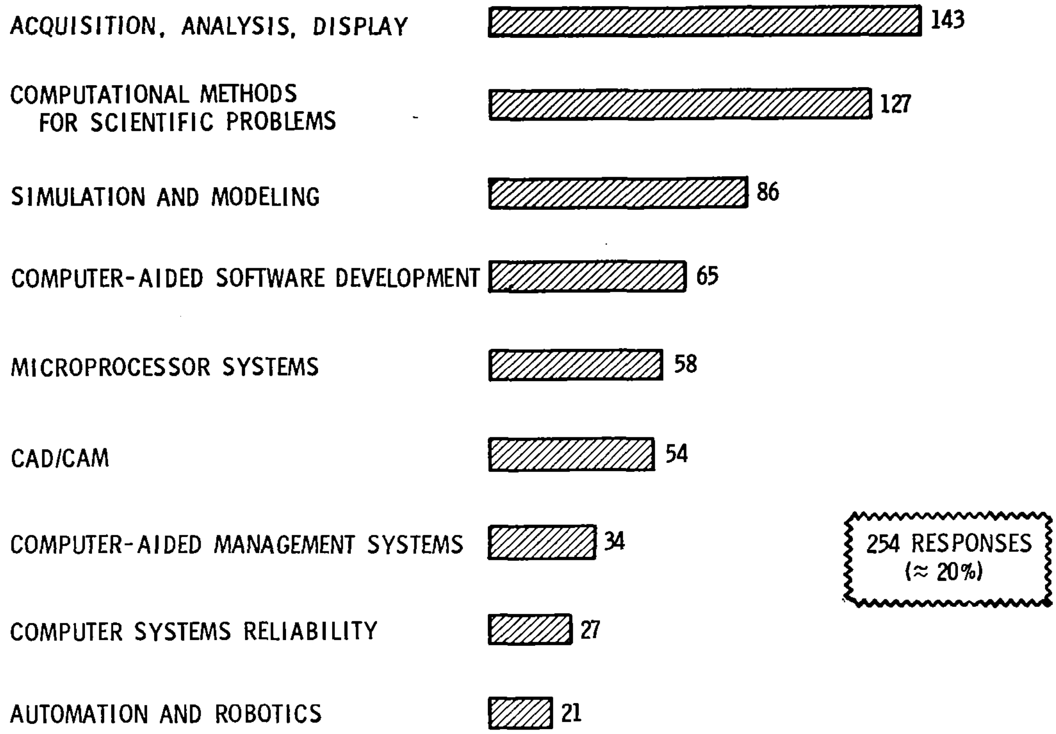


Figure 1.- Survey results: LaRC computer application areas.

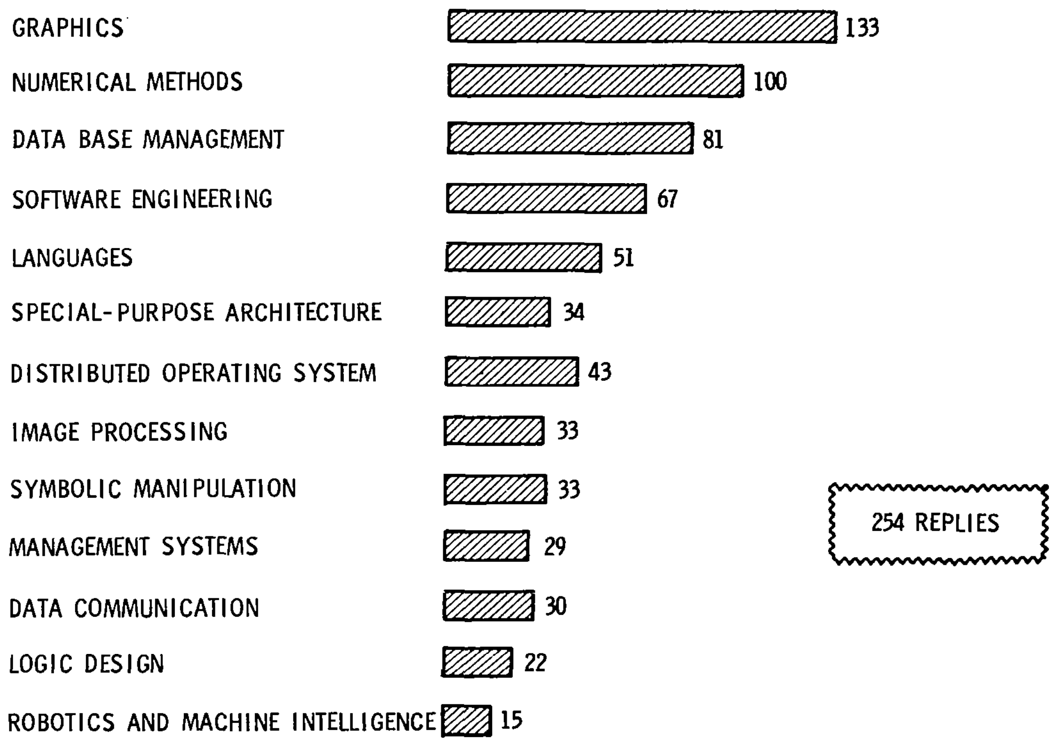


Figure 2.- Survey results: Areas of computer science research beneficial to LaRC.

responses. All questionnaire respondents were sent a final copy of the workshop program as an invitation to attend and participate.

The opening session was attended by at least 150 people, and between 40 and 75 people participated in each of the discussion groups. The workshop provided an excellent forum for information exchange and communication within the Langley computer user community. The areas of computer science research which emerged as the most important to Langley applications include graphics, numerical methods, database management, networked and distributed computing, and programmer support systems and tools. In addition, the need for improved communication among groups of Langley users with common concerns was clearly recognized. Recommendations from the workshop were useful in defining elements of a computer science research program to be included in an agency-wide program plan.

SUMMARY OF WORKSHOP SESSIONS

Opening Session and Highlights of Langley Computer Science Research

The workshop began with remarks by Langley Research Center Director Donald Hearth, who acknowledged the great dependence of NASA missions on computers and the importance of the role of computers at LaRC. Because computers are so pervasive, expertise in their application must be spread throughout the center. Information exchange through activities such as this workshop helps to improve our computing capabilities.

Susan Voigt summarized the results of the 1981 NASA/ASEE Summer Study entitled Computer Science: Key to a Space Program Renaissance, which was held from June 8 to August 14 in Port Deposit, Maryland. Seven Langley employees participated in the study, along with 19 faculty members from universities across the country and representatives from the other NASA centers. Slides from Susan Voigt's presentation are presented in Appendix D.

The ongoing computer science research was highlighted by brief overviews given by seven Langley employees representing four research divisions. These presentations were not highly technical, but they provided visibility to current computer science research activities sponsored by Langley in the areas of languages, software engineering, software fault tolerance, numerical analysis and graphics, database management, and special-purpose architecture systems.

Edwin Foudriat (FDCD) briefly described the evolution of programming languages and current real-time language research using Path Pascal aimed at support to "onboard" computer systems (Appendix E).

Ed Senn (ACD) discussed basic concepts of software engineering and current research addressing fundamental software development problems such as control and management of software development, requirements and design support, compiler development tools, testing techniques, and friendly user interface (Appendix F).

Earl Migneault (FED) summarized ongoing research in developing practical techniques for creating software with "internal fault tolerance," particularly aimed at eliminating the single point failure characteristics of software in a critical flight control system (Appendix G).

John Shoosmith (ACD) highlighted some research work in numerical analysis and graphical display of engineering results, including curve-fitting techniques, grid generation, and advanced numerical methods for partial differential equations including algorithms for vector and parallel computers (Appendix H).

George Salley (SDD) described several scientific and engineering database management systems being developed under NASA Langley sponsorship, including IPIP, the information processor of IPAD; the IPAD Relational Information Manager (RIM); the ARIS relational information system for the Aerospace Vehicle Interactive Design System; and an Engineering/Scientific Data Management System for FORTRAN under CDC/NOS, the operating system on the Langley central computing complex (Appendix I).

Nick Murray (FED) described SIFT and FTMP, two computer architectural concepts for fault-tolerant computer systems, which have been implemented in laboratory test models as forerunners of computers to control future civil aircraft (Appendix J).

Olaf Storaasli (SDD) summarized the status of the Finite Element Machine (FEM), a network of microprocessors for solving structural dynamic problems which will be used to evaluate the utility of special parallel architecture for engineering analyses (Appendix K).

Session 1

Acquisition, Analysis, and Management of Engineering Data

This session was concerned with data acquisition (particularly from wind-tunnel experiments), general data analysis (e.g., curve fitting, stability derivatives, and integration of pressure data), managing the massive amounts of data collected from computer-controlled systems and joining diverse data bases, and ways to conveniently transfer experimental data for comparison with theoretical results. Raymond E. Mineck (TAD) was the chairman. Several presentations were given prior to an open discussion. Mr. Charles Fox (TAD) described the standard interface file (SIF) concept, which uses generalized software for reducing wind-tunnel data from several facilities. Mr. Rodger Howell (SDC) described techniques which have been developed to allow different types of analysis to be used on a large data base. Mr. Robert Grandle (ANRD) described the problems of moving data between computers. Mr. Charles Bryant (IRD) described the requirements to improve communication between computers.

There was general agreement that little computer science research work is needed to support data acquisition, reduction, or analysis. Most analyses used are relatively straightforward applications of statistics, time series analysis, etc. Discussion was focused on the areas of data management and communications. Users have a need to access different parts of a large data base and to run various analyses on data subsets. Production database management systems for engineering data are desirable. Some groups at LaRC are beginning to use RIM (Relational Information Manager), developed under the IPAD project. Others are using the ERBE database system, which basically provides a cross-index for data files. Transfer of data from one computer to another is an area of concern to users. High-speed data communication, standardized communication protocols, and means to deal effectively with different machine word sizes and formats were other areas of interest. The newly formed Data Acqusition Users Committee could define specific requirements for data transmission links and could help to standardized data interface and exchange for LaRC experimental data acquisition.

Session 2

Graphical Display of Engineering Data

The questionnaire results indicated a great interest at LaRC in the graphical display of engineering data, so a session on graphics was held separately from the one on acquisition and analysis of data. As expected, the session had the greatest attendance (standing room only, with others turned away). The major portion of the session consisted of informal talks, arranged by chairman Sharon Stack (HSAD), covering several areas of ongoing graphics work and applications. The speakers and their topics were: Jack Kaylor (ACD), Generation of Cockpit Displays and Simulation of an Air Traffic Controller Station via a General Purpose Display System; Alan Wilhite (SSD), Display of Aerodynamic Data; Noel Talcott (HSAD), The Use of Interactive Graphic Displays for Interpretation of Surface Design Parameters; Don Speray (ACD), Color Shading Over 3-D Surfaces; Bob Smith (ACD), Color Visualization for Fluid Flow Predictions; Vince Roland (ACD), Image Processing Techniques and Applications; Jim Schwing (ODU), Implementation of a Hidden Line Algorithm; and Don Speray (ACD), Towards Real Device Independence at Langley.

The discussion that followed the talks indicated that many LaRC personnel are not aware of or are not applying the current graphics capabilities at Langley. For this reason, the workshop goal of identifying critical computer science research needs at Langley in graphics was not really addressed. This session did, however, highlight the tremendous interest in graphics.

It was apparent that the interest in graphics comes from a large cross section of LaRC covering many disciplines and includes people who are unfamiliar not only with graphics techniques but also with other techniques related to the use of computers. Some computer techniques appear to a user to be specialized tools in using a computer (e.g., for more efficiency), which are secondary in most users' priorities. Only if the tool can be directly related to his application (for example: "Unless you convert to Pascal, your program will no longer work!" or "If you use this technique you can retrieve your data in minutes instead of hours!") will a typical user decide to learn a new technique. Graphics, however, is a technique that sells itself because the user can clearly "see" the benefits to his application.

The user demand for graphics at LaRC has outdistanced the available hardware and software. Judging from the user response to this session, before appropriate areas of computer science research can be identified the gap between the ongoing graphics work and potential applications must be reduced. Some ways to narrow this gap which were suggested at this session were (1) organized distribution of information on Langley graphics research and applications, (2) guest speakers from the outside (leading edge and state of the art in graphics), and (3) special advanced training for applications programmers.

Research efforts indicated for the future were dynamic display capability, better techniques for 3-D visualization, effective color, shading, and hidden-line techniques, and friendlier user interfaces.

Session 3

Automation and Robotics

The workshop session on automation and robotics included presentations which addressed both applications and research in this very broad area. Computer science research areas cited during the discussion included computer networking (in particular, federations of loosely connected computers), information management, and man-machine interface.

Dr. R. A. Breckenridge (FED) spoke on work in progress on information adaptive systems. This is a research area which is allied with computer science in both hardware and software aspects. For example, future use of global monitoring of agriculture, minerals, and water resources will impose dramatic requirements upon spaceborne sensor platforms. Storage and transmission of raw data is not practical due to the very high data rates deriving from multiple sensors. Advanced hardware and software will enable adaptive systems to decide when to take data, and to correlate data from multiple sensors to provide comprehensive, meaningful information ready for the end user.

Kenneth L. Jacobs (RFED) outlined current applications and challenges of his group. Microprocessors provide significant benefits in facilities control such as wind-tunnel testing by allowing more efficient use of resources, but the tools of the trade required by the process control engineer have changed significantly since the imbedded microprocessor arrived. Major advances are required in development systems, both in software and hardware, from development to diagnostic analysis of on-line systems. A great deal of support has been given to users of microprocessors, but most of the operational systems which are used for development are ad hoc and are based on one or another manufacturer's development hardware. A unified support system is desirable which enables users to share efforts.

Charles T. Woolley (FDCD) presented current status and plans for robotics for space operations. The presentation included an overview of the Intelligent System Laboratory which includes an in-house developed network comprised of seven loosely coupled microcomputers interconnected via a packet-switching global bus. The network ties together two manipulators, a vision processor, voice interface devices, and several dedicated processors to form a test bed for development of teleoperators and robotics. The capability to develop intelligent systems for robots and teleoperator systems as well as for automatic controls relies on many aspects of computer science.

Session 4

Microprocessor-Based and Special-Purpose Architecture Systems

The microprocessor and special-purpose architecture session consisted of a panel discussion which dealt with various areas of computer science of particular interest to hardware designers. Advances in microprocessor technology have been so rapid that it is very difficult to keep abreast and apply new technology.

Kenneth Jacobs (RFED) cited the expanding use for control of microprocessors which are ROM based with little mass storage. The user interface for such systems is a control panel with switches and CRT displays.

Richard Bender (FED) stated that space flight requirements call for space-qualified microprocessors, but the only one currently available is the RCA 1802.

Charlie Husson (FED) spoke of the need for technology development and research into new concepts of hardware implemented algorithms.

Olaf Storaasli (SDD) briefly described the Finite Element Machine, which is a network of 16 microprocessors controlled by a TI990 for computing structural analyses.

Richard Staib (ACD) described the use of intelligent controllers to interface between incompatible computer facility components, replacing hard-wired logic used in the past.

Nick Murray (FED) mentioned the special fault-tolerant computers they have developed to research techniques for very reliable flight computing for active controls.

The primary concern expressed by the panel was the difficulty and cost of producing reliable software. A number of useful techniques and suggestions were offered to aid in the software engineering of microprocessor-based systems; however, it is obvious that additional work is needed in this area. Suggestions included using mature (off-the-shelf) software; machine-independent languages; top down, modular (small, with simple interface), and structured programming; and good, simple documentation and enough time to do software development and checkout. Software and hardware issues should be considered together; electrical engineers need training in both hardware and software. Cross-software tools are highly recommended as an inexpensive alternative to microprocessor development systems.

Session 5

Computer-Aided Software Development

Several presentations were made at this session describing research activities directed at software development and specific software tools currently at Langley. To set the stage, Susan Voigt (ACD), chairman, briefly described the concept of CASE (Computer-Aided Systems Engineering), which was discussed at the 1981 NASA/ASEE Summer Study. This calls for computer tools and assistance in all phases of systems engineering: requirements, design (CAD), model (simulate), build (CAM), test (CAT), and operate.

Ralph Will (CTMF) described the Interactive Software Invocation System (ISIS) which is being developed to provide (1) a friendly user interface for nonsophisticated users of complex computer software, and (2) an organized file management facility. The system is available on the CDC complex and is portable to other computer systems. The command language is oriented to the engineering user.

Professor Robert Noonan, College of William and Mary, spoke about Mystro, a compiler writing system under development through a research grant. The system generates various aspects of a compiler (e.g., parser and code generator) given a programming language syntax description and target machine characteristics. Mystro has been used to generate a Pascal-like language compiler for the 8748 microcomputer. Refinements to the system are continuing.

Edmond Senn (ACD) described a set of advanced testing tools for HAL/S code, called Integrated Verification and Testing System (IVTS), which is currently under development. These tools incorporate some of the most advanced techniques for static and dynamic analyses, including an interactive symbolic execution tool.

Fred Preller (SDC, contractor for data reduction) described his experience with several computer aids for software development which exist at LaRC, including XEDIT, PDL, RNF, UPDATE, PET, DAVE, Super Index, SFTRAN, ISIS, FTN5, and COPYL. He also cited deficiencies in the available tool set in the areas of design support tools (such as HIPO charts and data flow diagrams), project data bases and file management, and interactive interface.

