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INTRODUCTION TO THE LARC CENTRAL
SCIENTIFIC COMPUTING COMPLEX
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Acknowledgement

CHAPTER 1. INTRODUCTION

This manual contains a brief description of the LaRC Central Scientific Computing Complex (CSCC), the procedures for accessing and using its various subsystems, and the services provided by the Analysis and Computation Division (ACD). More detailed information can be found in user documents and on-line documentation that are described in Chapter 8.

1.1 The Central Scientific Computing Complex

The CSCC is a centralized, scientific computing resource for the Langley Research Center. It consists of computers, electronic file storage devices, input/output devices, and associated equipment located in Buildings 1268, 1268A, and 1268B at the corner of Langley Boulevard and West Taylor Road. This hardware is accessed and interconnected through electronic communication networks and functions under the control of extensive software. There are a number of laboratories for specific applications.
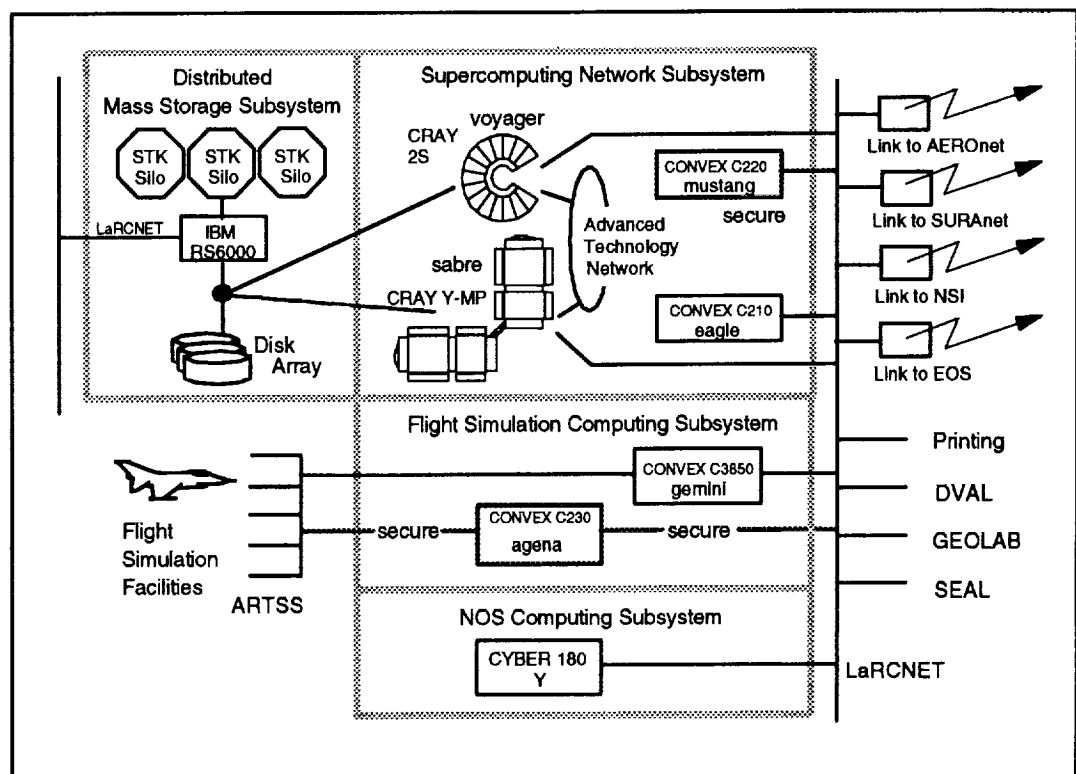
Figure 1. The Central Scientific Computing Complex

The principal services provided by the complex are:

- Large-scale computing (for such applications as computational fluid dynamics).
- Data storage and retrieval.
- Electronic communication within the Center and off site.
- Scientific visualization, animation, and image processing.
- Geometric modeling and grid generation.
- Flight-critical software development
- Real-time flight simulation involving pilots and/or flight hardware.

The Complex is divided into subsystems according to function. The "core" subsystems are outlined in Figure 1. They are the Supercomputing Network Subsystem (SNS), the NOS Computing Subsystem (NCS), the Distributed Mass Storage Subsystem (DMSS), and the Flight Simulation Computing Subsystem (FSCS). The SNS and NCS are discussed in Chapter 2, "Large-Scale Computing;" the DMSS is discussed in Chapter 3, "Distributed Mass Storage;" and the FSCS is discussed in Chapter 7, "Flight Simulation."

Electronic communication between the various components of the complex is provided by networks. The backbone of the SNS is a FDDI Advanced Technology Network, with access to mass storage via a High Performance Parallel Interface (HIPPI) switch. A centerwide network, called LaRCNET, provides access to the core subsystems, to special purpose facilities in the complex, to distributed computing facilities throughout the Center, and to outside networks. Data phone access is provided through the centerwide LaTS (telecommunications) terminal access system. These networks are discussed in Chapter 4.

Operational issues such as accounting, resource allocation, security, and standard output (printing, plotting, and graphics) are discussed in Chapter 5.

The CSCC includes three application laboratories; that is, areas containing work stations and specialized hardware/software facilities that are available to the researcher for specific purposes. These are the Data Visualization and Animation Laboratory (DVAL), Numerical Geometry Laboratory (GEOLAB), and Software Engineering and Ada Laboratory (SEAL). They are managed by ACD personnel who also provide assistance and consultation in their use. These laboratories are discussed in Chapter 6.

A major application of the CSCC is flight simulation. This is the use of high-speed computers to drive flight systems and displays in the simulation of the flight of aircraft-or spacecraft in real time. Flight simulation is discussed separately in Chapter 7.

Finally, documentation, training, and consultation services are outlined in Chapter 8.

The complex as a whole is operational at all times; however, various subsystems may be off-line from time to time for maintenance or upgrade. Scheduled shutdowns are announced through bulletins and electronic notices. Offices and user areas are accessible to NASA employees and contract personnel during prime shift; however, arrangements must be made in advance for access at any other time. Access to most core equipment areas is restricted to systems and maintenance personnel.

1.2 The Analysis and Computation Division

ACD is charged with the operation and development of the CSCC. The division (numbering about 110 LaRC employees), is organized into six branches which have the following responsibilities:

Branch	Responsibilities
Computer Management Branch	Access to and operation of the CSCC, data reduction, and archival storage.
Computer Systems Branch	System integration, operating systems, vendor provided hardware and software, and the design and development of computing system and mass storage enhancements.

Branch	Responsibilities
Computer Applications Branch	Supercomputing support, documentation and training, software libraries, symbolic computing, GEOLAB, and computational mathematics.
Flight Software and Graphics Branch	Development of software for flight projects (including SEAL), Scientific data visualization and animation (including DVAL), and contract analysis and programming support.
Communications and Network Systems Branch	Development and administration of data, voice, and video communication networks (LaRCNET, LaTS, and LaRCVIN); and interconnection to off-site networks.
Analysis and Simulation Branch	Development and integration of flight simulators, and simulation analysis and programming support.

1.3 Support Service Contracts

To assist ACD in running the CSCC there are three major support service contracts:

Scientific Computer Operations, Maintenance, and Communications (SCOMAC) Support

This contract, held by Computer Sciences Corporation, provides for operation and maintenance of equipment, development and maintenance of computer operating systems, development and maintenance of the LaRCNET, LaTS, and LaRCVIN communications networks, and support of selected distributed computing systems. The level of effort is of the order of 170 persons.

Computer Analysis and Programming Support (CAPSS)

This contract provides for applications program development and maintenance, graphics and flight software support, and computer user training. The level of effort is about 40 persons. This contract is held by Computer Sciences Corporation and is due for competitive renewal in January 1995.

Simulation, Communications, and Data Systems Support (SCADS)

This contract provides for analysis, programming, engineering, and maintenance services for the flight simulation facilities. The level of effort is about 45 persons. This contract is held by Unisys Corporation and is due for competitive renewal in February 1995.

1.4 Division Computing Managers

Each division or office which uses the CSCC has a person designated as the Division Computing Manager (DCM). This person keeps track of the computer accounts assigned to that division or office, and has the authority to add or delete users permitted to use the accounts. The DCM is also the person normally contacted by ACD on issues related to the use of the complex. A list of current DCMs is contained in the file ~acdcs/dcms on Eagle, You may also locate your DCM by calling the CSCC Operations Control Office (864 - 6562).

1.5 The Langley Computer User's Committee

The Langley Computer Users Committee (LCUC) functions as a forum for discussion of issues related to the use of the complex and as a means of influencing its operation and future development. The LCUC consists of representatives from all the user divisions across the Center. The committee meets monthly. Its functions and membership are set forth in Langley Management Instruction 1100.2. Users may participate in the standing subcommittees. A list of current members may be obtained from the Executive Secretary, currently Eric Everton, at extension 45778. Minutes of the LCUC meetings are contained in the notesfile, **lcuc**, on Eagle

CHAPTER 2. LARGE-SCALE COMPUTING

The powerful mainframe computers required for such large-scale applications as the computation of flow fields around aerospace vehicles are contained in the Supercomputing Network Subsystem (SNS). This subsystem is described in this Chapter. Also, the National Aerodynamic Simulator Facility which is accessible from LaRC; the NOS Computing Subsystem; and the HPPC project, currently under way at LaRC, are briefly described.

2.1 The Supercomputing Network Subsystem

A supercomputer is generally defined as one of the most powerful computers available at the current time. Very powerful computers are required to solve scientific and engineering problems involving multiple dimensions. Typical applications at Langley are computational fluid dynamics and continuum mechanics problems.
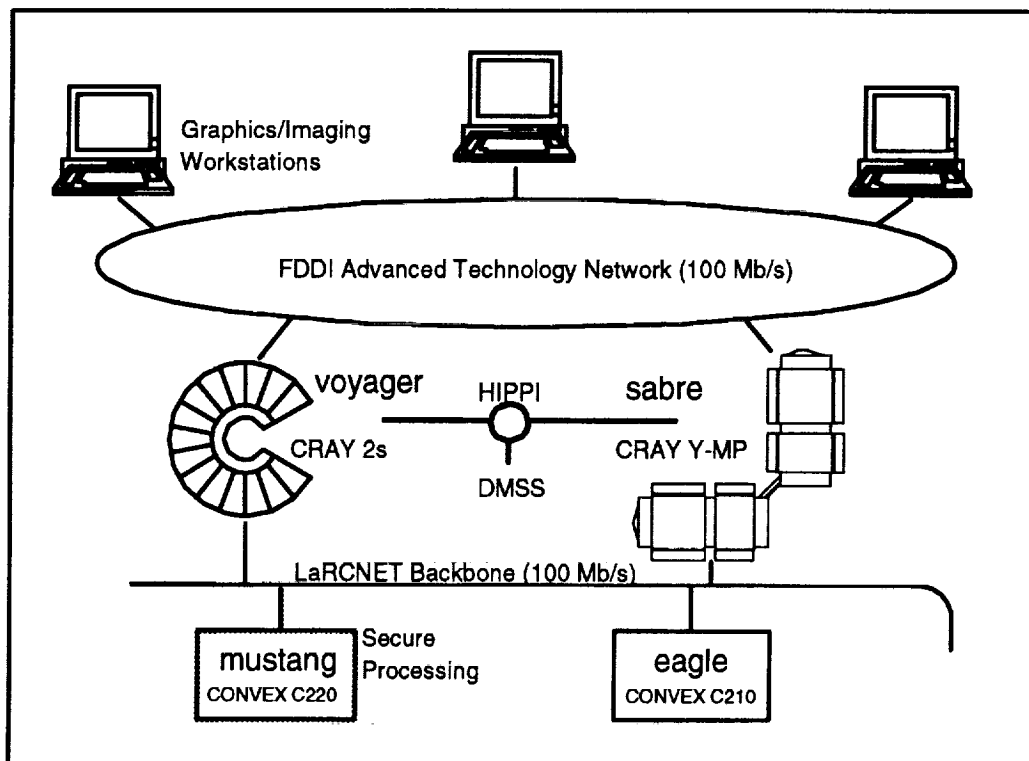
Figure 2. The Supercomputing Network Subsystem

The computers in the SNS were acquired as a consequence of a competitive procurement undertaken in 1987 which resulted in a contract with Cray Research Incorporated in August 1988. Starting with a CRAY 2, two CONVEX C2s, and a MASSTOR device under control of an IBM 4381, the SNS has evolved to its present configuration of a CRAY 2, a fully configured CRAY Y-MP, a CONVEX C220, and a CONVEX C210. The mass storage capability is now shared with other elements of the complex and is considered to be part of the separate Distributed Mass Storage Subsystem. The SNS configuration is shown schematically in Figure 2.

The computers in this subsystem are named after aircraft that have special significance in Langley's history of research and development. The CRAY-2 is called **Voyager** and the CRAY Y-MP is called **Sabre**. The two ancillary computers from Convex Computer Corporation, a C210 and a C220 are called **Eagle** and **Mustang** respectively.

From an application programmer's point of view the computers in the SNS are similar. **Voyager**, **Sabre**, **Eagle**, and **Mustang** use versions of UNIX as an operating system and have FORTRAN compilers that produce vectorized code. The major differences are speed, memory capacity, and the ability to multitask on **Voyager** and **Sabre**.

The CRAY-2s (Voyager)

Hardware:

The full designation of this computer is a CRAY-2s/4-128. The 4 after the slash designates four identical "background" processors and the 128 designates 128 million words of shared memory. In addition to the background processors there is a "foreground" processor for overall control. All processors operate with a cycle period of 4.1 nanoseconds (A nanosecond is one billionth of a second). The "s" after the first 2 in the designation of this machine indicates that the memory is "Static Random Access Memory" (SRAM) meaning that it does not require a refresh cycle to restore the contents of a memory cell after it has been read. This contrasts with "Dynamic Random Access Memory" (DRAM), which requires a refresh cycle. The background processors perform both scalar and vector operations and each has a local memory of 16,384 words. A word consists of 64 data bits. **Voyager** is configured with 76 Gbytes of auxiliary storage on 2 DS-4R disk drives.

Each of the background processors has eight, 64 word (64 bits per word) vector registers, eight scalar, and eight address registers. Each processor has a single port to the common memory, through which vectors are transferred to the vector registers. Single Error Correction, Double Error Detection (SECDED) logic is used in the retrieval of data from the common memory; thus, there are 72 bits stored in the memory for each word -- 64 data bits and 8 SECDED bits. There are four vector functional units, three scalar functional units, and two address functional units. It is possible for these functional units to be operating concurrently on independent operands. Chaining (the streaming of the output of one vector functional unit directly into the input of another) is not supported on **Voyager** as it is on **Sabre** and the CONVEX computers. A set of eight semaphore flags allows for communication and synchronization between the background processors. One flag is assigned to each background CPU and one is assigned to each currently active process.

The local memory is used to hold scalar operands during a period of computation. It can also be used for the temporary storage of vector operands when they are used more than once during a computation in the vector registers.

The foreground processor controls and monitors system operations and includes high-speed synchronous communications channels which interconnect the background processors, the foreground processor, disk, High Speed External (HSX) channel controllers, and external I/O controllers. The foreground processor also responds to background processor requests and sequences channel communications signals.

The entire mainframe, which includes all memory, computer logic, and DC power supplies, is integrated into a compact package consisting of 14 vertical columns, each four foot high, arranged in a 300 degree arc. Cooling is provided by a non corrosive liquid which circulates within the mainframe in direct contact with the integrated circuit packages.

Software:

The operating system used by **Voyager** is called UNICOS. It is derived from the AT&T System V UNIX, but has been enhanced for use on a supercomputer. The current version is UNICOS 7.0.5. There is a batch processing facility called NQS (Network Queuing System). Multitasking (the running of different segments of a single code on different processors) is supported through a facility called Autotasking. The FORTRAN compiler automatically vectorizes source code: it recognizes loops that address uniformly stored data and compiles vector instructions to execute them. Multitasking from within FORTRAN is supported via compiler directives and a multitasking library. There are also a PASCAL and a C compiler. UNICOS supports the standard UNIX editors vi, emacs,ex, and ed, and a symbolic debugging system called cdbx. Explicit Archival Retrieval and Storage (EARS) software is supported.

