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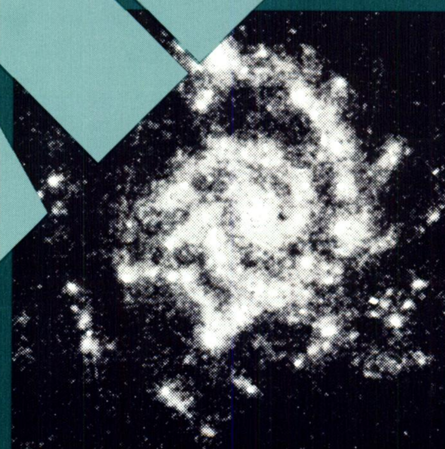

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93N29222* ISSUE 11 PAGE 3613 CATEGORY 82

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UTTL: Applied Information Systems Research Program Workshop

CORP: National Aeronautics and Space Administration, Washington, DC.

SAP: Avail: CASI HC A08

CIO: UNITED STATES Workshop held in Boulder, CO, 22-24 Jul. 1991

MAJS: /*INFORMATION SYSTEMS/*RESEARCH AND DEVELOPMENT

MINS: / DATA BASES/ DATA MANAGEMENT/ DISTRIBUTED PROCESSING/ INFORMATION TRANSFER

ANN: The first Applied Information Systems Research Program (AISRP) Workshop provided the impetus for several groups involved in information systems to review current activities. The objectives of the workshop included: (1) to provide an open forum for interaction and discussion of information systems; (2) to promote understanding by initiating a dialogue with the intended benefactors of the program, the scientific user community, and discuss options for improving their support; (3) create an advocacy in having science users and investigators of the program meet together and establish the basis for direction and growth; and (4) support the future of the program by building collaborations and interaction to encourage an investigator working group approach for conducting the program. For individual titles, see N93-29223 through N93-29241.

ENTER:

NASA-TM-108773

APPLIED INFORMATION SYSTEMS RESEARCH PROGRAM

WORKSHOP PROCEEDINGS

OSSA

JULY 22-24, 1991

BOULDERADO HOTEL
2115 13th Street
BOULDER, COLORADO

APPLIED INFORMATION SYSTEMS RESEARCH WORKSHOP

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APPLIED INFORMATIONS SYSTEMS RESEARCH WORKSHOP

PREFACE

The first Applied Information Systems Research Program (AISRP) Workshop provided the impetus for several groups involved in information systems to review current activities. Investigators representing fifteen of the twenty-two Office of Space Science and Applications (OSSA)/Information Systems Branch (ISB) NASA Research Announcement awards were in attendance. Attendees also included representatives from the Science and Technology divisions of NASA, directors of NASA's Centers of Excellence, specific research institutes, and members of the academic and remote sensing arena.

The objectives of the workshop are outlined:

- To provide an open forum for *interaction* and discussion of information systems research activities.
- To promote *understanding* by initiating a dialogue with the intended benefactors of the program, the scientific user community, and discuss options for improving their support.
- Create an *advocacy* in having science users and investigators of the program meet together and establish the basis for direction and growth.
- Support the *future* of the program by building collaborations and interaction to encourage an investigator working group approach for conducting the program.

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APPLIED INFORMATIONS SYSTEMS RESEARCH WORKSHOP

ACKNOWLEDGEMENTS

We wish to gratefully recognize the following persons for the skillful support given towards the success of this first Applied Information Systems Research Program (AISRP) workshop. The capable efforts and contribution of each individual are greatly appreciated. Thank you.

- Elaine Hanson/Colorado Space Grant Consortium, University of Colorado, for hosting the workshop
- Susan Solari/Colorado Space Grant Consortium, University of Colorado, for hosting the workshop and making local arrangements
- Karen Friedman/National Center for Atmospheric Research (NCAR), for giving assistance with local arrangements, especially for the workshop reception held at NCAR
- Anne Novotny/NASA HQ, Code SM, and Leslie Emerson/Center for Space and Advanced Technology (CSAT) for providing registration and on-site logistical support

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APPLIED INFORMATIONS SYSTEMS RESEARCH WORKSHOP

SYNOPSIS

The workshop proceeded according to the agenda provide herein, (see Appendix, attachment A). The first day was given to programmatic presentations. Joseph Bredekamp/NASA HQ, ISB, provided the overall context for the program. Representatives of OSSA Science Disciplines and of the Office of Aeronautics, Exploration and Technology reviewed current as well as planned data and information systems activities. Presentations were also made on the Center of Excellence in Space Data and Information Sciences (CESDIS) and the Center for Aerospace and Space Information Sciences (CASIS). These Centers work to encourage collaborations between government, academia, and industry.

Following this, presentations were made by the participating principal investigators of the Applied Information Systems Research Program. In attendance to these presentations were scientists, software developers, program managers, technologists and computer systems personnel. This diversity of audience allowed for evaluation of the broad issues regarding use, development, and maintenance in information systems.

Presentations topics included visualization and associated analysis, data management including distributed databases, and software tools for modeling. Several presentations highlighted remote sensing, software development, and high performance computing. Many of the activities reported on are based on existing and commercial products, but all included advances in the field.

The final day of the workshop was devoted to discussions centered toward three key topics; technology transfer options, technical issues and future interaction.

<u>Technology Transfer Options</u>

This discussion yielded three different directions for information diffusion, specifically across disciplines within OSSA, from OAET to OSSA, and across the broader science community. Issues and options for each direction area differed.

Across disciplines within OSSA, consensus was made that the at-large science community needs to be made aware of the tools and techniques under development for the Applied Information Systems Research program. Several attendees suggested that the transfer activity be made a formal, explicit part of the program. Some encouraged OSSA to provide the infrastructure to support and disseminate results. Others suggested that the technology transfer responsibility for results be made part of the NRA award.

OSSA to OAET

Workshop attendees agreed that a closer interaction between the two organizations was needed, but the mechanism was unclear. Attendees agreed that OSSA should be the 'implementing' code.

Broader Science Community

All agreed that outreach is important. There was also agreement that many options are already available, and need to be fully utilized. The group considered several other options. It was suggested that the Computer Software Management Information Center (COSMIC) at the University of Georgia be considered a candidate for functioning as the software distribution mechanism for the agency

Discussion's of technical issues emphasized a variety of interchange issues. Further discussion of these topics and development of additional topics, was delegated to future splinter group discussions. Overall, the discussion emphasized the need to consider user requirements, both current and future, during the tool development.

APPLIED INFORMATIONS SYSTEMS RESEARCH WORKSHOP

FOLLOW-ON ACTIONS

Two near-term actions were identified. The first is to poll investigators to identify current computing platforms being used, preferred mode of operation, etc. The second action is to establish a set of test dataset suites, to help compare and evaluate effectiveness of various software tools.

Since this was the first meeting of the Applied Information Systems Research activity, many of the continuing logistics aspects were discussed as well. The preferred format seemed to be an annual meeting, with 'splinter group' sessions for specific topics or subsets of the group to be included at the same meeting. As additional topics warrant, interim 'mini workshops' should be convened as well.

Future meetings will continue to include both the science and project communities, as well as investigators in the program. Future meeting sites will continue to require infrastructure for demonstrations of tools (workstations, network access, etc.) In the interim, a network bulletin board will be established for rapid and timely communications.

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APPLIED INFORMATION SYSTEMS RESEARCH WORKSHOP

JULY 22-24, 1991

BOULDERADO HOTEL
Boulder, Colorado

AGENDA

MONDAY, JULY 22,1991

11:30 a.m.	Registration	
1:00 p.m.	Welcome and Logistics	Elaine Hansen
1:15 p.m.	Program Overview	Joe Bredekamp
2:00 p.m.	Office of Space Science and Applications Data Environment and Future Plans	
	-Earth Observing System Data and Information System	Martin Ruzek
	-Planetary Data System	Randy Davis
	-Astrophysics Data Systems	Alice Bertini
4:00 p.m.	Office of Aeronautics, Exploration and Technology Information Systems Program	Paul Hunter
4:20 p.m.	Center of Excellence in Space Data and Information Sciences (CESDIS)	Ray Miller
4:40 p.m.	Center for Aerospace and Space Information Sciences (CASIS)	Mike Flynn
5:00 p.m.	Adjourn	

APPLIED INFORMATION SYSTEMS RESEARCH WORKSHOP

JULY 22-24, 1991

BOULDERADO HOTEL
Boulder, Colorado

AGENDA

TUESDAY, JULY 23, 1991

8:30 a.m.	Principal Investigator Presentations	
12:00 p.m.	Lunch	
1:00 p.m.	Principal Investigator Presentations	
5:30 p.m.	Reception at the National Center for Atmospheric Research	

WEDNESDAY, JULY 24, 1991

8:30 a.m.	Flight Project Office Information Systems Testbed (FIST)	Patricia Liggett
8:50 a.m.	Intelligent Data Management	Bill Campbell
9:15 a.m.	Open Discussion -Where we go from here to work together on program: potential collaborations, subgroups, future workshops, etc. -Technology Transfer and Infusion	
12:00 p.m.	Adjourn	

APPLIED INFORMATION SYSTEMS RESEARCH WORKSHOP

P.I. PRESENTATIONS
(Morning Session)

Experiment's Laboratory for Visualized Interactive Science	Ms. E. Hansen Univ. of Colorado	
Grid Analysis and Display System (GRADS): A Practical Tool for Earth Science Visualization	Dr. J. Kinter Univ. of Maryland	
A Distributed System for Visualizing and Analyzing Multivariate and Multidisciplinary Data	Dr. A. Jacobson JPL	
Advanced Data Visualization and Sensor Fusion: Conversion of Techniques from Medical Imaging to Earth Science	Dr. R. Savage Hughes	*
Development of an Expert Data Reduction Assistant	Dr. G. Miller STSCI	
System of Experts for Intelligent Data Management (SEIDAM)	Dr. D. Goodenough Canada Centre for Remote Sensing	
Construction of an Advanced Software Tool for Planetary Atmospheric Modeling	Dr. R. Keller NASA/ARC	
Knowledge-based Assistance for Science and Analysis Using Large Distributed Databases	Mr. T. Handley, Jr. JPL	
Multi-Layer Holographic Bifurcative Neural Network Systems for Real-Time Adaptive EOS Data Analysis	Dr. Hua-Kuang Liu JPL	

LEGEND: * P.I. Presentation not given/ ** P.I. not in attendence

APPLIED INFORMATION SYSTEMS RESEARCH WORKSHOP

P.I. PRESENTATIONS
(Afternoon Session)

A Distributed Analysis and Visualization System for Model and Observational Data	Mr. M. Arrott Univ. of Illinois	
An Interactive Environment for the Analysis of Large Earth Observation and Model Data Sets	Professor K. Bowman Univ. of Illinois	* **
A Land-Surface Testbed for EOSDIS	Dr. W. Emery Univ. of Colorado	
Geographical Information System for Fusion and Analysis of High-Performance Remote Sensing and Ground Truth Data	Mr. A. Freeman JPL	
Development of a Tool-Set for Simultaneous, Multi-Site Observations of Astronomical Objects	Dr. Chakrabarti Univ. of CA/Berkeley	* **
SAVS: A Space Analysis and Visualization System	Dr. E. Szuszczewicz Science Applications International Corp.	
Planetary Data Analysis and Display System: A Version of PC-McIADS	Dr. S. Limaye Univ. of Wisc., Madison	
Interactive Interface for NCAR Graphics	Mr. R. Lackman National Center for Atmospheric Research	
The Development of Generic and Extensible Software to Support the Study of Space Science Data	Mr. G. Goucher NASA/GSFC	* **
VIEWCACHE: An Incremental Database Access for Automous Interoperable Databases	Assoc. Prof. Nick Roussopoulos Univ. of MD	
A Spatial Analysis and Modeling System for Environmental Management	Mr. C. Vermillion NASA/GSGC	
Introduction to CADET: Center for Advanced Data Evaluation Technology	Ms. Cathy Schulbach NASA/ARC	
Topography from Shading and Stereo	Professor B. Horn MIT	* **
Multivariate Statistical Analysis Software Technologies for Astrophysical Research Involving Large Data	Mr. G. Djorgovski JPL	* **
High Performance Compression of Science Data	Dr. J. Storer Brandeis Univ.	* **

LEGEND: * P.I. Presentation not given/ ** P.I. not in attendence

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APPLIED INFORMATION SYSTEMS RESEARCH PROGRAM WORKSHOP

PROGRAMMATIC OVERVIEWS

APPLIED INFORMATIONS SYSTEMS
RESEARCH WORKSHOP

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APPLIED INFORMATION SYSTEMS RESEARCH PROGRAM WORKSHOP

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APPLIED INFORMATIONS SYSTEMS
RESEARCH WORKSHOP

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Applied Information Systems Reserach Program Workshop

Boulderado Hotel
Boulder, Colorado

July 22-24, 1991

Joe Bredekamp

Applied Information Systems Research Program

Workshop Objectives

- Exchange information on status and plans of research efforts
- Initiate dialog with OSSA science disciplines and other related NASA efforts
- Establish basis for conducting program
  - Means to facilitate communications and collaborations
  - Advocacy building
  - Technology transfer and infusion
  - Future directions

Applied Information Systems Research Program

- Objectives of Workshop
- Office of Space Science and Applications Information Systems Strategy
- Information Systems Research and Technology and Systems Evolution

Office of Space Science and Applications

Information Systems Strategy

- Science discipline divisions provide primary focus for discipline-specific data management systems that integrate project data plans and on-going research needs into total research capability
- Provide robust, multi-discipline infrastructure
  - Architecture, policies, standards, practices, etc. to promote interoperability and resource sharing
  - Access to high performance computing
  - Network services
  - Information services (directories, catalogues, etc.)
- Apply and exploit advances in technology to evolve and enhance systems capabilities

Information Systems Research and Technology and Systems Evolution

Objective: Apply advanced information systems technology as appropriate to improve support to OSSA science programs

Elements: Applied research (tools and capabilities, etc.)

Testbed demonstrations and insertations

Approach: Broaden participation through open solicitations

Provide as part of frastructure capability to support testbeds, rapid prototyping, etc.

Leaverage with related efforts in NASA/OAET; NSF, etc.

Status: Applied research program initiated (you are here!) and well-received

Next solicitation targeted for Summer 1992

Issues/Opportunities:

Need to develop systematic process for technology transfer and infusion

Sharpen research agenda to focus future solicitations

THE EARTH OBSERVING SYSTEM DATA AND INFORMATION SYSTEM

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APPLIED INFORMATIONS SYSTEMS
RESEARCH WORKSHOP

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NASA — Earth Science & Applications Division

The Earth Observing System Data and Information System (EOSDIS)

Applied Information Systems Research Workshop
Boulder, Colorado

Sara J. Graves
July 22-24, 1991

ESAD

NASA — Earth Science & Applications Division

EOSDIS and Earth System Science

- EOSDIS is a pivotal part of the U.S. Global Change Research Program and the international effort to understand how the Earth functions as a complete system
- Earth system science objectives require a data and information system that will
  - Encourage multidisciplinary and interdisciplinary investigations
  - Combine data from the EOS platforms with data from other agencies and nations (other satellites, aircraft, *in situ* operational and experimental data)
  - Integrate EOS information with models of environmental processes and global change

NASA — Earth Science & Applications Division

Major System Drivers of EOSDIS

Mission life	15+ years
International partners	Japan, European Space Agency (ESA), and Canada
Interdisciplinary research	Climate, hydrologic system, biogeochemistry
Multidisciplinary research	Land, oceans, atmosphere
Multiple instruments	MODIS, HIRIS, ITIR, SAFIRE....
Multiple platforms	EOS-A, EOS-B, EPOP-M, JPOP, EPOP-N
Distributed system architecture	GSFC, EDC, LaRC, JPL, ASF, MSFC, NSIDC, investigator sites
Large number of users	>500 AO scientists and thousands of users
Massive data volume	50,000 Tbytes
Massive data processing	As much as 60 Mbps input, 500 Mbps output
Metadata	Comprehensive directory, catalogs, inventories, and browse products

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EOSDIS Major Functions

- Mission planning, scheduling, and control
- Instrument planning, scheduling, and control
- Effective resource management
- Communications
- Computational facilities at Investigator sites to support research
- Production of standard data products
- Production of special data products
- Archiving and distribution of data and research results

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EOSDIS Strategy

- Work with the users to meet their needs
- Make data easily accessible for research users
- Begin development immediately
- Use lessons learned from current efforts
- Build on existing infrastructure
- Utilize open, distributed architecture
- Evolve with advances in technology and Earth science

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EOSDIS Research Users

Research users must abide by the stipulations outlined in a "Research Agreement"

- Publish in the open literature results of research based in whole or in part on data obtained from EOS
- Make available to the research community the derived data, algorithms, and models at time of acceptance for publication
- Data used only for the researcher's bona fide research purposes
- Data may be copied and shared among other researchers provided that they are covered by a Research Agreement or the researcher who obtained the data is willing to take responsibility for compliance

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Early EOSDIS Objectives

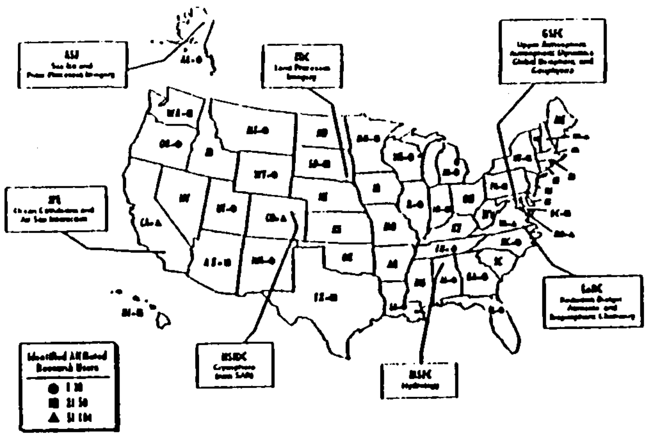
- Provide increased utility to scientists
  - Improve access to existing data sets
  - Produce new research-quality geophysical products
  - Provide better metadata/data services
  - Maintain existing services
- Build EOSDIS infrastructure/unifying capabilities
  - Build working relationship between DAACs, Project, and users
  - Implement first communications links, standards, etc.
- Prototype/test/evaluate DIS elements and standards
- Produce results to guide continuing development
- Adopt Earth system science vs. "Earth sciences" view

NASA — Earth Science & Applications Division

EOSDIS Design Implications

- EOSDIS is one system even though distributed
- DAACs are the institutionalization of EOSDIS
- Each new step should advance us towards the integrated EOSDIS
- The EOSDIS users are the researchers, not the general public
- Results as well as data must be archived
- System must be evolvable to survive
- Meeting user needs must be paramount
- Respond to DAAC User Working Group
- The payoff is in improved efficiency/effectiveness of the research

EOSDIS DAACs



NASA

NASA — Earth Science & Applications Division

▶ What is the EOSDIS Version 0?