Marvin Clemmons (ACD) described the recently created utility libraries (UTIL and UTLIB) on the CDC/NOS complex to provide on-line access to a variety of utility programs and subroutines. Brief documentation on these utilities is available on-line.

During the discussion Charles Woolley spoke of future trends, indicating that intelligent terminals will be available with friendly user interface (such as touch panels) and tools transparent to the user. Such terminals could be the basis for engineering work stations to support LaRC research and development activities.

Session 6

Computational Methods for Scientific Problems

The session on computational methods for scientific problems included presentations on use of the CYBER 203 vector processor for problems in aerodynamics, Navier-Stokes calculations, 3-D crack propagation problems, fine-grid weather modeling, and Monte-Carlo calculations for rarified gas dynamics.

Jay Lambiotte (ACD) spoke about some successes and failures with the CYBER 203, citing strengths and weaknesses of the hardware and the difficulty of vectorizing some classes of computations. The computer science research areas indicated as relevant to large-scale computation on vector machines include: new algorithms, utilities to aid in converting code to a vector machine, improved algorithms and programming techniques for virtual memory, and cross-software, such as moving the FORTRAN compiler to the front-end machine.

In describing 3-D Navier-Stokes calculations using explicit methods, Bob Smith (ACD) spoke of the success he has had using SL/1, the LaRC developed language for the STAR (CYBER 203), which provides effective access to 32-bit arithmetic. In Dr. Smith's opinion, the major advances needed are better techniques and equipment for input data preparation and solution analysis display.

In speaking on 3-D Navier-Stokes calculations using implicit methods and the Numerical Aerodynamic Simulator (NAS), Frank Thames (TAD) estimated the amount of storage required to solve the full Navier-Stokes equation around a wing span. The NAS under development at Ames Research Center will provide sufficient addressable memory to solve such problems. Currently available systems are inadequate.

Leonard Melfi (SSD) described rarified gas dynamic calculations with Monte-Carlo methods for calculating the flow field of orbiting vehicles such as the Shuttle and looking for the effect of rocket plume gases and contamination around a satellite. These molecular physics calculations run on both the CYBER 175 and CYBER 203. Three flow fields are modeled - continuum flow region, transition flow region, and rarified flow region. An alternative to computing on the large CDC mainframes would be to use a dedicated large minicomputer. He estimated that 1 hour of CYBER 203 calculations could be done by a minicomputer in 1 day.

Jim Keller (TAD) discussed the vectorization of 3-D transonic potential codes. These inviscid calculations require great computing speed. Because of limited grid size, the storage requirements are not as significant as computing speed. An automatic vectorizing compiler which would take maximum advantage of the CYBER 203 machine features is highly desirable. Carpet plots are used for display of pressure distribution.

Mike Kaplan (SAS) discussed simulation of the atmosphere with fine-grid weather calculations. Currently, on the CYBER 203, 1 hour of weather forecast can be computed in 1-1/2 minutes, yet displaying the results in a useful form takes much longer. There is a need for telecommunications and real-time graphics, as well as a 3-D post-processor of data for more immediate display of results.

Jim Newman (MD) discussed computational fracture mechanics and 3-D crack propagation in solids. The finite element technique is used to solve the stiffness equation. Key problem areas cited were mesh generation, which often takes weeks, and display of results across low speed lines (e.g., 1200 baud).

Session chairman Jerry C. South, Jr. (TAD) summarized the major topics identified during the session which may be fruitful for computer science research:

1. More powerful computers are always needed (bigger problems, faster computing); Parkinson's Law is definitely valid in scientific computing. Radical new architectures and new algorithms are probably needed for major breakthroughs.

2. There is a need for improved software that will allow better automatic vectorization for modern vector processors; for example, FORTRAN codes which can be modified in a few days to take advantage of vector architecture. It now takes months to rewrite a scientific code with explicit vector instructions. It was also noted that such software would be impossible or useless for the CYBER 203.

3. Researchers need improved capability for reviewing and displaying output. Results from 3-D codes are the worst cases, where huge amounts of data must be selectively organized and plotted. Now it typically takes 1-1/2 hours to examine a test computer run for a 3-D aerodynamics problem.

Session 7

Computer-Aided Management Systems

This session was oriented toward business and administrative types of management systems. Session chairman Andy Swanson (BDSD) arranged three brief talks to set the stage:

1. Status of BDSD systems and plans, by Andy Swanson

2. Characteristics of ADABAS, the database management system in use by BDSD, by Don McKay (PRC, contractor to BDSD)

3. A research division use of word processors and terminals in management systems, by Jim Gardner (LAD)

Charles W. Sibbers (PMSD) also mentioned the successful use of the PERT network program (now called PPARS) in scheduling support of over 100 projects at LaRC.

The conclusions of this session were summarized by the chairman:

1. The interest in the subject of computer-aided management at Langley was greater than anticipated. It apparently stems from interest in the research community in planning and tracking resources (such as tracking purchase requests, travel, RTR's, etc.). The technical managers would like better computer support than currently exists to help them.

2. The BDSD central computer complex is beginning to use DBMS technology that should make it easier for various groups to access data more easily and with more flexibility. This is a sound technical move, but the rate at which we will be able to apply this technology is slower than the users would like.

3. There will be a continuing need for research organizations (branches, divisions, directorates) to relate their records of resource expenditures (e.g., PR's initiated) to what the "official system" says is being done. Currently this is done manually, or in some cases by using a set of files maintained on the ACD computer via remote terminals. However, word processors or small computers (minis) located in the research organizations are increasingly being used to do this.

4. The "minis/word processors" don't talk to each other very well, and usually don't (can't) talk to the main centers (ACD and/or BDSD) at all. This has broader implications than just "business data processing" needs, since many of these minis are also used for technical data processing of various kinds.

5. There is a need to determine which minis/word processors are currently at the center and then to find a way to achieve some level of "standardization" along with some type of "networking" between the minis, the word processors, and the main host CPU's at ACD and/or BDSD. This is a potentially fruitful area for further seminars.

6. A management commitment and a team effort (of BDSD, MSD, ACD, and IRD) is required to adequately address what should be done to standardize and network systems for a LaRC computer-aided management system.

Session 8

Simulation and Modeling

This session addressed computer science aspects relevant to reliable and valid simulation and modeling of systems represented by continuous and discrete event processes, including large-scale dynamic systems, command and control processes, and reliability assessment. Session chairman Roland Bowles (ACD) invited several speakers.

Leonard Credeur (FED) described the Terminal Area Air Traffic Model (TAATM) used to model an airport terminal area. TAATM is a real-time, deterministic simulation written in FORTRAN.

Sal Bavuso (FED) spoke about advanced reliability modeling with an analytical system, CARE III, based on the Volterra stiff equations. Efforts are currently under way to validate this model for estimating the reliability of a computer-based system.

Roland Bowles discussed time-critical "people-in-the-loop" flight simulations. These simulations include real-time displays and mixed analog and digital processing to drive external devices. The three major elements of flight simulation are mathematical models, interface devices, and the pilot.

Some key research areas of concern to simulation and modeling applications are:

Improved numerical methods (e.g., integration)
Computer-generated imagery (visual systems)
Increased bandwidth (for some minimum sampling rate for interface devices)
Simulation languages efficient and compatible with real time
Concurrent processing and dynamic scheduling for distributed systems (i.e., smart executives)

Session 9

Computer-Aided Model Analysis, Design, and Fabrication

This session began with several presentations on topics relevant to CAD/CAM, including geometry, DBMS, graphics, distributed systems, numerical analysis, software engineering, special-purpose architecture, and fabrication.

Session chairman James L. Rogers, Jr. (LAD) began by describing the CADRE (Computer-Aided Design for Research and Engineering) Committee of which he is chairman. This committee is a forum for LaRC employees interested in technologies related to CAD in support of research activities.

Charlotte Craidon (ACD) described her work on the arbitrary geometry format and a common geometry database that can be used to describe a vehicle configuration from design through machine-tool cutting. Several LaRC analysis programs do use a particular geometry format, and utilities to convert these and others to the common geometry format are needed.

Ed Senn (ACD) made a few comments on the software development life cycle and the importance of iterating preliminary design and requirements prior to detailed design and coding. There is a need for a software engineering discipline to be used at LaRC.

John Shoosmith (ACD) discussed some mathematical and numerical analysis issues of concern to this session, including the need for better interactive capability in some of the analysis programs. Of special note is computer-aided optimization, particularly nonlinear minimization, both constrained and unconstrained.

Floyd Shipman (ACD) discussed databases and CAD, describing the transition from the early use of APT to current sophisticated systems. Computer science research areas appropriate to the database issue include performance, reliability, portability, pattern of use, and end user facilities.

Olaf Storaasli (SDD) briefly described the Finite Element Machine (FEM), which is an experimental network of microprocessors specifically designed to perform structural analysis using the finite element technique in a distributed system.

Don Speray (ACD) represented graphics issues relevant to this session. He stated that presently there are no areas of research to suggest, since currently available technology is not being used effectively at Langley. Training, education, a good graphics software package, and better hardware are all needed.

Gene Bowen (FD) talked about the numerical control capabilities now in place at LaRC. Several analysis programs have been interfaced with CAM tools, and the standardized geometry formats have been very useful for this. Graphics tools, especially 3-D, are required to verify the NC tool-cutting paths prior to final application.

Jim Rogers described how the Prime 750 minicomputer has been used in conjunction with the CDC 6600 to perform structural analysis and optimization studies in a distributed manner.

Based on the session discussions, the three areas in CAD/CAM requiring some effort are geometry, data management, and improved interface between designers and the fabrication shop. However, much of the effort should be at the applications level rather than in computer science research. CADRE is the appropriate committee which can address these three areas to solve the applications level problems, to determine what is needed, and then to define and investigate the computer science research areas needed to fill the gaps.

As in several of the other sessions, the themes of communications (person to person, computer to computer, and person to computer) came up. Standardization of existing software capabilities and education (high-level) into their use also seems to be a recurring theme.

CONCLUSIONS

Although the workshop was intended to identify areas of computer science research of particular benefit to the Langley computer user community, the most significant conclusion was the immediate need for better communication and computer technology infusion here at Langley. Information exchange among users with common concerns can be accomplished through seminars, workshops, newsletters, on-line "notes files," and standing committees. The success of the Microprocessor User Committee and of CADRE (Computer-Aided Design for Research in Engineering) indicates that subcommunities can share information and training effectively. This workshop brought several such subcommunities together and opened the lines of communication. Specific areas where better awareness of the state of the art is of particular concern to a significant number of people at Langley include graphics, scientific database management, software development, automatic programming, and administrative support.

Several areas for computer science research were also identified. It is recognized that before much research can take place in these areas, better foundations in the current state of the art are needed. In fact, some of the currently identified activities constitute adaptation of existing technology rather than advanced research.

Networking and Distributed Processing

This particularly applies to the many microprocessor-based systems springing up across the center which eventually ought to have some communication access to the large scientific computer complex in ACD and possibly to other computer sites (such as PDP/11 or VAX systems). During the final discussion of the workshop a suggestion was made that a team of LaRC experts should be formed to define the requirements for such a network, define interface and protocol requirements for systems connecting to it, and design a center-wide network facility. Commercially available products should be used in the implementation.

Graphics

The requirement for effective display of the results of engineering analyses was expressed in several workshop sessions. There was consensus that many capabilities already exist, so that many of the user requirements could be met with available technology. Education is the prime concern of many users, with strong interest also in improved graphics subroutine libraries.

Scientific Programmer Support System

The need for improved interactive computer user interface and better software development tools and techniques was expressed at several sessions. It was suggested that an intelligent terminal-based work station might provide the basis for a support system for scientific programmers. Education in software development techniques and software engineering is also needed.

Human Factors Related to Computer Systems

This area is related to the previous one. Friendly man-machine interface is of growing importance as computer use becomes more widespread and noncomputer professionals have frequent occasion to communicate with a computer. An English-like command language, easy-to-use graphic display systems, and informative diagnostics are desirable. The goal is an "easy-to-use" system.

Database Management

Data compression, standardized formats, and data display are requirements of the data acquisition community, among others. The ability to perform relational queries and join diverse databases in the analysis of engineering data is a definite requirement. The scientific data which are input to and output from engineering analysis programs must be managed effectively. This includes having common formats for exchange of data and interfacing several programs.

Numerical Methods

Of all the computer science areas currently active at LaRC, this is probably the most widely supported and the most advanced. Still, there were several areas discussed at the workshop which need further research, including better algorithms and techniques for the Cyber 203.

Additional Suggestions

A few specific suggestions were made during the closing session:

1. Make more frequent use of a team approach to scientific computing, where the team includes people with a mix of skills so that the researcher can concentrate on analysis of results while a computer expert provides efficient computing support.

2. Recognition from management, and in particular promotion consideration, should be given for developing computer programs. Just as research reports reflect varying degrees of difficulty and innovation of the work, so computer programs vary in difficulty and quality. A reward system for well-structured and well-documented programs would encourage better programming practices at the center.

3. The cost and benefits of new tools or methods should be considered before they are introduced. Ed Senn (ACD) has defined a value index which divides the bother of using the new tool or technique by the increased benefit derived from such use. If this value index is not less than 1, users will not find the new item effective and it will not be successful.

4. A "computer science magical black box," which would take an engineering problem formulation and produce engineering results, would constitute a quantum jump for computer science. (See Fig. 3.) Although this was a tongue-in-cheek proposal by Charlie Fox (TAD), it was his attempt to encourage innovative thinking. His vision is one of an automatic programming system designed for the engineers at LaRC.

RECOMMENDATIONS

Improved communication among the Langley computer user community can best be accomplished through the already existing Langley Computer User Committee. The stature of this committee should be increased. A reorganization or reorientation of the committee may be necessary to permit adequate focus on the LCUC as a clearinghouse for computing concerns, including research directions and information exchange. The committee could also provide coordination for maintenance and support software for the various common systems (e.g. VAX and PDP's) appearing around the center.

Education in computer science issues for the current LaRC computing community can be accomplished through:

(1) Additional offerings in the regular courses taught by ACD

(2) Use of the Learning Center in the LaRC Training & Educational Services Branch

(3) Series of guest lecturers in specific application areas, to illustrate effective use of computers and to broaden the LaRC perspective

A computer user newsletter should be established to provide a regular exchange of information on new capabilities, educational opportunities, and user experiences. This newsletter should be computer-generated to illustrate effective use of computer resources.

Research in a few key areas of common concern to a broad class of the Langley computing community should be undertaken under the new computer science research program being planned by NASA Headquarters. The research need not be conducted by a single group or organization within the center. Specific research topics can be selected later when the agency program begins to take shape; however, current areas of LaRC interest which are candidate topics include software development techniques, scientific programming environment, distributed systems, particularly with real-time considerations, reliable software, and graphics.

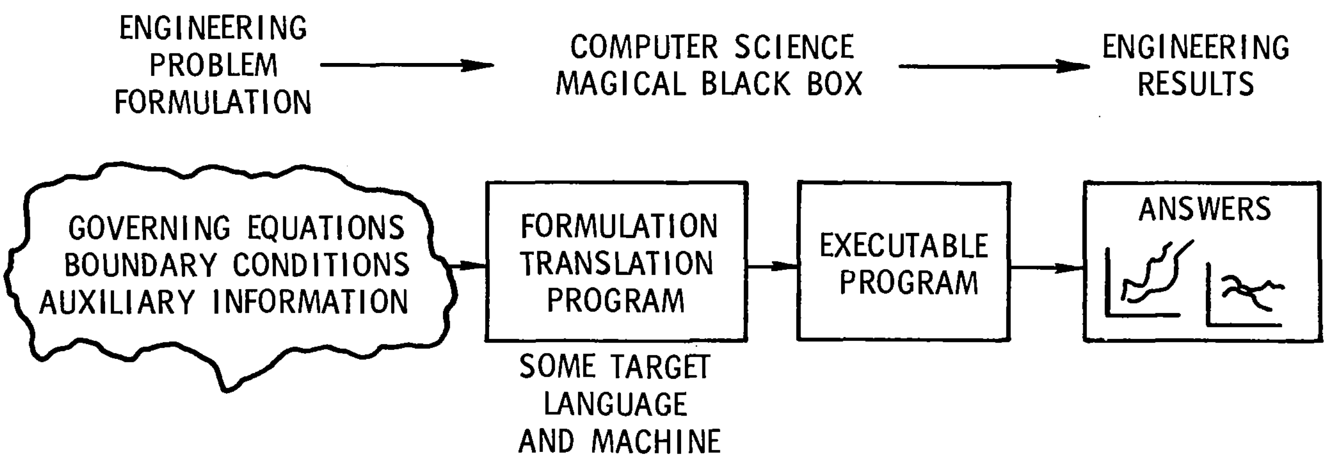


Figure 3.- A conceptual quantum jump for computer science.