Mathematical libraries include IMSL, LIBSCI (including LINPACK, EISPACK, and other routines optimized for the CRAY-2), BCSLIB, BCSLIB-EXT, and LARCLIB. Graphics packages include Precision Visuals Graphics software (DI-3000, etc.), the NCAR package, RM/RMT (Raster Metafile), RASLIB, PLOT3D, and interface to GAS (which runs on an IRIS workstation). The X Window version XIIR5 graphical user interface system is supported. Also, debugging utilities, and code management utilities are provided. UNICOS supports the Transmission Control Protocol/Internet Protocol (TCP/IP) utilities.

Performance:

Each of the four background processors is capable of performing floating-point operations at a rate in excess of 488 Mflops (Million Floating Point Operations per Second), although observed rates are typically less than 200 Mflops. The rate achieved in a program is application dependent, but increases as vector lengths (the number of iterations in the innermost DO loop) increase, when the elements of the vector are contiguous in memory, when there is a high ratio of computation to memory access, and when multiple functional units (such as the addition and multiplication units) can be executing simultaneously. Increased execution speed for a particular application can also be realized by multitasking, i. e., assigning segments of code to different processors.

The CRAY Y-MP (Sabre)

Hardware:

The full designation of this computer is a CRAY Y-MP8E/8256/512SSD. The first 8 indicates that the chassis can hold up to 8 processors, the leading 8 after the first slash indicates that it actually holds 8 processors, and the 256 indicates a central memory of 256 million words. The 512SSD indicates that the computer is configured with a 512 million word solid-state storage device.

The clock period for **Sabre** is 6 nanoseconds, compared to 4 nanoseconds for **Voyager**; however, greater parallelism in its architecture gives each processor in **Sabre** approximately 4/3 the processing power of a **Voyager** processor.

Each word in the central memory contains 72 bits: 64 bits for data and 8 bits for SECDED logic. The memory is organized into banks for parallel access and there are 4 access ports to each processor. There is no dedicated memory for the individual processors; however, each processor in the Y-MP contains 72 64-bit scalar registers, 8 64-element x 64-bit vector registers, and 72 32-bit address registers. It also contains 4 scalar functional units, 7 vector functional units, and 2 address functional units, all of which can operate independently and concurrently. Chaining is possible so that the output of one functional unit can stream into the input of another.

The integrated Input/Output Subsystem (IOS) provides high-speed data transmission between the central memory of the Y-MP8E mainframe and peripheral devices. The IOS can have from one to eight Input/Output Clusters (IOC's) but no more than one per CPU. On **Sabre**, the IOS has two IOC's. Each IOC has four integrated Input/Output Processors (IOP) that provide connections (channels) for up to 16 peripheral devices. These IOP's can be configured to connect either a low-speed device, such as an operator's workstation, or a high-speed device, such as a disk drive, to the Y-MP. Since each channel has private buffer memory, the IOS can run at full channel speed to the mainframe while the buffer is being filled or emptied by the external peripheral device. **Sabre** is configured with 117 Gbytes of auxiliary storage on 2 DS-4R and 2 DS-41 disk drives.

Software:

UNICOS (currently UNICOS 7.0.5) is also the operating system for **Sabre**. All compilers, editors, debug aids, other software tools, and libraries, given above for **Voyager**, are also available on **Sabre** with the exception of DI3000 and the common graphics library (CGL). EARS software is supported.

Performance:

The peak performance of the Y-MP is over 325 Mflops per processor, which is less than the peak per processor for **Voyager**; but, as noted above, its observed performance typically exceeds that of **Voyager** by 30%. This is due, primarily, to its greater memory bandwidth, ability to chain, and smaller penalty for unfavorable vector strides. The full **Sabre** system realizes greater than 2.5 times the computational capacity of the full **Voyager** system.

The CONVEX Computers (Eagle and Mustang)

The CONVEX-C210, **Eagle**, and C220, **Mustang**, are envisioned to be used to support applications on **Voyager** and **Sabre** through program development and checkout, debugging, and pre- and post-processing. Also, **Mustang** can be operated in a secure mode for classified processing. The following subsections describe these machines.

Hardware:

The CONVEX-C220 has two processors and the C210 has one. They are register to register vector processing computers with a virtual memory architecture. The clock period (minor cycle time) is 40 nanoseconds. The word length is 64 bits. **Eagle** has 256 Mbytes (32 million 64 bit or 64 million 32 bit words) of central memory, while **Mustang** has 512 Mbytes (64 million 64 bit words or 128 million 32 bit words) of central memory. The central memory of both machines is interleaved in 16 memory banks with a virtual address space of 4 Gbytes. Pages are 4096 bytes each.

The CPUs are similar in many ways to those of the CRAY supercomputers. They include 8 address, 8 scalar, and 8 vector registers. Each vector register holds up to 128 64-bit words. Vectors are transferred to and from the memory through a single port between the registers and the memory. There are two Vector Processing Unit Boards which process alternate elements from vector operands to provide a result per minor cycle when doing either a vector add/subtract (from the add/logical functional unit) or a vector multiply (from the multiply/divide/square-root functional unit). It is possible for both functional units to operate concurrently on independent operands or for chaining to occur between them. There is also a scalar arithmetic unit to do non-vector arithmetic and logical operations. That unit can run concurrently with the vector unit when no conflict exists.

Eagle is configured with 9 DKD-308 drives (about 8.5 Gbytes of storage) and **Mustang** is configured with 2 DKD 308 disk drives (about 2 Gbytes of storage) plus 7 DKD-314 removable disk drives. There are two nine-track, 6,250 bpi tape drives associated with each of the two computers.

Software:

CONVEX's UNIX-based operating system is an enhanced version of the University of California, Berkley UNIX 4.2 operating system that supports a demand paging virtual memory. The current version is CONVEX UNIX version 9.1 It supports all of the traditional features of UNIX. Batch use of **Mustang** and **Eagle** is implemented with the CXbatch utility. The FORTRAN compiler is standard FORTRAN-77 with some extensions. The compiler performs automatic vectorization on user source codes. There is no explicit vector syntax. Also available are UNIX editors, a C compiler, several mathematics libraries, including IMSL version 1.1, Mathematica (**mustang** only), graphics packages, and debugging utilities. EARS software is supported.

CXwindows V2.1 is the CONVEX supported version of the X-Window System Version 11 Release 4 (X11R4). It includes the X Protocol library, the X Toolkit library, the MIT Athena widget set, common MIT X clients , CONVEX-specific X clients, the OSF/Motif Window Manager, the OSF/Motif User Interface Language, and the OSF/Motif widget set. It is available on **Eagle** and **Mustang**.

Performance:

Each processor of the CONVEX-C200 series computers can provide one result per cycle from each of the two functional units in vector mode. This translates into a peak speed of 25 MFlops per unit or 50 MFlops when both units are simultaneously involved in independent operations or chaining (the output of one unit being fed directly into the input of the other). These computers support both 64 and 32 bit arithmetic, but there is no significant difference in speed between 32-bit and 64-bit modes.

Benchmark results indicate that the C210 has about 10% of the computing power of a single CRAY-2s processor when comparing kernel calculations which contain a mix of long and short vectors, non-unit-stride vectors and some scalar operations. Comparisons with highly vectorized codes would probably be less favorable. It is a good short-vector computer, achieving nearly the same performance on short-vector calculations (22 MFlops with average vector length of 80) as on long-vector calculations (23 MFlops with average vector length 5000). Performance using vectors of non-unit stride is not degraded, provided that the stride does not contain a factor of 16, 8, 4, or 2. The worst case, a stride of 16, causes memory load/store time to increase by a factor of 9. The scalar speed of the C210 has been measured at 3 MFlops.

SNS Networks

Access to the CRAY computers is provided by two Fiber Distributed Data Interface (FDDI) networks. The first is referred to as the Advanced Technology Network (ATN). A number of high performance graphics and image processing workstations are attached to the ATN to provide for interactive communication with the CRAYs at up to 100 Mb/sec. The second is the backbone of the Centerwide LaRCNET network to which many more slower workstations and a variety of peripheral devices are connected. The transfer of files between the CRAYs and the DMSS is accomplished via High Performance Parallel Interface (HPPI) communications. A more detailed description of these networks is given in Chapter 4.

2.2 The National Aerodynamic Simulator Facility

In addition to the SNS computers, Langley researchers have access to the National Aerodynamic Simulator (NAS) facility at the Ames Research Center, Mountain View, California. The primary resource is a 16

processor CRAY C-90 (**vonneumann**) which has 1 Gwds of central memory. It also has a 1024 Mwd SSD. Each C-90 processor is rated at 2.2 times a CRAY Y-MP processor.

A user is allocated time on NAS through the submittal and approval of a project proposal. There is normally a call in November for proposals for the next NAS Operational Year which begins in March. The LaRC NAS Steering Committee, under the direction of the Chief Scientist, evaluates the proposals and distributes LaRC's allotted hours to the approved projects. Langley projects receive about 20% of the NAS resources. Project application forms and further information can be obtained by contacting Jay Lambiotte at ext. 45794.

2.3 The NOS Computing Subsystem

The NOS Computing Subsystem (NCS) consists of a single Control Data CYBER 180/860 class computer, designated by the alphabetic letter Y. This subsystem is what remains of the primary complex of scientific computers at LaRC from the mid 1960's through the mid 1980's. The NCS evolved from CDC 6000 series computers which were installed at Langley in 1965 as the result of a competitive procurement to provide a uniform system of digital computers to service analytical, data reduction, and real-time flight simulation applications. At one time there were seven Control Data Computers in this subsystem, two of which were used primarily for real-time flight simulation. The term, NOS, refers to the Network Operating System, which was introduced in 1975 to provide interactive access from remote terminals to any of the computers and to share common file storage facilities.

The NOS computing subsystem is being maintained to service those applications that were developed to run on the Control Data computers and which have not yet been transitioned to the SNS subsystem. There are no plans to upgrade the NOS subsystem and it is anticipated that it will be retired by the end of 1994.

The Y computer is accessible through LaTS. Its resource designation is the single letter Y. Access is also available through LaRCNET (its host name is cyby).

2.4 The HPCC Program

The High Performance Computing and Communications (HPCC) Program is a national initiative for keeping the United States competitive in supercomputer technology. Through negotiations with NASA Headquarters Office of Aeronautics, Exploration, and Technology, the LaRC is designated as a site for a computational testbed for experimenting with Computational AeroSciences (CAS) problems on a massively parallel computer. In March 1993, LaRC took delivery of an Intel Corporation Paragon computer with 72 computational nodes, each with a 75 Mflop peak rate and 32 MBytes of local memory. The total system has a capacity of 5.5 Gflops peak computational rate and 2 GBytes of memory. It has 38 GBytes of disk storage, 2 each of HIPPI, FDDI, and ethernet controllers, and runs the OSF/1 UNIX operating system on each node.

In the initial stages at least, ACD and a relatively few LaRC researchers will be working to understand how to use the Paragon. It is not be a "production" computer, and thus should not be considered to be part of the CSCC; however, eventually it or its successors may achieve that status. Access to the Paragon is available on a limited basis.

CHAPTER 3. MASS STORAGE

Because the memories of computers have a limited capacity, auxiliary storage devices are required to hold source code, executable programs, and data in an electronically accessible manner for an indefinite period of time. These include solid state storage devices (SSD), magnetic and optical disks, and magnetic tape drives. The cost of these devices is relatively high; however, the cost per bit of storage tends to drop as the overall capacity of the device increases. Furthermore, if a computer is connected to a network, it may share remotely located "mass storage" systems with other computers. Such systems are typically managed by computers, called "file servers." Because of the large number of computers at the LaRC and the size of the files associated with many of the applications, particularly those that run on the supercomputers, an economy of scale can be achieved with large, centrally located storage devices. The system of file servers, storage devices and associated high speed communications networks used for this purpose at LaRC is referred to as the Distributed Mass Storage Subsystem (DMSS). Figure 3 is a schematic diagram of the DMSS.
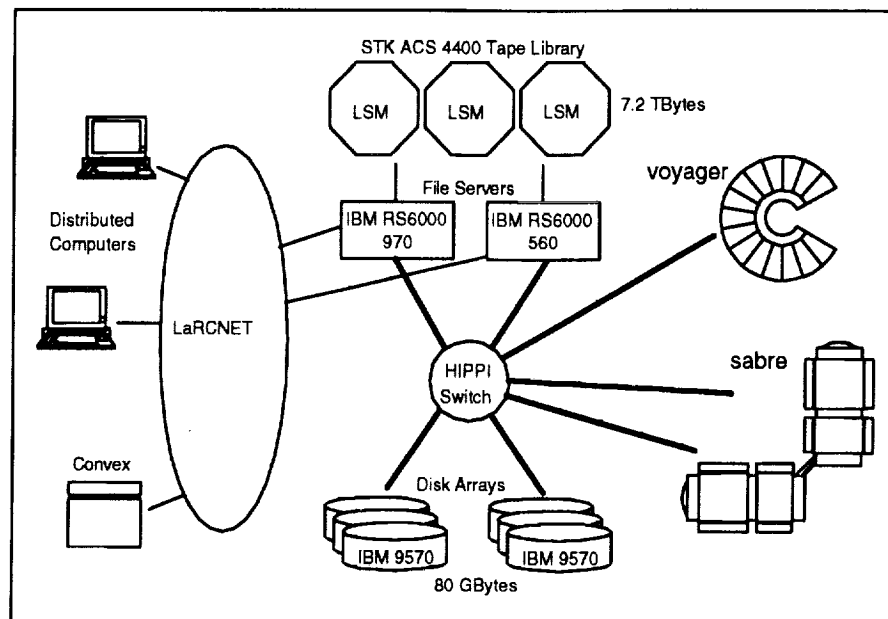
Figure 3. The Distributed Mass Storage Subsystem

The primary components of the DMSS are two IBM 9570 disk arrays, an IBM RS6000 Model 970 workstation, an IBM RS6000 Model 560 workstation, and a Storage Technology Corporation (STK) ACS (Automatic Cartridge System) 4400 Tape Library. The two workstations function as primary and back-up file servers, the disk arrays provide rapid access storage, and the tape library provides large capacity archival storage. Data transfer between the file servers and disk arrays, and to and from the two supercomputers, Voyager and Sabre, is carried by High Performance Parallel Interface (HIPPI) channels, indicated by bold lines in Figure 3. There are two HIPPI channels to Sabre. A Network Systems Corporation (NSC) PS32 HPPI switch makes the appropriate connections for requested file transfers. The tape library is connected to the file servers via block mux interfaces. Data transfer to and from distributed computers and workstations is accomplished via FDDI or ethernet connections to LaRCNET. Not shown in Figure 3. are ethernet connections between the file server and the other components of the DMSS for control and relatively low speed data transfer.

3.1 Disk Arrays

Each of the two IBM 9570 disk arrays has a capacity of 40 Gbytes (billion bytes). They comprise the primary storage because the access time is much shorter and the file transfer rate is greater for the disk arrays than it is for the tape library. The sustained transfer rate is nominally 50 Mbyte per second. On the other hand, the capacity of the disk arrays is much less than that of the tape library so that it is necessary to periodically move disk resident files to the tape library to make room for new files. The selection of files to be moved is made by the file servers based upon system parameter thresholds. When a file in the tape library is to be retrieved , it is moved to the disk array before being transferred to the requesting computer.

The disk arrays use the Intelligent Peripheral Interface (IPI3) protocol. IPI3 commands may be submitted to the disk arrays via either the HIPPI interface or the ethernet interface. Data can be directed to flow through either interface.

The disk arrays support the Redundant Array of Inexpensive Disks (RAID), level 3 and 5, in order to provide a high level of reliability. Should one of the disks in the array fail, all data is still available, with missing data reconstructed from the parity disk. The failed disk can be replaced while the system is on-line.

3.2 Workstations

Each of the two IBM RS6000 workstations has 128 Mbytes of memory and 3.5 Gbytes of local disk. The difference between the two is that the Model 970 is approximately twice as fast as the Model 560 and has two 80Mbyte /sec I/O channels compared to one 40Mbyte/sec I/O channel for the Model 560. They perform the function of file access control of the mass storage system, initiate file transfers between the supercomputers and disk arrays, perform file transfers to and from distributed computers, and manage the staging of files between the disk arrays and tape library. The Model 970 is the primary file server. The Model 560 provides additional transfer capacity and takes over should the 970 fail.

The software package used by the workstations for managing the DMSS is a modification by the National Storage Laboratory (NSL) of Unitree, a product of Open Vision. This software provides support for HIPPI attached disk arrays and multiple dynamic storage hierarchies. Unitree provides FTP and NFS interfaces to the file system.