- Version 0 is the first manifestation of EOS that anyone will see
- Version 0 is the working prototype of NASA's Earth science data system
- Version 0 is SCFs, DAACs, networks, and IMS
- Version 0 is populated by
  - Existing data
  - Pathfinders
  - *In situ*, aircraft, and field campaign measurements
  - Precursor missions
  - Modeling and other research results

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▶ Why is EOSDIS a Distributed System?

- Recognizes the distributed nature of Earth science community
- Recognizes the existing distribution of assets and capabilities
- Provides for diversity of styles in data use
- Provides for multiple prototypes
- Ensures capability to interface with external systems

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Early EOSDIS Pathfinder Data Sets

- For existing data important for global change
  - Level 1 data to active working storage/safe archive
  - Scientists (academic, agency) develop/select *community-consensus* algorithms/products
  - Generate and validate the derived products
  - Make data and products accessible through Distributed Active Archive Centers (DAACs) and metadata/browse services by Information Management System (IMS)
- Working with NOAA, start with four data sets
  - AVHRR—SST and vegetation products
  - GOES—Products TBD
  - TOVS—Vertical profile products
  - SSM/I—Sea ice, precipitation, etc.
- Others TBD—Science needs to drive selection

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▶ Version 0 - Version 1

- **Time scale of Version 0 is from now until**
  - Our needs require Version 1
  - Our means are adequate to implement Version 1
- **Transition from Version 0 to Version 1 should feel like a continuous activity**
- **EOSDIS is an evolutionary system**
  - Hardware and software will be coming and going forever
  - Service to the community is preserved by being institutionalized
    - Continuity of DAACs and network
    - Meet user expectations, listen to user advice, and obtain user support

ESAD

AN OVERVIEW OF THE PLANETARY DATA SYSTEM

Randy Davis
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APPLIED INFORMATIONS SYSTEMS
RESEARCH WORKSHOP

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An Overview of the Planetary Data System

PDS

Planetary Data System

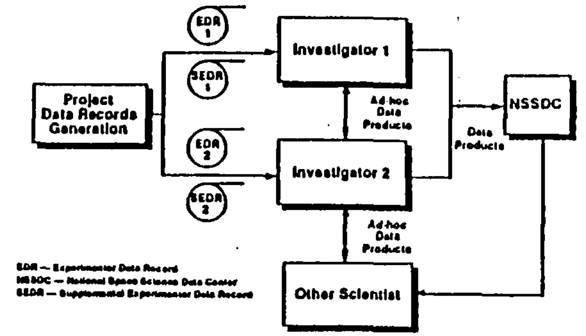
Presented at the
Applied Information Systems Research Workshop

by

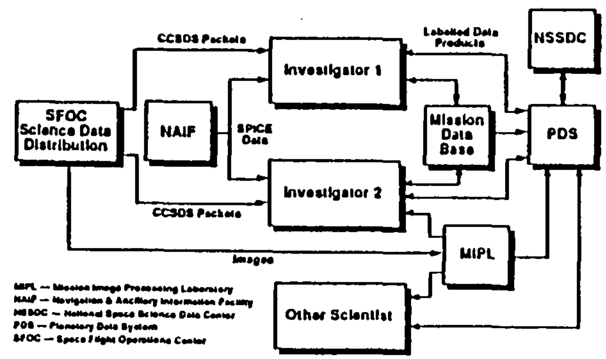
Randy Davis
University of Colorado
Laboratory for Atmospheric and Space Physics

22 July 1991

Old-Style Planetary Data Delivery



Modern Planetary Data Access



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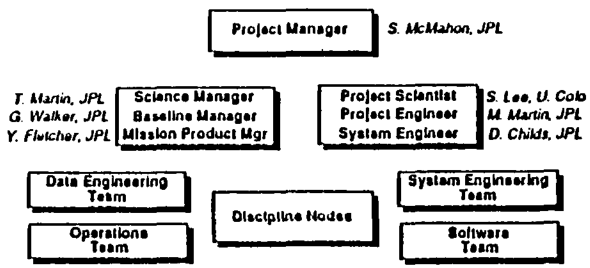
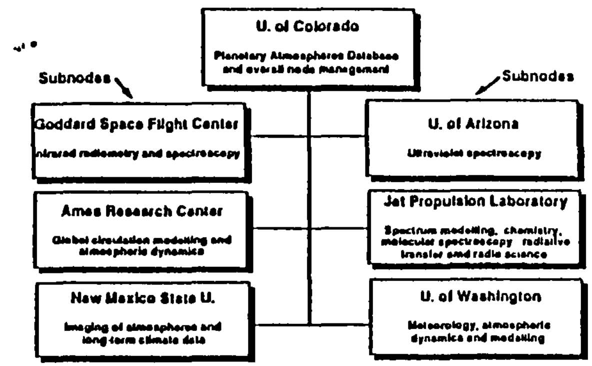
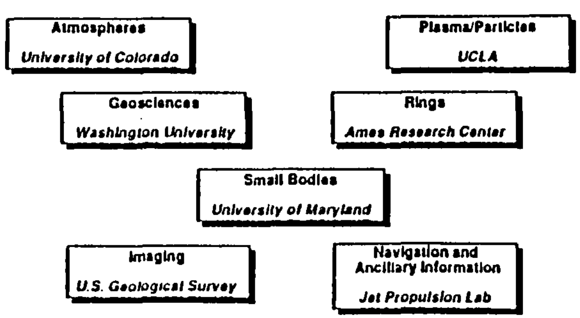
PDS Project Organization



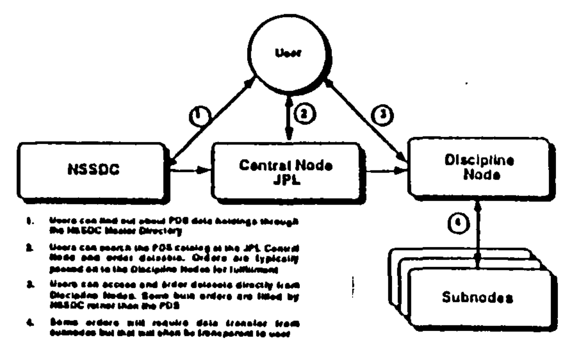
Sample Discipline Node (Atmospheres)



The PDS Discipline Nodes

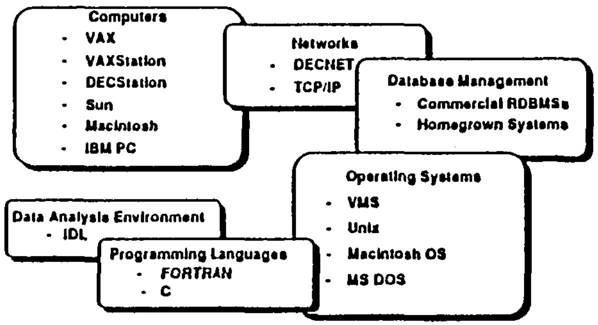


How Users Access the PDS



1. Users can find out about PDS data holdings through the NSSDC Master Directory
2. Users can search the PDS catalog at the JPL Central Node and order datasets. Orders are typically passed on to the Discipline Nodes for fulfillment
3. Users can access and order datasets directly from Discipline Nodes. Some bulk orders are filled by NSSDC rather than the PDS
4. Some orders will require data transfer from subnodes but that will often be transparent to user

Planetary Researchers Work in a Heterogeneous Computing Environment



PDS

Standards Being Embraced or Examined

- Operating Systems
  - Posix
- Networks
  - CCSDS telemetry/command systems for space-to-ground links
  - OSI-compliant ground networks
- Database Management Systems
  - SQL for queries
- Data Interchange
  - Object Description Language (ODL) for identifying and describing data
  - Limited use of CCSDS Standard Format Data Units (SFDUs)
  - ISO 9660 CD-ROM for importing/exporting large volumes of data
- User Interface
  - X Windows for basic user interface functions
  - Motif for *look and feel*

PDS

Concluding Remarks

- Thanks to CD-ROM, PDS is moving from *distributed databases* to *distributable databases*
  - Planetary CD-ROM disks are available for use in your work
- The common denominator computer hardware configuration for planetary science is changing:
  - From: a VAX and a VT-100
  - To: workstations with sophisticated graphics capabilities
  - Macs and MS DOS machines may become more important since good tools are available on these platforms
- The planetary community is striving for consistent and robust information interfaces between scientists, flight project systems, and the discipline archive (PDS)
- We in the PDS welcome discussions on how to make your research more useful and available to planetary scientists
  - PDS is a working system, with stringent quality and configuration control, but good new technology will always be considered

PDS

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ADS PROJECT REVIEW
INTRODUCTION & ADS OVERVIEW

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CASA
Univ. Of Colorado
Boulder, Co
(303) 492-6422

APPLIED INFORMATIONS SYSTEMS
RESEARCH WORKSHOP

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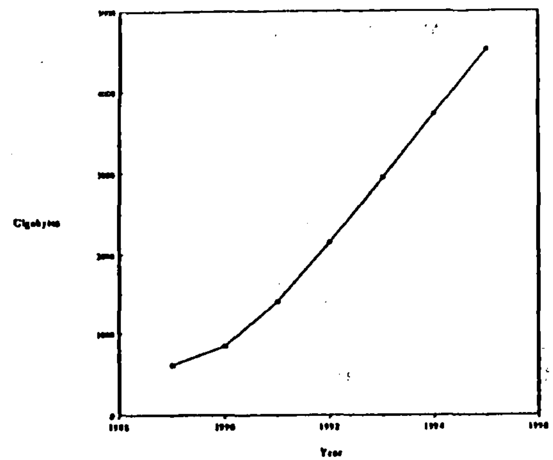
ADS PROJECT REVIEW

Introduction & ADS Overview

Alice Bertini
CASA/University of Colorado

NASA Mission Data Volume



ADS Project Review

Introduction

What is the Astrophysics Data System?

- **Response to Needs Recognized by Various Studies**

  CODMAC Reports I (1982) and II (1988)
  Astrophysics Data Operations "The Martin Report" (1988)
  Astrophysics Data Systems Study (1988)
  Information Systems Strategic Planning Project (1990)

- **Common Themes of Studies**

  Large Influx of Data - 10's Gigabytes/yr -> Terabytes/yr
  Knowledge of Data Holdings - What? Where?
  Access to Data and Meta-Data - Catalogs, Data Products, Archives, Documentation
  Multimission Access with Security - Networks, On/Near-Line Access, Authentication
  Applicable into 21st Century - Flexible, Extensible, Evolvable
  Science Driven System - Enhance or Enable Science Research e.g., "Pan Chromatic" Studies

ADS Project Review

Introduction

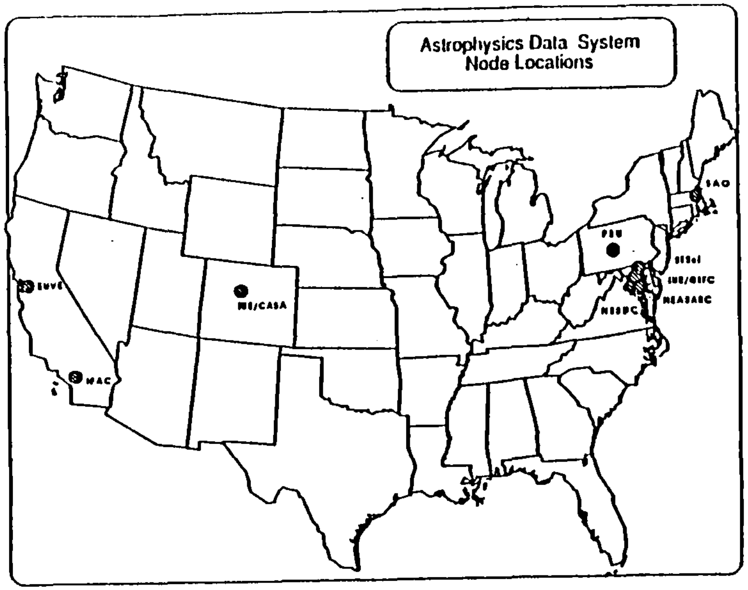
Status of System Now

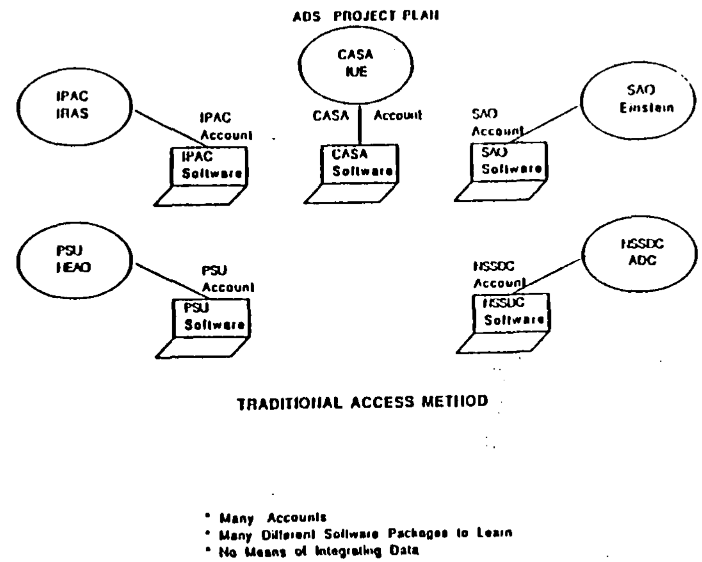
- **Operational System**

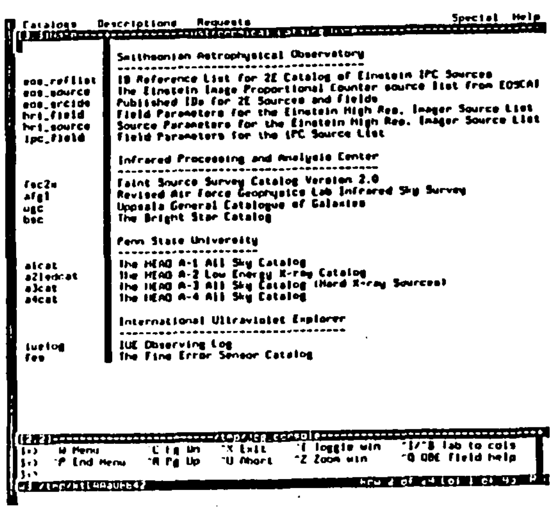
  100 Registered Users
  16 Databases from 5 nodes
  600 Queries 1st Month
  70,000 Records 1st Month