APPENDIX A

ABBREVIATIONS

ACD	Analysis and Computation Division
ANRD	Acoustics and Noise Reduction Division
BDSD	Business Data Systems Division
FD	Fabrication Division
FDCD	Flight Dynamics and Control Division (now Control Theory and Flight Management Division)
FED	Flight Electronics Division
HSAD	High-Speed Aerodynamics Division
IRD	Instrument Research Division
LAD	Loads and Aeroelasticity Division
MD	Materials Division
MSD	Management Support Division
ODU	Old Dominion University
PMSD	Projects Management Systems Division
PRC	Planning Research Corporation (contractor)
RFED	Research Facilities Engineering Division (now Facilities Engineering Division)
SAS	Systems and Applied Sciences Corporation (contractor)
SDC	System Development Corporation (contractor)
SDD	Structures and Dynamics Division
SSD	Space Systems Division
TAD	Transonic Aerodynamics Division

APPENDIX B

WORKSHOP PROGRAM

LaRC WORKSHOP ON COMPUTER SCIENCE RESEARCH

Computers are sophisticated research tools used and relied upon by many scientists and engineers at Langley. Computer science, the relatively new discipline which provides the know-how to use computers effectively, has recently received considerable attention within NASA. For example, a 1981 NASA/ASEE Summer Study entitled Computer Science: Key to a Space Program Renaissance was funded by several Headquarters program offices, and the recommendations made by the study team for increasing NASA's use of computer technology are now being carefully considered. One recommendation is a more focused and coordinated effort in computer science research.

The goals of this workshop are to highlight computer science research currently supported by Langley and identify additional research of critical importance to the center. These areas for additional research will form the basis for a coordinated computer science research program plan for Langley.

Participation is sought from all users of Langley computer systems who are concerned about the direction of such computer science efforts. Discussion groups have been organized around various Langley application areas and will encourage audience participation. Attendees are expected to participate in the discussion group(s) of particular relevance to their work.

PROGRAM

Opening Session

Welcoming Remarks
D. Hearth

Summary of NASA Summer Study on Computer Science
S. J. Voigt

Overview of Workshop Discussion Groups
S. J. Voigt

Highlights of Langley Computer Science Research

Languages
E. C. Foudriat

Software Engineering
E. H. Senn

Software Fault Tolerance
G. E. Migneault

Numerical Analysis and Graphics
J. N. Shoosmith

Database Management
G. C. Salley

Special-Purpose Architecture:

SIFT and FTMP
N. D. Murray

FEM
O. O. Storaasli

Workshop Discussion Groups

Tuesday, November 3

Group 1: Acquisition, Analysis and Management of Engineering Data
R. E. Mineck, Chairman

This session will address concerns relative to general data analysis (e.g., stability derivatives, integration of pressure data), managing massive data from computer-controlled systems, convenient ways to transfer experimental data to be compared to theoretical results, and relational database management capabilities.

Group 2: Graphical Display of Engineering Data
S. H. Stack, Chairman

This session will include informal presentations of LaRC work, either ongoing or planned, in the application of computer graphics and imaging techniques for displaying experimental (static/dynamic), flight, and analytical data.

Wednesday, November 4

Group 3: Automation and Robotics
A. J. Meintel, Jr., Chairman

The capability to develop intelligent systems is based on the technological advances in computing systems and the application of advanced algorithms. This session will discuss ongoing and future programs in automation of ground and space operations. Research programs to be addressed include Information Adaptive Systems, Facilities Automation, and Robotics for Space Operations.

Group 4: Microprocessor-Based and Special-Purpose Architecture Systems
J. H. Tucker, Chairman

This session will deal with various areas of computer science that are of particular interest to hardware designers. Topics covered will include items such as microprocessors, special-purpose architecture, logic design, data communications, and certain aspects of software engineering.

Group 5: Computer-Aided Software Development
S. J. Voigt, Chairman

This session will discuss the requirements for tools and techniques of software developers, including programming environments, friendly user interfaces, compiler generation, intelligent terminal facilities, and advanced test tools.

Group 6: Computational Methods for Scientific Problems
J. C. South, Jr., Chairman

This session will highlight concerns of researchers in the computational solution of engineering problems of interest to LaRC. Focus will be on the computer science aspects such as automatic vectorization compilers, development and analysis of new algorithms, and perceptions of computer speed and storage problems.

<u>Thursday, November 5</u>

Group 7: Computer-Aided Management Systems
A. G. Swanson, Chairman

This session is oriented toward business and administrative types of management systems. Brief talks will be given on the status of BDSD systems and plans, characteristics of ADABAS, the DBMS in use by BDSD, and a research division use of word processors and terminals in management systems.

Group 8: Simulation and Modeling
R. L. Bowles, Chairman

This session will address computer science aspects relevant to reliable and valid simulation and modeling of systems represented by continuous and discrete event processes including large-scale dynamic systems, command and control processes, and reliability assessment.

Group 9: Computer-Aided Model Analysis, Design, and Fabrication
J. L. Rogers, Jr., Chairman

This session covers the areas of computer science that relate to CAD/CAM, including geometry, DBMS, graphics, distributed systems, numerical analysis, software engineering, special-purpose architecture, and fabrication.

Open Discussion of Computer Science Research Directions
J. N. Shoosmith, Chairman

Panel: All session chairmen

Workshop Steering Committee

S. J. Voigt, Chairman
J. L. Harris
T. R. Rau
J. L. Rogers, Jr.
D. E. Speray
S. H. Stack
O. O. Storaasli
A. G. Swanson
C. T. Woolley

APPENDIX C

COMPUTER SCIENCE RESEARCH WORKSHOP QUESTIONNAIRE

COMPUTER SCIENCE RESEARCH WORKSHOP PLANS

Many computer applications at LaRC rely on research results in computer science. Recent activities within NASA have brought attention to computer science and its importance to the Agency missions and operations. NASA Headquarters has invited LaRC to develop a plan for a computer science research program.

A Workshop is being planned for November 2-5 to highlight LaRC research in computer science and to identify additional areas for research which would have direct benefit to LaRC applications. Langley employees and their contractors will be invited to participate. In order to prepare for appropriate sessions, we would appreciate your response to this questionnaire by October 16 (or as soon as possible thereafter).

Please indicate with a checkmark which of the typical computer applications listed below describe your applications. If the list does not cover your applications, please use the extra lines provided.

_____ a. Acquisition, Analysis, and Display of Engineering Data
_____ b. Automation and Robotics
_____ c. Computational Methods for Scientific Problems
_____ d. Computer-Aided Management Systems
_____ e. Computer-Aided Model Analysis, Design and Fabrication (CAD/CAM)
_____ f. Computer-Aided Software Development (Techniques and Tools)
_____ g. Computer Systems Reliability
_____ h. Microprocessor-Based Systems
_____ i. Simulation and Modeling
j. ______________________________
k. ______________________________
l. ______________________________

Please indicate in which of the computer science categories listed below research is or would be critical to your particular applications. Do not check categories from which only routine results are required. As before, please expand the list, if necessary. For each application checked above, place the corresponding letter beside the appropriate category (categories).

_____ 1. Data Communications (e.g., Fiber Optics)
_____ 2. Database Management Systems
_____ 3. Distributed Operating Systems
_____ 4. Graphics
_____ 5. Image Processing
_____ 6. Languages (Programing, Query, Command)
_____ 7. Logic Design
_____ 8. Management Systems (Word Processing, Planning, Resource Mgt., etc.)
_____ 9. Numerical Analysis and Software
_____ 10. Robotics and Machine Intelligence
_____ 11. Software Engineering and Development
_____ 12. Special Purpose Architecture (e.g., Finite Element Machine, FTMP)
_____ 13. Symbolic and Algebraic Manipulation
14. ______________________________
15. ______________________________
16. ______________________________

APPENDIX D

SUMMARY OF 1981 NASA/ASEE SUMMER STUDY ON COMPUTER SCIENCE: KEY TO A SPACE PROGRAM RENAISSANCE

S. J. Voigt

1981 NASA/ASEE SUMMER STUDY

JUNE 8 - AUGUST 14, 1981

U OF MARYLAND - DONALDSON BROWN CENTER,
PORT DEPOSIT MD

SPONSORED BY: GSFC & U OF MARYLAND

FUNDED BY: OFFICE OF UNIVERSITY AFFAIRS (HQ)
OAST
OSTA
OSTDS
OSS

CHRONOLOGY

March 1980	"Sagan Report" on Machine Intelligence and Robotics
Early 1981	Study Plan drafted by HQ Steering Committee (Codes D, E, M, N, R, S, T)
June 1-5	Goal Setting Workshop (12 university and industry advisors)
June 8-Aug. 14	Study Team (19 faculty fellows, 8-10 NASA residents)
Dec. 1981	Final report ready for publication

LANGLEY PARTICIPATION

J. N. Shoosmith (ACD) S. J. Voigt (ACD)	June 11	Center presentation on mission, role of computers, C. S. issues
T. R. Rau (SSD) S. H. Stack (HSAD)	June 15- June 26	NASA residents during orientation and "Information Dump"
J. L. Harris (ACD) S. J. Voigt (ACD)	June 29- July 17	NASA residents during fact-finding by 3 teams: Networks Info. Systems C S & T
O. S. Storaasli (SSD) C. T. Woolley (FDCD)	July 20- Aug. 7/14	NASA residents during synthesis and report preparation
Many (at HQ and via telecon)	Aug. 14	Final oral report by faculty (recorded on video tape)

STUDY PLAN SOUGHT ANSWERS TO

HOW SHOULD COMPUTER SCIENCE AFFECT NASA?

PLANNING	METHODS
ORGANIZING	PROGRAMS
STAFF	PRODUCTS

HOW SHOULD NASA GET AND STAY UP-TO DATE?

WHAT STEPS SHOULD BE TAKEN FIRST (IN FY 82) ?

GOALS SET FOR SUMMER STUDY

- IDENTIFY NASA OPERATIONS WHERE COMPUTER-BASED INFORMATION MANAGEMENT TECHNIQUES/SYSTEMS CRITICALLY NEEDED
- DEVELOP PLAN FOR COMPUTER NETWORKS FOR RESOURCE SHARING (HARDWARE/SOFTWARE/DATA/PEOPLE)
- FORMULATE CHARTER FOR NASA COMPUTER SCIENCE AND TECHNOLOGY (C S & T) ORGANIZATION

SUMMER STUDY CONCLUSIONS

WITHIN NASA

1. CS will play increasingly critical role in success of NASA missions
2. CS useful in enhancing efficiency and effectiveness of management and operations
3. CS expertise in NASA should be increased
4. R&D in specific CS areas should be primed by NASA
5. NASA should monitor itself and surrounding community

SUMMER STUDY CONCLUSIONS

EXTERNAL TO NASA

1. CS expertise will remain scarce

2. Hardware costs will continue to fall

3. Wideband communications at hand

4. Technology to support storage, retrieval, and exchange of information will move from paper to electronic media

CONCLUSIONS

AN AGGRESSIVE COMPUTER SCIENCE AND TECHNOLOGY PROGRAM CAN--

- Make new missions possible

- Lower manpower requirements

- Lower costs

- Improve internal operations

SUMMER STUDY RECOMMENDATIONS

1. ESTABLISH A PROGRAM OFFICE OF COMPUTER SCIENCE AND TECHNOLOGY (C S & T)
   - Support R & D
   - Nurture NASA C. S. community
   - Promote software exchange
   - Develop guidelines, standards, plans
   - Monitor C S & T effort in NASA

2. CREATE A COORDINATED INFORMATION SYSTEM
   - General resource sharing networks
   - Integrated scientific data bases
   - Automated work environments

3. DEVELOP PERSONNEL PROGRAMS
   - Recruiting and retention
   - Incentives for continuing education
   - Improved interaction between NASA personnel and university and industrial communities
   - Expand co-op and student intern programs

SEQUEL

1. A COMPUTER SCIENCE RESEARCH PROGRAM HAS GAINED SUPPORT
   - OAST ENDORSES
   - FY82 PLANNING RTOP (LaRC, JPL, GSFC)
   - THIS WORKSHOP IS ONE STEP

2. A FEW STEPS TAKEN TOWARD COORDINATED ACTIVITIES
   - INTERCENTER COMPUTER NETWORK PLANNED (LaRC, ARC, LeRC)
   - PILOT MANAGEMENT SUPPORT SYSTEM AT HQ AND GSFC

3. PERSONNEL PROGRAM GETTING ATTENTION AT LaRC
   - TAKING STEPS TO INCREASE CO-OP STUDENTS IN COMPUTER SCIENCE
   - ENCOURAGING UNIVERSITY/LaRC COMPUTER SCIENCE ACTIVITIES

GOALS OF LANGLEY WORKSHOP

TO PUBLICIZE CURRENT COMPUTER SCIENCE RESEARCH AT LaRC

TO PROVIDE LaRC COMPUTER USERS THE OPPORTUNITY TO TELL US WHAT AREAS OF RESEARCH WILL BENEFIT THEIR APPLICATIONS

TO IDENTIFY DIRECTIONS FOR A LaRC PROGRAM

TO IMPROVE COMMUNICATION AMONG THE LaRC COMPUTER SCIENCE COMMUNITY

ON-GOING COMPUTER SCIENCE RESEARCH AREAS

LANGUAGES (PROGRAMING, QUERY, COMMAND)

SOFTWARE ENGINEERING AND DEVELOPMENT

COMPUTER SYSTEM RELIABILITY

NUMERICAL ANALYSIS AND GRAPHICS

DATABASE MANAGEMENT SYSTEMS

SPECIAL PURPOSE ARCHITECTURE
FINITE ELEMENT MACHINE, SIFT, FTMP

COMPUTER BULLETIN SURVEY

(243 RESPONSES)

PRIMARY APPLICATION AREAS

- ACQUISITION, ANALYSIS, AND DISPLAY OF ENGINEERING DATA
- COMPUTATIONAL METHODS FOR SCIENTIFIC PROBLEMS
- SIMULATION AND MODELING

COMPUTER SCIENCE CATEGORIES MOST CRITICAL

- GRAPHICS
- NUMERICAL ANALYSIS
- DATABASE MANAGEMENT
- SOFTWARE ENGINEERING

APPENDIX E

LANGUAGES

E. C. Foudriat

COMPUTER LANGUAGES

- LANGUAGES AND THE COMPUTER
- VIGNETTE OF SOME LaRC RESEARCH

LANGUAGES - A BRIEF HISTORY

DECADE	LANGUAGE CONCEPTS	TYPICAL LANGUAGE
50's	CONTROL OF MACHINE NUMERIC CALCULATIONS TRANSLATION, PARSING, DATA REP.	MACRO ASSEM. FORTRAN
60's	PROGRAMMING AS ENG. ACTIVITY STRUCTURES - LOGIC AND DATA NON-NUMERIC COMPUTATION MACHINE AND LANGUAGE ABSTRACTION	ALGOL 68 PL/1
70's	A VIRTUAL EXPLOSION OF LANGUAGE TECHNOLOGY	

SOME MODERN COMPUTER LANGUAGES
(A VERY TRUNCATED LIST)

LANGUAGE	FEATURE
BASIC	SIMPLE - USER ORIENTED
COBOL	BUSINESS ORIENTED
GYPSY	VERIFIABLE - CORRECTNESS
PASCAL, ADA	COMPLEX DATA STRUCTURES GENERIC OPERATIONS LOGIC STRUCTURES
UNCOL	UNIVERSAL PROGRAMMING
LISP, SETL	SPECIAL VIRTUALIZATION OF STRUCTURE
MODULA, ADA	INFORMATION ENCAPSULATION
CONCURRENT PASCAL PATH PASCAL	REAL TIME

WHAT'S IN A LANGUAGE

	FEATURES
. USER INTERFACE	
COMPILE TIME	ERROR DETECTION, ROBUSTNESS, SEPARATE COMPILATION, UTILITIES
RUN TIME	ERROR DETECTION, DEBUG, EFFICIENCY
. EXTERNAL INTERFACE	O/S SOFTWARE HARDWARE DEVICES
. MAINTENANCE EXTENSIBILITY	WHO? SOURCE VS. OBJECT PRODUCTION VS. EXPERIMENTAL
. PORTABILITY	COMMON SUBSET, READABILITY

REAL TIME LANGUAGE RESEARCH

OBJECTIVE: PROGRAM "ONBOARD" COMPUTER SYSTEMS

PATH PASCAL:

FEATURES -

- CONCURRENCY - PROCESSES EXECUTING AT SAME TIME
- INTERRUPT HANDLING - HARDWARE REGISTER MAPPING
  VECTORED INTERRUPTS
  PROCESS SUSPENSION - REACTIVATION
- INFORMATION SYNCH. - OBJECTS (NETWORKED), PATH EXPRESSIONS
- DEADLINES - ENABLE PROCESS COMPLETION AND RESCHEDULING

AVAILABILITY - HOST ALL MAJOR MAINFRAMES - SOME MIDDIES
TARGET - PDP11, M68000, Z8000, IBM SERIES 1, PRIME 500,
DISTRIBUTED TO OVER 50 GOVERNMENT, UNIVERSITY
AND INDUSTRY INSTALLATIONS WORLD-WIDE

USER INTERFACE SYSTEMS RESEARCH

OBJECTIVE: ENVIRONMENT FOR SOFTWARE DEVELOPMENT

INTERACTIVE SOFTWARE INVOCATION SYSTEM (ISIS):

FEATURES -

- MULTIPLE PAGE EDITOR
- HIERARCHICAL DATA BASE/FILE MANAGER
- INTERACTIVE PROGRAMMING LANGUAGE (IPL) BASED ON PASCAL
- EDITOR, FILE MANAGER, HOST O/S INTERFACE, IPL ALWAYS AVAILABLE
- TAILORED ENVIRONMENTS

AVAILABILITY - PRODUCTION SYSTEM AVAILABLE ON LaRC CDC COMPLEX
REHOSTED TO VAX 11/70 SYSTEM
CURRENTLY BEING REHOSTED TO M68000 WITH FULL SCREEN
EDITOR AND CONCURRENCY (FOREGROUND/BACKGROUND) CAPABILITY

LANGUAGE - THE COMPUTER USER

- LANGUAGE IS THE INTERFACE TO COMPUTERS
- TECHNOLOGY PROVIDES EXCELLENT, MATURE LANGUAGES
- LaRC RESEARCH DEALING WITH INTERESTING AREAS

: CONSIDER - USING LANGUAGE TECHNOLOGY TO IMPROVE INTERFACES
- USING "NEW" LANGUAGE FOR NEXT PROGRAM
- GETTING "NEW" LANGUAGE FOR LOCAL MACHINE

USE REQUIRES SUPPORT (TIME/MONEY)

APPENDIX F

SOFTWARE ENGINEERING

E. H. Senn

BASIC NOTIONS

- HARDWARE DETERIORATES OVER TIME......SOFTWARE DOES NOT.
  - SOFTWARE HAS THE POTENTIAL OF BEING PERMANENTLY ERROR-FREE, AND ANY ERRORS PRESENT ARE THERE FROM THE OUTSET.