3.3 Tape Library

The tape library consists of three Library Storage Modules (LSM), each in the form of a 12 sided regular polygon, and a SUN workstation controller (not shown in Figure 3.) Each LSM contains approximately 6000 standard IBM 3480 tape cartridges located in cells or slots on the inside periphery. When there is a request for a particular tape, a robotics arm, mounted on the vertical axis, picks the tape and places it in one of 16 read/write transports interfaced to the DMSS file servers. When processing is complete, the tape is removed from the read/write transport and placed back into a cell. The maximum access time to data is 60 seconds. Data transfer occurs at a rate of 2.8 Mbytes/sec. Currently, each cartridge can hold 200 Mbytes of data; thus, the capacity of each LSM is 1.2 Tbytes (trillion bytes) and the total capacity of the tape library is 3.6 Tbytes. An upgrade of the tape drives is scheduled for the fall of 1993, which will double the density of recording, thereby increasing the total capacity to 7.2 Tbytes.

3.4 Explicit Archival and Retrieval System

The DMSS is a file based system that uses the UNIX directory structure. An extension to the usual UNIX commands is used to access and manipulate files in the DMSS. These are referred to as Explicit Archival and Retrieval System (EARS) commands and include, as examples, *masput, masget, masrm, masls,*

masmkdir, masmv, maschmod, maschgrp, masrmdir, and *maspwd.* They perform the same function as the UNIX command that follows the *mas,* except with respect to the mass storage system instead of the computer's local file space. For example, the command

> *masls*

will produce a list of the files in the user's home directory on DMSS.

The implementation of EARS differs slightly between the computers that use the LaRCNET connection and the supercomputers that are connected to the DMSS via the HIPPI channels. Those computers using LaRCNET require a set of scripts to implement the EARS commands through use of the usual UNIX commands; whereas the supercomputers have modifications made to the UNIX kernel to implement the direct movement of files over the HIPPI channels. Special validation is required for all users of the DMSS.

CHAPTER 4. NETWORKS

Within any computing environment a critical requirement is for electronic communication among computers, storage devices, workstations, and other equipment. This communication takes the form of the transfer of files, which may be as small as a brief command or message or as large as all the data required for a flow field definition about an aircraft. The design of a network to carry these communications must take into account the number of connected devices and the speed at which they can transmit and receive information. The network architecture at LaRC is illustrated in Figure 4.
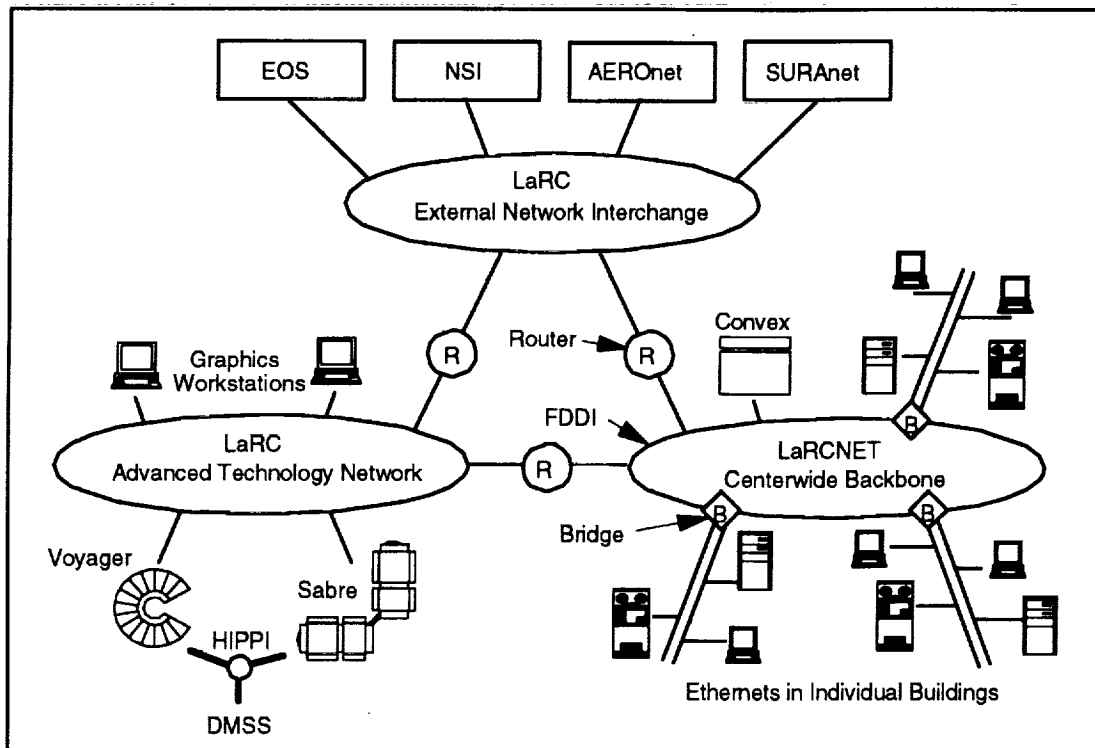
Figure 4. LaRC Computing Network Architecture

4.1 HIPPI Network

As discussed in Chapter 3, the supercomputers access each other and mass storage devices via the High Performance Parallel Interface (HIPPI) network. This network has a star topology with a HIPPI switch at the center of the star. As the name implies, HIPPI is a multi-channel cable that carries 64 bits in parallel, one bit per channel. It operates at the rate of 800 Mbps; however, it is limited in range and requires special interfaces to the supercomputers and other devices. Also, in contrast to the FDDI networks discussed below, complete files are transmitted at one time. Once a connection has been made between two machines, that path remains busy and locked out from other communications until the transmission is complete. The HIPPI network is shown schematically in the lower left corner of Figure 4.

4.2 LaRCNET

LaRCNET is the name given to the Local Area Network (LAN) which enables communication among computers distributed throughout the Langley Research Center campus. It consists of a combination of

Fiber Distributed Data Interface (FDDI) "ring" and Ethernet "bus" networks and uses standard packet switching protocols to permit multiple simultaneous transmissions to share common communication paths.

FDDI Rings

Fiber optic technology has been used for some time for high speed electronic communication over relatively long distances (of the order of a few miles). This technology is embodied in the FDDI standard that provides for file transfer at rates of 100 Mbps.

FDDI networks have a "ring" topology and operate under a token-passing paradigm. Briefly, a series of "nodes," consisting of computers, high-performance work stations, and "bridges" to other networks, are interconnected in a ring by a fiber optic cable. Signals called tokens are transmitted continuously around the ring. When a node needs to send a file to another node, the file is first broken up into packets with maximum size 4470 bytes. Each packet includes the destination address and information describing the packet. The next token that arrives at the node is removed and the first packet is substituted. As the packet passes each node on the ring, the address is checked for a match. It is merely sent on to the next node if there is no match. When the packet arrives at the destination node, it is copied into a buffer and a bit is set to indicate receipt. Finally, when the packet reaches the originating node, having traversed the entire ring, the packet is removed and replaced with the token signal. The process is repeated until the complete file has been sent.

There are three FDDI "rings" currently in operation at LaRC. One of them, the Advanced Technology Network (ATN), shown to the left of Figure 4, connects high performance graphic and image processing workstations directly to the supercomputers, thereby permitting the transfer of data sets between workstations and supercomputers at the 100 Mbps rate. A second FDDI ring, shown at the top, center of Figure 4, takes care of the interface between LaRCNET and outside networks. Finally, an FDDI ring, shown to the right of Figure 4, forms the backbone of a centerwide collection of local Ethernets. The nodes on this ring are bridges that each interface to one or more ethernet segments serving distributed mainframes, workstations, personal computers, and other devices. Over 90 buildings are serviced in this manner.

Ethernet Buses

Ethernets are coax or twisted-pair cables in a "bus" configuration. They operate at 10 Mbps. For coax connection, computers, PC's, bridges, and other devices are attached via clamp-on connectors. For twisted-pair connection, computers are attached via a standard telephone cable to the bottom jack on the telephone wall plate. When a device prepares to transmit a file of information, software breaks the file into packets of less than 1,514 bytes, adds information, including destination address, and stages the packets to internal buffers. When the Ethernet is quiescent, it transmits the first packet. If there is a conflict with a transmission initiated by another device in the short period before either has sensed the activity of the other, the transmission is terminated and each tries again after a different, random waiting period. Each device on the Ethernet examines the header of every packet and reads those with its address into a buffer. After successfully transmitting the first packet, the sending device continues with the rest of the file. Software in the receiving device assembles the packets from the buffers and the resulting file is stored. Ethernet is limited to a length of about 2 km. because of timing constraints for longer distances.

Bridges and Routers

An Ethernet/FDDI bridge ignores all messages between devices on the same Ethernet, retaining only packets addressed to an external destination. These it sends out on the FDDI ring. In the other direction, it

picks packets off the ring that are addressed to devices on its local network and transmits those packets over the Ethernet.

Routers are similar to bridges but permit more monitoring and control of traffic. At LaRC, routers are used to interface among FDDI rings and to the outside world.

Protocols

The format of information packets transmitted and received in the manner indicated above, including addresses and information on how to assemble the packets into files, is governed by what is called the transmission protocol. The generation and interpretation of packets is performed by software that forms part of the operating system of the communicating devices.

There are two, distinctly different forms of electronic communication in an environment such as exists at Langley. First, there is the transfer of files, be they text files, source programs, object programs, or numerical data. Here, the volume of data may be great, requiring high transmission speed in order to accomplish the transfer in a reasonable time period. Second, there is the interactive communication between the human and the computer. This involves "logging into" a computer and establishing a dialog with its operating system. In this case the volume of information exchange is relatively low (as low as a single keystroke) but the time criticality is high. The transmission protocol handles both kinds of communication.

The LaRCNET FDDI bridges and routers support both DECnet, and TCP/IP protocols. DECnet is used by the VMS operating system of DEC computers (There are some 200 distributed DEC VAX computers at the center, most of which use VMS). The most recent, and now the defacto industry standard, is the Department of Defense TCP/IP (for Transmission Control Protocol/Internet Protocol) which is used by the UNIX operating system (and others including VMS, PC-DOS, and Apple System 617). Control Data provides CDCNET which is an implementation of the TCP/IP protocol under NOS.

Access

It is possible to access LaRCNET via a computer, a terminal, or a workstation. It is strongly recommended that acquired systems support TCP/IP. Of the smaller systems, a SUN workstation, an IBM PC, or Apple Macintosh computer is suitable.

The SUN family of workstations comes with the necessary hardware for Ethernet connection and operates under UNIX, which includes TCP/IP.

For the IBM personal computer family and its clones, ACD will provide the hardware interface such as the 3-COM 503 board, which fits in an expansion slot. ACD will also provide TCP/IP software under a site license from FTP Software, Inc.

For the Apple Macintosh series of computers, the preferred connection to LaRCNET is via direct connection, for which ACD will provide the appropriate hardware and software.

The user must decide on and register a host name for his or her computer on LaRCNET. The user's Division/Office Computer Manager (DCM) should be able to assist in this. ACD maintains a list of all host names on LaRCNET to ensure uniqueness. To request connection to LaRC, or for further information, contact D. Edward Phillips, LaRCNET Administrator, at 864-6553.

Login and File Transfer over LaRCNET using TCP/IP

There are a number of different commands for effecting communication over LaRCNET, depending upon the protocol, implementing software, and nature of the transmission desired. You should refer to the documentation for your particular software package (e.g. PC/TCP User's Guide from FTP Software, Inc.) The following illustrates the use of telnet and ftp, two of the most commonly used TCP/IP commands:

Remote login to any accessible computer on LaRCNET (called a host computer) is accomplished by typing at the system prompt:

telnet *hostname*

where *hostname* is the name of the host computer; for example,

telnet eagle

will signal the CONVEX-C210, eagle, that you wish to login. A message concerning the TCP/IP software will appear followed by

Trying...Open

CONVEX UNIX, RELEASE V9.1 (eagle)

Press the carriage return. The host computer will respond with a login prompt followed by a password prompt (see Chapter 5, Section 5.3). The standard procedure for logout is to type (Ctrl-D).

In a similar fashion, to transfer a file to or from a remote computer, type

ftp *hostname*

In this case you will be prompted for login name and password (unless you have a .netrc file with the proper validation information). Under ftp, you will not be able to execute most UNIX commands on the host computer; however, you can change directories and list the contents of directories. To transfer a file from your computer to the host computer, type

put *localfilename remotefilename.*

To transfer a file from the host computer to your computer, type

get *remotefilename localfilename.*

CSCC Computers on LaRCNET

The host names of the principal computers in the Central Scientific Computing Complex that are connected to LaRCNET are shown in Fig. 5. Not shown are personal computers and workstations that are used for systems development by ACD personnel.
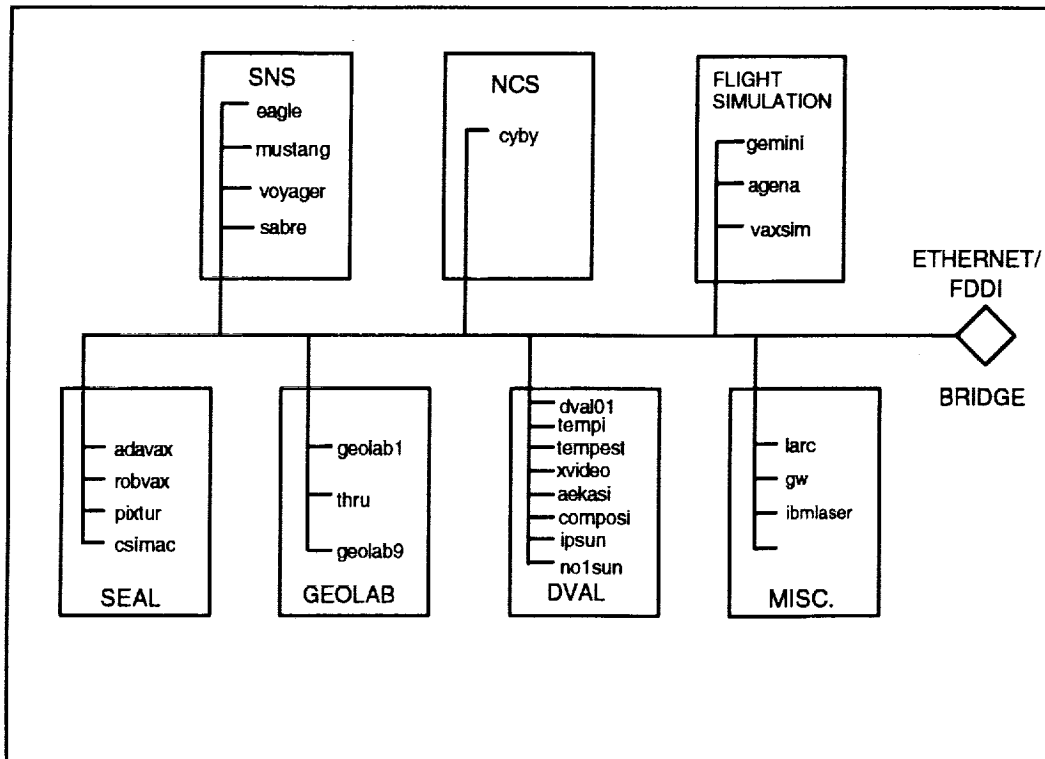
Figure 5. CSCC Computers on LaRCNET

Access to External Networks

The FDDI ring depicted at the top center of Figure 4. provides electronic communication to external networks. Currently there are four external networks that are accessed via routers and dedicated telephone lines. A T1 telephone line carries information at a rate of 1.5 Mbps.

Four T1 lines connect to the NAS facility at the Ames Research Center, Moffet Field, CA. The NAS network is referred to as AEROnet and permits login to NAS computers.

A single T1 line connects to the NASA Science Internet (NSI) network, via the Goddard Space Flight Center. This provides access to the institutional computers at Ames and also to NSI/DECnet, which is the DEC computer network.

A single T1 line is used to connect to a node on the Southeastern Universities Research Association network (SURAnet) located in Norfolk, VA. SURAnet provides access to many southeastern universities as well as NSFNET (National Science Foundation), MILNET (DOD), and INTERNET.

Finally a dedicated 168 Kbs telephone circuit is used to connect to the Earth Observing System (EOS) Data and Information Service Version 0 network.