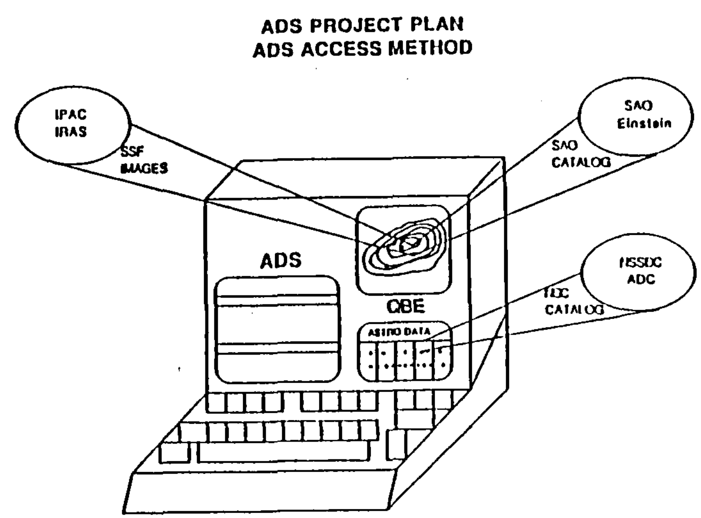
- **Transition from Development to Operations**

  Internal Re-organization of Project in Progress
  Emphasis on Operation of System
  Project Plan Based on Providing Science Services to Users


Astrophysics Data System
Node Locations
SAO

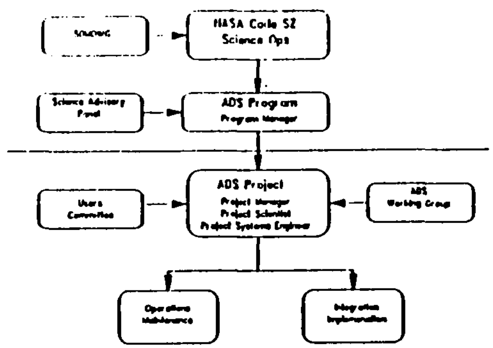

ADS PROJECT PLAN
CASA
IUE
IPAC
IRAS
IPAC
Account
CASA
Account
SAO
Account
SAO
Einstein
IPAC
Software
CASA
Software
SAO
Software
PSU
HEAO
PSU
Account
NSSDC
Account
NSSDC
ADC
PSU
Software
NSSDC
Software
TRADITIONAL ACCESS METHOD
• Many Accounts
• Many Different Software Packages to Learn
• No Means of Integrating Data


Catalogs Descriptions Requests Special Help
Smithsonian Astrophysical Observatory
eos_reflist IB Reference List for 2E Catalog of Einstein IPC Sources
eos_source The Einstein Image Proportional Counter source list from EOSCAT
eos_srcids Published IDs for 2E Sources and Fields
hri_field Field Parameters for the Einstein High Res. Imager Source List
hri_source Source Parameters for the Einstein High Res. Imager Source List
ipc_field Field Parameters for the IPC Source List
Infrared Processing and Analysis Center
fsc2w Faint Source Survey Catalog Version 2.0
afgl Revised Air Force Geophysics Lab Infrared Sky Survey
ugc Uppsala General Catalogue of Galaxies
bsc The Bright Star Catalog
Penn State University
a1cat The HEAO A-1 All Sky Catalog
a2ledcat The HEAO A-2 Low Energy X-ray Catalog
a3cat The HEAO A-3 All Sky Catalog (Hard X-ray Sources)
a4cat The HEAO A-4 All Sky Catalog
International Ultraviolet Explorer
iuelog IUE Observing Log
fes The Fine Error Sensor Catalog
W Menu
^P End Menu
^A Pg Up
^X Exit
^U Abort
^Z Zoom win
^Q QBE field help


ADS PROJECT PLAN
ADS ACCESS METHOD
IPAC
IRAS
SSF
IMAGES
SAO
Einstein
SAO
CATALOG
NSSDC
ADC
ADS
QBE
ASTRO DATA

ADS Project Review

Top Level Organization Chart



ADS Project Review

Overview

Major Milestones of ADS

- **Astrophysics Data System Workshops: 1987, Report 1988**
  Working Group Formed 1988
- **Internal Alpha Release 1 - Q2 1989**
  User Interface Prototype
- **Internal Alpha Release 2 - Q4 1989**
  Distributed Data Access Prototype
- **External Beta Release 1 - Q2 1990**
  Distributed Data Base Access via MPS
  Prototype Command Language
- **External Beta Release 2 - Q1 1991**
  DataBase Server
  Novice Environment
  Operational Testing
- **Operational System Release 1 -Q2 1991**
  16 Catalogs On-Line with Documentation
  100 Registered Users

ADS Project Review

Overview

Science Objectives of ADS

- **Provide Information on Existence and Location of Data Holdings**
- **Provide Access to Data Holdings**
- **Provide Sufficient On-Line Information on Data for Scientific Use**
- **Provide Tools for Selection, Retrieval, and Manipulation of Data**
- **Provide Tools for Information Retrieval (Textual Data Access)**
- **Provide Access to Data Processing Services**
- **Provide Tools for Data Processing, Visualization**

ADS Project Review

Overview

Scientific Based Senarios Imply Functional Requirements

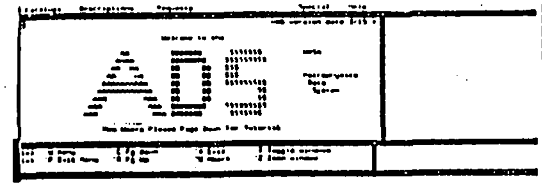
- **Cross Correlation of Catalog Data**
  Coordinate Conversion
  Sky Binning, Distance Test (Search in Cone)
  Combining Data
  Export Results
- **Location of Data/Objects**
  Name Resolution
  Browse Data Sets
  Order Data Sets/Immediate Transmission
  Visualization
- **Data Processing (Examples)**
  Source Detection with Custom Parameters
  Deconvolution of Images
  Spectral Fitting
  Flat Fielding

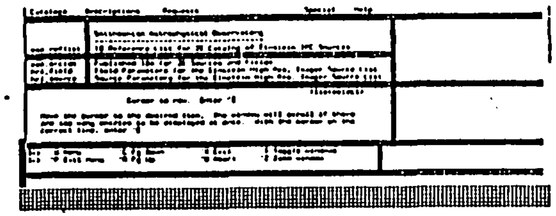
ADS Project Review

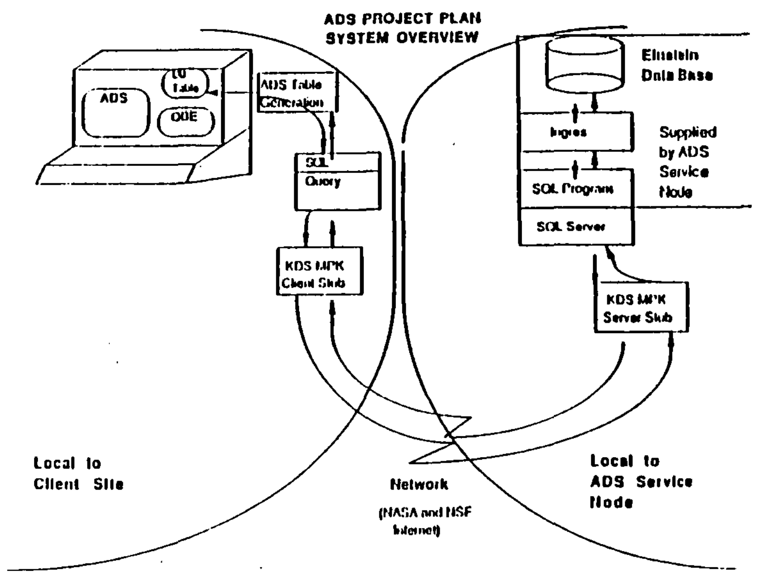
Overview

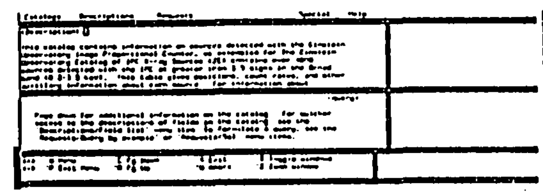
Scientific Based Senarios Imply Functional Requirements

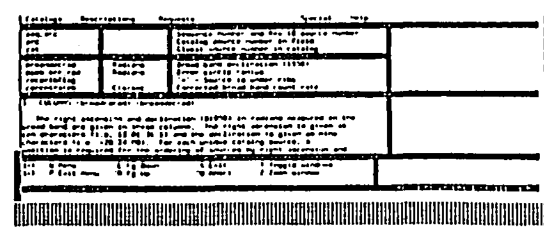
- **Simple User Scenario**
  - What sources are seen in both X-ray and IR space observations?
  - Is there a correlation of X-ray and IR fluxes for a class of objects?
- **Actions**
  - Get X-ray sources over some range of parameters, e.g., RA, DEC, Class
  - Get IR sources in same range of parameters
  - Compare source lists
  - Plot flux vs flux
- **Functions**
  - Access Remote Databases
  - Convert Coordinates
  - Match Objects by Postion
  - Extract Interesting Measurement Data
  - Plot Results

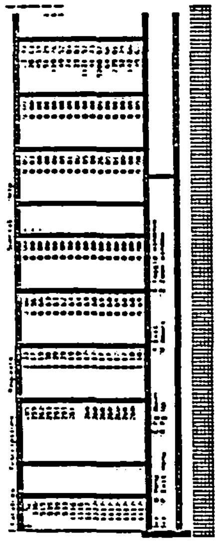


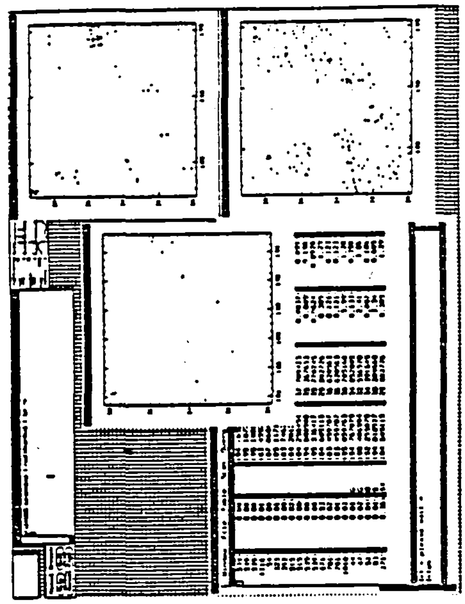


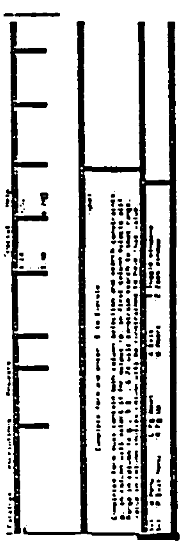


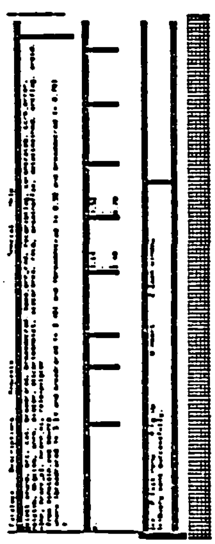


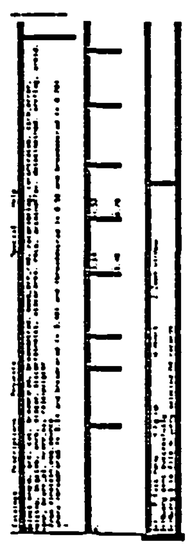


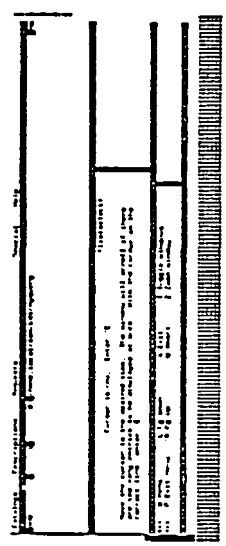












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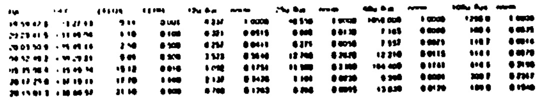

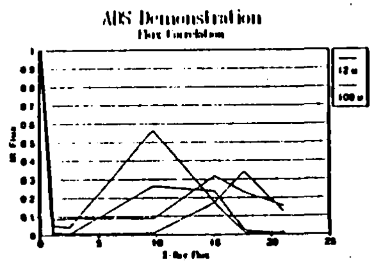

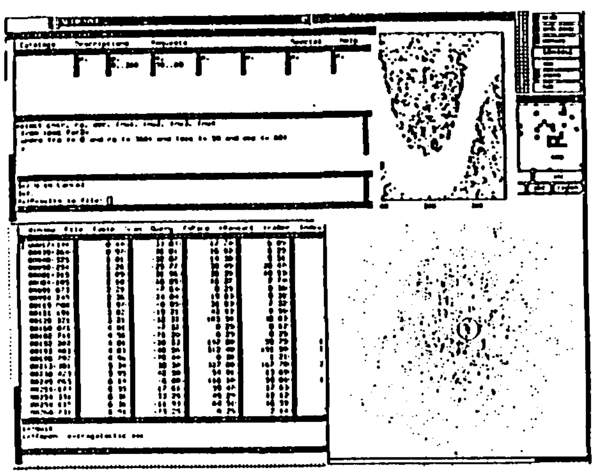

ADS Project Review

Overview

Future Functional Milestones

- **Catalog Access Tools**
  - NED Interface Q1 '92
  - Name Resolver Q2 '92
  - Locate Data on an Object (P Q3 '92) Q2 '94
  - SIMBAD Interface ?
- **Data Set Access**
  - Data Archive Capability (P Q2 '92) Q4 '92
  - Image Display (P Q2 '93) Q2 '94
  - Graphics Display (P Q2 '93) Q2 '94
  - Proprietary Data Access Q1 '95
  - Data Analysis Tools ?
- **Text Retrieval**
  - Distributed Documentation Q4 '92
  - Text Database Indexing Scheme Q2 '95
  - Keyword Augmentation to Indexing Q3 '95
  - Text Retrieval System Q4 '95

ADS Project Review

Overview

Scientific Project Enabled by Functionality of ADS

- **On-Line Astronomical Literature and Documentation**

  Scanned Literature from Astronomical Journals
  - Data Archive

  Document Retrieval Technologies
  - Indexing, Retrieval

  Transmission and Viewing of Documents
  - Display of Graphs and Images
  - Display of Scanned Text is a New Function

OAET COMPUTER SCIENCE & DATA SYSTEMS PROGRAMS

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NASA/OAET
CODE R
Washington, D.C.
(202) 453-2704

APPLIED INFORMATIONS SYSTEMS
RESEARCH WORKSHOP

NOTES:

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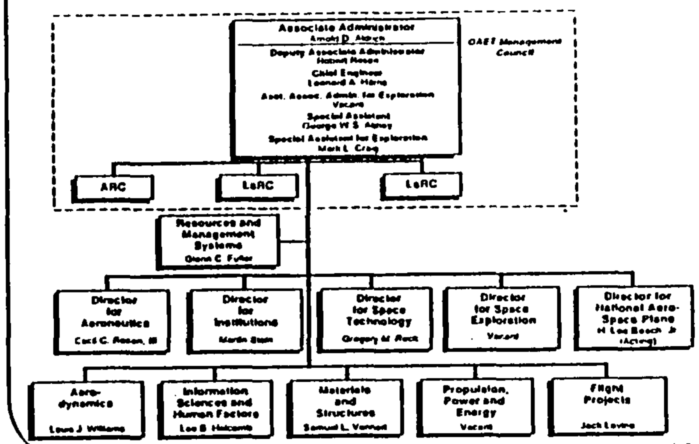
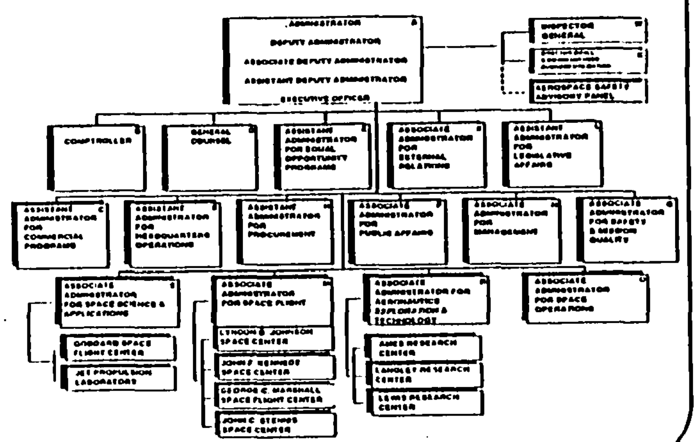
OAET COMPUTER SCIENCE & DATA SYSTEMS PROGRAMS