  ------JOHN KNIGHT/LaRC

- THE PROBLEM OF ACHIEVING HIGH RELIABILITY IN CRUCIAL SOFTWARE IS TOTALLY WITHIN THE FABRICATION PROCESS.
  - A MAJOR BREAKTHROUGH IN SOFTWARE DEVELOPMENT TECHNOLOGY SEEMS UNLIKELY IN THE NEAR FUTURE.
  - HENCE, THE ONLY VIABLE APPROACH TODAY IS TO USE THE BEST AVAILABLE TECHNOLOGY IN EACH STEP OF CONSTRUCTION.

  ------JOHN KNIGHT/LaRC

- LESSONS LEARNED ABOUT SOFTWARE ENGINEERING DISCIPLINE ARE NOT HEEDED ABOUT 50% OF THE TIME.

  ------BARRY BOEHM/TRW

SOFTWARE DEVELOPMENT TRUTHS

- NEITHER QUALITY NOR RELIABILITY CAN BE ACHIEVED BY TESTING POORLY DESIGNED SOFTWARE...HARLON MILLS/IBM

- THE ONLY SOUND BASIS FOR DEVELOPING QUALITY SOFTWARE IS GOOD SPECIFICATION AND DESIGN, NOT TESTING...HARLON MILLS/IBM

- GOOD SOFTWARE REQUIREMENTS ARE AN AD-HOC BLEND OF SYSTEMS ANALYSIS PRINCIPLES AND COMMON SENSE. THE POOR ONES ARE AN AD-HOC BLEND OF POLITICS, PRECONCEPTIONS, MISCONCEPTIONS AND SALESMANSHIP...BARRY BOEHM/TRW

- IT IS NO CONTEST BETWEEN A PROGRAMMER AND A COMPUTER ON FINDING ERRORS IN WELL-DESIGNED PROGRAMS---THE PROGRAMMER WILL WIN HANDS DOWN...HARLON MILLS/IBM.

MAJOR SOFTWARE DEVELOPMENT PROBLEMS

- ACHIEVING CORRECT AND COMPLETE SOFTWARE REQUIREMENTS IS A DIFFICULT AND NON-TRIVIAL TASK.
- SOFTWARE REQUIREMENTS AND DESIGN SUPPORT IS FREQUENTLY NON-EXISTENT, INADEQUATE, OR OVERLY COMPLEX.
- PROJECT AND MANAGEMENT PRESSURES OFTEN FORCE, OR PERMIT, SHORT-CUT SOFTWARE DEVELOPMENT METHODS.
- SOFTWARE REQUIREMENTS ARE OFTEN INCOMPLETE, INCONSISTENT, AMBIGUOUS AND NOT CLEARLY DISTINGUISHED FROM OTHER SYSTEM REQUIREMENTS.

WHAT IS SOFTWARE ENGINEERING?

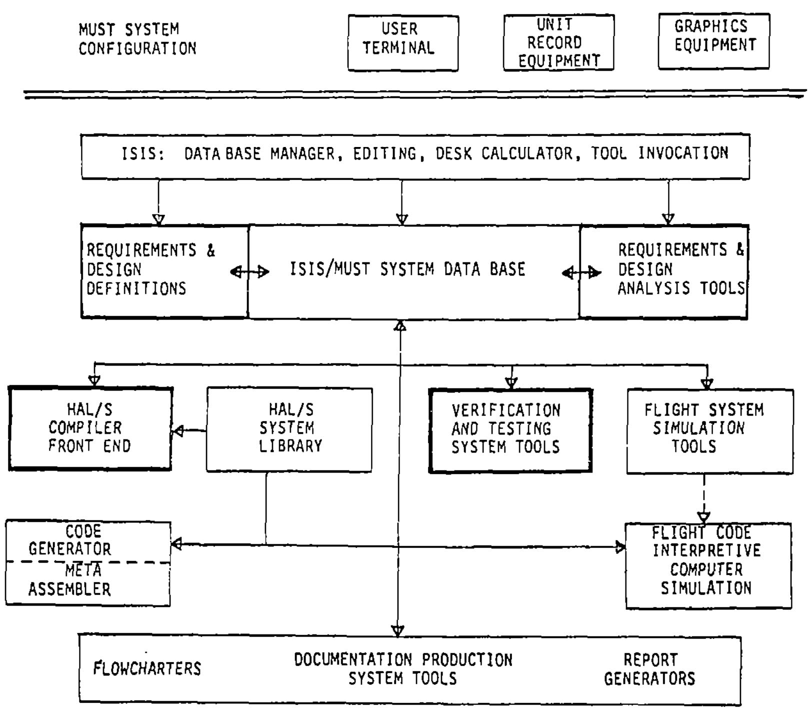
- CANDIDATE DEFINITIONS:
  - CONSISTENT APPLICATION OF AN ORGANIZED, DISCIPLINED APPROACH TO SOFTWARE DEVELOPMENT
  - STRUCTURED SOFTWARE DEVELOPMENT
  - CONTROLLED APPLICATION OF THE "SOFTWARE DEVELOPMENT LIFE CYCLE" TO THE PROCESS OF SOFTWARE DEVELOPMENT

WHY DO WE NEED S/W ENGINEERING?

- FOR CONSISTENT AND SUBSTANTIAL IMPROVEMENT IN SOFTWARE QUALITY.

- FOR CONSISTENT AND SUBSTANTIAL REDUCTION IN SOFTWARE DEVELOPMENT AND LIFE-CYCLE COSTS
  - SOFTWARE TESTING COSTS
  - SOFTWARE MAINTENANCE COSTS

- GOAL: CONSISTENT DEVELOPMENT OF "MAINTENANCE FREE SOFTWARE"



CURRENT RESEARCH ACTIVITIES

- SMS (SAGA) GRANT WITH U. OF ILL. -- SOFTWARE CONTROL, ORGANIZATION, MANAGEMENT AND ANALYSIS
- SRAD GRANT WITH U. OF MASS. -- SOFTWARE REQ.'S AND DESIGN SUPPORT
- TWS GRANT WITH W & M -- SEMI-AUTOMATED TRANSLATOR DEVELOPMENT
- IVTS CONTRACT WITH BCS -- SOFTWARE CODE DEVELOPMENT PHASE
- ISIS DEVELOPMENT -- FOR MICROPROCESSORS

APPENDIX G

SOFTWARE WITH INTERNAL FAULT TOLERANCE

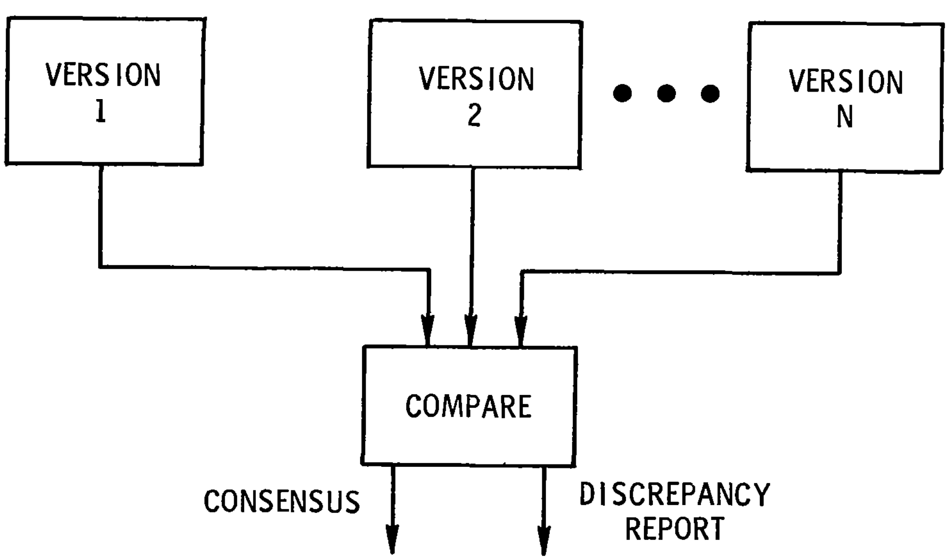
G. E. Migneault

OBJECTIVE

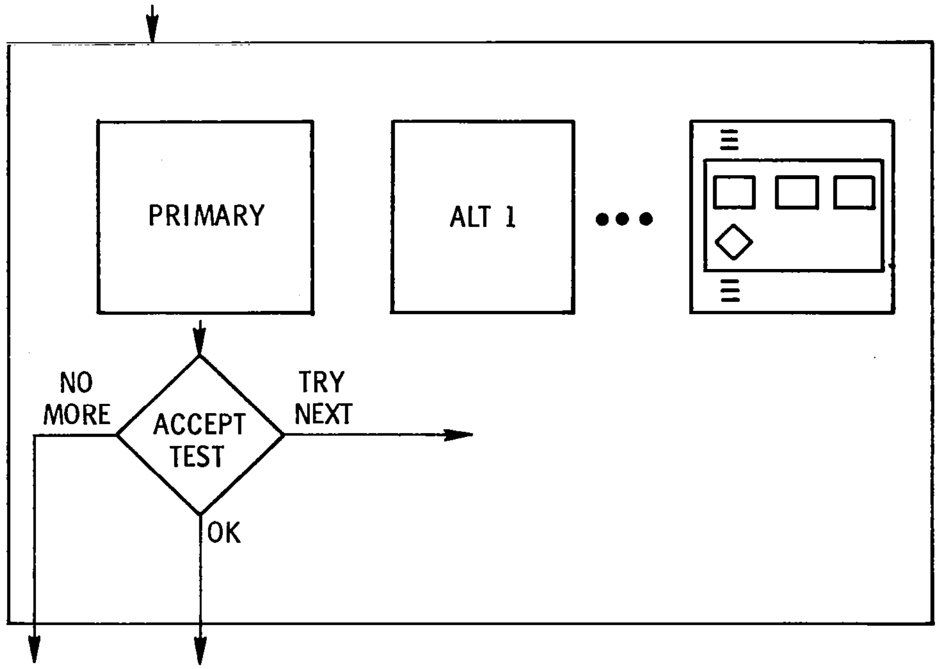
TO ELIMINATE THE SINGLE-POINT-FAILURE CHARACTERISTIC OF SOFTWARE FAULTS.

- o DEVELOP TECHNIQUES FOR MAKING PRACTICABLE USE OF ALTERNATE ALGORITHMS
  - o RECOVERY BLOCKS & CACHE
  - o N - VERSION PROGRAMMING
  - o -----

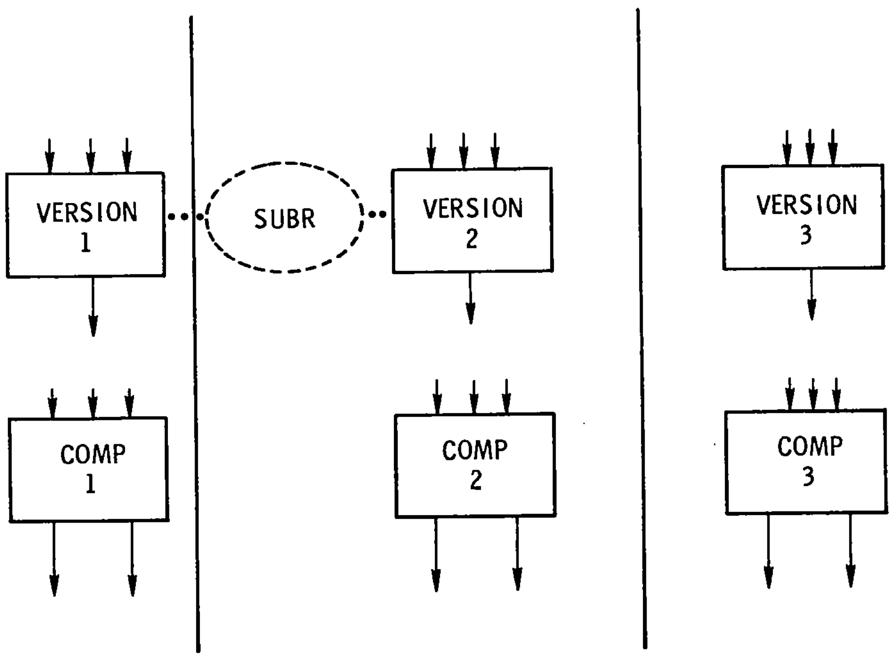
N - VERSION



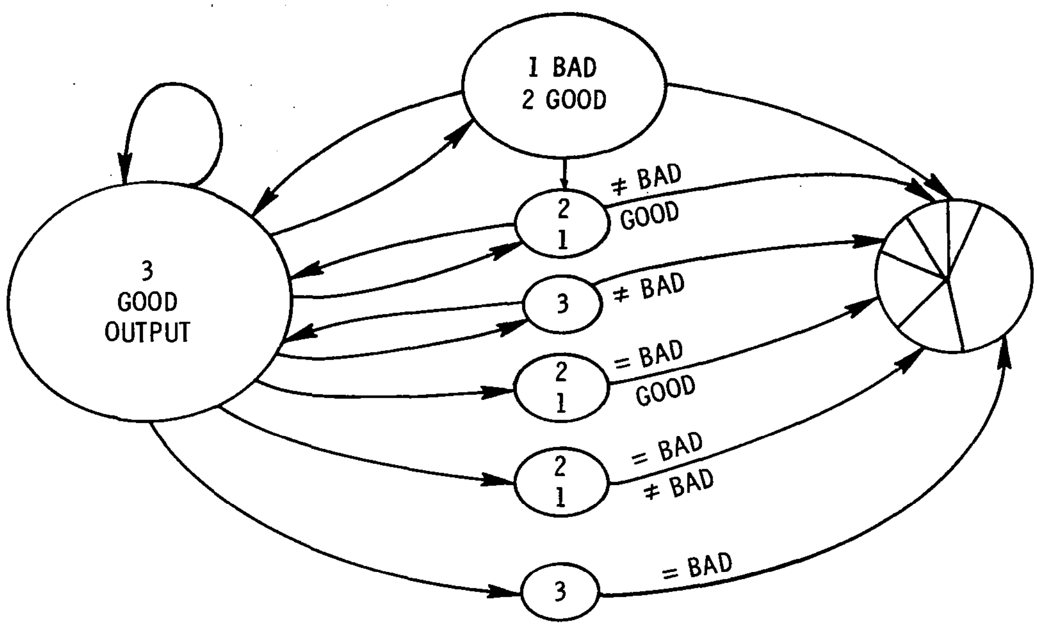
RECOVERY BLOCKS



N = 3 VERSION



N = 3 VERSION



ACTIVITIES

- o STUDY OF FEASIBILITY FOR AIRCRAFT APPLICATION
- o IMPLEMENTATION SPEC AND DEMO IN FAULT TOLERANT COMPUTER PROCESSOR
- o ICASE REPORTS
- o FUTURE AIRLAB ACTIVITY