In order to maintain uniqueness of name beyond the domain of the center, the host name is extended to form a domain host name, i.e., **eagle.larc.nasa.gov**. Domain name servers, running on two CSCC computers, provide a directory service for obtaining network addresses of computers on LaRCNET and outside networks.

4.3 The LaTS Terminal Access System

This refers to the data communications subsystem of the centerwide IBM/ROLM telecommunications system, a 9751 CBX which provides for both voice and data communications. Connection is possible via office telephone sets to many computers on the field, including most of the computers of the CSCC. IBM document 430025, entitled 9751 CBX User Guide, provides information on the use of this system. The key aspects for access to CSCC computers via LaTS are summarized here.

Physical Connection

To access LaTS from an office at LaRC, the terminal, personal computer, or other workstation must have a serial RS-232 port, the ROLMphone must contain a DCM II digital communications card (If so, it has a 25 pin RS-232-C connector on the back), and there must be a RS-232 cable to make the physical connection.

Terminal Attributes

Not all terminals have the same keyboard, and the digital signal generated for a particular keystroke may differ from terminal to terminal. It is important, therefore that the host computer knows what terminal is being used. For the SNS (and other computers using UNIX) this is accomplished via the SET TERM command which can be included in the user's .login file. For the NCS computers, which use CDCNET, refer to the CDCNET Access Guide. Personal computers emulate a terminal through software such as CROSSTALK XVI. It is suggested that it be configured to emulate a DEC VT-100. The UNIX command

SET TERM = vt100

in the user's .login file will suffice to establish compatibility with UNIX computers, and no special action is necessary for the NCS computers.

Electronic Connection

Electronic connection is established by typing the "enter" key (carriage return or line feed). The message

CALL, DISPLAY, OR MODIFY?

should appear on the screen. Electronic disconnect occurs automatically after no activity for three minutes at this prompt or manually by pressing the ROLMphone data key twice rapidly.

CALL (or just C) is used to access a resource; e.g.,

call eagle or **c eagle**

will request access to eagle. LaTS indicates that it is calling, and when the connection is made the message

CALL COMPLETE

appears. A carriage return will bring up a message similar to

CONVEX UNIX, RELEASE V9.1 (eagle)

and initiate the login sequence. Various, self-explanatory messages are displayed if the call fails.

DISPLAY is used to display transmission characteristics, permissions, and groups.

Characteristics refers to data transmission rate (in bits per second or baud), type of parity checking, echo checking, and answer mode. By typing **Display Characteristics** or **D C**, the assumed values of these characteristics are displayed. LaTS automatically senses the baud rate of your terminal at the electronic connect. It will accommodate rates in the range 300 to 19,200 baud.

It initially assumes that the parity parameter is "none", echo parameter is "on" and answer mode is "manual".

A simple terminal will operate at a fixed rate (bits per second or Baud). Some are switchable between two rates. PC's and workstations use a software package, such as PROCOMM, SMARTCOM II, CROSSTALK XVI, and PC-TALK III. Versaterm and Microphone are communications packages for a Macintosh. These packages can be configured to cause a PC or Macintosh to emulate a variety of terminals, including different rates, parity settings, etc. By typing **Display Permissions** the user can determine whether or not dial-out is possible, calls are queued in line, a password is required before making a call, and the data line can answer calls. Groups refers to data groups, that is groups of lines that have the same call address. This is similar in concept to the rotary phone number. By typing **Display Groups** a three column list of available call addresses is displayed. Resources of the CSCC as well as many other computers and devices that can be accessed from LaTS are included in this list. The SNS computers are identified by their names, the NCS computers are identified by a single letter. Other CSCC resources available through LaTS are discussed elsewhere in this document. Data groups that are password protected are identified with a following asterisk.

MODIFY may be used to change parameters.

Outside Access via LaTS

MDIAL is the name of the LaTS resource that allows users at on site computers connected to LaTS to dial off-site data communication facilities without the need for a locally attached modem. MDIAL is comprised of a central bank of modems that employ a subset of the Hays "AT" command set for call initiation. MDIAL supports the following speeds and protocols:

>300 bps - Bell 103
>1200 bps - Bell 212A
>2400 bps - CCITT V.22bis
>9600 bps - CCITT V.32, V.42 and V.42bis

CALL INITIATION:

1. Data calls may be initiated from a terminal or PC connected to LaTS via the ROLMphone. PC's must run a communications package such as PROCOMM PLUS, CROSSTALK, or Windows Terminal.
   - Set the baud rate to the desired speed.
   - Set the data bits, parity, and stop bits to the recommended setting of the remote location.
      Note: LaTS will respond to any combination of parity and 7 data bits; however if 8 data bits are required, the parity must be set to none.
   - Select the terminal emulator mode if using a PC communications package.

2. Type **<CR>** to initiate a LaTS data call.

3. At the "CALL, DISPLAY, OR MODIFY?" prompt, type **CALL MDIAL** and **<CR>**

4. Upon receiving the "CALL COMPLETE" message, a connection to a MDIAL modem has been established. Use the Hayes "AT" command to dial the call.
      Dial Command Format: ATDTnnnnnnnnnn <CR>

      Where n can be:
      0-9 : Telephone Number Digits
      W : Wait for dial tone

Examples:

On-site extension 4-1234	Command: ATDT41234<CR>
Local number 555-1234	Command: ATDT9W5551234<CR>
Long Distance (714) 555-1234	Command: ATDT9W7145551234<CR>
Toll Free 1-800-555-1234	Command: ATDT9W18005551234<CR>

MODEM RESPONSE MESSAGES:

One of the following messages will be sent by the MDIAL modem to your terminal/PC after a dial command has been executed:

CONNECT xxxx : Connection to remote modem at xxxx bps has been established.

NO DIAL TONE : Modem or telephone line failure.

NO CARRIER : Local modem has not detected carrier from remote modem within 60 seconds, or loss of carrier was detected.

BUSY : a busy tone was detected during dialing.

ERROR : The command line was never accepted by the modem. The command line may have exceeded 39 character maximum or contained incorrect syntax. An ERROR message is also generated by some unsupported commands.

Note: If the connection is broken a few seconds after a "CONNECT" is received, it may be that the MDIAL modem and the remote modem do not support the same level of error control. This generally happens with modems that are older and only support lower speeds, e.g. 2400 baud and below. To disable error control, include "\N" in the dial string; for example, enter "AT\NDT9,5551234" to call the off-site number 555-1234 without negotiating error control.

CALL TERMINATION:

Once a connection has been established, it is important to log off the remote resource before you drop the local modem connection. Normally, logging off of the remote resource drops the local modem (MDIAL) connection and returns you to the LaTS "CALL, DISPLAY, OR MODIFY" prompt. If, however, the remote logoff does not return you to the LaTS prompt, use the following procedure to force the disconnect:

1. Type the escape code +++ (no <CR>).
2. The MDIAL modem will respond with "OK."
3. Type the Hangup command, "ATH" <CR>.

If you need to disconnect from MDIAL before a remote connection has been established, enter the hangup and/or exit command for the communications package being used, or press the 'DATA' button on your ROLM phone two times.

ACCESSING MDIAL FROM A WORKSTATION CONNECTED TO LaRCNET:

If a workstation is connected only to LaRCNET, it can still access the LaTS MDIAL modem pool by using the following procedure:

1. Use the TCP/IP "telnet" command as follows:

Type "telnet xxxxxx" where xxxxxx is one of the network names listed below. Choose the appropriate name for the desired data rate.

Data Rate	Network Name
300 bps	lats3
1200 bps	lats12
1200 bps	lats24
9600 bps	lats96

2. Once connected, enter a <CR> to get the LaTS "CALL, DISPLAY, OR MODIFY" prompt.

3. Follow the CALL INITIATION procedure, above, starting with step 3.

At the end of the session, the logoff procedure should disconnect all the way back to the workstation prompt. If it is necessary to disconnect before completing a call connection, refer to the manual for the TCP/IP package being used for information on its escape and disconnect commands.

Off-site Access to LaRC Computer Resources via LaTS

LaRC computer resources are accessible from off-site using the LaTS incoming modem pools via two local numbers and a toll free 800 number. The 800 number is intended for users calling from outside the local calling area (e.g., Norfolk, Williamsburg, on travel, etc.). To call from the Peninsula, please use one of the two local telephone numbers. Each of these telephone numbers allows access to a pool of modems that support specific sets of speeds and standard protocols. The following table lists the speeds and protocols supported by the different pools.

TELEPHONE NO.	SPEED	PROTOCOLS	MODEM TYPE
864-4875	300 bps 1200 bps 2400 bps	Bell 103 Bell 212A CCITT V.22bis	Racal VA4492E
864-7496	9600 bps 19200 bps	CCITT V.32 PEP(*)	Telebit T2500
800-572-5200	All of the above speeds and protocols		Telebit T2500

(*) This is a Telebit proprietary protocol. To communicate at 19,200 bps you must use a Telebit modem that supports PEP to call one of the incoming modem pools that also supports PEP.

CALL INITIATION:

1. Data calls may be initiated from a terminal or PC connected to a modem that supports any of the speed/protocol combinations in the table above. PC's must run a communications package such as PROCOMM PLUS, or CROSSTALK.
   - Set the terminal or communications package to the appropriate speed for a given protocol (see table above).
   - Set the data bits, parity, and stop bits to the recommended setting of the intended LaTS resource.
     NOTE: LaTS will respond to 7 bits and any parity. However, if 8 data bits are required, i.e., for binary file transfers, the parity must be NONE.
   - Set the terminal emulator mode if using a communications package.
2. Using the modem's dialing commands, dial the telephone number of the LaTS modem pool that is compatible with the modem's speed and protocol capability.

NOTE: The modems in the inbound modem pool are configured to work with the majority of other vendor's modems. A modem initialization string, which is a set of Hayes commands that modifies the modem's configuration, may be required if any of the problems described in the section on "Common Problems" below is experienced.

3. Once a connection has been established between the modem and one of the modems in the LaTS pools, it will respond with a "CONNECT" message. Upon receiving this message, wait a few seconds, then enter a carriage return to initiate a LaTS data call.

4. At the "ENTER NUMBER" prompt, enter the name or number of the desired LaRC resource.

CALL TERMINATION:

Before droppinga a modem connection, it is important to log off the host computer. Normally, logging off the remote resource drops the connection and the modem goes back on hook; however, if the remote logoff does not place the modem on hook, the following procedure shouls be used to drop the modem from the telephone line.

1. Type the escape code +++ (no <CR>).
2. The local modem responds with "OK."
3. Type the hangup command, "ATH"<CR>.

USING THE MODEM POOLS TO ACCESS A COMPUTER CONNECTED TO LaRCNET:

To access a resource via LaRCNET, follow the steps in the CALL INITIATION procedure and use "LARCNET" as the response for the "ENTER NUMBER" prompt. Upon receipt of the "CALL COMPLETE" message, press carriage return several times until the "CISCO>" prompt is displayed. The TCP "telnet" command may then be used to access computers connected to LaRCNET.

COMMON PROBLEMS

REPEATED NO CARRIER RESPONSE:

If you are trying to connect to either the 9600 bps or the toll-free modem pool and you hear the modems negotiating, but get a "NO CARRIER" message with each attempt, the modems may need more time to negotiate the connection. Your modem's "WAIT FOR CARRIER/DIAL TONE TIME" parameter may need to be modified to lengthen the amount of time your modem will wait for a valid carrier tone from the remote modem. This parameter is defined within one of your modem's S-registers; consult your modem user manual for the correct S-register to be modified and procedure for doing so.

CALL DROPS SHORTLY AFTER CONNECT MESSAGE:

If the connection is broken a few seconds after a "CONNECT" message is received, your modem is most likely configured for error control. Consult your modem user manual for how to check your modem's configuration. If error control is enabled, turn that feature off and try again.

GARBLED TEXT:

If the "ENTER NUMBER" prompt is replaced by erroneous characters, check the data bits and parity to insure settings as described in step 1 under CALL INITIATION.

Also, check to make sure the speed of the "CONNECT" message and the speed of the terminal/PC communications package are the same. You may have dialed the wrong number or set your terminal/PC speed incorrectly for the desired speed.

NO CONNECT MESSAGE:

If you do not receive a "CONNECT" message, consult your modem user manual for start-up operation and configuration. If your modem's configuration seems correct, try calling another modem to see if your modem will connect with something other than the inbound modem pools.

DATA COMPRESSION:

Data compression protocols, including CCITT V.42bis and MNP 5, are not currently supported for any of the incoming modem pools because the lack of reliable flow control may cause loss of data. We are currently investigating possible solutions to this problem.

4.4 Electronic Mail and the LaRC E-Mail Post Office

An important capability provided by LaRCNET, LaTS, and their connections to other networks is the sending and receiving of mail messages to individuals and groups of users. This is actually a special form of file transfer and it requires software in both the sending and receiving computers. Such software is provided by UNIX and the TCP/IP packages mentioned above. It is not provided by NOS/CDCNET. The basic command structure is:

mail *username @ hostname*

where *username* is the login name on the computer named *hostname* of the person you wish to address. An alias will permit a single user name to address a group of individuals. The @ *hostname* is not necessary if the addressee is a user of the originating computer. The system provides prompts for writing the message. Reference should be made to the appropriate mail documentation for descriptions of the many options that are available.

There are a number of different electronic mail (e-mail) systems in use, some of which are limited to particular computer platforms, operating systems, or user communities (e.g. QuickMail, UNIX mail, DECnet mail, NASAmail, BITNET mail, and UUCP mail), and communication between persons who happen to use different e-mail systems is, at best, difficult. The LaRC E-mail Post Office has been established to help alleviate this problem, and, at the same time, to provide a uniform LaRC addressing system and a local directory service.

The LaRC E-mail Post Office is a UNIX computer which uses the UNIX e-mail system (also known as SMTP or Internet mail). Gateways are installed that will allow the transfer of e-mail among the following systems widely used at LaRC:

> QuickMail (available on Macintosh computers and PCs)
> UNIX mail (available on UNIX workstations)
> DECnet mail (available on DEC computers)
> NASAmail (NASA packet switch subsystem)

The user of one system can send e-mail (excluding binary files) to the user of a different system; users without access to their own mail software can use the Post Office for sending and receiving mail, and users can look up the e-mail address, fax number, and other directory information for persons working at LaRC.

Post office accounts are available at no charge to all persons working at LaRC and may be obtained by completing an *LaRC E-mail Post Office Account Application* form, which is available from the Post Office

Account Manager at extension 47478. Send the completed application to E-mail Post Office, Mail Stop 124, or fax to FAX number 47605. The account name will be assigned by ACD, which, when unique, will be *first initial.second initial.last name* of the user. If not unique a modification will be made, such as spelling out one of the first names. E-mail sent to a user's Post Office address can be forwarded to wherever the user prefers to receive his e-mail (provided one of the above four systems) or can be held at the Post Office.

The Post Office host name is **larc.nasa.gov**. Once a user has an account, he or she can log into the Post Office, via LaRCNET or LaTS, to retrieve mail held there; change options for forwarding mail, password, nickname, or FAX number; or query the directory.

The Post Office directory includes the information given for every individual listed in the LaRC telephone directory plus e-mail address and nickname and FAX number for those individuals having an account at the Post Office. Directory information for individuals can be obtained as well as lists of individuals having the same last name, the same organizational code, the same mail stop, or same building number.

For future information, obtain the latest version of the *LaRC E-Mail Post Office User's Guide* available from the Computer and Network Systems Branch, Mail Stop 124 (extension 47777).

4.5 The NASA Packet Switch Subsystem (NPSS) and NASAMAIL

The LaTS data group "NPSS" provides access to the NASA Packet Switch Subsystem which interconnects all NASA sites in the continental United States via the Program Support Communications Network (PSCN). The NPSS Directory describes procedures for the use of NPSS and contains a listing of service names (mnemonics) for all NASA host computers, LANS, etc., which are accessible through the NPSS. Copies of this directory are available from the LaRC PSCN Coordinator (Joe Nolan, extension 47352). Copies of the service name list are also available from the Operations Control Office.

NPSS also provides access to NASAMAIL, a NASA-wide electronic mail service. A NASAMAIL Users list is provided in the Langley Telephone Directory. For additional information contact the NASAMAIL ADMINISTRATOR (Janice Yates, extension 43253).