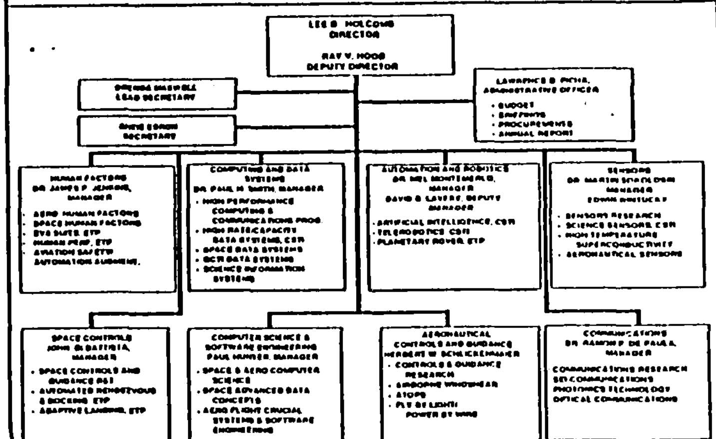
OSSA Applied Information Systems Program Workshop
Boulder, Colorado

JULY 22, 1991

Paul Hunter
OAET/RC







Research Institutes & Centers of Excellence

University Centers of Excellence

ICLASS
Illinois Computer Laboratory for Aerospace Systems & Software
University of Illinois, Urbana Champaign / LaRC
POC: Dr. Jane Liu, (217) 333 0135;
Dr. Ravi Iyer, (217) 333 9732

CASIS
Center for Aeronautics and Space Information Sciences
Stanford University, Palo Alto, CA / HQ
POC: Dr. Mike Flynn, (415) 723-1450

Space Engineering Research Centers

VLSI Hardware Acceleration Center for Space Research
University of Idaho / HQ
POC: Dr. Gary Maki, (208) 885-6500

RESEARCH INSTITUTES

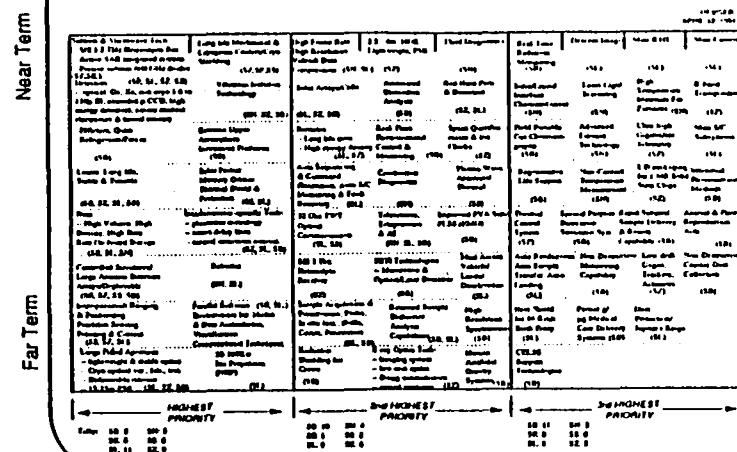
CESDIS
Center of Excellence for Space Data and Information Science
University of Maryland, College Park / GSFC
POC: Dr. Raymond Miller, (301) 286-3805

ICASE
Institute for Computer Applications in Science and Engineering
LaRC
POC: Dr. Robert Voigt, (804) 864 2173

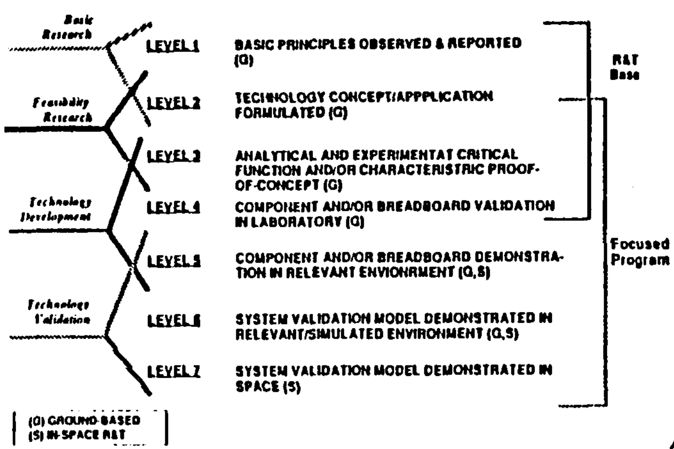
RIACS
Research Institute for Advanced Computer Science
ARC
POC: Dr. Joe Oliger (Acting), (415) 961-6407

RICIS
Research Institute for Computing and Information Sciences
University of Houston - Clear Lake / JSC
POC: Dr. Charles W. McKay, (713) 283-3830

OSSA TECHNOLOGY NEEDS



TECHNOLOGY MATURITY LEVELS



OAET PROGRAMS

- Computer Science
- Software Engineering
- Space Data Systems
- High Performance Computing and Communications (HPCC)

COMPUTER SCIENCE PROGRAM

- Includes: ARC, LaRC, GSFC, & JPL
- Supports: RIACS, ICASE, CESDIS, CASIS & ICLASS
- Program Drivers:
  - Accelerating NASA application software
  - Immense data set access, distribution, and visualization
  - Distributed, heterogeneous computing systems
  - Advanced information processing concepts
  - Collaborative research & telescience

NASA Y91

CONCURRENT PROCESSING RESEARCH

J Dorband - Code 935

ACCOMPLISHMENTS

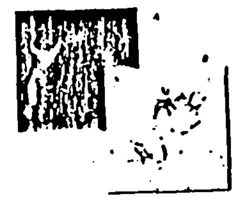
Demonstrated running in the MPP array with
- Fractal Dimension Computation

Demonstrated running in the MPP array with
- Nebula Gas Velocity Computation
- Cellular Dynamical Systems Simulation

Validated generic fine grained parallel C compiler

BENEFITS

- Image Understanding
- Physical System Modeling
- Higher Speed Field Simulation
- Portability of programs between massively parallel computers and heterogeneous hardware architectures



Nebula Gas Velocity Computation

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Cellular Dynamical Systems Simulation

[illegible]

CS 17

CONCURRENT PROCESSING RESEARCH - FY90
506-45-11

OBJECTIVE:
Provide fundamental research to develop algorithms that map effectively to computers with both very large numbers of processors and high speed connections between processors for application to NASA problems.

ACCOMPLISHMENTS:
During FY90, new algorithms were developed to run in the array unit of the newly acquired MasPar MP-1, a commercial massively parallel SIMD machine, and of the Massively Parallel Processor (MPP). The algorithms are extremely compute intensive, map very well to the SIMD architecture, and include:

Fractal Dimension Computation: This technique is used to indicate the degree of scaling of underlying processes causing phenomena captured by data sets. We demonstrated on the MPP an application package which computes the fractal dimension (capacity) of point data sets of one, two or three dimensions. This work was performed in collaboration with the National Institute of Standards and Technology (NIST).

Cellular Dynamical Systems Simulation: These simulations provide useful models for systems such as neural membranes, heart muscle, reaction diffusion devices, and ecological systems. We demonstrated on the MPP simulations of large cellular dynamata consisting of 512 by 512 cells (i.e. a quarter million coupled chaotic oscillators). Regions in the parameter space were found where random initial conditions result in recognizable structure after a few hundred iterations. We presented a paper on this topic at the second Artificial Life Conference in Santa Fe, NM in February 1990. This work was performed in collaboration with Dr. John Collins/Georgetown University, and Dr. Ralph Abraham/UCSC.

Also during FY90, the compiler for a generic fine grained parallel C language (first defined in FY88) was completed and validated. The motivation for the development of this C language and its computational libraries is to define and develop ways that allow user programs to port between new massively parallel and heterogeneous hardware architectures as they appear. It is gratifying to note that MasPar adopted and implemented many of the generic fine grained parallel C language ideas first specified under this RTOP for their MasPar Parallel Applications Language (MPL) which they deliver with their system.

STATUS:
In FY91 we will develop virtualization techniques that will enable users to easily port their code to larger SIMD machines. We will study virtualization extensions to fine grained parallel languages such as multiple geometries and their interconnection, logical architectures, and automatic recognition of parallel variable storage types. We will continue to research the simulation of cellular dynamical systems, and the application of sorting as a data routing utility, on massively parallel architectures. We will collaborate with Dr. Sarah Heap of Goddard's Astronomy Branch on a MasPar demonstration application to calculate the velocity of gases in nebulae from multispectral astronomical images. This will involve development of specific image processing routines such as median filtering.

Technical Contact: John E. Dorband, GSFC, (301) 286-9419

CS 17

Dynamic Load Balancing Strategies for Multiprocessors

Description

Research is being carried out to develop advanced system software and programming environments to enable parallel processors to be used effectively for solving applications chosen under the Aeroscience Grand Challenge of NASA's High Performance Computing Initiative (HPCI). In particular, work is being carried out in four areas: (i) compile-time and (ii) run-time strategies for mapping parallel programs onto multiprocessors; (iii) simulation and (iv) visualization tools for performance prediction and validation for the mapping strategies developed.

Significance

As described in the HPCI Program Plan, one important problem to be solved in order to attain "*1000 fold increase in system performance*" involves the development of intelligent operating systems for high performance, highly parallel computing systems. These operating systems must be able to automatically map applications onto multiprocessors in a manner that take maximum advantage of the computational resources without requiring changes to the application. Static mapping strategies operate at compile time; they distribute a problem across many processors so as to minimize elapsed time to complete a evaluation of an application. Dynamic mapping strategies that operate at run time must also be developed to deal with dynamic system load variation that result from treating multiple disciplines or from time dependent changes in a given discipline. Simulation and visualization tools must also be developed to provide rapid feed back for incremental refinement of these mapping strategies.

Current Status of the Accomplishment

As a result of the simulation and performance visualization tools developed in FY90, we were able to understand and validate "Post game Analysis", a static mapping strategy for object oriented parallel programs and multiprocessors developed in FY89. An article describing these simulation and visualization tools (called *AXE*) has been selected for publication in a special issue (3/91) of IEEE Software. Currently, *AXE* is being used for the development of dynamic mapping strategies. Preliminary simulation results show that the strategy we developed outperform conventional load balancing strategies and even post game analysis. In FY91, we plan to validate these strategies with more NASA applications on the Intel iPSC/2 Γ — a 128 node multicomputer at ARC. The visualization tools will also be extended to enable the programmer to correlate observed performance bottlenecks and specific events (such as message passing) with specific code bodies.

TECHNICAL CONTACT: Dr. Jerry Yan, ARC, (415) 604-4381

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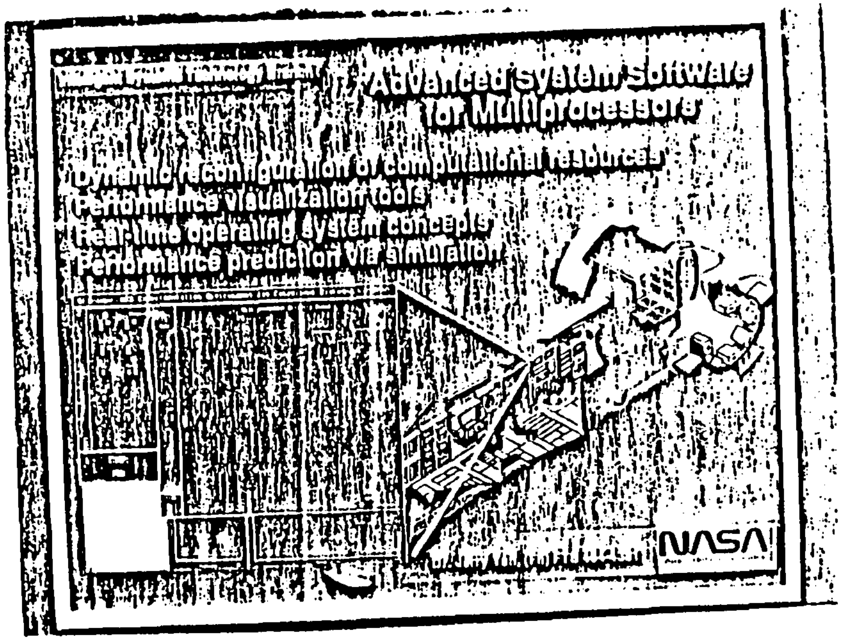

4 18

Erasable PROM Neural Network Implementations and Applications

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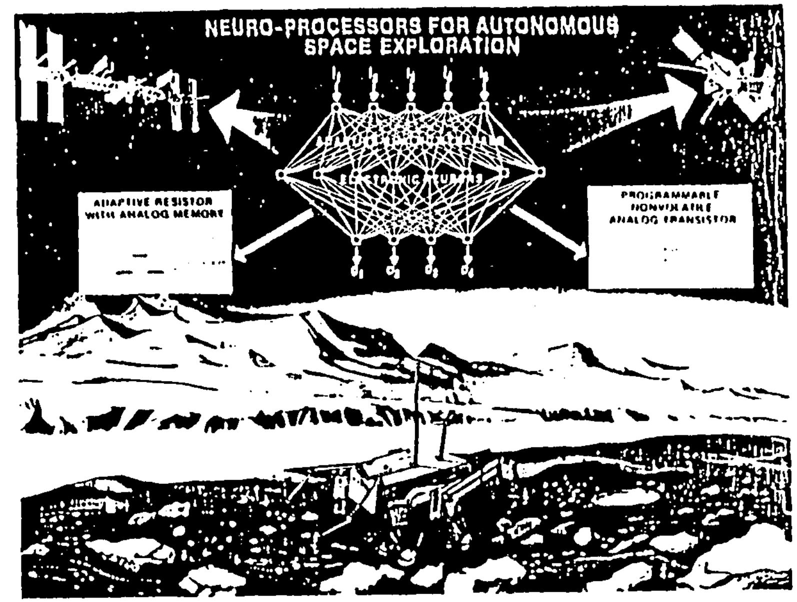


DISTRIBUTED ACCESS VIEW INTEGRATED DATABASE (DAVID) SYSTEM

Due to the diversity of computers, operating systems, management systems, network protocols, etc., NASA space scientists have to learn many different access methods in order to obtain data. For example, in NASA's Space Astrophysics Program, Astrophysics observatories such as the International Ultraviolet Explorer (IUE), Hubble Space Telescope, Gamma Ray Observatory (GRO) etc. generally have one or more data centers for the analysis and distribution of data. The heterogeneity of its data centers makes Astrophysics multi-mission research almost impossible.

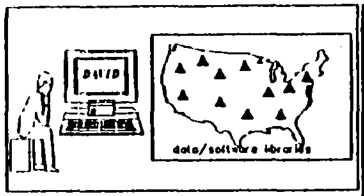
The DAVID approach to the heterogeneous distributed systems problem is at four levels. At the lowest level, we develop universal object type management systems to provide uniform access to heterogeneous database, images; spreadsheet, manuscript, etc management systems. At the second level, we develop "book" and "kit" management systems to provide uniform access to aggregate sets of data objects. At the third level, we develop "libraries" to provide uniform access to a local area networks of computers containing "books", "kits", and other data objects. At the fourth level, we develop consortiums of libraries to provide access to sets of libraries.

The DAVID software is being used on the NSSDC Data Archive and Distribution System (NDADS) as a front-end and to distribute IUE observational data.

Technical Contact: Barry E. Jacobs, GSFC, (301) 286-5661

PROBLEM:
NASA space scientists have to learn many different access methods in order to obtain data/software.
SOLUTION:
Distributed Access View Integrated Database (DAVID)

DAVID Concept



DAVID Approach

- Universal object type management systems: database, spreadsheet, software tool, index, image, etc.
- Aggregate Sets of Related Objects: books, serials, kits.
- Libraries– Collections of holdings
- Consortium of Libraries– Aggregate set of related libraries.

CS 21

INTELLIGENT DATA MANAGEMENT PROCESSES

OBJECTIVE:

The objective of the Intelligent Data Management project is the research into intelligent knowledge base and database technical areas, including intelligent query formulation based on domain knowledge using artificial intelligence research developments in expert systems, structured search, automated learning, automatic data labeling, cataloging and characterization, knowledge acquisition, interactive graphics, knowledge based problem solving, object oriented databases and geographic information systems and natural language processing. The research effort address the technical areas in the context of the generalized types of database systems that are required by NASA: knowledge (meta) databases, spatial databases and complex relational databases.