APPENDIX H

NUMERICAL ANALYSIS AND GRAPHICS

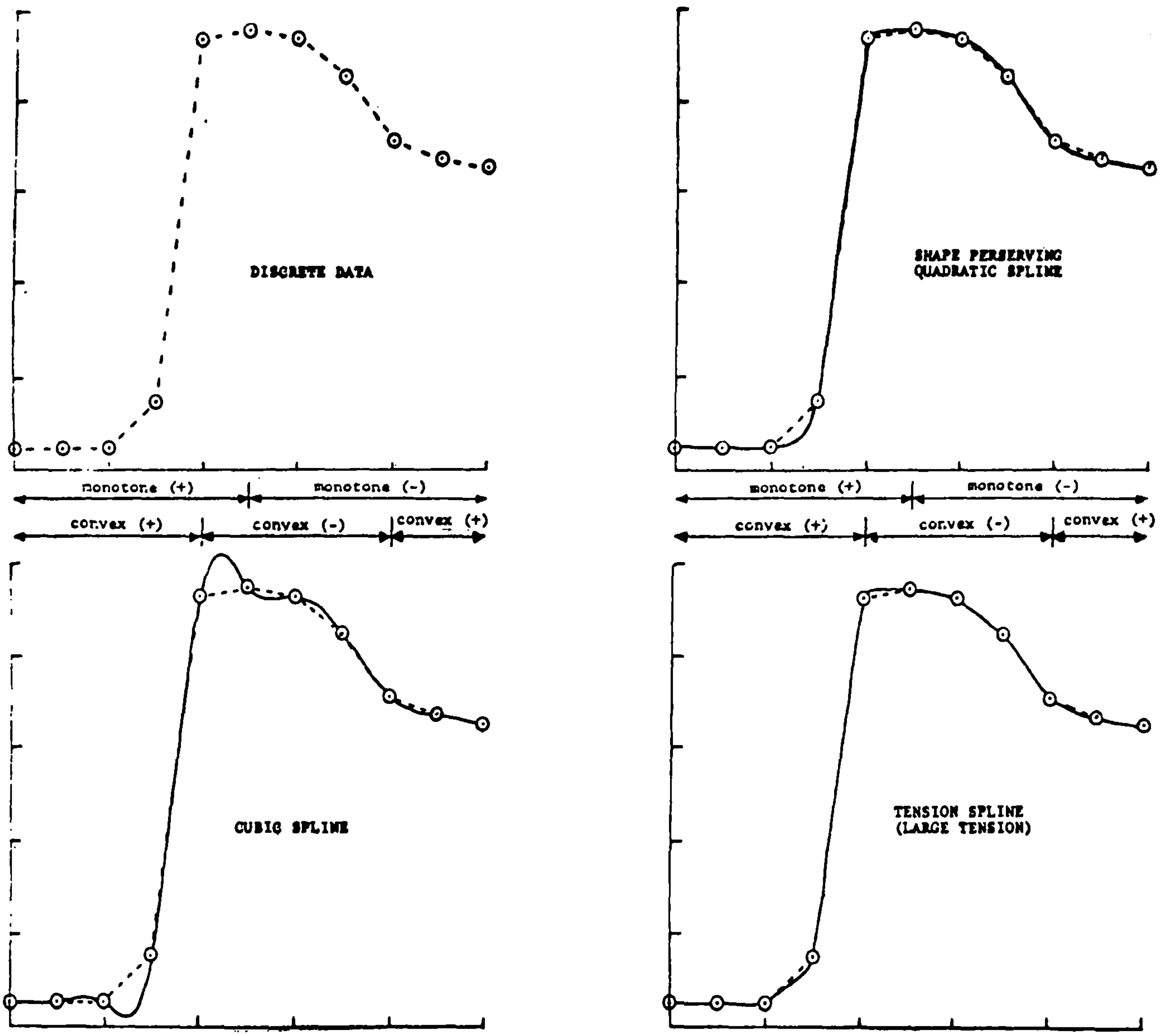
J. N. Shoosmith

NUMERICAL ANALYSIS AND GRAPHICS

- FUNCTIONAL REPRESENTATION OF DATA
- GRID GENERATION
- NUMERICAL METHODS FOR THE SOLUTION OF PARTIAL DIFFERENTIAL EQUATIONS
- ALGORITHMS FOR VECTOR AND PARALLEL PROCESSORS
- COMPUTER GRAPHICS
- OTHER RELATED RESEARCH

FUNCTIONAL REPRESENTATION OF DATA

- SPLINES UNDER TENSION
  - ALAN CLINE UNIVERSITY OF TEXAS
- SHAPE PRESERVING APPROXIMATION
  - DAVID MCALLISTER NORTH CAROLINA STATE
  - JOHN ROULIER UNIVERSITY OF CONNECTICUT
- FITTING MULTIDIMENSIONAL SPLINES USING STATISTICAL VARIABLE SELECTION TECHNIQUES
  - PAT SMITH OLD DOMINION UNIVERSITY
- ARBITRARY AIRCRAFT GEOMETRY REPRESENTATION
  - CHARLOTTE CRAIDON ACD



DATA FITTING WITH CONTINUOUS FUNCTIONS

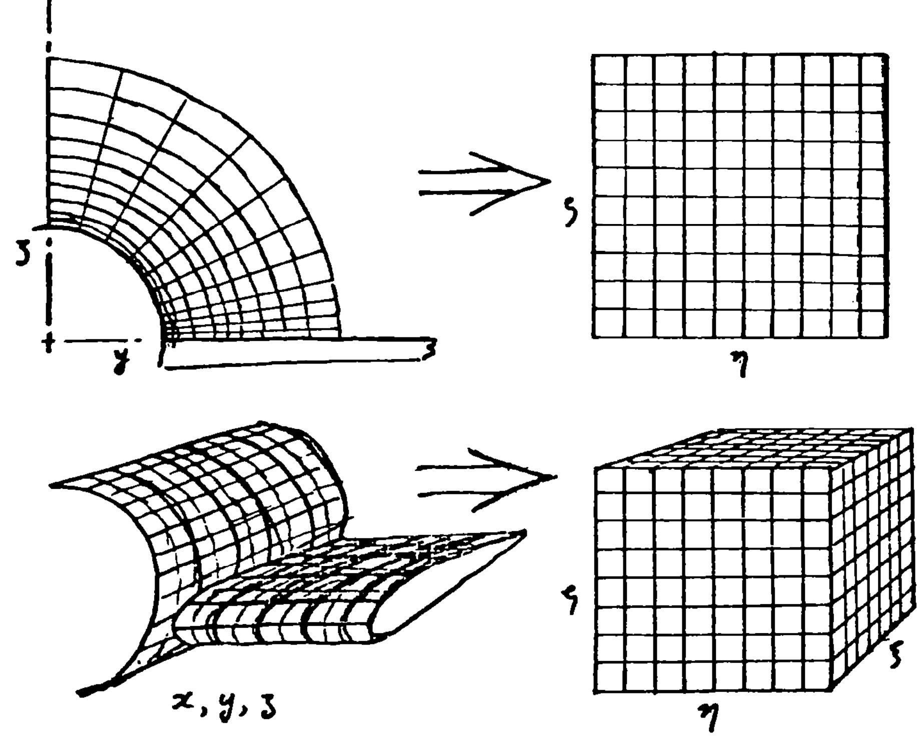
GRID GENERATION

INTERACTIVE GRID CONTROL FOR THE TWO-BOUNDARY METHOD; ROBERT E. SMITH, ACD.

DEVELOPMENT OF INTERACTIVE MESH GENERATION SYSTEM; PETER EISEMAN, COLUMBIA UNIVERSITY, AND ROBERT E. SMITH, ACD.

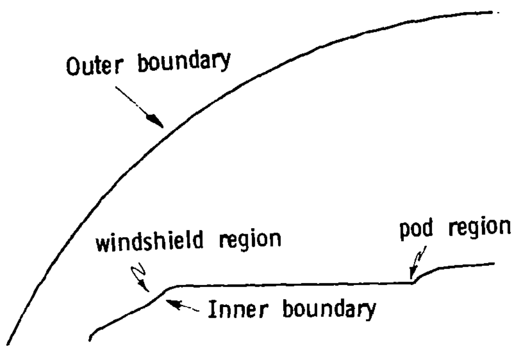
TRANSFORMATION OF TWO- AND THREE-DIMENSIONAL REGIONS BY ELLIPTIC SYSTEMS; JOE THOMPSON AND WAYNE MASTIN, MISSISSIPPI STATE UNIVERSITY.

COORDINATE TRANSFORM

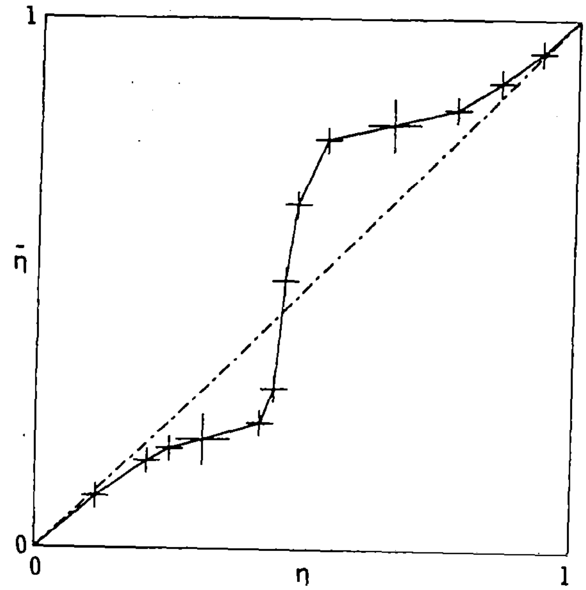


THE METRIC TENSOR $M = \begin{bmatrix} \frac{\partial \xi}{\partial x} & \frac{\partial \xi}{\partial y} & \frac{\partial \xi}{\partial z} \\ \frac{\partial \eta}{\partial x} & \frac{\partial \eta}{\partial y} & \frac{\partial \eta}{\partial z} \\ \frac{\partial \zeta}{\partial x} & \frac{\partial \zeta}{\partial y} & \frac{\partial \zeta}{\partial z} \end{bmatrix}$

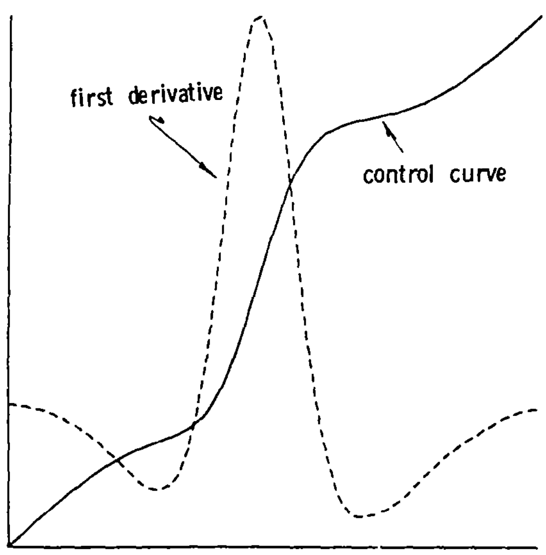
THIS MAY BE DETERMINED ANALYTICALLY (THOMPSON & MASTIN) OR NUMERICALLY (R.E.SMITH)



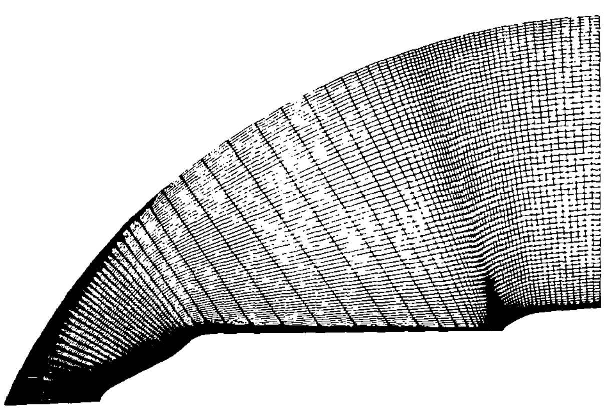
Boundaries for Shuttle-like Configuration



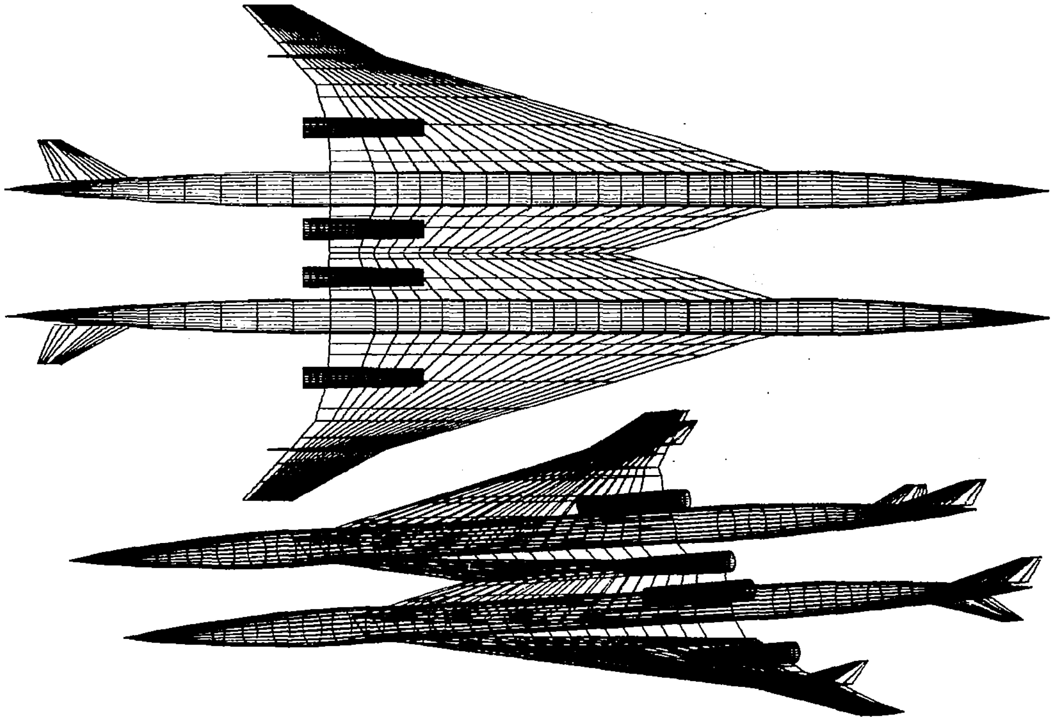
Digitized Points to Concentrate Grid in Windshield and Pod Regions



Smoothed Control Plot and First Derivative to Concentrate Grid



Computed Grid with "two-boundary method"



NUMERICAL METHODS FOR PDE'S

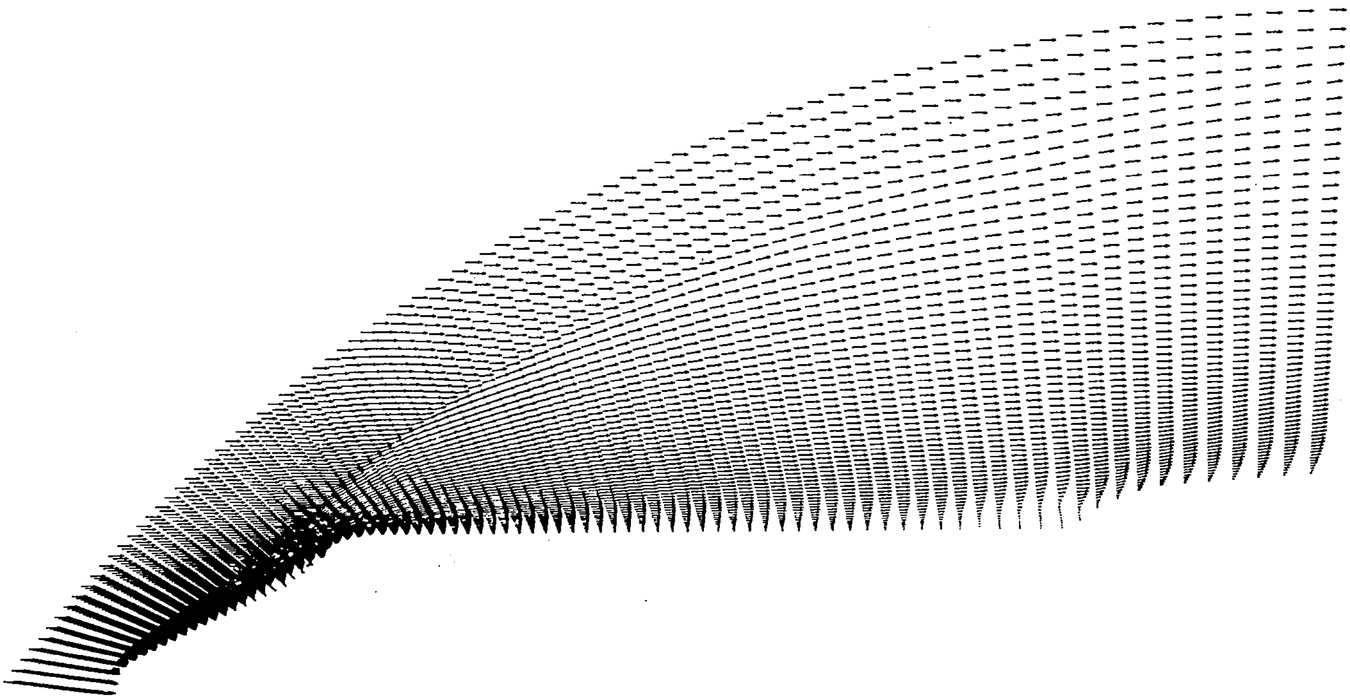
- FINITE ELEMENT APPROACH TO FLUID FLOW PROBLEMS; JERRY BAKER, UNIVERSITY OF TENNESSEE.
- METHOD OF LINES FOR ELIPTIC PDE'S; BRUCE EDWARDS, UNIVERSITY OF FLORIDA.
- COMBINATION OF GRID GENERATION AND MACCORMACK'S METHOD FOR 3-D FLOW PROBLEMS; R. E. SMITH AND J. I. PITTS, ACD.
- ICASE RESEARCH
  - PROBLEM DISCRETIZATION
    - FINITE ELEMENTS
    - FINITE DIFFERENCES
    - BOUNDARY TREATMENT
  - PROBLEM SOLUTION METHODS
    - MULTIGRID
    - SPECTRAL METHODS
    - CONJUGATE GRADIENTS
    - SPECIAL METHODS
- DISCRETIZATION CONTROL BASED UPON ENTROPY CALCULATIONS; R. PROZAN, CONTINUUM, INC.