CHAPTER 5. MANAGEMENT AND OPERATIONS

Most of the computers in the Central Scientific Computing Complex are managed by the Computer Management Branch.

5.1 Computer User Authorization

The use of the CSCC is for US Government purposes only. Authorization to access the complex must be approved by a Division Computing Manager (DCM) and the CMB.

Separate authorization is required to use each of the subsystems, SNS, NCS, and FSCS. These may be obtained by filling out a "LaRC Computer User Authorization," form ACD-CMB N-972, available from your DCM. The form must be signed by your DCM and forwarded to the CMB (Mail Stop 157D). Login is usually possible on the first working day following the receipt of the form by CMB.

5.2 User Identification/Login Code

You may select your own user identification/login code, which must start with an alphabetic character, be at least three characters long, and no more than 7 characters for NCS or 8 characters for other computers. Alphabetic characters must be in lower case for all but NCS computers (which will accept both upper and lower case). To avoid duplicate identifications, you should give three choices in priority order. If possible, CMB will assign one of your choices. If not, an arbitrary code (alphabetic characters always in lower case) will be assigned.

5.3 Passwords

To protect against unauthorized use of your identification/login code by another person, you will be issued a personal password, good for every computer in the relevant subsystem, at the time your authorization is approved. You should change this password the first time you login to a subsystem computer. You will be required to change it at least once each year thereafter. You may, if you wish, have a separate password for each computer. The Computer Management Branch does not keep track of your password, thus the only recourse, should you forget it, is to request that a new password be issued. To obtain a new password or obtain help with password problems, call extension 48282.

5.4 Accounts

Computer accounts are established by the DCMs for activities requiring the use of the central scientific computers. An account number consists of the letter "a" followed by five digits (Previously established accounts consisting of six digits are not acceptable on SNS computers but are still valid on NCS.)

Computer resources are measured in a standard unit called a Computer Resource Unit (CRU). CRUs are computed by a formula specific to the particular computer on the basis of cpu use, memory allocated, and auxiliary storage used. They are accumulated against the designated account. Each account has a CRU budget allocation for a given fiscal year. DCMs receive periodic listings of CRUs for use in managing their accounts. In addition, the Computer Resource Usage Visibility System (CRUS) is available for access from any UNIX platform (SNS, work stations or PC's) or from the NCS.

To access CRUS interactively from NCS enter

        GET,CRUS/UN=LIBRARY
        CRUS

In order to access CRUS on UNIX, you must be an SNS user.

From any SNS computer enter:

rlogin cmbserv

You will be prompted for a password that will be the same password you have on **Sabre**. (**Sabre's** password will be transferred daily.) Once you have logged on to **cmbserv**, you will be prompted by a menu to initiate CRUS.

From a Sun or PC:

The table entry '128.155.2.54 cmbserv.larc.nasa.gov' must be in the /etc/ hosts file, or your Sun/PC must be configured to use the domain name server. This must be set up by the system administrator. Enter:

rlogin cmbserv

Once you have logged onto **cmbserv** you will be prompted by a menu to intiate CRUS.

When you fill out the LaRC Computer User Authorization form, your DCM will enter the computer accounts that you are authorized to use. The first of these becomes your default so that computer time will be charged against that account as soon as you log into a computer. If it fails validation (out of CRU's), you will be prompted for another account number. If you wish to charge the time to another account, you must use the "charge" command.

5.5 Login on SNS Computers

After you establish a connection with an SNS computer through either LaRCNET or LaTS (see Chapter 4), the prompt

login:

appears. Type your login code exactly (all logins are lower case). The prompt

password:

then appears. Type your password, but note that it does not echo (that is you do not see your password on the screen.)

If both login code and password are validated by the particular computer, a warning message concerning use of the computer for non-government use is displayed followed by the "message of the day", information on your last login, and the account to which the session will be charged. After this the computer will execute your .cshrc and .login scripts (the .login script contains a prompt for your terminal type). The system then gives the system prompt, e.g.,

eagle%

You are then free to command the computer. If you wish to change the account number, you should use the charge command at this point.

charge *new_account_number*

If you wish to change your password, enter

passwd

You will be prompted for your old password and then the new one that you wish to establish. It must be entered twice.

A periodic review of the contents of your .login file is recommended. You may wish to modify it to avoid the terminal-type prompt or change the meaning of specific keys (erase and arrow keys, for example).

5.6 Login on NCS

After you establish a connection with the Y computer through either LaRCNET or LaTS, the warning message appears, followed by the prompt

FAMILY:

At this point you should type the sequence

*,login_code,password,*iaf

If the login code and password are validated, the system prompt

/

appears. The previously established default account number is used to charge the computer resources for the current session. To change the account number, use the command

CHARGE,*new_account_number,*lrc

To change the default account number for all NCS computers, use the command

DEFACCT,*new_default_account_number*

The new default account number will take effect the following day.

If you wish to change your password, enter

PASSOUT

The system will prompt you for your old password and the one you wish to substitute.

5.7 The Operations Control Office (OCO)

The focal point for day-to-day operations is this office located in room 1047 of building 1268 (phone: 864-6562). It is staffed from 7:15 a.m. to midnight each weekday (but closed weekends and holidays). It is the distribution point for all CSCC documentation and computer bulletins (see Chapter 7). It handles the distribution of printed and graphical output; requests for special processing, such as involving magnetic tapes; and requests for priority and secure processing. Should you encounter any problems that appear to be due to CSCC equipment failure, contact this office.

As stated in the introduction, the complex is operational at all times except for Christmas and New Year, emergencies, or major building maintenance. Anticipated shut downs are announced in advance by bulletins and electronic announcements.

5.8 High Speed Printing and Plotting

An IBM laser printer is used for printed output and "working" plots. It has has a printing speed of 134 pages per minute and a plotting resolution of 240 x 240 dots per square inch. The printer uses fan fold paper that has an addressable printing and plotting area of 13.88" x 7.5". An IBM 9370 computer is used as the controller for the printers. SNS computers send print and plot files to the 9370 over LaRCNET using the TCP/IP protocol. NCS computers send print and plot files to the 9370 via two PCs over LaRCNET using the XNS protocol.

From an NCS computer, standard print output is routed as a file to a print queue while plot files are routed to a plot queue. NOS resident procedures periodically interrogate the print and plot queues and send print files to the PC designated for printing and plot files to the PC designated for plotting. An arbitrary text file can be routed from either a batch or interactive job by means of the ROUTE command; however, the first

column of the text file must be blank because the first position in each line is used to control line spacing. A blank first column can be inserted by a COPYSBF command. The font used is 12 pitch prestige.

From an SNS computer, a file can be printed on one of the printer by the lpr command with the printer address ibmlaser for landscape (horizontal) or ibmlaserp for portrait (rotated 90[degree]) mode. Graphics metafiles can be plotted on one of the laser printers by using the mfibm3800 command.

Output from the laser printer, both printed and plotted, is identified by an eight character "banner" and other information on the front page. If the banner reads BINXXX, it will be routed to a bin in the I/O area of the CSCC (near the front entrance to building 1268). If the banner reads BLDGXXXX, it will be delivered to the user's building. This information is taken from the JOB statement or DELIVER statement (NCS) or from the delivery information option in the lpr or mfibm3800 commands (SNS). Output with ambiguous or no delivery information is held in the Operations Control Office for 24 hours, then discarded.

Further information on the laser printer is available in document G-10 and from the SNS on-line file by entering:

man mfdev

5.9 Production Graphics

Several computer graphics software packages are available though the CSCC. These packages support various graphics applications including: 2-D and 3-D modeling, graph and chart generation, contour and surface rendering, mapping, and animation. They also conform to several of the current and proposed ANSI graphics software standards such as CORE, GKS, and PHIGS. Table 1. lists available software packages and categorizes each in terms of functionality and general characteristics. All of these packages are available on SNS computers with the exception of those marked "workstation only," that generally execute on IRIS 4D class high-performance workstations.

There are two fundamentally different graphics formats: in vector graphics the image is composed of a variable number of line segments defined by beginning and end coordinates, whereas in raster graphics it is composed of a fixed, rectangular array of pixels. The color and/or intensity of either line segment or pixel is designated by a numerical code.

The graphics system provides host, package, and device independence by means of a portable graphics output file called a "metafile." Each software package produces a metafile in either vector or raster format. In the case of vector data, this format is compatible with the ANSI CGM standard.

Production graphics devices are located in the I/O area of Bldg. 1268, room 1051. They include pen plotters, an electrostatic plotter, a thermal plotter, laser printers, and film recorders. Each device accepts input data in the form of a graphics metafile through an appropriate driver program. Table 2 summarizes the available devices and their characteristics. Users execute commands that transfer their data to a particular device. For some devices, magnetic tapes are used as the transfer medium; others use LaRCNET. Hardcopy output is delivered to the user through the delivery service in the same manner as printed output.

	FUNCTIONALITY										CHARACTERISTICS							
	GENERAL PURPOSE	CHARTS & GRAPHS	CONTOURS	SURFACES	HIDDEN LINES	HIERARCHICAL MODEL	ANIMATION	RENDERING	MAPPING	VISUALIZATION	VECTOR	RASTER	3-D	MENU/CMND DRIVEN	SUBRTN CALLABLE	PORT. GRAPH. FILE	WORKSTATION ONLY	X DRIVER
CGL		X									X				X	X		
CONTOUR			X	X	X						X				X	X		
DI-3000	X										X		X		X	X		
DI-3000 XPM				X	X						X		X		X	X		
FIGARO	X			X	X	X		X			X	X	X	X	X	X		
GAS/FAST		X	X	X	X		X			X	X	X	X	X		X	X	
GKS	X										X				X	X		X
LARGOS		X									X				X	X		
MOVIE.BYU				X		X	X					X	X	X	X	X	X	
NCAR		X	X	X					X		X		X		X	X		
PICSURE		X									X			X		X		
PLOT3D		X	X	X	X					X	X	X	X	X		X		
PVWAVE		X	X	X	X					X	X	X	X	X			X	
RASLIB				X						X		X	X		X	X		
SURF		X	X	X			X			X	X	X	X	X		X	X	
TECPLOT		X	X	X	X				X	X	X		X	X		X	X	X
UNIGRAPH		X									X			X		X		X
UNIMAP		X	X	X	X				X	X	X		X	X		X		X
WAVEFRONT			X	X	X		X	X		X	X	X	X	X			X	

Table 1. Available Graphics Packages

An E-6 automatic film processing system is installed in the Film Recording Laboratory for developing film from central site film processors. The turnaround for developed film is three days.

The capabilities of the graphics system together with usage and access information are detailed in the Graphics Mini Manual, Document G-1a.

The Data Visualization and Animation Laboratory (DVAL) is a user area in Building 1268A that contains several high performance graphics workstations that can be used in conjunction with a number of the graphics packages outlined above. ACD personnel associated with DVAL are available to assist users in becoming familiar with these capabilities. DVAL is described in Chapter 6, User Areas.

	CHARACTERISTICS						FORMAT		
	BLACK/WHITE	COLOR	FILM	A-SIZE	B-SIZE	ROLL	VECTOR INPUT	RASTER INPUT	POSTSCRIPT
CALCOMP 11" DRUM PLOTTER	x	x				x	x		
CALCOMP 34" DRUM PLOTTER	x	x	x			x	x		
COLOR FILM RECORDING SYSTEM		x	x				x	x	
IBM LASER PRINTER	x						x		
QMS LASER PRINTER	x			x					x
VERSATEC ELECTROSTATIC PLOTTER		x				x	x	x	
VERSATEC THERMAL PLOTTER		x	x	x	x		x	x	

Table 2. Available Production Graphics Devices

5.10 Secure Processing

Occasionally Langley becomes involved in projects that require computations that must be classified under national security regulations. In order to accommodate these situations, one of the SNS computers (the CONVEX-210, **mustang**) is located in a secure area in the building 1268B and can be isolated from the rest of the complex. In order to use this computer in secure mode, the researcher must contact the Computer Management Branch to arrange a schedule.

Because neither LaRCNET nor LaTS are protected for classified information, the researcher must come to building 1268 and use a designated terminal in the secure area. When possible, secure processing is deferred to a non-prime shift.

CHAPTER 6. APPLICATION LABORATORIES

Applications of large-scale scientific computers frequently involve the generation and manipulation of very large data sets such as geometric descriptions of complex objects, or raster images. Much of the processing of this type of data is accomplished in an interactive mode on powerful workstations having high resolution graphic displays. The software tends to be specialized, requiring a certain amount of experience and skill to use effectively.

On another front, the rapid development of complex programs that must be reliable and efficient, such as the software for computers embedded in flight or ground test systems, requires an interactive Computer-Aided Software Engineering (CASE) environment, consisting of workstations and a suite of programming aids and libraries of commonly used program modules. Again the help of experienced people is an important factor for the new programmer.

For these reasons, ACD maintains three user areas in buildings 1268, 1268A, and 1268B. They are the Data Visualization and Animation Laboratory (DVAL), the Numerical Geometry Laboratory (GEOLAB), and the Software Engineering and Ada Laboratory (SEAL). These areas are discussed in this chapter.

6.1 The Data Visualization and Animation Laboratory (DVAL)

The ability to view data obtained from observation, experiment, or computer simulation in a visual form may lead to insights and scientific understanding that could not be obtained from the numbers alone. As an example, pressure readings taken on the surface of a wing become more meaningful when displayed in color (blue through red as the pressure changes from low to high) on top of an image of the wing. In dynamic situations such as structural deformation or fluid flow a continuously changing image can be even more revealing.

In some situations data is obtained in a visual form. Examples are photographs of smoke patterns in a flow field, Schlieren photographs, or interference patterns obtained from irradiating a flow field with coherent light. Recently, a technique has been developed to illuminate a flow field with a laser generated light sheet that sweeps through the region of interest and which is viewed with a video camera. Such images can be enhanced by increasing contrast, adding color, or emphasizing regions of rapid change, and quantitative information can be obtained by scanning the image and performing an analysis of the resulting numerical data.

The Data Visualization and Animation Laboratory (DVAL), Bldg. 1268A, room 1101A, provides advanced visualization tools on an integrated system of high-performance graphics workstations, digital image processing equipment, and a digital video editing system. An experienced team of visualization specialists is available to help researchers import, visualize, and interpret data derived from a wide variety of sources including in-flight experiments, wind tunnel tests, computer simulations, and atmospheric studies. Video reports can be created as a means for analyzing and presenting dynamic scientific results. Hardcopy output of image data in the form of prints and vugraphs is also available

Interactive Scientific Visualization

DVAL contains five SUN Workstations, four Silicon Graphics IRIS Workstations, two NCD X-terminals, a Gateway 486/DX PC Compatible, and a Macintosh Quadra 800, that are configured with various high resolution monitors and disk drives. Several of the workstations are connected directly to the Advanced Technology Network (100Mbyte/sec FDDI ring) in order to obtain high bandwidth access to the SNS supercomputers. The other devices have normal access to LaRCNET through an ethernet connection.

Image input and output devices include two color film recorders (Focus & Matrix), a Sharp color flatbed scanner, an Eikonix digitizing camera, a Tektronix color network printer, a Sony video printer, and a Barco large screen projection TV.

The following software is available:

PLOT3D (Ames Research Center)

Flow Analysis Software Toolkit (Sterling Software)

Fieldview (Intelligent Light)

Advanced Visualizer (Wavefront)

Voxel View (Vital Images)

IDEAS Solid Modeler (S.D.R.C.)

CFDView (CFD Research Corp.)

PV~Wave (Precision Visuals)

Khoros (Public Domain)

KB-Vision (Amerinex Artificial Intelligence)

AutoCAD (Autodesk)

Image Processing

The Image Processing capability of DVAL provides researchers with an interactive capability to enhance, analyze, and extract useful information from digital images. Typical applications are the enhancement and analysis of flow-field images obtained from wind-tunnel or in-flight flow visualization experiments; the visualization of 3-D volumes of data obtained computationally or experimentally; and the processing of images obtained from satellite-borne instruments.

Digital image processing is supported on a number of computer platforms in the DVAL, including a 486 PC, a Macintosh Quadra 800, Sun sparcstations, and Silicon Graphics, Inc., high-end workstations. A number of peripheral devices are interfaced to these computers for image input and output. Various image processing packages are available on the different platforms. The capabilities for image input, processing and output are described in more detail below.