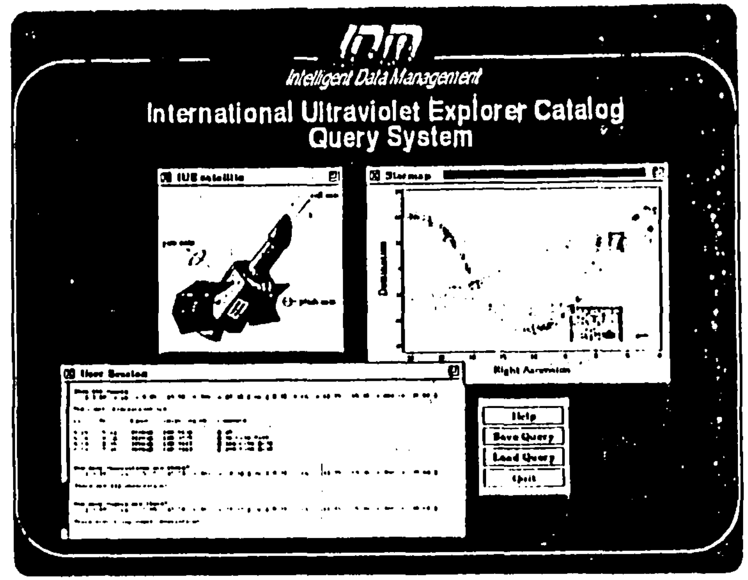
ACCOMPLISHMENTS:

The most recent efforts have concentrated on the development and implementation of the system architecture for an intelligent information fusion system. This design encompasses the processing of low level image data for the subsequent detection and identification of pertinent geographic regions and real world objects; validation and verification of this labeling through the usage of scientific models and classification schemes; cataloging of the resulting object descriptors into an object oriented database for increased representational power and improved query access times; and the construction of a high level user interface that incorporates natural language processing, spatial reasoning as supported by a geographic information system, and the ability to permit users to create private knowledge bases that contain descriptive and procedural knowledge specific to the scientists field of research. By extracting highly descriptive metadata that is orders of magnitude smaller than the raw data, the metadata can be searched to satisfy the scientists queries, resulting in a substantial reduction in query response times.

STATUS

This work has been presented at various conferences and in refereed journals, including an invited article for Photogrammetric and Remote Sensing, June 1990, and the Fourth International Conference on Spatial Data Handling.

TECHNICAL CONTACT: William J. Campbell, GSFC, (301) 286-8785



CS 20

Automatic Image Data Encoding and Analysis

506-59-11 C

OBJECTIVES:
Our main objective is to perform fundamental research in automated approaches for encoding multispectral imagery data into image segments based on the spatial structure of the multispectral data, and investigate automated methods for analyzing this encoded data on a segment-by-segment basis. A secondary objective is to develop criterion for evaluating the effectiveness of our analysis approaches on NASA remotely-sensed image data.

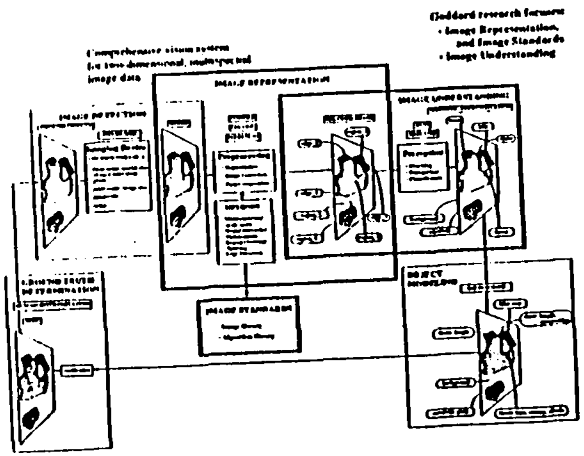
ACCOMPLISHMENT:
There are a variety of ways for determining ground reference data for satellite remote sensing data. One of the ways is to photo interpret low altitude aerial photographs and then digitize the cover types on a digitizing tablet. The resulting ground reference data can then be registered to the satellite image, or, alternatively, the satellite image can be registered to the ground reference data. Unfortunately, there are many opportunities for error when using a digitizing tablet and the resolution of the edges for the ground reference data depends on the spacing of the points selected on the digitizing tablet. One of the consequences of this is that when overlaid on the image, errors and missed detail in the ground reference data become evident. This task developed an approach for correcting these errors and adding detail to the ground reference data through the use of a highly interactive, visually oriented process. This process involves the use of overlaid visual displays of the satellite image data, the ground reference data, and a segmentation of the satellite image data.

Several programs were implemented on the Science Information Systems Center (SISC) VAXCluster and with an IVAS image display system to effect interactive editing of an edge map from an image segmentation to leave only those edges that correspond to boundaries between the ground cover types distinguish by the ground reference file. The resulting refined ground reference file that can be used for more accurate evaluation of new image analysis algorithms.

STATUS:
At the point funding ran out for this task, the interactive line editing programs have been applied to a 128-by-256 pixel portion of a Landsat Thematic Mapper data set, giving excellent results. When more funds become available, this refinement technique will be applied to several other tests data sets and ground reference files.

Technical Contact: James C. Tilton, GSFC, (301) 286-9510

AUTOMATIC IMAGE DATA CODING AND ANALYSIS



SOFTWARE ENGINEERING PROGRAM

- Includes: LaRC, GSFC, JPL, & JSC
- Supports: RICIS
- Program Drivers
  - Very reliable software
  - Software productivity
  - Very large/complex software systems
  - Legacy systems
  - Process management

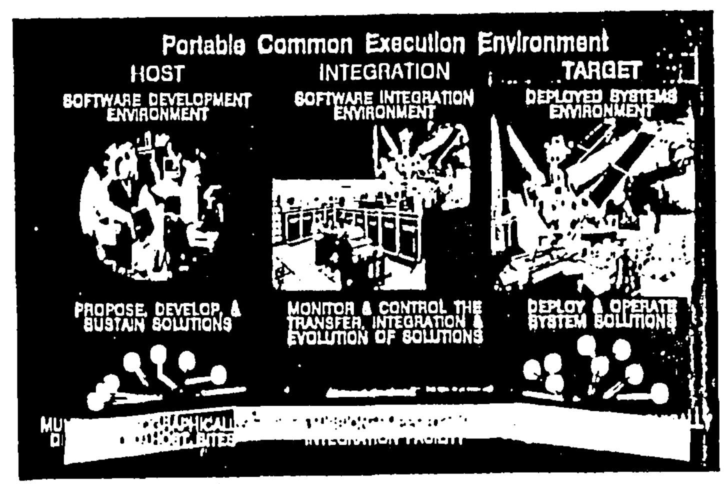
I. Introduction

A. What is PCEE

The Portable Common Execution Environment (PCEE) project is a research effort addressing the life cycle support of large, complex, non-stop, distributed computing applications with Mission And Safety Critical (MASC) components. Such applications typically have extended lifetime (e.g., 30 years) requirements, such as the NASA Space Station Freedom Program. PCEE focuses on the system software, the interface to applications, and the system architecture necessary to reliably build and maintain such systems. The requirements extend from the target system environment to the integration environment, and ultimately to the host environment. The integration environment serves as the single logical point of software test, integration, deployment, and configuration control whereas system development occurs in the host environment. Life cycle issues include an integrated approach to the technologies (environments, tools, and methodologies) and theoretical foundations (models, principles, and concepts) that span these three environments. The project goals include the advancement of the edge-of-knowledge, the state-of-the-art, the state-of-the-practice, and narrowing the gaps among them.

The scope of the effort is necessarily broad, as it addresses the problems faced in a project such as the Space Station Freedom Program. There are, however, substantial research foundations to support development across the breadth of the project. Furthermore, with a foundation and framework which addresses the broadest scope, areas can be developed with the expectation that they can and will scale down appropriately to improve software engineering in less demanding applications.

At its core, PCEE consists of a set of policies for the management of distributed computing services and resources in a non-stop, secure and safe environment. Its primary aim is to provide a portable interface to a fault tolerant, distributed, realtime set of integrated system software. In doing so it inevitably prescribes certain properties for the underlying software and hardware. It therefore can perhaps best be seen as an interface specification plus the minimal architecture needed to build/implement the interface. It provides a common interface to both hide and support the use of differing instruction set architectures, data bases, data communications systems, bare machine implementations and operating systems without regard to their underlying implementations. Derived from this core are the requirements for support elements including rules for evolution and modification and the integration and host development environments.



Information and Controls R&T 506-59
11 Computer Sciences - NASA Initiative in Software Engineering (NISE)

Machine Learning in the Knowledge-Based Software Engineering Environment (KBSEE)

Description: Any software engineering environment that is constructed to only apply current technology to current problems is likely to become obsolete within five years. What is needed to mitigate this potential obsolescence is a learning function to 1) adapt to evolving NASA system requirements and evolving software practices, and 2) build on lessons learned from past experiences in software development. A Knowledge Based Software Engineering Environment (KBSEE) is being prototyped for the Office of Space Operations to support the management and synthesis of systems from reusable software components for spacecraft control centers. Within this KBSEE, the concepts of machine learning and case based reasoning are being developed, and an experiment demonstrating a KBSEE's ability to learn new design concepts within a Payload Operations Control Center (POCC) is underway.

Significance: A process of human directed machine learning can insure that newly acquired knowledge in conjunction with previously acquired expertise can be properly and systematically utilized for new software engineering activities. Incorporating such a capability within a KBSEE will increase the useful lifetime and the effectiveness of the KBSEE.

Status: An experiment is in progress to incorporate machine learning in a software engineering environment. The software domain of the experiment is the POCC software system for the Gamma Ray Observatory (GRO). The question to be answered by the experiment is "can the KBSEE be taught to prototype a new design principle based on the specific case of the GRO POCC History subsystem, and have the ability to generalize that example into an internal design principle that can be applied to the Command subsystem?" Successful completion of this experiment will be a first demonstration of a KBSEE's learning capability. Preliminary phases of the experiment have been successfully executed. This first experiment is scheduled for completion by the end of this calender year.

Technical Contact:
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The Software Management Environment

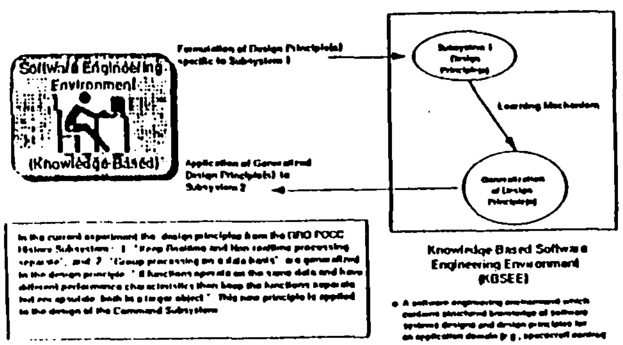
The Software Management Environment (SME) is a software tool designed to assist a manager in monitoring, analyzing, and controlling an ongoing software project. The major functions of the SME include tracking software project parameters, analyzing the differences between the current project's development patterns and the expected development pattern within the application environment, predicting characteristics such as milestones, cost, and reliability; assessing the overall quality of the project's development process; and providing advice and guidance on management of the software project. To provide these functions the tool continually examines available development data from the project of interest including manpower, software changes, computer utilization, and completed milestones and compares this information to data from past projects and to a model of the "typical" project.

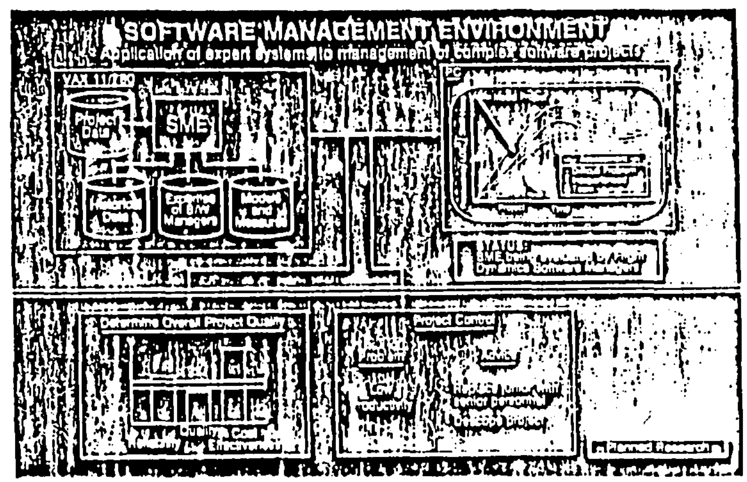
During fiscal year 1990, the SME has been extended and improved to include functionality for expert assessment of project problems and for extending its ability to model the project environment. With these extensions in place, the SME has been released for use by software managers within the Flight Dynamics Division at the GSFC. By utilizing the SME on ongoing software development projects within Flight Dynamics, the managers will be able to effectively compare, predict, and analyze key project parameters. This release of the SME represents the first use of the tool on actual projects and will provide valuable insight into the accuracy and usefulness of the tool, as well as help to establish future research needs for the SME.

During the next year, the SME will be prepared for release to other organizations outside of Flight Dynamics. This planned release will begin to establish the usefulness of such a tool in an environment beyond the one for which it was originally designed. Other planned research includes the development of an overall project assessment function and to begin examining ways of providing guidance to managers for solving development problems.

Technical Contact: Jon Valett, GSFC, (301) 286-6584

Machine Learning Experiment in the KBSEE





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ESC, or Encyclopedia of Software Components

TASK DESCRIPTION:

- a hypermedia software cataloguing and retrieving system
- an electronic metaphor of an encyclopedia
- organizes software into a dynamic, linked knowledge structure
- multiple access modalities
  - — goal-directed searching
  - — browsing with hyperlink tracing
- distributed contents
- contents in many programming languages and of many levels of granularity
- contents of many forms: code, documentation, graphics, etc.
- Encyclopedia Construction Kit supports user contributions and specialized handbooks

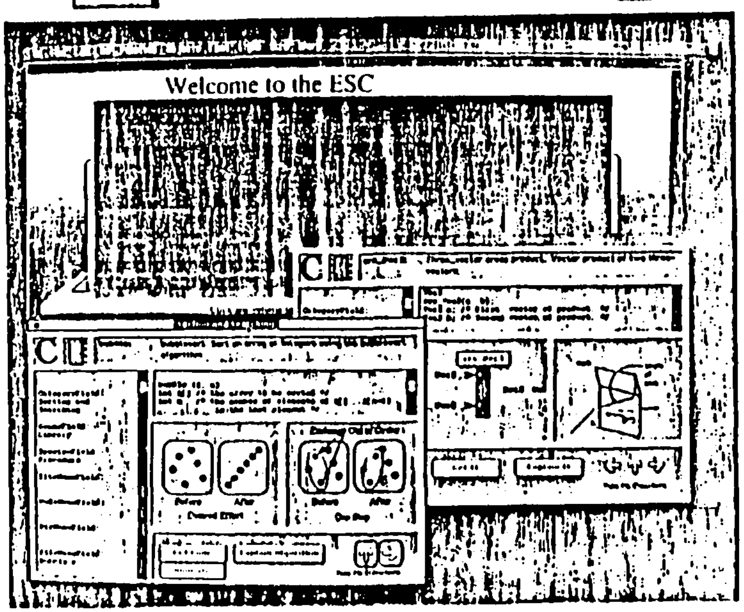
NASA NEED AND SIGNIFICANCE:

- an interchangeable software parts technology is greatly needed
  - — such a technology has existed for hardware for over a century
- reuse will not be widespread until it is easier and cheaper to find software than to write it anew

CURRENT STATUS:

- conceptual prototype: June 1990
- prototype runs on color Macintosh systems
- Activities for 1991
  - — collect feedback on interface and contents
  - — update the conceptual prototype
  - — engineer insertion and retrieval mechanisms
  - — conduct preliminary investigation of roles of AI (artificial intelligence)

Technical contact: Dr. Brian Beckman, JPL, (818) 354-1252



DS 11 cS

Application and Assessment of Industry-Standard Guidelines for the Validation of Avionics Software

Kelly J. Hayhurst
System Validation Methods Branch
Ext. 46215

Anita M. Shagnea
Research Triangle Institute

January 1990
RTOP 505-66-21
Code AC
MS 59

Objective
Incorporate industry standards for the development of real-time software into an experimental test-bed for studying the failure process of avionics software and assess the effectiveness of methods which comply with these standards.

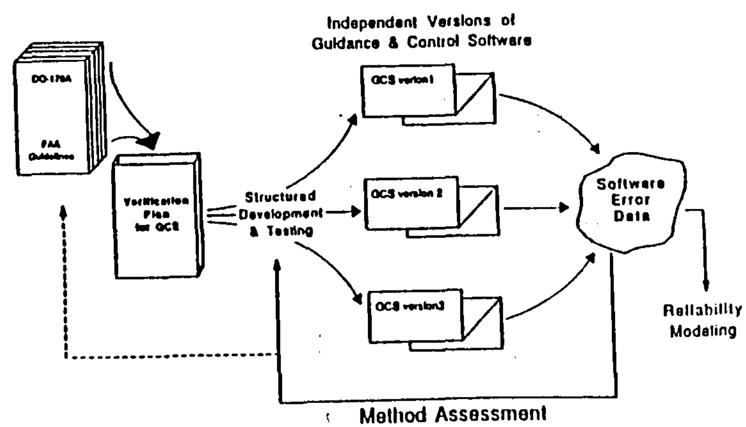
Approach
Define verification activities along with configuration management and software quality assurance policies for the development of Guidance and Control Software (GCS) in accordance with the Radio Technical Commission for Aeronautics RTCA/DO-178A guidelines used by the Federal Aviation Administration (FAA) for the certification of avionics software. Apply these verification procedures in the generation and testing of three independent versions of the GCS code. Collect all software error data needed to assess the effectiveness of software development and verification methods and to provide the basis for software reliability model development.