ALGORITHMS FOR VECTOR AND PARALLEL PROCESSORS

- CONVOLUTION AND FILTERING ALGORITHMS; GEORGE IOUP, UNIVERSITY OF NEW ORLEANS.
- LEAST SQUARES AND BASIC LINEAR ALGEBRA ALGORITHMS; SHANTI SHAH, HAMPTON INSTITUTE.
- FAST FOURIER TRANSFORM ALGORITHMS; JAY LAMBIOTTE, ACD.
- FAST POISSON EQUATION SOLVER; JAY LAMBIOTTE, ACD.
- ICASE RESEARCH
  - DIRECT VS. ITERATIVE METHODS
  - VECTORIZATION OF PDE METHODS (I.E., MULTIGRID, CONJUGATE GRADIENT)
  - ALGORITHMS FOR THE FINITE ELEMENT MACHINE

GRAPHICS

- RASTER GRAPHICS SOFTWARE, PARTICULARLY RASTER EXTENSIONS TO THE CORE GRAPHICS STANDARDS; JAMES FOLEY, GEORGE WASHINGTON UNIVERSITY
- SURFACE VISUALIZATION - E.G., THE DISPLAY OF THE INTENSITY OF A SCALAR VARIABLE ON A GIVEN SURFACE IN THREE DIMENSIONS; DON SPERAY, ACD
- FLUID FLOW VISUALIZATION - E.G., THE DISPLAY OF DENSITY OR VELOCITY IN A THREE-DIMENSIONAL DOMAIN; DON SPERAY AND ROBERT SMITH, ACD
- INVESTIGATION OF A HIDDEN SURFACE ALGORITHM FOR FLIGHT SIMULATION USE; DON SPERAY, ACD



OTHER RELATED RESEARCH

- o ALGEBRAIC MANIPULATION; MIT LABORATORY FOR COMPUTER SCIENCE
- o RANDOM VARIABLE GENERATION FROM AN ARIBITRARY CONTINUOUS PROBABILITY DISTRIBUTION; JAMES SCHIESS, ACD
- o ICASE RESEARCH
  - PARAMETER ESTIMATION METHODS
  - FUNCTION MINIMIZATION ALGORITHMS (CONSTRAINED AND OTHERWISE)

APPENDIX I

DATABASE MANAGEMENT

G. C. Salley

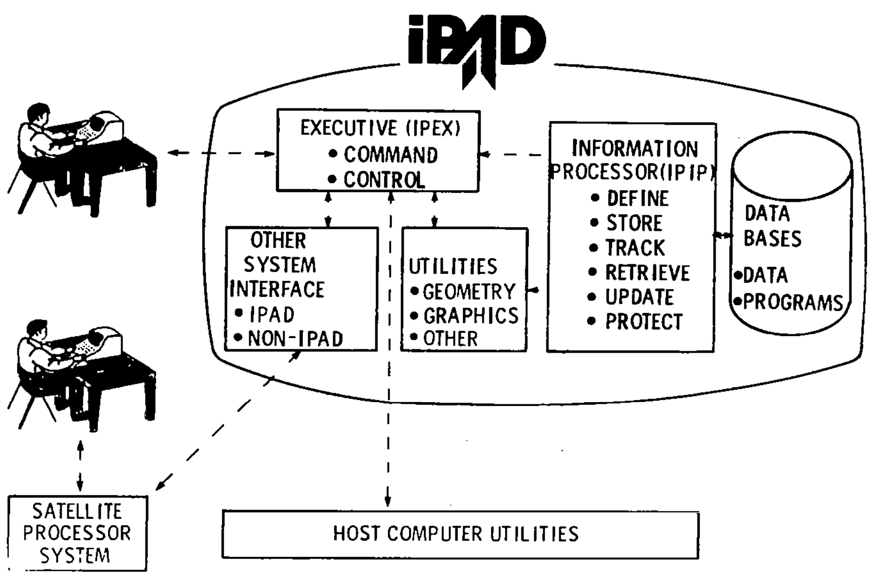
INTEGRATED PROGRAMS FOR AEROSPACE-VEHICLE DESIGN

IPAD

INDUSTRY/GOVERNMENT R & D PROJECT TO IMPROVE PRODUCTIVITY THROUGH USE OF COMPUTER TECHNOLOGY FOR INTEGRATED, COMPANY-WIDE MANAGEMENT OF ENGINEERING DATA AND COMPUTER PROGRAMS

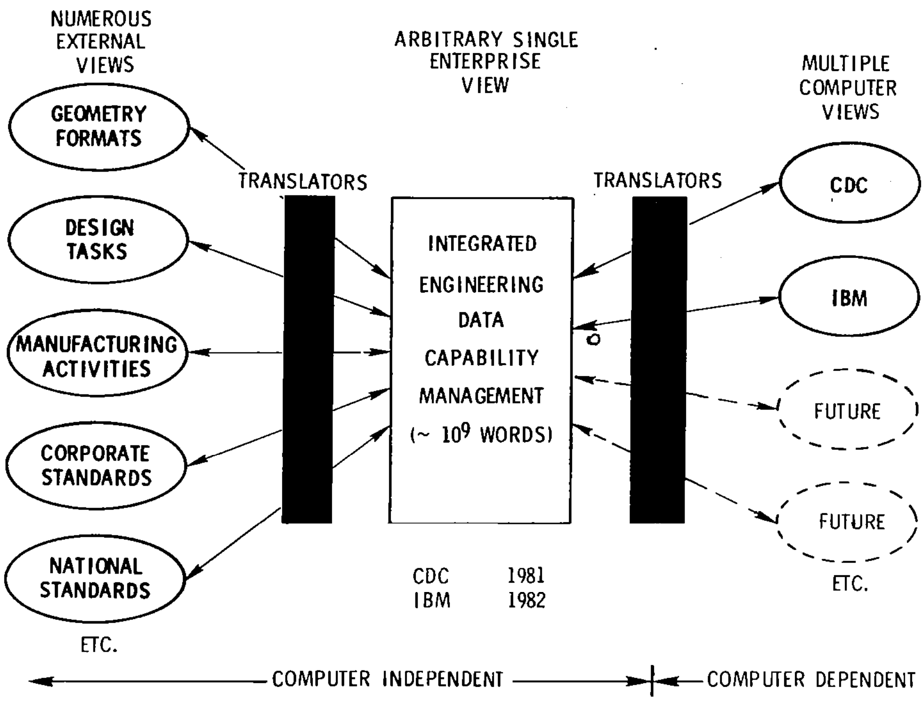
PRODUCTS: TECHNOLOGY REPORTS
PROTOTYPE SOFTWARE

FULL IPAD COMPONENTS

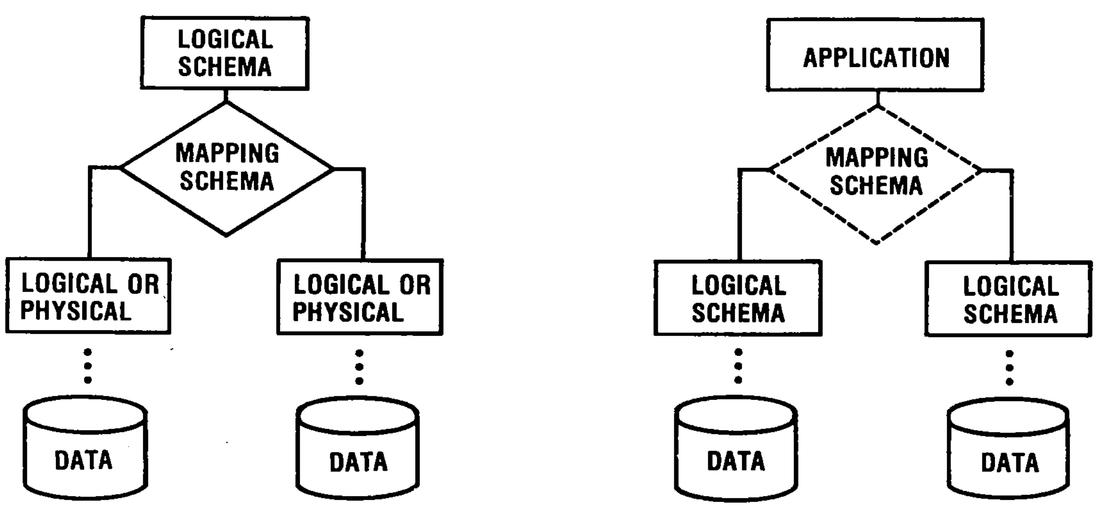


IPAD ENGINEERING DATA MANAGEMENT APPROACH (IPIP)

MULTI-SCHEMA/VIEW DATA BASE



COUPLING DATA BASES

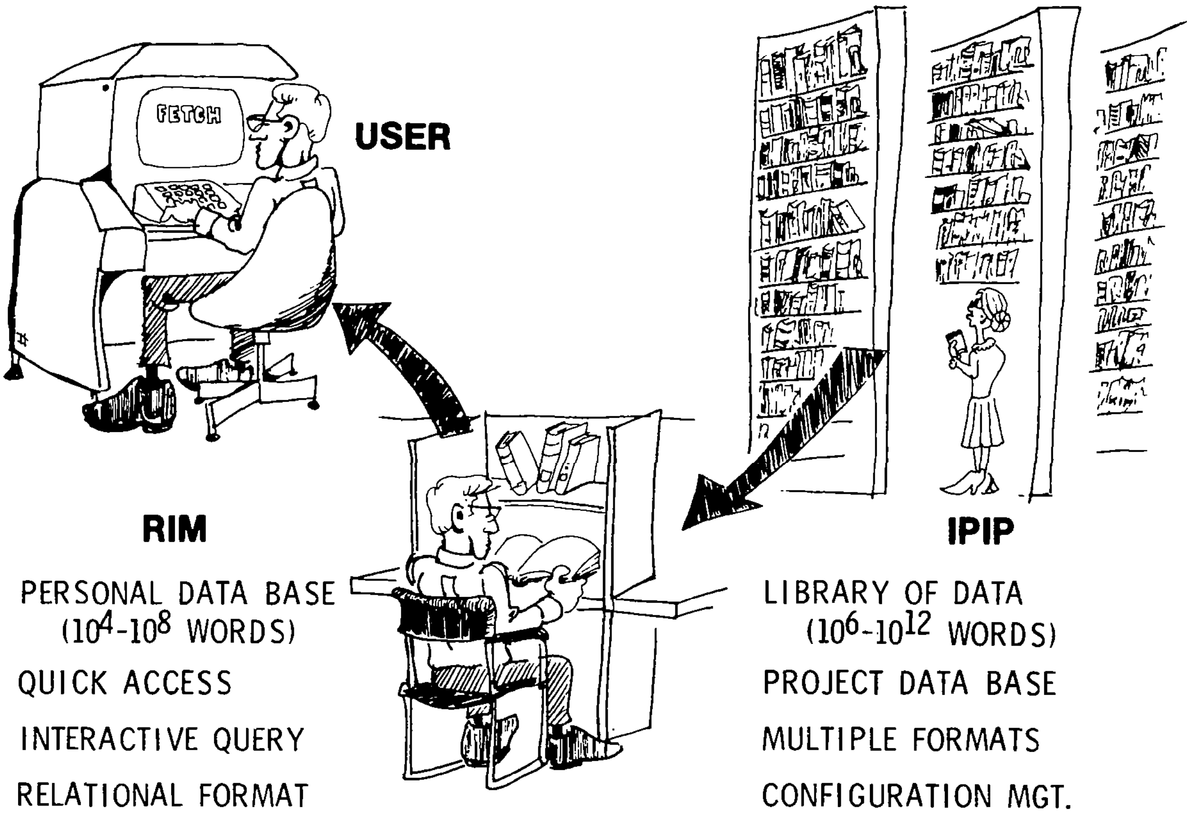


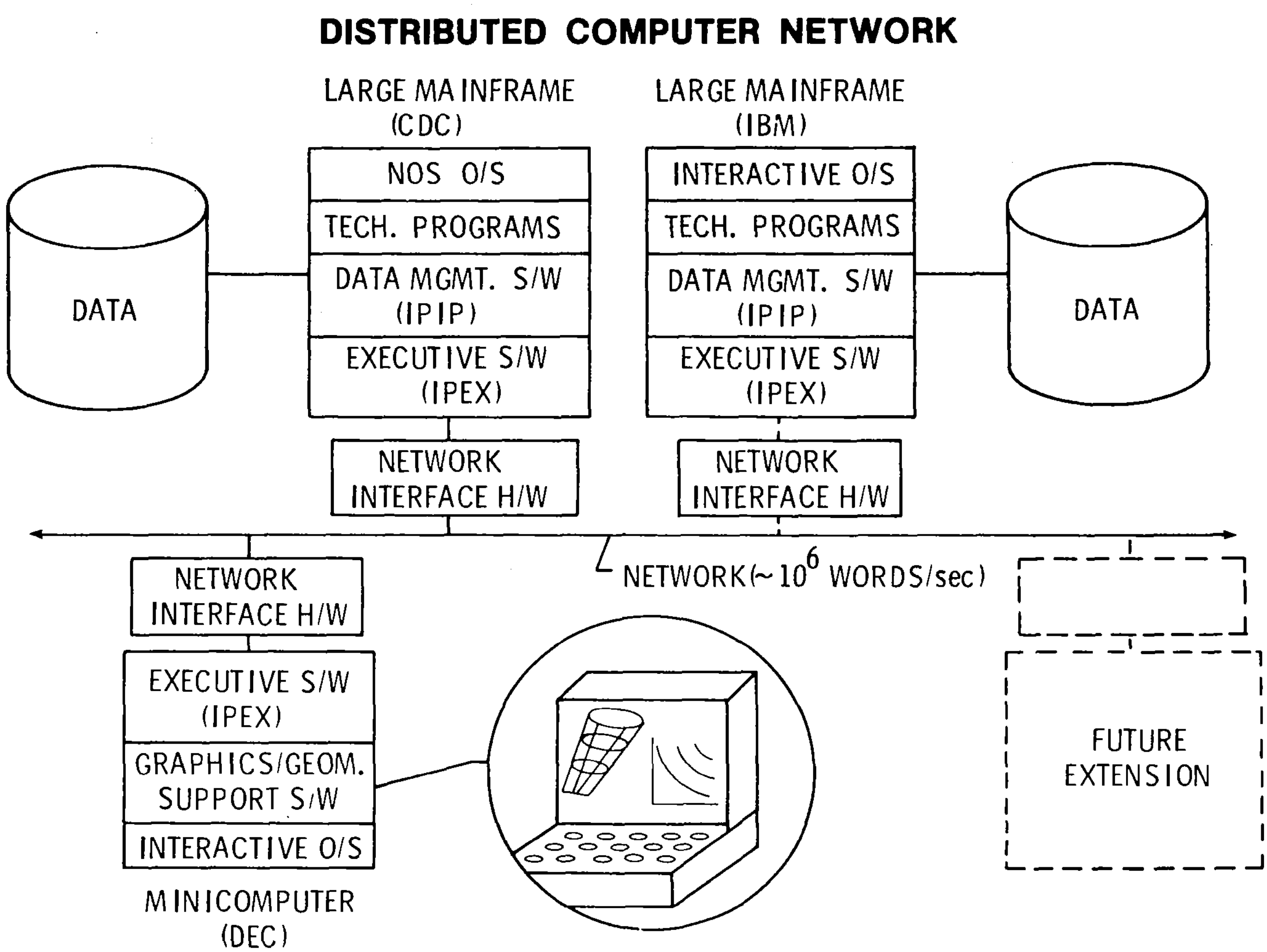
- CENTRALIZE/DECENTRALIZE DATA ADMINISTRATION TO REFLECT STRUCTURE OF THE ORGANIATION

RIM

- RELATIONAL DATA MANAGER
- QUERY AND FORTRAN CAPABILITIES
- ENGLISH-LIKE QUERY USER INTERFACE, DIRECT OR MENU MODE
- APPLICABLE TO BUSINESS AND-SCIENTIFIC DATA
  - TEXT ATTRIBUTES
  - INTEGER, REAL, DOUBLE PRECISION ATTRIBUTES
  - VECTORS AND MATRIX ATTRIBUTES
  - FIXED OR VARIABLE LENGTH ATTRIBUTES
- SUPPORTS RELATIONAL ALGEBRA
- HIGHLY EFFICIENT PROCESSING
- PORTABLE, FORTRAN 77 CODE (CDC, VAX, UNIVAC, IBM, AND OTHERS)

COMPANY WIDE DATA MANAGEMENT APPROACH

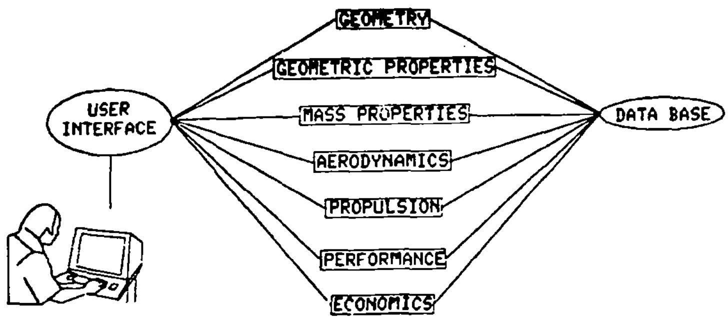




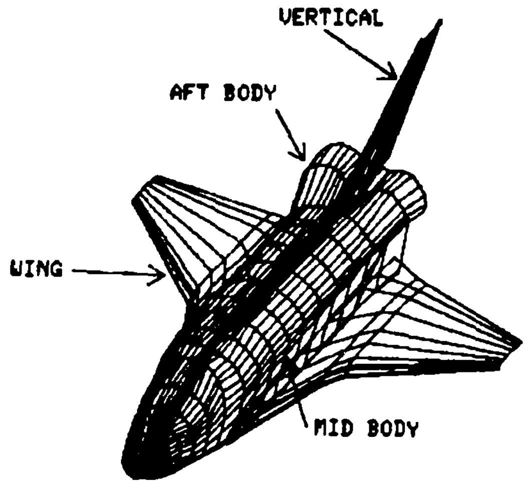
IPAD hardware/software configuration.