The input of image data can be accomplished in a variety of ways. Data in digital form, i.e., already existing in a computer file, may be transferred to any of the computers in the DVAL through LaRCNET or read from 9-track magnetic tape. Photographic media in the form of photographs, negatives, or x-ray images, can be digitized with either the Eikonix Model 1412 Digitizing Camera or the Sharp JX-600 Flatbed Scanner. Finally, a video Image Processing System (VIPS) is available through which video frames may be digitized for further processing.

Processing is accomplished through the use of a variety of software packages. There are basically three styles of package: The first is self-contained, general purpose software such as PV~WAVE or TAAC-1. In general, the features available in this software must be accessed through an interface. The second is the toolkit package such as ALV or HIPS. These packages are also general purpose but the features are available as commands at the operating system level and can be used independently; thus some features may be used as pre- or post-processing steps for other packages. The third is the program dedicated to a specific function. An example is "Camtool" for Eikonix camera operation.

Much of this software is acquired commercially, or is public domain software; however, many packages have been developed locally in response the requirements of LaRC researchers. They include tools for image analysis, enhancement, registration, and the interactive analysis of interferometric fringe patterns.

The functionality and characteristics of the various image processing software packages available in the DVAL are shown in Table 3

	FUNCTIONALITY														CHARACTERISTICS		
	IMAGE ACQUISITION	IMAGE DISPLAY	IMAGE CONVERSION	IMAGE ANALYSIS	IMAGE DATA COMPRESSION	IMAGE EDITING	IMAGE ENHANCEMENT	IMAGE GRAPHICS OVERLAY	IMAGE ORIENTATION	IMAGE TRANSFORMS	MATHEMATICAL FUNCTIONS	NOISE TECHNIQUES	PLOTTING	VOLUME RENDERING	GRAPHICAL USER INTERFACE	MENU/COMMAND DRIVEN	PROGRAMMABLE
ALV		*	2				*		2						S	Y	
Blobtool		2		*		2									S		
Camtool	*	2													S		
Dumpregion	*														S		
Enhancetool		2		2			*			*					S		
HIPS		2	2	*	*		*		2	*		*			S/X		
Image Pro Plus		2		*		2	2	2		2		2				Y	
KBVision		2		*			2	2	2		2	2	2		X		Y
Mathematica		2								2	*		*		X	Y	Y
NCSA Imagetool		2				2	*		2				2		S		
NIH Image		2					*						2			Y	
PBMPlus			*													Y	
PV–Wave		2	2	2		2	*	2	2	2	*		*		S/X	Y	Y
Registertool		2							*						S		
Rmtran			*			2										Y	
TAAC		2					*	2	2				2	*	S		Y
Tapetool	*	2													S		
Tecplot		2				2							*		S/X		
Touchup		2				*		*	2						S		
Visilog	*	2		*		2	*	2	2	2			2		S		Y
Xloadimage		*				2	2		2						X		
xv		*	*				*	2		2					X		

Table 3. Available Image Processing Packages

Output is available is a variety of forms. The results of processing data files or image files may be sent to other systems using LaRCNET. Since the output from a lab session is most often a picture, many methods exist to obtain hardcopy. Within the lab, Matrix and Focus film recorders are available to provide on-the-spot Polaroid hardcopy. Black and white laser and color printers are also available. The ACD production output devices, including Versatec color printers, a color PostScript printer, and color film recorders, are available (see Chapter 4). Video output capabilities are resident on the VIPS and the supported video formats include VHS, S-VHS, U-Matic SP and Betacam.

Video/Audio Editing and Recording

Video tapes are portable and can be shown with readily available video tape players. In contrast to film they can be created online and require no time-consuming chemical processing. A facility, referred to as the Scientific Visualization System (SVS), is available in DVAL to create video tapes from computer graphics generated on the SNS computers or high performance graphic workstations and to edit video tapes from a variety of sources. It can be used to produce video reports of time dependent theoretical and experimental data. The system consists of a DF/X Composium video editor which controls both digital and

analog video machines. The digital video machines include two SONY D1 tape recorders and two Abekas real-time disk drives. Because these machines are digital video they preserve the integrity of the original image regardless of the number of editing generations, so they are used as the primary editing sources and destinations. Also the Abekas drives are connected to LaRCNET so that digital images can be transferred to the SVS from computers or workstations on the network. The analog machines include WORM laser disk recorders and numerous tape recorders (Betacam SP, S-VHS, and Umatic). These are used for input (e.g. a wind tunnel or in-flight experiment recorded onto video tape) and final output. One laser disk recorder is mounted into a transportable rack with a multiple frequency scan converter so that it can be shipped to the researcher's site and connected to a workstation/PC for local recording. Finally an audio system and a recording booth have been incorporated into the system to support narrations and background music.

Mode of Operation

DVAL is an open-shop research environment. The staff are available to consult with researchers on their specific graphics, image processing, and video projects and to assist with the use of equipment and software. The processing of large amounts of data is the responsibility of the researcher.

6.2 The Numerical Geometry Laboratory (GEOLAB)

Large-scale computations at the Langley Research Center are generally for the purpose of simulating and analyzing fluid flow, plasma dynamics, or continuum mechanics phenomena. The governing laws and corresponding equations of motion are well known and apply equally to all problems of a given class; however, the boundary data and geometric aspects such as the configuration of boundary surfaces account for the great variety and complexity of solutions which is typical of these problems.

In order to obtain a numerical solution to a problem of this type, the spatial domain must be discretized, that is partitioned into cells sufficiently small that dependent variables such as density or fluid velocity can be considered constant or uniformly varying within them. The network of lines which outline the boundaries of cells is called a grid and the process of creating the grid is referred to as grid generation. In regions where the variables of the problem are changing rapidly with respect to spatial distance, the grid must be fine in order to preserve accuracy; on the other hand, where the variables are changing slowly, the grid must be as coarse as possible to conserve computing resources. There are other problems associated with generating an effective grid; for example, at corners of a boundary the grid cells may become infinitesimally thin, causing the numerical equations to become poorly conditioned.

It has been found that in a typical Computational Fluid Dynamics (CFD) problem, about 95% of time expended by the investigator is consumed in defining the boundary surfaces, establishing the surface grids, and generating the volume grid in the region between surfaces. The Computer Applications Branch has been involved in grid generation for about 20 years, and now has developed a capability consisting of workstations, software, and expertise in grid generation that can be brought to bear on numerous CFD (and other) problems.

The Numerical Geometry Laboratory (GEOLAB) is located in room 2119 of building 1268A. It is a centralized, open-shop, hands-on facility for use by the research community in defining the boundary surfaces and generating grids in preparation for the solution of CFD and similar problems. Members of the GEOLAB staff will assist in planning grid generation strategy and help the new user to use the available hardware and software.

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Hardware

Currently there are nine Silicon Graphics high-performance graphics workstations and four X-terminals in GEOLAB. Four of the workstations are the new 150 MHz ONYX series with two CPUs and 128MB of memory. Three of the ONYX workstations have VTX graphics and one has the Reality Engine2 Graphics. Also, there is a 4D-440/VGX and a CRIMSON/VGX, both with 128MB of memory; two INDIGO R4400/Elan 150MHz workstations with 128MB of memory; and a Personal Iris 35/Elan with 64MB of memory. It is planned to upgrade one or more of the ONYX workstations CPUs to the new Totally Floating Point (TFP) CPU, which has an estimated peak performance of 300Mflops, and to add another Raster Manager to the ONYX workstation with Reality Engine2 graphics. There is a Cyberware 3D Laser Digitizer which has been used to scan wind tunnel models like the X-15, F-22, and Waverider.

Software

Software available in GEOLAB is divided into four categories: surface definition, grid generation, flow field solution, and CFD visualization.

Surface Definition

ICEM-DDN

ICEM-DDN is a commercial system for Computer Aided Design/Drafting (CADD), Computer Aided Manufacturing (CAM) and Computer Aided Engineering (CAE). It contains modules for 3-D wireframe modeling, surface modeling based upon Non-Uniform Rational B-Splines (NURBS), surface-surface intersection, trimmed surfaces, fillets, color shading for surfaces, and dynamic viewing of the modeled geometry. The software has a rich instruction set for geometry creation that includes surface-surface matching with respect to position, tangents, and curvatures. Also the package is capable of receiving externally generated geometry via a file containing a set of points or CAD data in the IGES (Initial Graphics Exchange Specification) format. It contains the capability for finite element analysis and numerical machine tool control; however these are not supported by GEOLAB. ICEM-DDN interfaces with the ICEMCFD grid generation code described below.

Scaffold:

Scaffold is an interactive program which runs on IRIS workstations. The program is designed to create surface grids from surface measurements such as laser digitizer or cordax machines. This program is still under development.

Grid Generation

GRIDGEN

GRIDGEN (General Dynamics GRID GENeration system) is a collection of codes for 3-D multiple block grid generation. GRIDBLOCK (Version 8.3) provides an interactive graphics environment for creating and modifying multiple block structures and block connectivity data. GRIDGEN2D (Version 8.4) is an interactive graphics program for generating grids on surfaces and in 2-D regions. GRIDGEN3D (which runs on a CRAY) and GRIDVUE3D generate and view grids in 3-D regions.

ICEMCFD:

ICEMCFD is a grid generation system built on top of ICEM DDN, described above. Geometry data can either be created within the system or read in either in a point format or in an IGES format. The grid is created independent of the geometry and at the end of the process projected directly on the CAD surfaces. This patch-independent approach can overlook small gaps and overlaps of the surfaces in the geometry. ICEMCFD can be used to produce multi-block structured grids, unstructured tetrahedral grids, and body

fitted Cartesian grids. The resulting grids, topology and boundary conditions can be output in a number of formats to match different flow solvers that may be used.

AZ2000:

AZ2000 is a software package for generating and displaying two-dimensional multiblock structured grids. The package automatically determines the blocking structure around complex geometries and easily accommodates nested grids. This package has only just been acquired and is being evaluated. Based on the results of the evaluation of the 2D package, a 3D version of the code may be purchased.

VOLUME:

VOLUME is an interactive program written for IRIS workstations to generate multi-block structured volume grids. The code reads the surfaces of each block in either GRIDGEN or PLOT3D format. A transfinite method is used with the following blending functions: (1) Soni, (2) exponential, and (3) natural log. The unique feature of this program is the capability of not only specifying the boundary surfaces of each block but also the internal surfaces.

GridTool (version 2.5):

GridTool is an interactive program for IRIS workstations. This program has been developed for unstructured and structured grids. In unstructured areas, the code is capable of generating an input file for VGRID systems. Surfaces can be read either in point form such as GRIDGEN, PLOT3D, LaWGS, etc., or NURBS form such as IGES-128. Then, the surfaces are represented internally as NURBS surfaces. Also, the code can be used to project either unstructured or structured surface grids onto NURBS surfaces. There is a batch version available for projecting unstructured and structured surface grids.

CONVERT:

CONVERT is a batch program that allows one to convert grids to/from various formats such as binary, formatted, unformatted, single precision, double precision, PLOT3D, GRIDGEN, LaWGS, Tecplot, etc.

Flow Solver Codes

The following flow solver codes have been developed by Langley researchers and are used in GEOLAB. They are also available for distribution to the US government and its contractors. Separate focal points are listed for each:

VGRID/USM3D:

The VGRID/USM3D aerodynamic analysis system is available for computing the flow-fields around complex configurations. VGRID is a robust, user-oriented code for generating unstructured tetrahedral grids around very complex geometries by the Advancing Front Method. USM3D is an upwind flow code for solving the Euler equations on tetrahedral grids. Input for the system is facilitated through the GridTool utility developed by CSC Corporation and available through GEOLAB. The system is widely used and is supported by the Transonic Aerodynamics Branch (POC: Dr. Neal Frink/42864).

TLNS3DMB and CFL3D:

Two Reynolds-Averaged Navier-Stokes solvers developed in the Computational Fluid Dynamics Laboratory (B1192) are available for computations on block-structured grids. The two codes, TLNS3DMB and CFL3D, can and have been used extensively for a variety of applications across the Mach number range. The features of the two codes are:

1) Steady and unsteady strong conservation law forms of compressible flows.

2) Finite-volume discretizations

3) Euler and Navier-Stokes (laminar and Reynolds-averaged) solvers

4) Second-order spatial accuracy

5) Range of turbulence models from algebraic to two-equation models

6) Full MultiGrid (FMG) acceleration, including grid sequencing, to steady state

7) Perfect gas equation of state

The TLNS3DMB code has evolved from central-differencing concepts for the convective and pressure terms while the CFL3D code has evolved from upwind-differencing concepts. Both codes treat the viscous terms with central differencing. Either code allows an arbitrary number of generalized coordinate blocks. The CFL3D code has generalized patched and overset grid capabilities while TLNS3DMB requires a one-to-one connection between the grid points of the blocks. A unified input and output format is being currently developed and tested for both codes. Points of contact for the two codes, CFL3D and TLNS3DMB, are Dr. Chris Rumsey (x42165) and Dr. Veer Vatsa (x42236), respectively.

CFD Visualization

The graphics software used in conjunction with surface rendering and grid generation consists primarily of the packages SURFACE, FAST, FIELDVIEW, and TECPLOT. The functionality and characteristics of these packages are summarized in Table 1. (Chapter 4.)

Procedures

Persons wishing to use GEOLAB should contact Pat Kerr at extension 45782 or Eric Everton at extension 45778. Members of the GEOLAB group will describe the capabilities of the laboratory in more detail, will get the researcher started, and be available for subsequent consultation. There is a newsletter, entitled Surface Modeling and Grid Generation News that is published semi-annually. To get on the mailing list contact the editor, Marie Noland, at MS 125 or e-mail: m.s.noland@larc.nasa.gov.

6.3 The Software Engineering and Ada Laboratory (SEAL)

The Software Engineering and Ada Laboratory (SEAL), located in room 1121, Building 1268A, is best described as a total environment for the rapid development of highly-reliable, cost-effective, embedded flight and ground software for LaRC flight projects. Software is followed through its entire life cycle from concept, development, integration, testing in a simulated flight environment, and maintenance.

A Sun Sparc Server 690 MP and a NT Advanced (486 PC) Server provide access to common files and software tools. These machines are tied to a local area network to which are connected two Sun workstations, a Vax Station 4100 (with DECNet access) and a number of 486 PCs operating in the Windows NT environment. The LAN is, in turn connected to LaRCNET, providing access to the DMSS and other workstations and flight hardware setups located throughout the center. For testing purposes, engineering models of 80x86 and 1750A flight computers are located in SEAL and interfaced to simulated flight systems.

The major thrusts of the SEAL are to: support and improve a repeatable software development process; implement and measure effectiveness of the process on flight programs; provide a focal point for software development for LaRC flight projects, and promote technolgy transfer. The approach is to enforce standard software engineering practices, use state-of-the-art Computer Aided Software Engineering (CASE) tools, and make maximum use of previously developed and tested modules.

Ada compilers are available for PC, MAC, VAX, and SUN computers. There are also Ada cross compilers for embedded 80x86 and 1750A systems. Tools used in the SEAL Software Development Environment include:

CADRE Teamwork and Ensemble CASE Tools

Paradigm Plus (Object Oriented Meta-CASE Tool)

McCabe Tools (Analysis of Complexity, Battlemap Analysis, and Ada Language Parser)

Ada Measurement and Analysis Tool (AdaMAT/D)

VAX Software Engineering Tools (VAXset)

PC Data Acquisition Hardware and Software

InQuisiX- Reuse Repository Tool

In-Circuit Emulators

CADRW Software Analysis Workstation (SAW)

Logic Analysers/Oscilloscopes

Titan SESCO 80x86 Flight Equivalent Computer

PROM Tools

Recent LaRC projects that have used SEAL include the Controls-Structures Interaction (CSI)Project, a prototype exeriment to demonstrate real-time control of a large space structure using an embedded computer system; and the Lidar In-Space Technology Experiment (LITE), involving a shuttle born pallet carrying high-powered lasers for measuring trace elements in the atmosphere. The CSI project involved writing 2,500 lines of real-time Ada for the embedded 1750A control processor, 3,300 lines of real-time Ada for embedded 1750A interface units, and 9,000 lines of real-time Ada for the PC-based ground software system. The LITE project involved 12,200 lines of real-time Ada for the embedded 80186 flight computer and 80,000 lines for PC and MAC ground computers.