Accomplishment
Verification and validation activities in accordance with the DO-178A standards for avionics software have been defined and implemented in the development process of the GCS versions. Software error data is being collected throughout the development cycle.

Significance
Although many software reliability experiments have been conducted, these experiments have not considered complex avionics software that is critical to mission success. The GCS experiment provides a realistic baseline for investigating the failure behavior of avionics software. Employing the DO-178A guidelines will yield error data from real-time software developed according to industry standards, and the integrity of this error data along with the ability to reproduce it are guaranteed by the implementation of the verification plan. Since adequate models for dependable estimation of software reliability do not currently exist, the error data from the GCS experiment will provide an indispensable basis for improving software reliability models. This experiment further establishes a pragmatic baseline for investigating the effectiveness of development methods, such as those prescribed by the FAA, for avionics software.

Future Plans
Complete testing of the three GCS versions and analysis of the resulting software error data. Develop more precise software reliability models and more effective software development procedures based on this information.

PRODUCTION OF REALISTIC SOFTWARE ERROR DATA



DS 12

AUTOMATIC GENERATION OF ADA CODE

Carrie K. Walker
Systems Architecture Branch

John J. Turkovich
Charles Stark Draper Laboratory

Ext 41704 March 1990
RTOP 505 65-11
Code HC WBS 59-3

Research Objectives
Demonstration and assessment of the ability of the Charles Stark Draper Laboratory (CSDL) Computer Aided Software Engineering (CASE) system to generate Ada flight control code

Approach
The cost of designing, developing, testing, and maintaining avionics software is steadily increasing. Until recently, the lack of appropriate tools to aid in the creation of software has led to non uniform development techniques and software that is often unreliable and difficult to maintain. The Advanced Launch System (ALS) Advanced Development Program is sponsoring the development of a Computer Aided Software Engineering (CASE) tool by the the Charles Stark Draper Laboratory that could dramatically improve the software development process and reduce production and maintenance costs. As a demonstration of this tool, the flight control system software of the Boeing 737 autopilot autoland was produced using the ALS CASE system.

Accomplishment
Ada source code and specification documentation were automatically generated with the ALS CASE system. The specifications for the autoland design were reverse-engineered from inspections of FORTRAN flowcharts and source code. The software requirements were interactively specified in the form of hierarchical engineering block diagrams via the system's highly flexible, graphic interface. The requirements defined by these diagrams were checked for data type consistencies by the CASE system and captured in a centralized knowledge base. The knowledge base was then used to automatically produce executable code and a formatted requirements document. A test methodology was developed which maximized coverage but minimized the number of tests. Duplicate tests were run on both the FORTRAN and Ada code and then the results compared. Open and closed loop testing uncovered eleven discrepancies. Nine of these errors were attributed to mistakes in the entry of the specifications into ALS CASE. (Human errors, analogous to programming errors.) Two errors were traced to the FORTRAN code. No errors were traced to the ALS CASE system.

Significance
The development and testing of 'real' software applications, such as the autopilot autoland, will lend much to the credibility of the ALS CASE system. In addition to the two errors found in the FORTRAN code, several ambiguities and inconsistencies were discovered in the specification as a result of using the ALS CASE diagram methodology. ALS CASE has the potential to significantly increase the reliability of the generated code by: 1) checking for inconsistencies, ambiguities and completeness of the specification; 2) allowing the user to specify software using engineering notation and block diagrams familiar to him; 3) automatically performing the usually error-prone transformation to Ada code; and 4) supporting reuse of code. The ALS CASE effort has demonstrated the feasibility of a knowledge based approach to software development and has identified areas that warrant research to further automate the software development process.

Future
Progress is being made to enhance the ALS CASE system in a number of areas. These include a software design methodology interface, an automated testing facility, and project management capabilities. In addition, as a further demonstration, the guidance and control software for the final decent phase of a planetary lander is being generated using the ALS CASE system. This code will be used in a software error-data gathering experiment to be conducted by Langley and the Research Triangle Institute.

SPACE DATA SYSTEMS PROGRAM

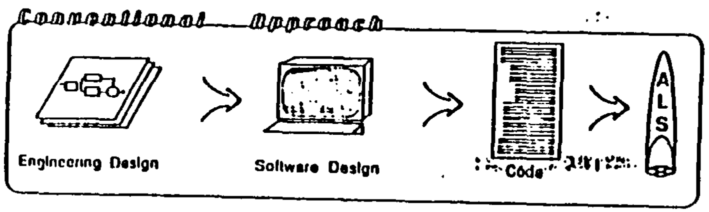
- Includes: GSFC, JPL, LaRC, ARC
- Supports: VLSI Design @ U. Idaho
- Program Drivers
  - Ambitious future space instruments
  - Long-duration, high-radiation requirements
  - Time delay for insertion of commercial technology
  - Transition activity for externally developed technology (e.g., DoD)

ALS
Advanced
Development
Program

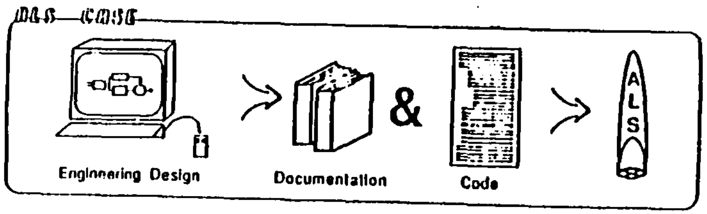
Avionics & Software

CASE for ALS

Conventional Approach



ALS CASE



SPACE DATA SYSTEMS
STATE-OF-THE-ART-ASSESSMENT

MISSION EPOCH	PROC TYPE	MISSION	READINESS AS OF 4/91	PERFORMANCE	CPU CHIP SET PWR	RAD HARD CHARACTERISTICS
70 S	1802	GALILEO	FLOWN	100 KIPS 1802	0 5W	TOTAL DOSE—YES SEU—YES OLD 4 MICRON TECH NO LONGER AVAILABLE
80'S	80C86	MAGELLAN	FLOWN	250 KIPS 8086	0 5W	TOTAL DOSE—YES SEU LATCH UP—YES UPSET—LIMITED
90 S	80386	SSFi	LEVEL 6	3 MIPS VAX	2 5W	NOT RAD HARD UNKNOWN LATCHUP WILL UPSET WITH SEU
	80486	SSF	LEVEL 5	10 12 MIPS VAX	3 5W	NOT RAD HARD UNKNOWN LATCHUP WILL UPSET WITH SEU
	GVSC 1750	CRAF / CASSINI EOS	LEVEL 5	2 4 MIPS DAIS	5W	ALL—YES
	SA 3300	MM2	LEVEL 5	750 KIPS VAX 32000	1 5W	ALL—YES
	80586	SSF	LEVEL 2	20 25 MIPS VAX	4 5W	NOT RAD HARD UNKNOWN LATCHUP WILL UPSET WITH SEU
2000 S	RH 32	SDIO BSTS / AWS	LEVEL 2	20 MIPS RISC	3W	ALL—BY CURRENT DESIGN

NOTE: RH 32 is currently underfunded to meet its objectives

SPACEFLIGHT OPTICAL DISK RECORDER

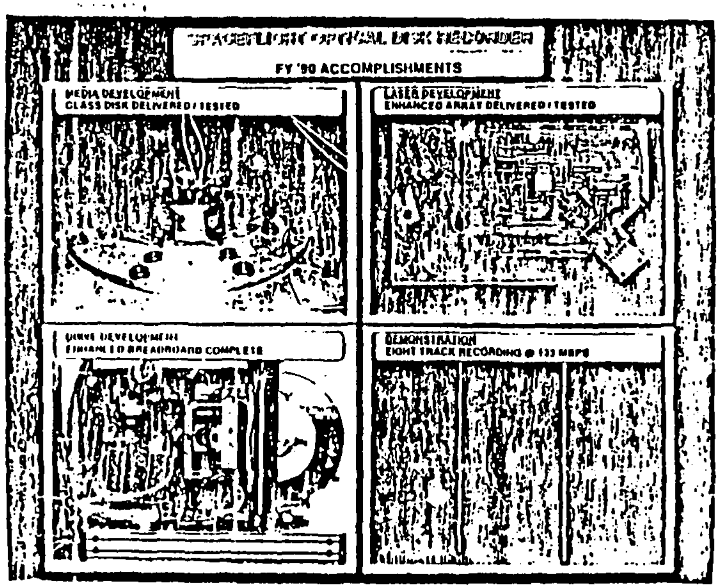
High rate, high capacity data storage has been identified as an enabling capability for future NASA missions including earth observation, geostationary, and planetary exploration in the 1990's and beyond. The Spaceflight Optical Disk Recorder (SODR) program has been established to develop components and subsystems based on rewriteable optical disk technology, which form the basis for high performance, mass storage systems. There are three technology development areas: 14 inch magneto optic media; multi element diode laser arrays; and a multi track electro optic head assembly. Feasibility was demonstrated in [illegible]. The FY '90 goal of demonstration of full eight track recording has been achieved. Written data is shown in the polarized microscope photo of the "marks" on the media. This represents 133 megabit/second data transfer rate and five gigabyte (4×10^{10} bit) capacity on one disk surface exceeding the rate and capacity of any other known disk data storage device.

Also during the past year, a new laser structure was developed which enables more efficient (generating less heat), thus longer lived devices. Samples have been delivered and are under test at LaRC. A nine element laser has exceeded 1000 hours of burn in (at David Sarnoff Research Center). Glass substrate media have been produced and undergone environmental testing. Media performance optimization for harsh environments is proceeding. This technology is directly transferable to a companion Air Force program. A NASA sponsored NIST/NASA/DoD/Industry working group has been formed to establish ruggedized 14 inch MO media test standards.

An associated modular controller is being developed at Langley to produce a configurable, expandable system supporting the use of multiple Drive modules to obtain data rates in excess of one gigabit per second, a rate that exceeds any other known or planned optical recording device or flight tape recorder and capacities up to 1.2 terabit (160 gigabytes).

The current work represents significant technology risk reduction toward development of a completely flight qualified optical disk Drive and Controller. NASA and Navy funding is being used to initiate procurement of a Brassboard Drive Unit for flight demonstration in FY '94.

Technical Contact: Thomas A. Shull, LaRC, (804)864-1837



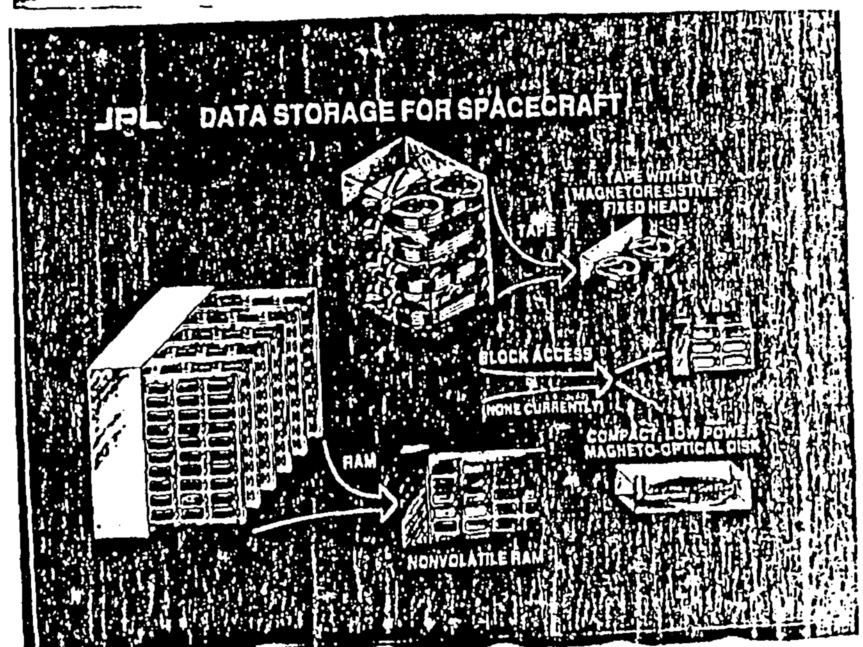
DATA STORAGE TECHNOLOGY
R. KATTI

DESCRIPTION: The purpose of this task is to evaluate the state of magnetoresistive (MR) fixed tape head technology for achieving high data rate and high capacity data storage.

SIGNIFICANCE: The significance of this work is to identify an attractive method for simultaneously achieving high data rate and high capacity recording with high *reliability*, *effective* data rate matching, and low mass, volume, and power.

CURRENT STATUS OF ACCOMPLISHMENT: The evaluation results indicate that *MR head technology* is an extremely viable and promising technology. Results indicate that storage density using MR head technology is at least *three times greater* than optical storage densities. Results also indicate that reliability figures using MR heads are one to two orders of magnitude greater than those achieved with rotary head tape recorders. MR heads can be developed to achieve 300 Mbps and terabit storage in tape recorder formats with *low mass, volume, and power*. Additionally, high performance and compact memory modules can be designed which can offer higher performance than block access optical and magneto-optical disk drives. Interactions and dialogues have been established with corporations including Applied Magnetics, IBM, Kodak, Odetics, *and StorageTek*. *Discussions* are underway with these organizations to support us technically in our follow-on FY'91 baseline demonstration effort.

TECHNICAL CONTACT: Dr. Romney R. Katti, JPL, (818)-354-3054.



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MAX FLIGHT MULTICOMPUTER

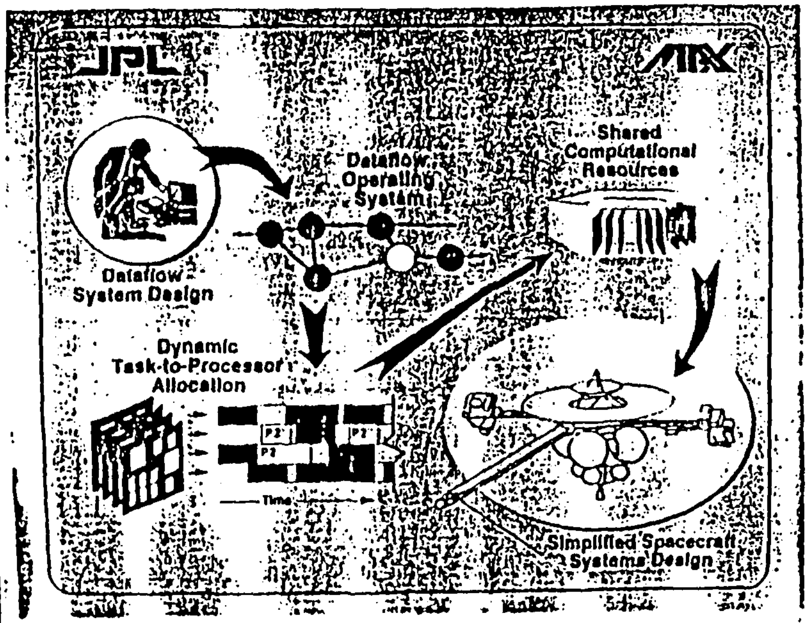
OBJECTIVE:
To develop a real time, general purpose computing system and environment which addresses the high reliability needs of interplanetary spacecraft and planetary rovers. MAX is a fault tolerant parallel computing architecture specifically adapted to tight resource limitations. It has been designed to support a large, heterogeneous collection of tasks in an unpredictable, event driven environment, and is easily reconfigurable to a wide range of mission requirements.

DESCRIPTION OF THE TECHNICAL DEVELOPMENT:
On board computational processing technology has unique requirements and constraints. In order to keep costs down and make optimal use of the available hardware without sacrificing reliability, the MAX architecture was developed. MAX consists of any number of conventional computing elements connected via a dual network topology. One network operates as the prime data highway between these elements and I/O, the other as a broadcast medium which synchronizes tightly coordinated real time events and tasks. Orchestrating these elements is a very high level operating system which allows these tasks to execute in a highly non deterministic, event and data driven environment while maintaining appropriate redundancy for increased reliability.

NASA RATIONALE AND BENEFIT:
With the advent of new high performance spacecraft processors developed by DoD, integrated autonomous spacecraft operation is now possible. The MAX architecture leverages these new device capabilities into a unique system oriented approach based on hardware resource pooling. This approach maximizes the utility of available hardware and software resources in order to minimize system mass, power and volume without compromising reliability.