PRESENT ARIS APPLICATIONS

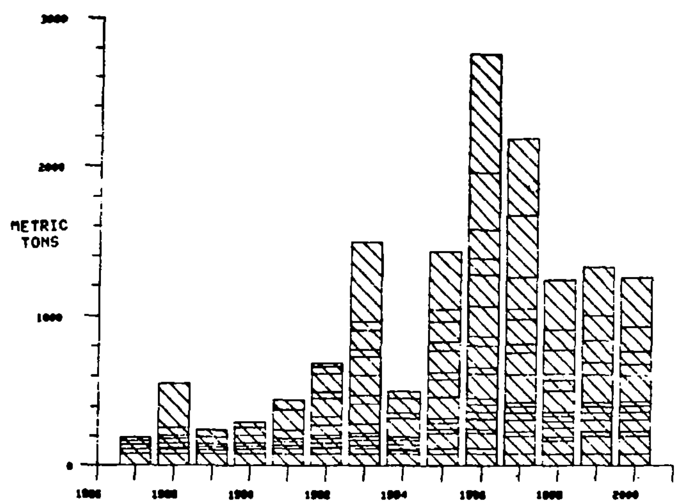
AVID SOFTWARE SYSTEM



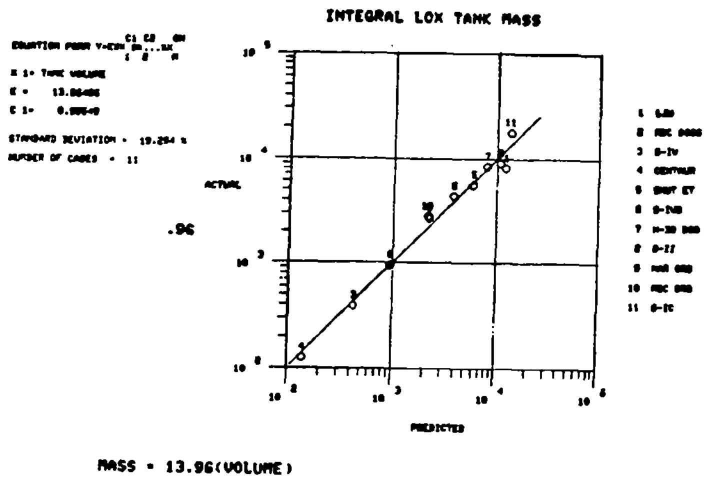
GEOMETRY DATA



PAYLOAD MISSIONS ANALYSIS



COMPONENT MASS DATABASE



A state-of-the-art data management system has been developed called ARIS. It is based on the relational data model for its simplicity of use and utilizes the B*-trace data structure for quick sequential and random access. It was developed as a foundation for the Aerospace Vehicle Interactive Design system to be used for the user interface and design data communications. It has also been used for launch vehicle mission model analysis, geometric data structuring, and a database of aerospace vehicle component masses that is used to develop mass estimating relationships.

ENGINEERING/SCIENTIFIC DATA MANAGEMENT SYSTEM

DATA BASE MANAGEMENT PROGRAMMING

E/S DMS

WRITE DDL PROGRAM.

COMPILE DDL

WRITE DML + FORTRAN PROGRAM.

COMPILE DML

FORTRAN PROGRAM FOR COMPLETE TASK

COMPILE FTN

LOAD COMPILED PROGRAM PLUS E/S DMS RUN-TIME SYSTEM.

EXECUTIONS

MAKE MODIFICATIONS, CORRECTIONS, ETC.

USE CCL PROCEDURES TO "HIDE" THE DDL, DML, AND FTN COMPILERS.

APPENDIX J

SPECIAL-PURPOSE ARCHITECTURE: SIFT AND FTMP

N. D. Murray

FAULT TOLERANT COMPUTER TECHNOLOGY

ACTIVE CONTROLS FOR CIVIL TRANSPORT AIRCRAFT

- REQUIREMENTS AND SYSTEM CONTEXT
- TWO COMPUTER ARCHITECTURAL CONCEPTS
- CHARACTERISTICS OF LABORATORY TEST MODELS

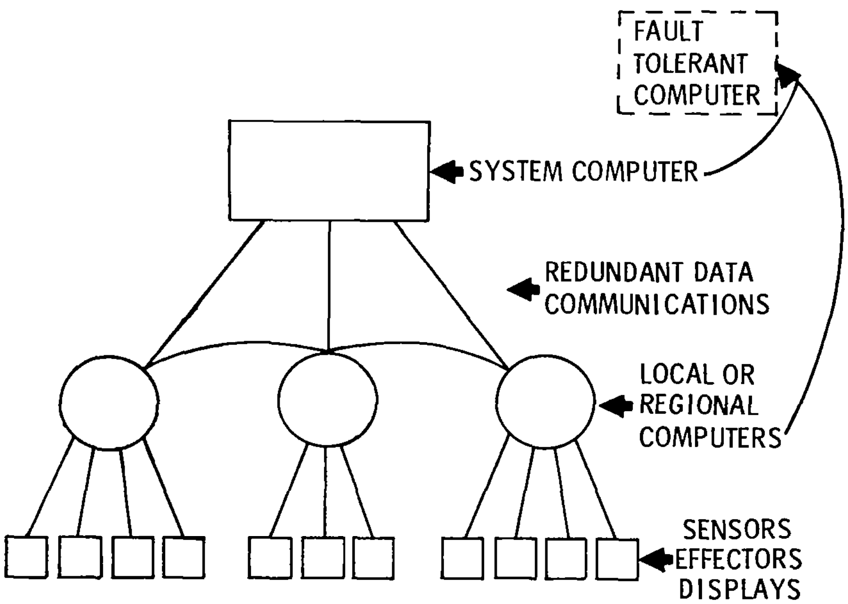
DIGITAL ACTIVE CONTROLS EVOLUTION

- NEAR TERM ACTIVE CONTROLS WILL MOST LIKELY:
  - HAVE LIMITED EFFECTIVENESS AND BENEFIT
  - APPLY TO DERIVATIVE AIRCRAFT
  - BE NON-FLIGHT SAFETY CRITICAL ($P_f \leq 10^{-5}$ AT 10 HOURS)
- FAR TERM ACTIVE CONTROLS WILL:
  - HAVE MAXIMUM EFFECTIVENESS AND BENEFIT
  - APPLY TO NEW GENERATION AIRCRAFT
  - BE FLIGHT SAFETY CRITICAL ($P_f \leq 10^{-9}$ AT 10 HOURS)

DIGITAL ACTIVE CONTROLS EVOLUTION (CONT.)

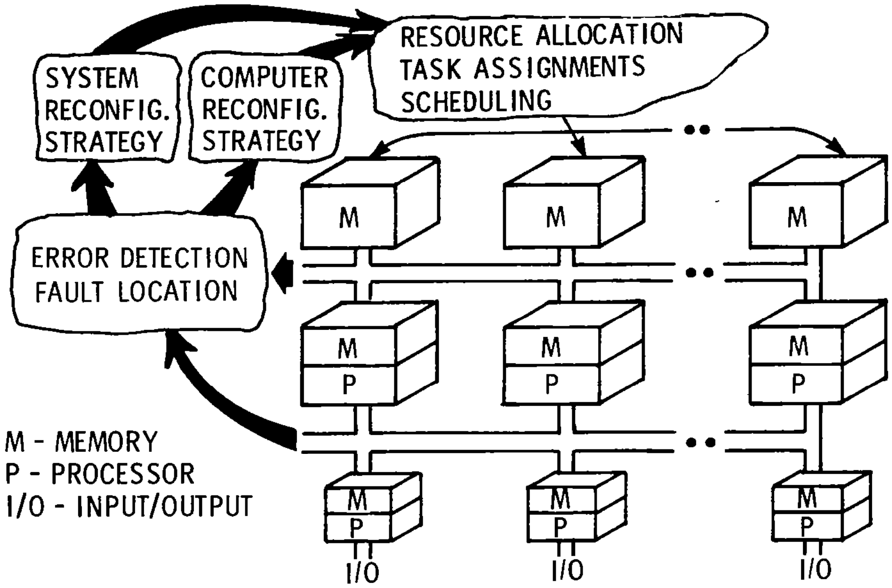
LIMITED	MAXIMUM	BENEFIT
REDUCED STATIC STABILITY	NEGATIVE STATIC STABILITY	PERFORMANCE
LOAD CONTROL	LOAD CONTROL	ECONOMIC
LOAD ALLEVIATION	LOAD ALLEVIATION	AVAILABILITY/ DISPATCH
RIDE CONTROL	RIDE CONTROL	
	FLUTTER SUPPRESSION	

EXAMPLE SYSTEM HIERARCHY

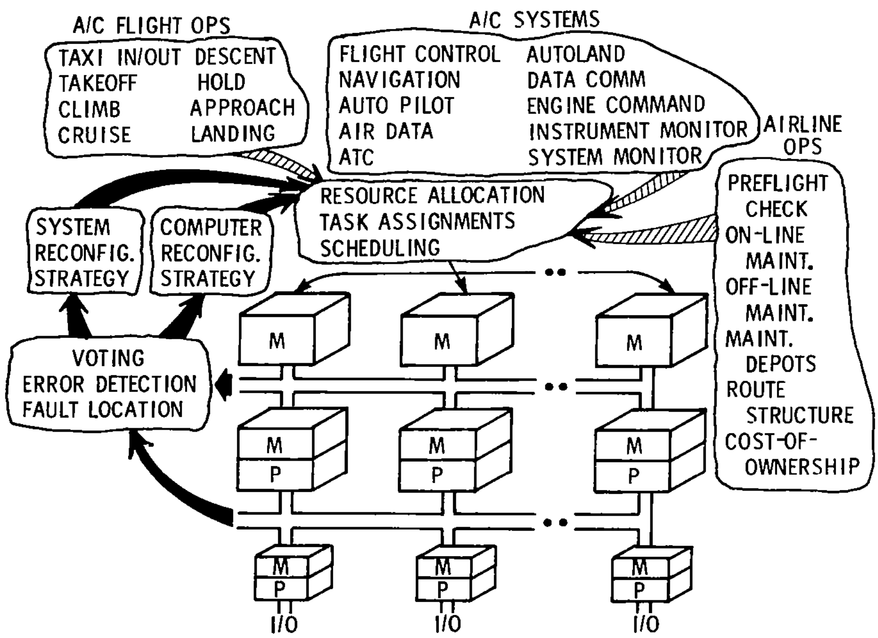


FAULT TOLERANT COMPUTERS

HOW DO THEY FUNCTION?



FTC COMPUTING ENVIRONMENT



CANDIDATE FAULT TOLERANT COMPUTER ARCHITECTURES

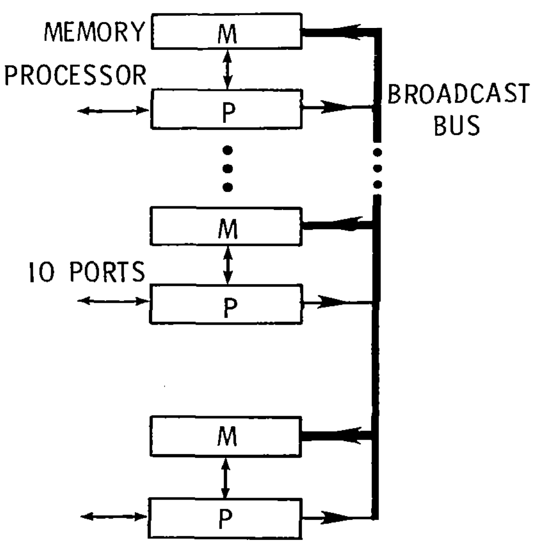
- SOFTWARE IMPLEMENTED FAULT TOLERANCE (SIFT) BY SRI INTERNATIONAL/BENDIX
- FAULT TOLERANT MULTIPROCESSOR (FTMP) BY CHARLES STARK DRAPER LABORATORY/COLLINS

FOR EACH FTC ARCHITECTURE

- RESOLVED MOST OF CRITICAL DESIGN ISSUES
- ESTABLISHED DESIGN SPECIFICATIONS
- CONSTRUCTED LABORATORY MODELS
- UNDERGOING BENCHMARK AND FAULT INJECTION TESTS
- EVALUATION/DISSEMINATION OF TECHNICAL RESULTS

SIFT ORGANIZATION

MULTICOMPUTER WITH VARIABLE VOTING AND SPARE CAPACITY



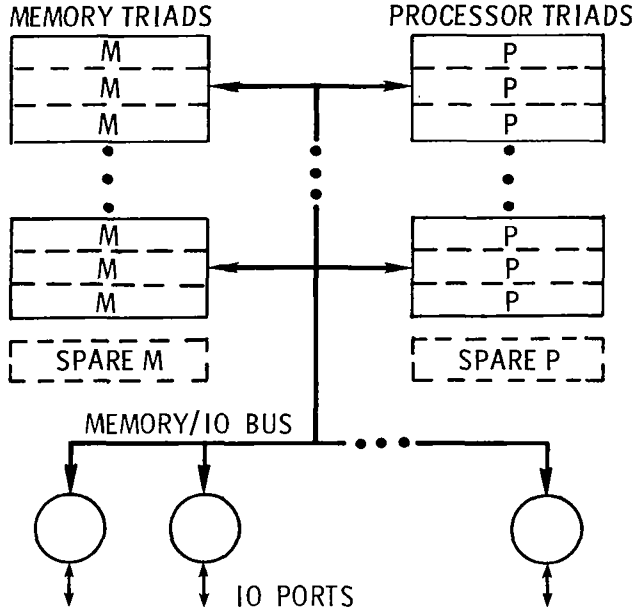
COMPUTERS

TASKS	1	2	3	4	5 • • M
A	×	×		×	
B			×		×
C		×			
D	×		×	×	
E	×	×	×	×	×
F			×		×
G	×	×	×		
H	×			×	
⋮ N					

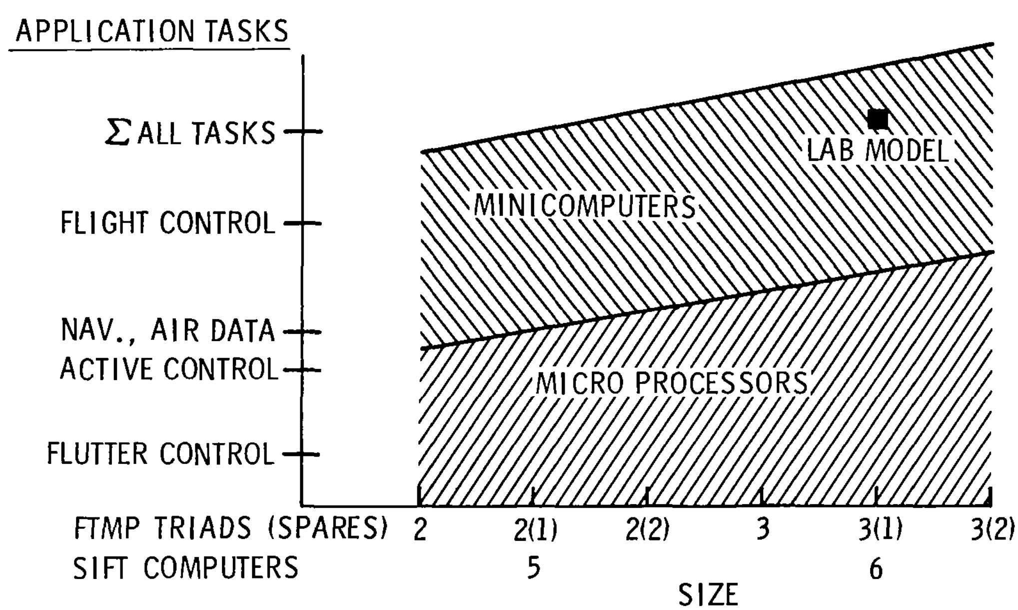
REPLICATED TASKS

FTMP ORGANIZATION

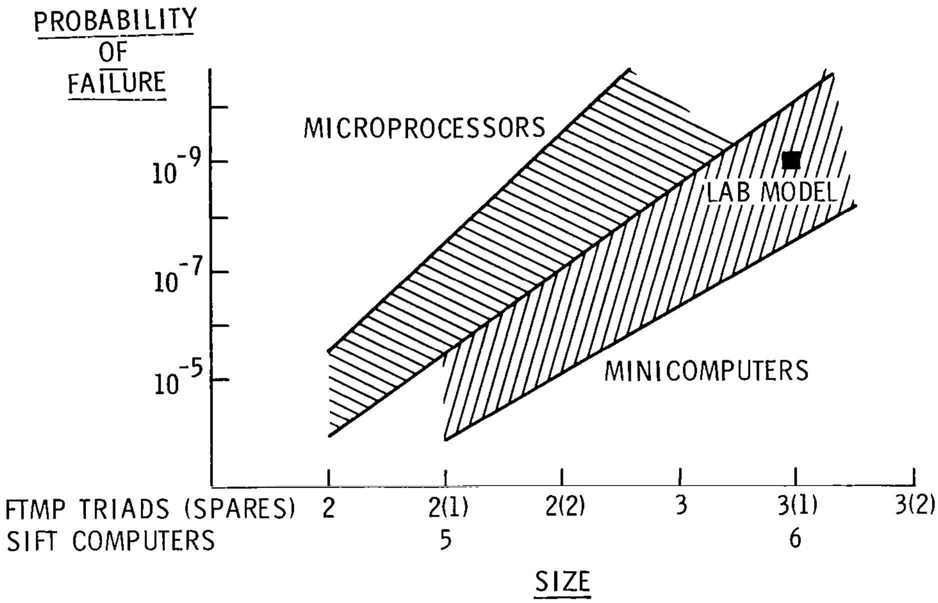
MULTIPROCESSOR WITH TRIPLE REDUNDANCY AND SPARES