In 1991, SEAL was selected by NASA Headquarters to be a "Center of Excellence" for its accomplishments in technology transfer and in developing mission critical flight and ground support software for LaRC space flight and avionics projects.contributions in software engineering. SEAL personnel are participating in the NASA Software Engineering Program to establish NASA-wide policies and standards for software engineering, management and assurance.

SEAL contains extensive documentation on software development, and software development training is sponsored by the laboratory. SEAL staff members are available to help software developers to get started and to consult as needed.

CHAPTER 7. FLIGHT SIMULATION

Flight simulation involves the use of flight vehicle hardware in a ground-based laboratory setting with the translational and rotational motion of the vehicle (and the response of any actual flight hardware systems not physically implemented) being simulated by computers. In most cases, in order to provide a realistic evaluation of the performance of the flight system being studied, an appropriate flight deck is included in the hardware and a pilot is "in-the-loop." In these cases the simulation must proceed in "real-time;" that is, the computer program time is synchronized with the real world time and the computer must generate the motion and response of the simulated vehicle systems so rapidly and frequently that the pilot is not aware of any time delay or loss of continuity. In recent years flight simulation has included the computer generation of visual scenes such as out-of-the-window views of terrain, sky, and other aircraft; the incremental motions of flight deck and pilot; and the generation of electronic flight displays.

The Langley Research Center has employed flight simulation to support engineering research for at least 35 years. The vehicles most often studied are aircraft and spacecraft; but occasionally the same techniques are used to analyze other, more exotic systems, such as trains, flexible space structures, flow control in wind tunnels, and aircraft landing carriages. The research engineer is usually testing a new or improved design in the areas of automatic or augmented control, vehicle handling qualities, guidance, navigation, flight management, terminal air traffic management, high performance aircraft maneuverability, or some combination of these.

Until the late 1960's, analog computers (continuous and parallel) were used to compute the system model because digital computers (discrete and serial) were not fast enough. The advantages of digital computers, i.e., rapid setup through software, accuracy, and repeatability, were considerable, so that in 1967, when it appeared that the speed of digital computers was high enough, simulation was integrated into the CSCC through the use of two CDC 6600 computers with appropriate analog/digital conversion equipment. Each of these computers could support up to three different simulations simultaneously and perform unrelated scientific computation in the background. Various simulation setups and control consoles could be patched into the analog/digital converters via analog cable.

Over the next several years the CDC 6000 computers were upgraded to CDC Cyber 175s and the number of simulation configurations grew in number and complexity. With the advent of local area computer networks in the early 1980's, high speed digital communication became possible; thus, in 1986 the facility was reorganized to move the analog/digital conversion equipment from the computers to the simulation sites. This enabled more flexibility in configuring the available equipment for different studies and made it easier to include digital flight systems in the simulation. The entire system was referred to as the Advanced Real-Time Simulation System (ARTSS).

In 1987, a review of projected simulation requirements indicated that computing power needed to be increased by a factor of eight over that available at the time in order to simulate systems with a higher frequency response, greater complexity, and involving multiple aircraft interactions. Following a competitive procurement, Convex Computer Corporation was selected to provide two CONVEX computers to replace the Cyber 175s.

The current status of the ARTSS is shown schematically in Figure 6. The principal components are the two Convex computers that comprise the Flight Simulation Computing Subsystem (FSCS); the Configuration Switch; the CAMAC "highways," and a collection of facilities including control consoles, a Computer Generated Image (CGI) system and simulators for specific flight systems. When a simulation is initiated on one of the computers, the configuration switch is commanded by the program to activate all the necessary facilities on one or two highways.
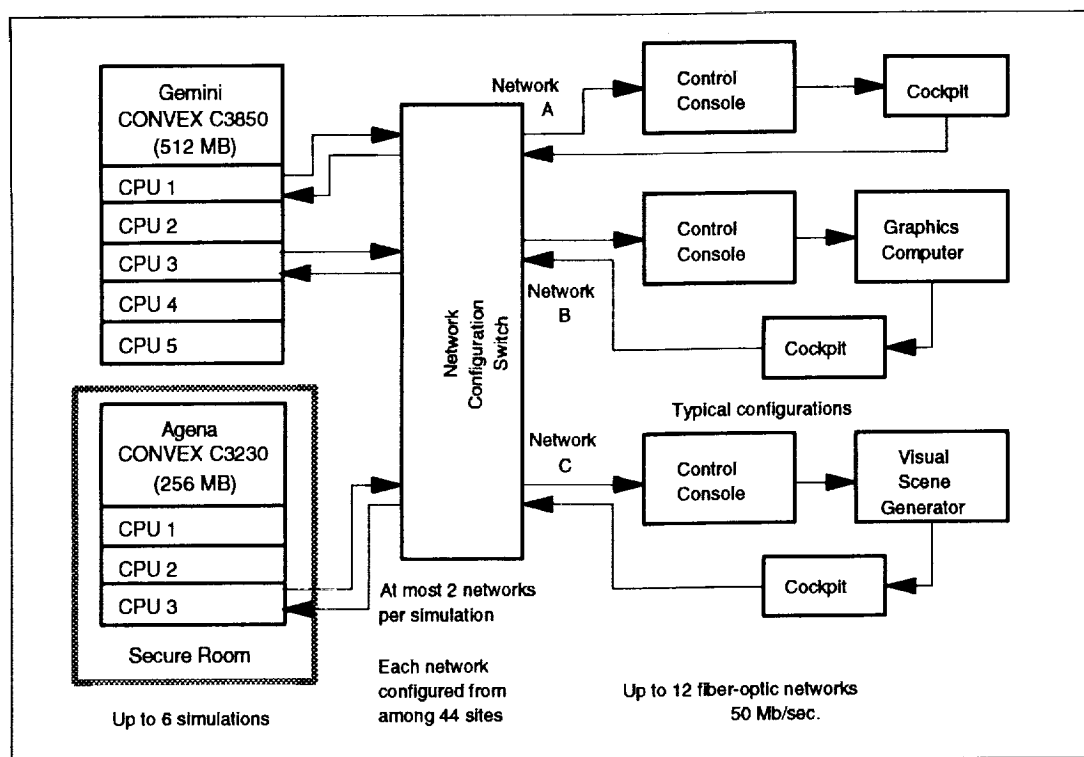
Figure 6. Advanced Real-Time Simulation System

7.1 The Flight Simulation Computing Subsystem

The FSCS consists of two Convex Computer Corporation supercomputers having similar architectures supporting both 64- and 32-bit scalar, vector, and parallel processing technology. One (Gemini) is a C3850 with 5 CPUs and 512 MBytes of common memory, and the other (Agena) is a C3230 with 3 CPUs and 256 MBytes of common memory. Agena is located in a secure area so that it can be used for classified processing and simulations when necessary. Four of Gemini's processors and two of Agena's processors can be used simultaneously for separate simulations, providing a total capacity of 6 simultaneous simulations. Using a benchmark simulation, it has been found that each CPU of the C3850 runs 5.6 times faster and each CPU of the C3200 runs 2.7 times faster than the previously used CYBER 175.

The real-time operating system consists of a full UNIX kernel with additional features necessary to support simulations operating in real time. Normal processing is interrupted by real time requests and the response to these requests is very rapid.

7.2 The CAMAC Highways

The ARTSS employs eight high-speed digital networks called CAMAC highways. At any given time, six totally independent simulations can be accommodated simultaneously. An aircraft simulation model is solved on one of the two Convex computers and it is normally assigned one highway. In certain special cases, a second highway can be assigned to a job. The purpose of the network is to communicate data between the central computers and the simulation sites (control console, cockpit, display generator, etc.). At set-up time, each job requests the sites it needs by a computer control statement. If the sites are available, the Network Switch, shown in the center of Fig. 6, is dynamically configured and the job will be

elevated to real-time status. The Network Switch provides for up to 44 sites to be configured into up to 12 networks in this way.

Each highway is in the form of a ring network. If we trace a signal from the central computer, it passes through the Network Switch, out to the first site, back to the switch, out to the second site, back to the switch, and so on, until it has passed through all the sites. The signal then returns to the central computer to complete the circuit. Communication between the Network Switch and the sites is provided by fiber-optic cables. The interface between the cable and each of the sites is accomplished by a device called a "crate." The effective data rate of the highway is 24 Mbits per second and the sites can be more than 6000 feet removed from the Network Switch.

All simulations are synchronized to a central clock which provides signals that are sent to the sites via a star network sharing the same fiber optic cable as the CAMAC highways. Clock signals trigger the start of analog-to-digital conversion and notify the central computer of the beginning of every simulation cycle.

7.3 The Computer-Generated Image System

This is a facility for generating visual scenes for all but one of the Langley simulators. It is a four-channel Evans and Sutherland CT-6 system with each channel having two display processors capable of updating 500,000 pixels in real-time. It contains two terrain data bases: the Dome data base; and the Denver, Stapleton airport environs data base.

The CGI is capable of providing images from two views for two independent eye points. Each eye point can be located in either of the two data bases, thus can be used for independent simulations in the same data base, independent simulations in different data bases, or co-located in the same data base to provide all four channels to the same simulation.

The Dome data base is for use in the Differential Maneuvering Simulator (DMS) although it can be used in any of the other simulators. It is described under the DMS, below. Distortion of the image which is inherent in a dome projection system is corrected for by the use of a technique known as Non-Linear Image Mapping (NLIM) so that all aspects of the image appear to be correct when viewed from the pilots eye-point at the center of the sphere.

The Denver data base is centered around the Denver Stapleton Airport and modeled with Defense Mapping Agency (DMA) data. This airport is modeled in its entirety, including all runways, taxiways, terminal buildings, strobe lights, beacon lights, runway lights, taxiway lights, approach lights, and VASIs. Surrounding the airport are a few buildings, a water tower, and the city of Denver. Aircraft models that can be displayed are the B-707, B-727, and DC-10. Any three aircraft can be active in the scene at any one time with control from another piloted simulator or a simulation such as MOTAS.

Various environmental effects can be incorporated in the scene, such as variable visibility, variable sun position and intensity (time of day), cloud cover, ground fog and haze, surface texture, lightning, variable intensity lights, and reflections of lights. Occultation occurs correctly when, for example, an aircraft flies behind a mountain.

In April, 1993, a contract was awarded to Evans and Sutherland to deliver three Image Generator Subsystems (IGS) to LaRC. The first will be available for production in September 1994, the second in February 1995, and the third in February 1996. Once all of these are in place, it will be possible to simultaneously run from three to five simulations with out-the window images. Additional features provided by the new IGS's include additional data bases, higher performance, two independent layers of clouds, and collision detection.

7.4 Cockpit Motion Facility

Currently under construction, the Cockpit Motion Facility (CMF) will considerably enhance the Center's flight simulation program by providing motion cues for several of the simulators. The completed facility will contain four motion capable flight simulators and a state-of-the-art six-degree-of-freedom motion system that can be used interchangeably with any of the designated simulators. The CMF will consist of two building additions (Phase 1 and Phase 2), the new motion system, extensive modifications to two existing flight simulators, and two additional simulators to be acquired in the future. An additional major component under consideration is the acquisition of a Wide-angle Infinity Display Equipment (WIDE) system which when connected to the Advanced Computer-Generated Image (ACGI) system will give a large field-of-view display to the simulator crew members.

Progress to date has included the architectural and engineering design and award of contract for the Phase 1 building, the development of specifications, and award of a contract for the new motion system, plus the conceptual design for modifying the simulators to be mounted upon it. Present plans are for initial operation of the facility with one cockpit during the spring of 1995.

Flight simulators to use the CMF include the existing Transport Systems Research Vehicle (TSRV) and Visual Motion Simulator (generic) cockpits with planned future additions of a High-Speed Research (HSR) and Terminal Area Productivity (TAP) cockpits.

7.5 Simulation Facilities

In this section a number of the simulation facilities developed and maintained by the Analysis and Simulation Branch (ASB) are briefly described. Further information may be obtained from ASB.

The Differential Maneuvering Simulator

The Langley Differential Maneuvering Simulator (DMS) provides a means of simulating two piloted aircraft operating in a differential mode with a realistic cockpit environment and a wide-angle external visual scene for each of the two pilots. The system consists of two identical fixed-based cockpits, each based in a 40 ft. diameter projection sphere. Each projection system consists of two terrain projectors to provide a realistic terrain scene, a target image projector, and an area-of-interest projector. The terrain scene, driven by a Computer-Generated Image (CGI) system, provides reference in all six degrees of freedom in a manner that allows unrestricted aircraft motions. The resulting sky/earth scene provides full translational and rotational cues. The internal visual scene also provides continuous rotational and bounded (300ft. to 45,000 ft.) translational reference to the other (target) vehicle in six degrees of freedom. The target image, a computer-generated model, is presented to each pilot and represents the aircraft being flown by the other pilot. This dual simulator can be tied to a third dome (the General Purpose Fighter Simulator) and thus provides for three aircraft interactions when required. The image for the second aircraft is generated by a digital laser projector. For a higher resolution visual scene, an area-of interest projector system is available in each sphere to provide a 30° vertical by 40° horizontal display.

Each cockpit provides three color displays with a 6.5-in. square viewing area and a wide-angle heads-up display. Kinesthetic cues in the form of a g-suit pressurization system, helmet loader system, g-seat system, cockpit buffet, and programmable control forces are provided to the pilots consistent with the motions of their aircraft. Other controls include a side arm controller, dual throttles, and a rotor-craft collective. Simulated engine sounds and wind noise add realism.

Research applications include studies of advanced flight control laws, helmet-mounted display concepts, and performance evaluation for new aircraft design concepts for development programs such as F-18 E/F, AX, and F-22.

The Visual/Motion Simulator

The Visual/Motion Simulator (VMS) is a general-purpose simulator consisting of a two-person cockpit mounted on a six-degree-of-freedom synergistic motion base. Four collimated visual displays, compatible with the CGI system, provide out-the-window scenes for the left and right seat front and side windows. Six electronic displays mounted on the left and right side instrument panels provide for displays generated by a graphics computer. A programmable, hydraulic-controlled, two-axis side arm and rudder pedals provide for roll, pitch, and yaw controls in the left seat. Another programmable, hydraulic control loading system for the right seat provides roll and pitch controls for either a fighter-type control stick or a helicopter cyclic controller. Right-side rudder control is an extension of the left-side rudder control system. A friction-type collective control is provided for both the left and right seats. An observer's seat allows a third person to be in the cockpit during motion operation.

A realistic center control stand, in addition to providing transport-type control features, provides auto-throttle capability for both the forward and reverse thrust modes. A Cockpit Display Unit (CDU) is provided in the forward electronics panel of the center control stand. Motion cues are provided in the simulator by the relative extension or retraction of the six hydraulic actuators of the motion base. Washout techniques are used to return the motion base to the neutral point once the onset motion cues have been commanded.

Research applications have included studies for transport, fighter, and helicopter aircraft, including the National Aerospace Plane (NASP), Personnel Launch System (PLS), and High-Speed Civil Transport (HSCT). These studies addressed phenomena associated with wake vortices, high speed turnoffs, microwave landing systems, energy management, noise abatement, multi-body transports, maneuvering stability flight characteristics, windshear recovery guidance, vortex flaps, and stereographic displays. Numerous simulation technology studies have also been conducted to evaluate the generation and usefulness of motion cues.

Mission Oriented Terminal Area Simulation

The Mission Oriented Terminal Area Simulation (MOTAS) facility is an advanced simulation capability that provides an environment in which flight management and flight operations research studies can be conducted with a high degree of realism. This facility provides a flexible and comprehensive simulation of the airborne, ground-based, and communications aspects of the airport terminal area environment. The major elements are an airport model, several aircraft simulators, air traffic controller stations, and a realistic air-ground communications network. The airport terminal area represents today's Denver Stapleton International Airport and surrounding area with either an advanced automated air traffic control (ATC) system or a present-day vectoring ATC system using air traffic controllers.

The MOTAS facility combines the use of several aircraft simulators and pseudo pilot stations to fly aircraft in the airport terminal area. The facility is presently operational with the Transport Systems Research Vehicle (TSRV) Simulator, the DC-9 Full-Workload Simulator, and the General Aviation Simulator. The Advanced Civil Transport Simulator will be interfaced to the facility after the conversion to the FSCS has been completed. These aircraft simulators allow full crews to fly realistic missions in the airport terminal area. The remaining aircraft flying in the airport terminal area are flown through the use of the pseudo-pilot stations. The operators of these stations can control five to eight aircraft at a time by inputting commands to change airspeed, altitude, and direction. The final major components of the facility are the air traffic controller stations, which are presently configured to display and control the two arrival sectors, the final approach sector, and the tower and/or departure sectors. Because of its flexibility in reconfiguring according to research requirements, the MOTAS facility can support a variety of flight

vehicle and/or air traffic control system research studies that would not be possible in the real world due to safety, economic, and repeatability considerations.