STATUS AND ACCOMPLISHMENTS:
In 1990, the MAX program continued implementation of fault tolerant features and of software development tools. A MAX system with three computing modules has been delivered to ARC for independent evaluation. Redundant execution of critical application code with voting of results has been implemented and tested. VLSI implementation of the MAX inter-processor communication controllers has begun. A demonstration application which controls an autonomous planetary rover is being developed.
JPL and LRC have developed a joint plan and specification for the COSMOS computer system which will combine and build on their experience with dataflow control of multi processor systems. This system will use VHSIC components developed under DoD sponsorship and is projected to handle the foreseeable general purpose computing needs of NASA missions as well as of JPL.
FY '91 plans include completion of the VLSI communications chips and the MAX software tool set. Plans also include starting the implementation of COSMOS on MAX hardware.

TECHNICAL CONTACT: Dr. Bob Lewis, JPL, (818) 354-0912



ALGORITHMS/APPLICATIONS - FY90
CONFIGURABLE HIGH RATE PROCESSOR SYSTEM (CHRPS)
590-32-01

OBJECTIVE:
Develop and demonstrate algorithms and applications that can exploit, in Earth orbit, the high capacity processing capabilities provided by CHRPS. These algorithms are generally categorized as data compression and data analysis. Demonstrate the CHRPS concept that the scientist can, from his laboratory, program and control the onboard high rate processing and receive only the meaningful results at his workstation.

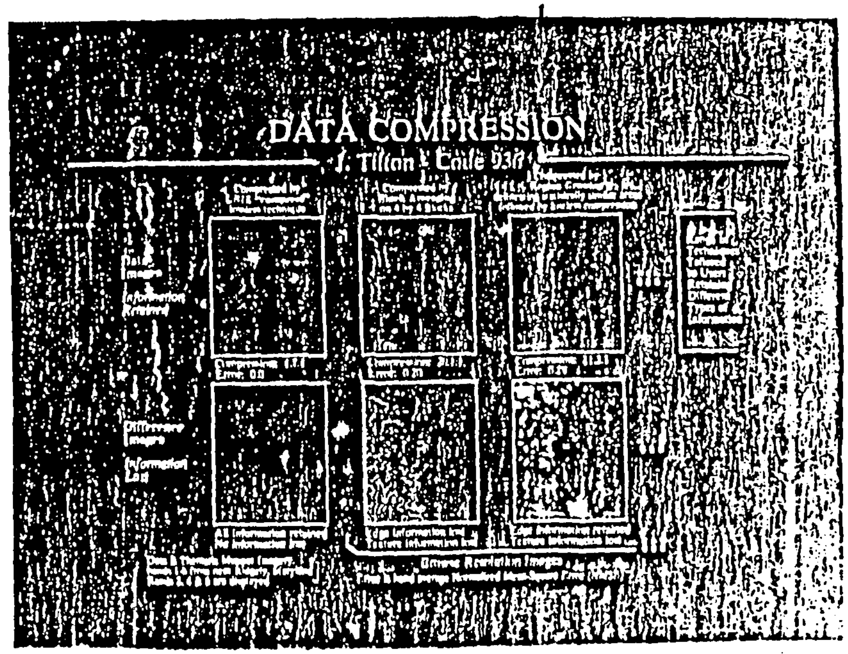
ACCOMPLISHMENTS:
In FY90, this task developed a lossless data compression package that provides a selection of compression algorithms from which a user can choose the one most appropriate to the data set at hand. This package was presented to the National Space Science Data Center (NSSDC) User Group and installed on the NSSDC VAXCluster for experimental use by that user community.

In addition, a multi spectral image compression scheme was developed based on region growing and quadtree data structures that compresses multi spectral images to three different levels: lossy, moderately lossy, and lossless. Browse resolution results of this scheme are shown on the accompanying illustration in the right hand column of images. This scheme achieves a 20:1 compression ratio by locating and retaining only the edges of regions and discarding the texture information held within the regions. New schemes retaining different types of information are targeted for development in FY91.

The SPAM (SPectral Analysis Manager) software was installed on the Science Information Systems Center's VAXCluster. Two SPAM analysis approaches, spectral signature matching and mixture analysis, were selected for FY91 use in evaluating the effects of data compression on AVIRIS analyses.

STATUS:
In FY91, evaluation of at least three approaches to data compression for AVIRIS data will be performed. Analysis scenarios for use in data compression evaluations of simulated MODIS data will be selected. Three additional algorithms will be added to the baseline (NSSDC) compression package. Evaluation will be performed of at least three approaches to data compression for MODIS data. A report will be prepared comparing results using the baseline (NSSDC) compression package for a wide variety of data set types.

Technical Contact: James C. Tilton, GSFC, (301) 286-9510



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SIMD CHIP - FY90
CONFIGURABLE HIGH RATE PROCESSOR SYSTEM (CHRPS)
590-32-01

OBJECTIVE:
Demonstrate the feasibility of a flight qualifiable compute engine able to sustain at least one gigaflop per second when performing data compression and image analysis algorithms.

ACCOMPLISHMENTS:
Most data compression and image analysis algorithms including synthetic aperture radar signal processing can be readily performed by computers with a very large number of processing elements controlled by a main control unit. This type of computer architecture is generally called the Single-Instruction stream Multiple-Data stream (SIMD) architecture. The SIMD architecture is a good match to applications which involve massive numbers of data elements, all being processed in a similar manner. It is inherently more energy efficient than any other parallel computer architecture since only one controller and one program memory are required to control a massive number of processors.

In FY90, the Microelectronics Center of North Carolina (MCNC), operating under a second year NASA grant, designed, fabricated, and demonstrated on a test board a fully functional custom CMOS integrated circuit containing 128 processing elements implemented with 1,109,340 transistors. A rad hard version of this chip is the basic building block of a massively parallel gigaflop compute node.

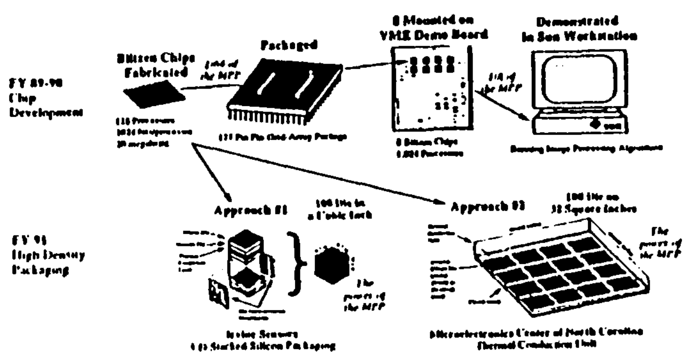
STATUS:
In FY91 we will contract with AT&T Bell Laboratories to define the approach, schedule and cost to produce a rad-hard version of the MCNC chip.

We will explore the establishment of collaborations with several Earth scientists and astrophysicists involving application of a high rate processor to address their upcoming requirements. Candidate areas are prototype Eos instrument testing in aircraft, Eos direct readout data product formation in space, and HST third generation instrument imbedded processing. We will derive requirements and detailed scenarios based on a network architecture or an imbedded processor to express their requirements.

We will initiate design of a scalable prototype system incorporating the MCNC chip component to address the processing and data handling requirements derived from the above mentioned collaborations. Options for packaging of such a prototype system include high density approaches such as the "stacked silicon" modules being developed by Irvine Sensors, and the thermal conduction unit being developed by MCNC.

Technical Contact: James Fischer, GSFC, (301) 286-3465

CONFIGURABLE HIGH RATE PROCESSOR SYSTEM (CHRPS)
SIMD CHIP



FY 92 Utilization — Enable accelerated development time tables for prototype EOS instruments
- Collaborate with two Earth scientists developing prototype imaging sensors
- Demonstrate high speed processor systems performing realtime data processing in their aircraft onboard data systems.

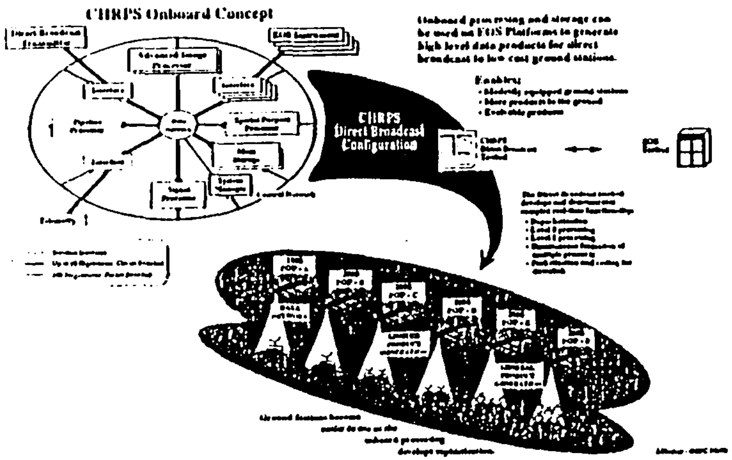
STATUS

FIRST PLANNED USE IN NASA MISSION OF PRODUCT FROM THE UNIVERSITY SPACE ENGINEERING RESEARCH CENTER (USERC) PROGRAM

- **UNIVERSITY CENTER DESIGNED VLSI CHIP BEING INCORPORATED INTO HUBBLE SPACE TELESCOPE GROUND DATA CAPTURE SYSTEM**
  - REPLACEMENT DATA SYSTEM TO BE OPERATIONAL BY END OF YEAR
  - WORLD'S FASTEST REED SOLOMON ENCODER/DECODER ERROR CORRECTING CHIP
  - PERFORMS 800 MILLION OPERATIONS PER SECOND, CONTAINS 200,000 TRANSISTORS
  - MAJOR IMPROVEMENT IN PERFORMANCE / RELIABILITY OVER EXISTING SYSTEM
- **DEVELOPED BY THE UNIVERSITY OF IDAHO--SPACE ENGINEERING RESEARCH CENTER FOR VLSI (Very Large Scale Integration) SYSTEM DESIGN**
  - ONE OF NINE CENTERS SELECTED IN MID 1988
- **POSSIBLE FUTURE USE OF CHIP IN FLIGHT DATA SYSTEM REFURBISHMENT**

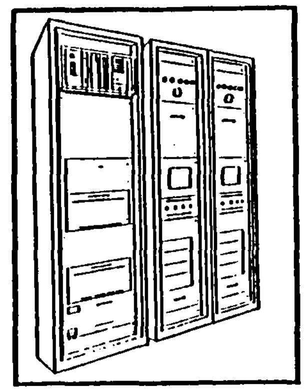
CONFIGURABLE HIGH RATE PROCESSOR SYSTEM (CHRPS)

ARCHITECTURE DEFINITION



WHAT IS THE ADSP ?

ENGINEERING MODEL HARDWARE



DESIGN ATTRIBUTES

- FLEXIBLE SAR PROCESSOR
- OVER 6 GIGAFLOPS PEAK COMPUTE RATE
- REAL TIME RATE CAPABILITY FOR MISSIONS SUCH AS SEASAT & SIR-B
- 150 MEGABYTES OF MEMORY
- ABOUT 35,000 INTEGRATED CIRCUITS

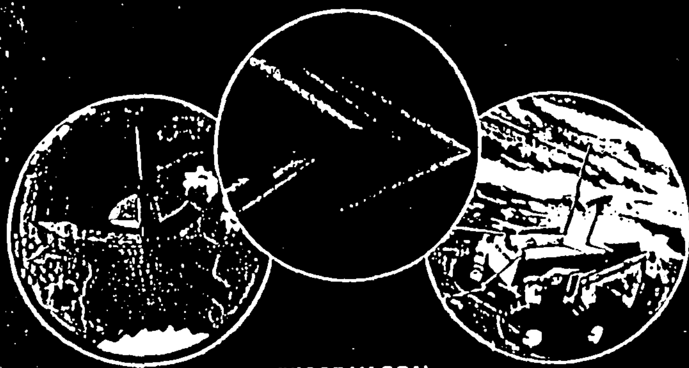
ADSP CHARACTERISTICS

- THE ENGINEERING MODEL CONTAINED 73 TOTAL BOARDS (EXCLUDING INTERFACES) WHICH INCLUDED 26 UNIQUE DESIGNS
- THE BOARDS CONTAINED A TOTAL OF APPROXIMATELY 28,000 ICs, NEARLY FILLING TWO ELECTRONICS RACKS AND CONSUMING ABOUT 15 KW OF POWER
- AT THE 20 MHZ MAXIMUM CLOCK RATE THE PROCESSOR COULD SUSTAIN ABOUT SEVEN BILLION FLOATING POINT OPERATIONS PER SECOND, THE APPROXIMATE COMPUTE RATE REQUIRED TO PROCESS SEASAT DATA AT REAL-TIME RATE
- MAGELLAN ADDED FIVE ADDITIONAL BOARDS FOR SPECIAL RADIOMETRIC COMPENSATION AND MULTI LOOK CONTROL RESULTING IN A PROCESSOR CAPABLE OF PROCESSING THE MAGELLAN SAR DATA AT LEAST FOUR TIMES FASTER THAN THE REAL-TIME ACQUISITION RATE
- THE I/O COMPUTER SYSTEM LIMITS THE ACTUAL PROCESSING RATE TO APPROXIMATELY REAL TIME. THIS RATE IS STILL ABOUT FOUR TIMES FASTER THAN BACK UP (ENGINEERING SAR PROCESSOR), WHICH IS BUILT FROM THE MOST EFFICIENT COMMERCIAL HARDWARE AVAILABLE WHEN THE ADSP WAS COMPLETE IN 1986

HIGH PERFORMANCE COMPUTING & COMMUNICATIONS PROGRAM

- **Includes: ARC, GSFC, LaRC, LeRC, JPL**
- **Supports: CESDIS, RIACS, ICASE**
- **Program Drivers**
  - NASA mission needs for high-performance computation in
    - Aeronautics/Astronautics
    - Space & Earth Science
    - Exploration
  - Support for nationally & globally networked collaboration
  - Highly trained scientists & engineers for future missions

HIGH PERFORMANCE COMPUTING AND COMMUNICATIONS PROGRAM



PROGRAM GOAL

ACCELERATE THE DEVELOPMENT AND APPLICATION OF HIGH PERFORMANCE COMPUTING TECHNOLOGIES TO MEET NASA SCIENCE AND ENGINEERING REQUIREMENTS

GOAL AND OBJECTIVES

GOAL:

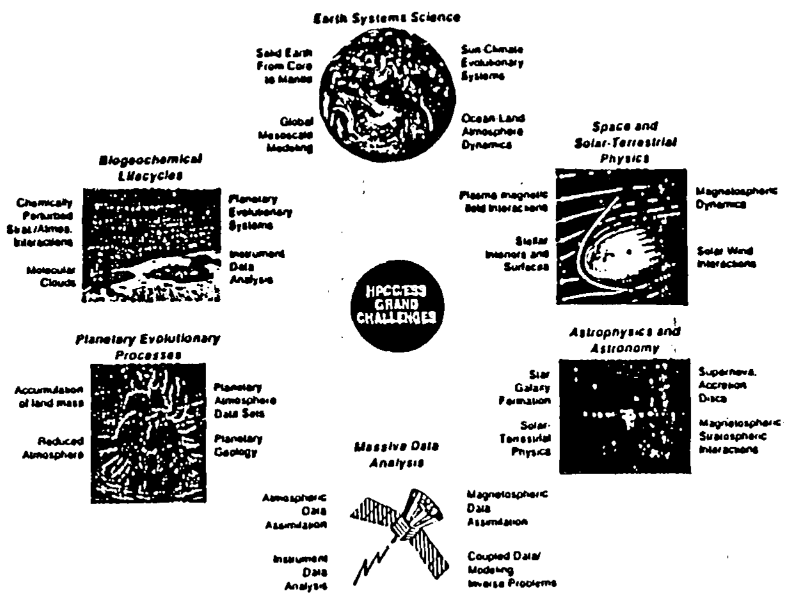
- ACCELERATE THE DEVELOPMENT AND APPLICATION OF HIGH PERFORMANCE COMPUTING TECHNOLOGIES TO MEET NASA SCIENCE AND ENGINEERING REQUIREMENTS

OBJECTIVES:

- DEVELOP ALGORITHM AND ARCHITECTURE TESTBEDS CAPABLE OF FULLY UTILIZING MASSIVELY-PARALLEL CONCEPTS AND INCREASING END-TO-END PERFORMANCE
- DEVELOP MASSIVELY-PARALLEL ARCHITECTURES SCALABLE TO SUSTAINED TERAFLOPS PERFORMANCE
- DEMONSTRATE TECHNOLOGIES ON NASA RESEARCH CHALLENGES
  - INTEGRATED AEROSPACE VEHICLE SYSTEMS
  - EARTH AND SPACE SCIENCE PHYSICAL PHENOMENA
  - SPACEBORNE APPLICATIONS