LABORATORY MODEL CHARACTERISTICS



LABORATORY MODEL CHARACTERISTICS



APPENDIX K

SPECIAL-PURPOSE ARCHITECTURE: FEM

O. O. Storaasli

JAPAN PLANS FOR COMPUTER TECHNOLOGY

FIFTH-GENERATION COMPUTER DEVELOPMENT PROJECT:* "A PROJECT WHICH, WITH THE TARGET YEAR OF 1990, HAS THE AIM OF DEVELOPING TRULY WORLD LEADING COMPUTER SYSTEM TECHNOLOGY AND PROMOTING THE DEVELOPMENT OF JAPAN'S COMPUTER INDUSTRY THROUGH R&D INTO FIFTH-GENERATION MACHINES."

IMPACT AREAS

- INCREASE WORKER PRODUCTIVITY
- PRESERVE INTERNATIONAL COMPETITIVE CAPABILITY
- HELP SOLVE ENERGY AND RESOURCE PROBLEMS
- SUPPORT NEED OF AGING SOCIETY
- IMPROVE INFORMATION NEEDS FOR SOCIETY

R&D THEMES

HARDWARE DEVICES
ARCHITECTURE/HIGH PERFORMANCE PROCESSORS
FUNCTION DISTRIBUTION SYSTEMS
SYSTEM TECHNOLOGY
NETWORK ARCHITECTURE
OFFICE AUTOMATION
CAD/CAM/CAE
ARTIFICIAL INTELLIGENCE
SOFTWARE ENGINEERING
DATA BASE TECHNOLOGY
ROBOTICS
RELIABILITY/SECURITY

*INTERIM REPORT ON STUDY AND RESEARCH ON FIFTH-GENERATION COMPUTERS
JAPAN INFORMATION PROCESSING DEVELOPMENT CENTER-1980

ADVANCED COMPUTER METHODS
(RTOP 505-33-63)

OBJECTIVE:

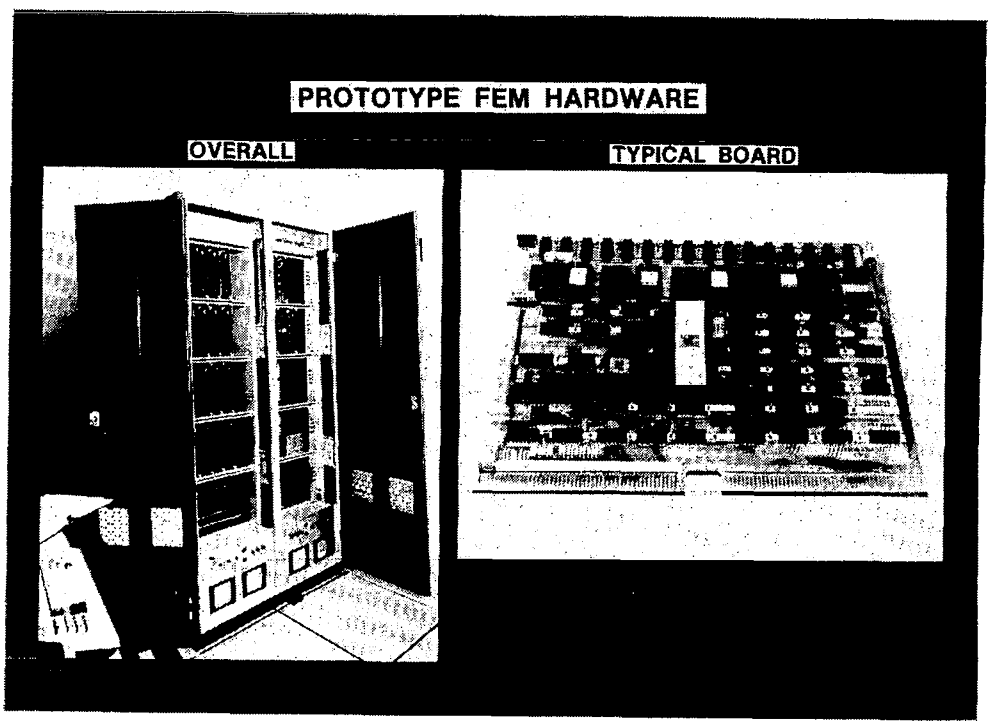
EXPLOITATION OF ADVANCES IN COMPUTER HARDWARE AND SOFTWARE TO IMPROVE THE EFFICIENCY OF STRUCTURAL CALCULATIONS

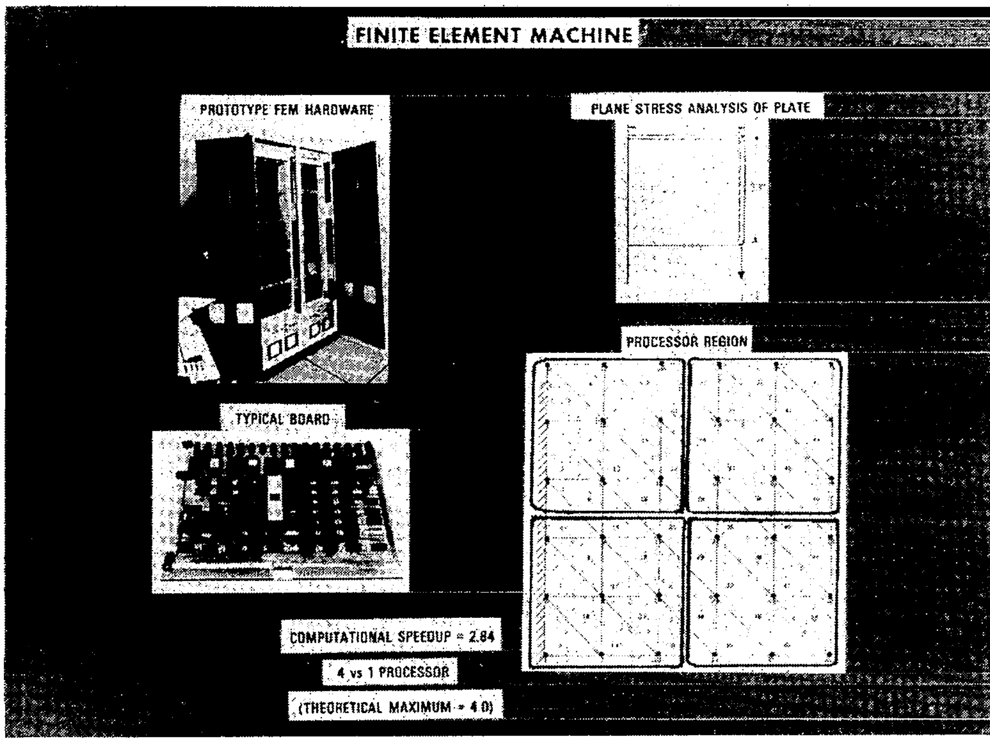
EXPECTED RESULTS:

- DEVELOP A PROTOTYPE FINITE ELEMENT COMPUTATIONAL DEVICE USING MICROPROCESSOR COMPONENTS WHICH IS CAPABLE OF REDUCING COMPUTATIONAL TIMES BY A FACTOR OF 10 BY END OF FY 1981
- (NEW) SIMULATE LARGE-SCALE FINITE ELEMENT MACHINE BY END OF FY 1983
- (NEW) ASSESS USEFULNESS OF MAN-IN-THE-LOOP METHODS FOR ENGINEERING ANALYSIS AND DESIGN
- (NEW) DEVELOP FINITE ELEMENT COMPUTATIONAL DEVICES USING MICROELECTRONICS BY FY 1985

PLANS

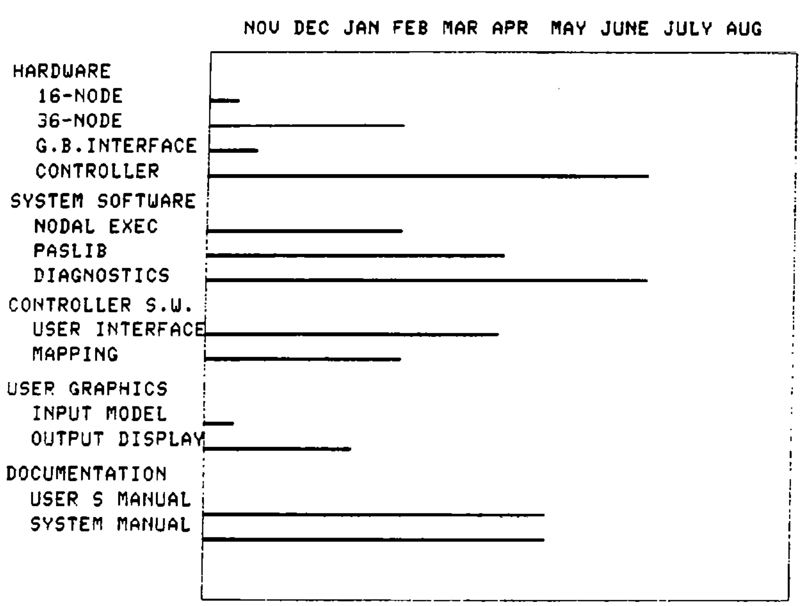
- COMPLETE 36-NODE FEM
- COMPLETE 1024-NODE FEM SIMULATION PROGRAM
- PERFORM BENCHMARK CALCULATIONS AND COMPARE WITH CONVENTIONAL SEQUENTIAL COMPUTERS
- EVALUATE OTHER SOLUTION ALGORITHMS AND FEM CONFIGURATIONS
- EXAMINE APPLICATIONS TO DYNAMICS AND NONLINEAR PROBLEMS
- JUNE 1982: REVIEW RESULTS; PLAN NEXT PHASE OF DEVELOPMENT (FY 84/85 NEW INITIATIVE)





OCTOBER 30, 1981

FINITE ELEMENT MACHINE
STATUS

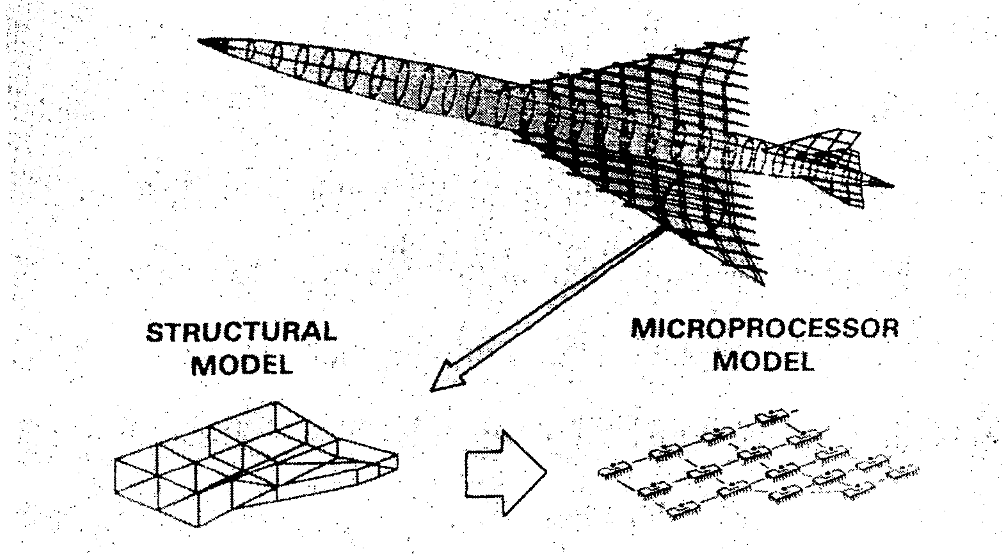


STATUS

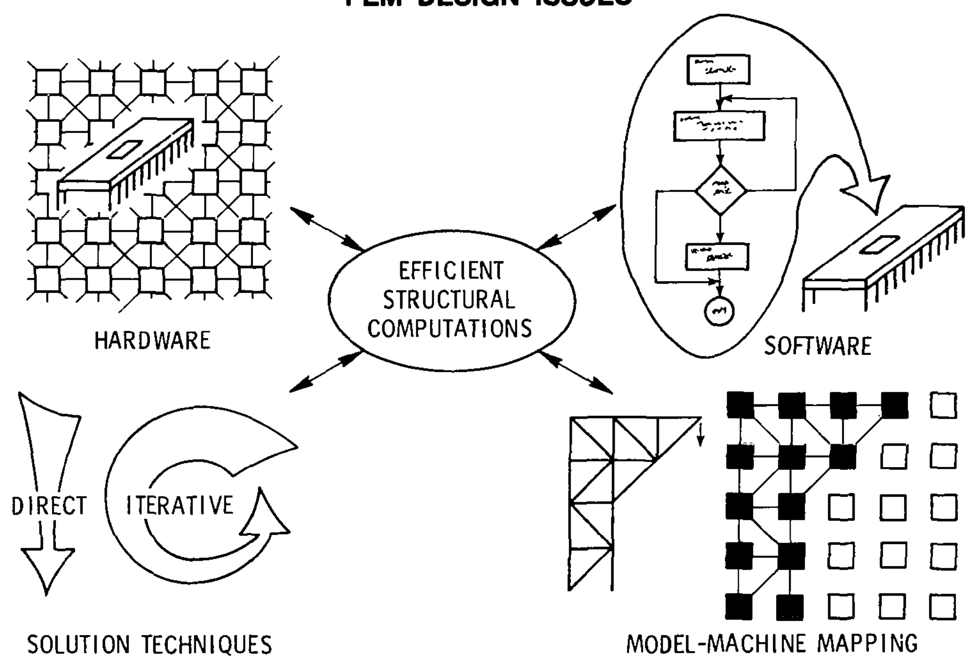
- FOUR-NODE SYSTEM OPERATIONAL
- EVALUATION OF FOUR SOLUTION ALGORITHMS FOR LINEAR STATIC SOLUTIONS IN PROGRESS
- 16-NODE SYSTEM IN ASSEMBLY (PLANNED COMPLETION AUG. 81)
- NEW SOLUTION ALGORITHMS BEING DEVELOPED TO TAKE ADVANTAGE OF PARALLEL ARCHITECTURE

[redacted]

NEW CONCEPT FOR COMPUTATIONAL EFFICIENCY



FEM DESIGN ISSUES



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7. Author(s) Susan J. Voigt, Editor		8. Performing Organization Report No. L-15418
9. Performing Organization Name and Address NASA Langley Research Center Hampton, VA 23665		10. Work Unit No.
		11. Contract or Grant No.
12. Sponsoring Agency Name and Address National Aeronautics and Space Administration Washington, D.C. 20546		13. Type of Report and Period Covered Conference Publication
		14. Sponsoring Agency Code

15. Supplementary Notes

16. Abstract

A workshop was held at Langley Research Center, November 2-5, 1981, to highlight ongoing computer science research at Langley and to identify additional areas of research based upon the computer user requirements. A panel discussion was held in each of nine application areas, and these are summarized in the proceedings. Slides presented by the invited speakers are also included.

A survey of scientific, business, data reduction, and microprocessor computer users helped identify areas of focus for the workshop. Several areas of computer science which are of most concern to the Langley computer users were identified during the workshop discussions. These include graphics, distributed processing, programmer support systems and tools, database management, and numerical methods.

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