The General Aviation Simulator

The General Aviation Simulator (GAS) consists of a general-aviation aircraft cockpit mounted on a three-degree-of-freedom motion platform. The cockpit is a reproduction of a twin-engine propeller driven general-aviation aircraft with a full complement of instruments, controls, and switches, including radio navigation equipment. Programmable control force feel is provided by a "through-the-panel" two-axis controller that can be removed and replaced with a two-axis side-stick controller mounted in the pilots left-hand, center, or right-hand position. A variable-force-feel system is also provided for the rudder pedals. The pilot's instrument panel can be configured with various combinations of cathode ray tube (CRT) displays and conventional instruments to represent aircraft such as the Cessna 172, Cherokee 180, and Cessna 402B. A collimated-image visual system provides a nominal 40° horizontal by 23° vertical view out-the-window color display. The visual system accepts inputs from the CGI system. A Calligraphic/Raster Display System (CRDS) is used to generate the heads-down displays and for mixing with the CGI for the heads-up display.

Research has been conducted to improve the ride quality of GA aircraft by developing gust alleviation control laws to reduce the aircraft response to turbulence while still maintaining generally good flying characteristics. A research study recently completed is the GA Easy Fly, a program to investigate ways of making GA airplanes easier to fly, especially for low time or non pilots.

The Transport Systems Research Vehicle Simulator

The Transport Systems Research Vehicle (TSRV) simulator is a primary research tool used by the Advanced Transport Operating Systems (ATOPS) program. The goal of the ATOPS program is to increase the operational capability of modern aircraft and foster their integration into the evolving National Airspace System.

The TSRV Simulator provides the means for ground-based simulation in support of the ATOPS research program. The simulator allows proposed concepts in such areas as guidance and control algorithms, new display techniques, operational procedures, and man/machine interfaces to be thoroughly evaluated. Four out-the-window display systems (driven by the CGI system) allow realistic real-world scenes to be presented to the crew. The system is capable of daytime, nighttime, and all ranges of weather effects. The simulator has a full complement of eight electronic displays and two side arm controllers representative of the technology available in commercial transports in the 1990's. Promising simulation research results become the subjects of actual flight test research. The simulator is fully integrated with a realistic air traffic control facility to provide an environment for systems level studies.

The DC-9 Full-Workload Simulator

This simulator consists of a fixed-base McDonnell-Douglas DC-9-30 cockpit, a test console, and electronics cabinets. The cockpit was formerly a DC-8 cockpit, but was upgraded to provide the capability for dedicated DC-9 full workload simulations. Stations are available in the cockpit for a captain and first officer. Flight control responses for elevator, aileron, and rudder are simulated by forces from hydraulic servo systems. Manual or auto throttle control for two engines is provided on the center console. The forward electronics panel of the center console is outfitted with a Control Display Unit (CDU) which has a Cathode Ray Tube (CRT) display and keyboard to enable the pilot to interact with the flight management computer in advanced aircraft navigation systems. Two visual displays, driven by the CGI system, provide

out-the-window scenes and a maximum field-of-view of 43° horizontal by 36° degree vertical for each crew member.

A full complement of operational navigation and communication radios are available. Full workload studies can be performed in this simulator because the capability exists to simulate all aircraft instruments, enunciators, switches, and alarms.

Research applications have included a cockpit procedures study, a terminal time-based Air Traffic Control (ATC) delivery performance of conventional aircraft study, a Microwave Landing System (MLS) study, and a study for Managing Approach and Landing Information (MAPL).

The General Purpose Simulator

The General Purpose Simulator (GPS) is a single seat, fixed-base fighter simulator. The system consists of a cockpit inside a 20-ft. diameter projection sphere. The cockpit presents to the pilot standard fighter instrumentation, single or dual throttles, programmable control forces for pitch and roll, and a spring-loaded rudder system. The instrument panel has two 14-inch Cathode Ray Tube (CRT) displays. The standard pitch and roll controls can be replaced with a spring-loaded hand controller. The dome projection system consists of a horizon line projector and two laser target projectors representing other aircraft, typically being flown by pilots in the DMS. A Heads-Up Display (HUD) is available

Research applications include Remote Piloted Vehicle drop model studies (X31) in support of the Plum Tree Island test facility, and interactive air combat simulation (2 versus 1).

The Advanced Civil Transport Simulator

The Advanced Civil Transport Simulator (ACTS) is a futuristic aircraft cockpit simulator, designed to provide full mission capabilities for researching issues that will affect future transport aircraft flight stations and crews. The unique desk-top design uses the latest innovations in electronics to help the pilot and crew become effective managers of increasingly more complex aircraft systems. The objective is to heighten the pilot's situation awareness through improved information availability and ease of interpretation, in order to reduce the possibility of missed signals and misinterpreted data. Traditional columns and wheels have been replaced by side-stick controllers that make room for the desk-top design. The simulator's five CRT monitors are designed to display flight information in a logical, easy-to-see format.

Specifically, the five 13-inch color CRTs present 10 active displays to the pilot, that may be selected from a menu of over 100 separate displays. The two outside screens show flight and navigation data. The center three screens typically show engine and systems status, data linked Mode S transponder system information, weather data, surrounding air traffic information, checklists, and the status of functional systems such as fuel, electrical, and environmental, all controlled by touch panel overlays. Two monochromatic flat panel display units with keyboards and touch sensitive screens provide monitoring and modification of aircraft parameters, flight plans, flight computers, and aircraft position. Three collimated visual display units have been installed to provide out-the-window scenes via the CGI system.

The simulator will be used to study and exploit advanced automation concepts. The major research objectives are to examine needs for transfer of information to and from the flight crew, study the use of advanced controls and displays for all-weather flying, explore ideas for using computers to help the crew in decision making, and study visual scanning and reach behavior in different conditions with various levels of automation and flight deck arrangements.

CHAPTER 8. USER RESOURCES

8.1 Documentation

There are a number of sources of information on the CSCC. These include standard (paper) manuals and user guides, bulletins, electronic (on line) notes and documentation, and miscellaneous documents. This chapter will attempt to categorize these sources and how to access them.

CSCC Documents

Documents describing and providing information on how to use the various subsystems of the CSCC are organized into a collection of free-standing manuals. Currently they are divided into series as follows:

A   - General (red covers)

CX   - CONVEX Computers (yellow covers)

CR   - CRAY Computer (blue covers)

G   - Graphics (red covers)

N2   - NCS Computers (red covers)

R   - Real-Time Simulation (red cover)

Z   - Applications (red covers)

Within each series the documents are numbered sequentially, i.e., CX-1, CX-2, etc. The first document in each series is a "mini-manual" which summarizes the subject matter and lists the contents of that series. Thus to find out more about any one of the above topics, the first step is to obtain the corresponding mini-manual. The manuals following the first are assigned numbers in the order they are established. They may be documents written at Langley or by the vendor of the particular subsystem They are intended to be uniform in style, and at least the cover should conform to the established style. It is possible that any of the documents be published as a NASA formal document. A lower-case letter following the document number indicates a revision level. For example, A-1a is an updated version of A-1, A-1b is an updated version of A-1a, and so on.

Every new user of the CSCC should receive a copy of A-1. The new user of SNS computers should automatically receive a copy of A-8, SNS Programming Environment User's Guide, CX-1 and CR-1. Most manuals are automatically distributed to CSCC librarians located at various sites. A complete set of user documents is maintained in the Operations Control Office (OCO), Building 1268, Room 1047. Users may request personal copies of frequently used documents from the OCO (ext. 46562).

Computer and LaRCNET Bulletins

Bulletins are short notices sent out from ACD to provide important information to computer users as rapidly as possible. They include notices of system changes and updates, new features, training opportunities, and in general, are used to attempt to keep users up to date.

There are two series of bulletins: Computer Bulletins are used to provide information relevant to the CSCC and LaRCNET Bulletins are used to provide information relevant to LaRCNET and the distributed computing environment at LaRC.

Bulletins are sent electronically via the LaRC E-Mail Post Office (see Chapter 4), with the exception that paper copies are mailed to LaRC mail stops for persons who do not have access to e-mail. There are separate address lists for the two bulletins. When a CSCC Computer User Authorization Form (ACD-

CMB-N-972) is approved for a new user or to delete a user, it is used to update the Computer Bulletin address list. Similarly, when a LaRCNET Service Request Form is approved for a new person or to delete a person it is used to update the LaRCNET bulletin address list. E-mail addresses can be added, changed, or deleted by calling the Operations Control Office (864-6562).

Information contained in bulletins is also posted in the notes files "cbullet" or "lbullet" on eagle and mustang.

SNS On-line Documentation

This refers to information on the use of the SNS which can be accessed and displayed via interactive terminals.

Messages (msgs) and Notes (notes) are utilities supported by UNIX and available on the SNS Convex computers. msgs is for short term information such as "eagle will be down for maintenance on Saturday". You will be notified if there are any messages when you login to a computer. To view messages type

    msgs

and the message(s) will appear on the screen one page at a time. notes is for more lasting information on topics relevant to the use of the system. This may include new features, known problem areas and work-around suggestions, announcements of meetings or seminars, or special interest information. notes is controlled by the system administrator, but you can arrange for a particular notes topic and permission to post notes by contacting the system administrator. At the system prompt a list of available notes topics can be displayed by typing

    notes

To obtain a list of notes on a given topic, type

    notes topic_name

The notes are listed in numerical order. To read a given note just type its number at the "?" prompt. To leave the notes system type q at the prompt.

Users are encouraged to check the notes frequently. An appropriate command in your .login file may be used to automatically read new notes in specific categories.

On-Line Manual

The on-line manual is a means of obtaining detailed information on any of the UNIX commands. Type

    man command-name

to obtain a display of the manual page(s) that describe the command command-name. If you cannot remember the command name but have a keyword that is associated with the command, type

    man -k keyword

to obtain a listing of commands associated with keyword. Related commands are

    whatis command-name

to obtain a brief description of the command, and

    apropos keyword

to obtain a list of commands that are related to the keyword.

CONVEX help

The CONVEX computers have a command called **info** to provide help. The first time you type info, several screens of information will come up that will explain how to use the help system. Thereafter, a menu of topics will appear. To obtain further information on these topics, follow the prompts.

Mathematical Library On-Line Documentation

imsldoc and **larcdoc** are scripts that will provide on-line documentation on the IMSL and LaRC mathematical subroutine libraries implemented on CONVEX and CRAY computers. BCSLIB and BCSLIB-EXT documentation can by obtained by entering the command

man bcslib

on the Cray computers. To obtain more information on accessing this documentation, see the appropriate Mini-Manual or Mathematical Libraries Manual.

Mosaic and Gopher

Mosaic is a high-level information browser that will execute on workstations and personal computers with access to internet (interconnected networks spanning most of the world). At LaRC, internet access is provided via LaRCNET and SURAnet. The Mosaic display includes both text and graphics and uses a technique called "hypertext" or, more generally, "hypermedia." Segments of the display (word, phrase, graphic, or icon), for which further information is available, are highlighted. If the user points at a one of these segments, using a mouse, and clicks the mouse button, Mosaic automatically links to the information represented by that highlight. This, in turn, is a similar display with highlighted segments; thus the user may search to any desired depth or "navigate" through a virtually unlimited space of information. Major installations, such as LaRC, have a "Home Page" display which can be invoked when Mosaic is first called. The Home Page is an entry point to information maintained by that installation and a starting point for branching out over the network. For example, the LaRC home page gives entries to information on various organizational elements at LaRC, but also an entry to the NASA home page, which, in turn can provide an entry to the Goddard Space Flight Center. For those workstations having audio capability, certain highlights can invoke a recorded message; also some graphics can be "blown up" to full screen size.

Gopher is a text only subset of Mosaic; thus under the Analysis and Computation Division highlight of the LaRC home page, there is an entry called "ACD Gopher." By clicking on this highlight the user can access textual information on the CSCC and a number of the topics addressed in this report.

The Mosaic software is currently available, free of charge, from its developers at the National Center for Supercomputing Applications (NCSA) University of Illinois, Urbana-Champaign. There are versions available for the X-Window system, Apple Macintosh computers, and PCs operating under Windows. Send an e-mail message to **mosaic@ncsa.uiuc.edu**, to obtain the latest information for retrieving this software.

8.2 Training

Training in topics relevant to the use of the CSCC is available through periodically scheduled classes that are sponsored by ACD; through self-study courses offered by the Learning Resource Center of the Training and Education Section, PD; and through Center sponsored courses offered by the Training and Education Section.

ACD Sponsored Classes

These classes are normally restricted to subject matter which is necessary to use the computers of the CSCC. They are given by ACD or support service contractor personnel. They are usually given in a series covering a broad aspect of CSCC use.

The classes are announced through computer bulletins which have tear-off, mail-back enrollment forms. The individual enrollee is notified of the time and place of each class. Handouts are usually prepared for distribution to attendees and are available for others who desire them. Attendees are asked to complete an evaluation form. Classes being offered currently are described below.

Introduction to UNIX

This is a course consisting of 8 classes. The classes are presented as a block and it is recommended that all be attended since each class assumes knowledge of material presented in preceding classes. Each class lasts 1[1/2] to 2 hours. The course is given two or three times each year.

Class 1	Basics.
Class 2	ex and vi Editors, Part 1.
Class 3	Compile, Load, and Execute.
Class 4	Customizing the C Shell Environment.
Class 5	1) Pipes and Filters, and 2) Controlling Processes.
Class 6	User to User Communications.
Class 7	Networking.

SNS User Course

This is intended to introduce new users to the SNS. Experience in programming (but not necessarily for supercomputers) and a knowledge of UNIX is assumed.

Class 1   SNS Computing Environment.

Class 2   Architecture and Performance of the SNS Computers.

Class 3   SNS Job Execution.

Class 4   SNS Debugging.

Using the X Window System

The X-Window system is a graphical user interface for UNIX.

Learning Resource Center Courses

A variety of self-teaching audio/visual and computer terminal media are available at the Learning Resource Center located in building 1194, 2 West Durand Road (864-2325). Over one hundred courses or individual lectures on computer related topics are available, covering many aspects of the use of the CSCC. Included are courses in the UNIX operating system; FORTRAN Ada, and C programming; parallel computing, numerical techniques, and the use of many application programs. These courses are listed in the Learning Center Catalog published by the Employee Development Branch.

Center-Sponsored Computer Training

Short courses on special topics of interest to computer users are offered at times by the Employee Development Branch. Some of the current topics which may be or recently have been offered include programming in a variety of languages, software management, microprocessor fundamentals, engineering problem solving with computers, UNIX, software cost estimating, and courses specific to computers in widespread use at the Center.

Annually, the courses to be offered during the fiscal year are described in an issue of the On-Site Training Catalogue. Each Division has a training coordinator who is notified when additional courses are to be offered. Requests to attend classes or course offerings should be made though your division training coordinator.

Graduate study courses offered under the LARC Graduate Study Program include computer-related university courses. Those courses to be offered are described in a Langley Announcement prior to each semester. For more information contact the Employee Development Branch (ext. 42585)

8.3 Getting Assistance

ACD personnel and CSCC support contractor personnel wish to help the researcher make the best possible use of the CSCC. The OCO maintains an "ACD Customer Services List" which gives telephone numbers and e-mail addresses of offices or individuals assigned to various specialty areas within the complex. This list is also available as the ascii file ~acdcs/list on all SNS computers.

REPORT DOCUMENTATION PAGE

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13. ABSTRACT (Maximum 200 words)

This document describes the computers and associated equipment that make up the Central Scientific Computing Complex of the Langley Research Center. It describes the electronic networks that provide access to the various components of the complex and a number of application laboratories that can be used by Langley and contractor staff for special applications (scientific visualization, image processing, software engineering, and grid generation). Flight simulation facilities that use the central computers are described. Management of the complex, procedures for its use, and available services and resources are discussed.

The document is intended for new users of the complex, for current users who wish to keep apprised of changes, and for visitors who need to understand the role of central scientific computers at Langley.

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