NASA NEEDS

- NASA NEEDS TERAFLOPS (10^{12}) COMPUTATIONAL CAPABILITIES TO ADDRESS GRAND CHALLENGES, THE SOLUTIONS OF WHICH, ARE ESSENTIAL TO ACHIEVING NASA'S MISSION
- CONVENTIONAL APPROACHES WILL NOT PROVIDE THE PERFORMANCE NECESSARY TO SOLVE GRAND CHALLENGES IN COMPUTATIONAL AEROSCIENCES, EARTH AND SPACE SCIENCES AND REMOTE EXPLORATION AND EXPERIMENTATION
  - COMPUTATIONAL AEROSCIENCES
    - INTEGRATED, MULTIDISCIPLINARY SIMULATIONS OF AEROSPACE VEHICLES THROUGHOUT THEIR MISSION PROFILES
  - EARTH AND SPACE SCIENCES
    - MULTIDISCIPLINARY MODELING AND MONITORING OF THE EARTH AND ITS GLOBAL CHANGES AND ASSESSMENTS OF THEIR IMPACT ON THE FUTURE ENVIRONMENT
  - REMOTE EXPLORATION AND EXPERIMENTATION
    - EXTENDED-DURATION HUMAN EXPLORATION MISSIONS AND REMOTE EXPLORATION AND EXPERIMENTATION



EARTH AND SPACE SCIENCES

GOAL DEMONSTRATE THE POTENTIAL TO ADDRESS THE GRAND CHALLENGES AFFORDED BY TERAFLOPS SYSTEM PERFORMANCE ON SELECTED MULTIDISCIPLINARY MODELING AND MASSIVE DATA HANDLING APPLICATIONS

OBJECTIVES

SUPPORT THE DEVELOPMENT OF MASSIVELY PARALLEL SCALABLE MULTIDISCIPLINARY MODELS AND DATA PROCESSING ALGORITHMS

MAKE AVAILABLE PROTOTYPE SCALABLE PARALLEL ARCHITECTURES AND MASSIVE DATA STORAGE SYSTEMS TO ESS RESEARCHERS

PREPARE THE SOFTWARE ENVIRONMENTS TO FACILITATE SCIENTIFIC EXPLORATION AND THE SHARING OF INFORMATION AND TOOLS

DEVELOP DATA MANAGEMENT TOOLS FOR HIGH-SPEED ACCESS, MANAGEMENT AND VISUALIZATION OF DATA WITH TERAFLOPS COMPUTERS

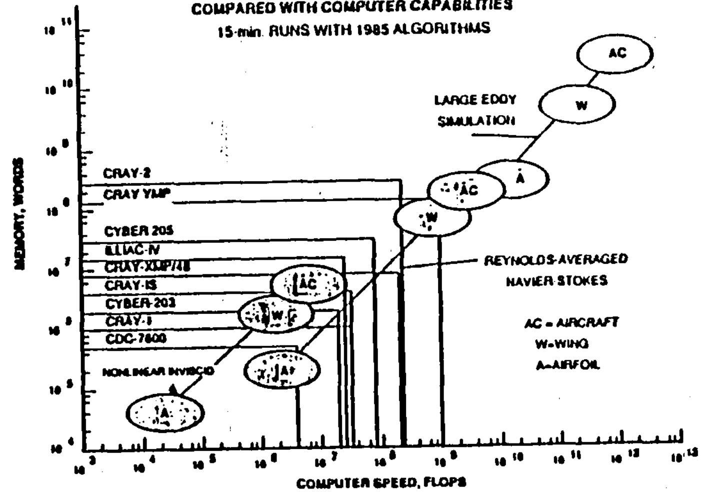
DEMONSTRATIONS OF SCIENTIFIC AND COMPUTATIONAL IMPACT FOR EARTH AND SPACE SCIENCE APPLICATIONS

CANDIDATE APPLICATIONS

COUPLED EARTH ATMOSPHERE SYSTEMS SCIENCE
SPACE AND SOLAR-TERRESTRIAL PHYSICS
ASTROPHYSICS AND ASTRONOMY
BIOGEOCHEMICAL CYCLES AND EVOLUTIONARY PROCESSES
PLANETARY EVOLUTIONARY PROCESSES
ANALYSIS OF MASSIVE DATA SETS ACQUIRED BY NASA PROGRAMS

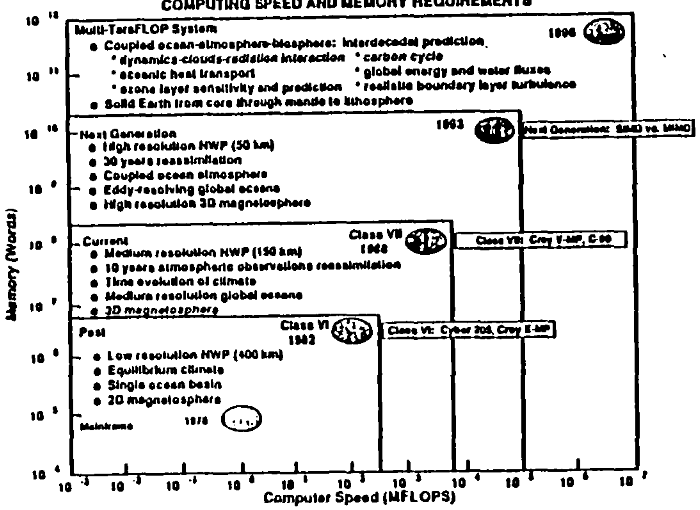
COMPUTATIONAL AERODYNAMICS

COMPUTER SPEED AND MEMORY REQUIREMENTS COMPARED WITH COMPUTER CAPABILITIES



EARTH AND SPACE SCIENCES

COMPUTING SPEED AND MEMORY REQUIREMENTS



COMPUTATIONAL AEROSCIENCES

GOAL DEVELOP NECESSARY COMPUTATIONAL TECHNOLOGY FOR THE NUMERICAL SIMULATION OF COMPLETE AEROSPACE VEHICLES FOR BOTH DESIGN OPTIMIZATION AND ANALYSIS THROUGHOUT THE FLIGHT ENVELOPE.

OBJECTIVES

DEVELOP MULTIDISCIPLINARY COMPUTATIONAL MODELS AND METHODS FOR SCALABLE, PARALLEL COMPUTING SYSTEMS

ACCELERATE THE DEVELOPMENT OF COMPUTING SYSTEM HARDWARE AND SOFTWARE TECHNOLOGIES CAPABLE OF SUSTAINING A teraFLOPS PERFORMANCE LEVEL ON COMPUTATIONAL AEROSCIENCE APPLICATIONS

DEMONSTRATE AND EVALUATE COMPUTATIONAL METHODS AND COMPUTER SYSTEM TECHNOLOGIES FOR SELECTED AEROSPACE VEHICLE AND PROPULSION SYSTEMS MODELS ON SCALABLE, PARALLEL COMPUTING SYSTEMS.

TRANSFER COMPUTATIONAL METHODS AND COMPUTER SYSTEMS TECHNOLOGIES TO AEROSPACE AND COMPUTER INDUSTRIES.

CANDIDATE APPLICATIONS

POWERED-LIFT VEHICLE
HIGH-SPEED CIVIL TRANSPORT
AEROBRAKING
NATIONAL AERO-SPACE DERIVED VEHICLES

REMOTE EXPLORATION AND EXPERIMENTATION

GOAL DEVELOP SPACEBORNE COMPUTING TECHNOLOGY WHICH WILL ENABLE HIGH PERFORMANCE, FAULT-TOLOERANT, ADAPTIVE SPACE SYSTEMS FOR A NEW GENERATION OF MISSIONS TO EXPLORE THE EARTH AND SOLAR SYSTEM

OBJECTIVES

DEMONSTRATE THE FEASIBILITY OF 1000-FOLD INCREASE IN SPACEBORNE COMPUTER SYSTEMS PERFORMANCE

DEMONSTRATE A PARALLEL, SCALABLE ARCHITECTURE
- LOW WEIGHT AND LIMITED POWER
- AFFORDABLE
- FAULT TOLERANT

DEMONSTRATE A SOLID PROTOTYPE-TO-FLIGHT SYSTEM ENGINEERING PATH

CANDIDATE APPLICATIONS

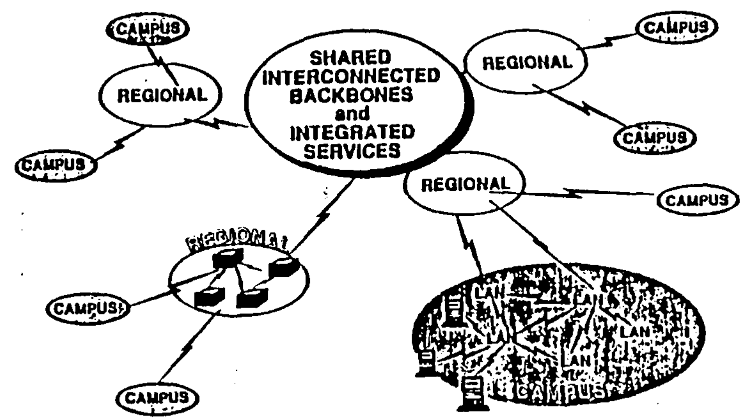
ANALYSIS OF DATA FROM THE TROPOSPHERE EMISSION SPECTROMETER, AN EARTH OBSERVING SYSTEM INSTRUMENT

INTEGRATION OF ROBOTIC ALGORITHMS FOR SENSING AND MANIPULATION

ASTROPHYSICS MISSIONS

ROBOTICS

NATIONAL RESEARCH & EDUCATION NETWORK



CESDIS
THE CENTER OF EXCELLENCE IN SPACE DATA AND INFORMATION SCIENCES

Raymond E. Miller
CESDIS Director And
Professor Of Computer Sciences
University Of Maryland
College Park, MD
(301) 286-3805

APPLIED INFORMATIONS SYSTEMS
RESEARCH WORKSHOP

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CESDIS

The Center of Excellence

in Space Data and

Information Sciences

NASA Goddard Space Flight Center
Greenbelt, MD

Raymond E. Miller
CESDIS Director
and
Professor of Computer Science
University of Maryland at College Park
College Park, MD

CESDIS MISSION

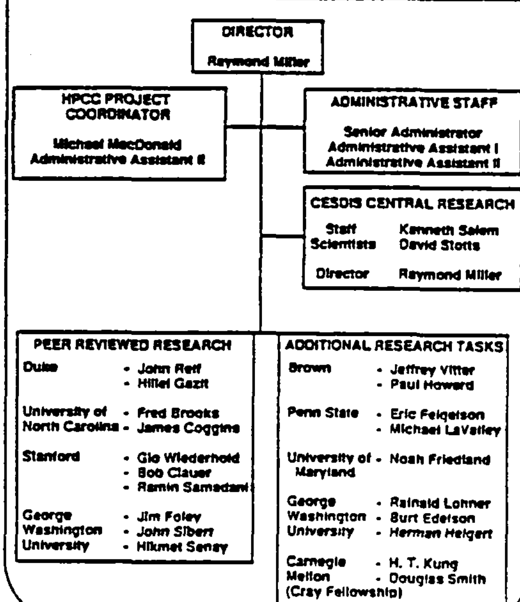
To bring together computer scientists from university, industrial, and government laboratories to:

- Conduct computer science research having application to Earth and space science;
- Focus attention on accessing, processing, and analyzing data from space observing systems; and
- Collaborate with NASA space and Earth scientists.

GOALS TO BE ACCOMPLISHED BY:

- Funding research projects selected on the basis of peer reviewed proposals;
- Supporting additional research personnel for projects funded by NASA through other programs;
- Providing a computer science research environment on-site at GSFC and encouraging visits by project personnel;
- Conducting workshops and conferences;
- Organizing seminars for GSFC, university, and industrial Earth, space, and computer scientists;
- Administering fellowships established by industrial associates;
- Developing areas for collaborative efforts through contacts established by Director and Staff Scientists;
- Producing technical report series of papers prepared by CESDIS members.

CESDIS



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TASK GOALS AND ACCOMPLISHMENTS

DUKE UNIVERSITY

Parallel Compression of Space and Earth Data

PERIOD OF PERFORMANCE: October 1988 - September 1991

GOALS

- Develop parallel algorithms and architectures for lossy and lossless data compression.
- Design compressions applicable to large variety of data.
- Design good parallel vector quantization algorithm.

ACCOMPLISHMENTS

- Devised several algorithms, investigated their theoretical aspects, and evaluated performance against USC image database to compare results with existing schemes using same images.
- Developed multiresolution lossy methods capable of controlling amount of information lost by trading off between compression rates and distortion.

TASK GOALS AND ACCOMPLISHMENTS:

GEORGE WASHINGTON UNIVERSITY

A Knowledge-Based Advisory System for General Scientific Data Visualization

PERIOD OF PERFORMANCE: September 1988 - August 1991

GOALS

- Investigate and specify visualization vocabulary to embody essential concepts required for scientific visualization.
- Incorporate user interface for visualization - naive users.
- Develop system design extendable for knowledge refinement and new visualization techniques.

ACCOMPLISHMENTS

- Compiled 145 rules and principles pertaining to expressiveness of visualization techniques.
- Implemented primitive rendering algorithms.
- Designed VISTA (Visualization Tool Assistant) and completed first prototype.
- Conducted preliminary test of prototype using data supplied by GSFC NSSDC.

TASK GOALS AND ACCOMPLISHMENTS:

Stanford University

Computer Assisted Analysis of Auroral Images Obtained From High Altitude Polar Satellites

PERIOD OF PERFORMANCE: January 1989 - December 1991

GOALS

Develop, implement, evaluate, and utilize advanced computer software tools whose purpose is to automate the analysis of global auroral images obtained from DE-1 and Viking satellites.

ACCOMPLISHMENTS

- Completed implementation and testing of "snakes" algorithm for finding auroral oval inner boundary.
- Have made progress on extending technique to regions where daylight overlaps aurora and to simultaneously find both inner and outer boundaries.
- Project personnel met with 13 GSFC and NASA HQ scientists to discuss potential collaborative efforts.

TASK GOALS AND ACCOMPLISHMENTS:

University of North Carolina at Chapel Hill

Image Pattern Recognition Supporting Interactive Analysis and Graphical Visualization

PERIOD OF PERFORMANCE: September 1988 - August 1991

GOALS

- Develop research software base to support interactive image pattern recognition;
- Develop artificial visual systems to solve measurement and detection problems;
- Develop multi-resolution image descriptions as a language for human-computer communication.

ACCOMPLISHMENTS

- Have explored nature of image regions formed by some coherence of intensity, edge surround, orientation, or texture, across scales based on 2 image description techniques: Multiscale Orientation Fields and Spatial Spectrum Classification.
- Beginning to apply to Landsat images obtained from GSFC.
- Applied algorithm to Hubble data in effort to reduce blurring of images without destroying frequency spectra.

ADDITIONAL RESEARCH TASKS

Brown University: Jeffrey Vitter and Paul Howard
Data Compression Algorithms

Penn State University: Eric Feigelson and Michael LaValley
Advanced Statistical Methods for Improved Data Analysis of NASA Astrophysics Missions

University of Maryland: Noah Friedland
Simulated annealing, neural networks and Markof random field methods to solve inversion problems in atmospheric sounding

George Washington University: Burt Edelson and Herman Helgert
Concepts, plans and experiments to utilize the Advanced Communications Technology Satellite in supercomputing networking

George Washington University: John Sibert and Cindy Starr
Computer graphics tools and techniques for scientific visualization

George Washington University: Rainald Lohner
Computer codes for simulation of 3D compressible magneto hydrodynamic flows

Stanford University: Philip Scherrer and Richard Bogart
AstroMail: Electronic mail for the Astrophysics Community

Carnegie Mellon University: Douglas Smith (Cray Fellow) and H.T. Kung (Advisor)
Intermediate Language and Virtual Architecture for High Performance Image Processing

WORKSHOPS

AUGUST 1989

Computing Challenges in Managing Future Massive Image Systems

OCTOBER 1990

The Role of Computer Science in Mission to Planet Earth

TECHNICAL REPORT SERIES

Technical reports from CESDIS research projects.

Currently have 74 reports.

FUTURE PLANS

- Develop industrial associates program
- Fund additional research associated with HPCC and EOS
- Run small specialized workshops
- Continue to cooperate in organizing and running conferences
  e.g., *Data Compression Conference*
  Workshop on Parallel Algorithms
- Build more collaborative efforts

NASA TRENDS AND CESDIS ROLE

- NASA missions are moving from using state-of-the-art computing techniques and technologies to missions requiring major advances in computing hardware, software, algorithms, and communications.
- Advanced computing needs lie at the center of the NASA missions.
- Many areas of computer science research have a direct bearing on NASA needs.

  Database systems, distributed computing systems, networking and communication, AI/Expert Systems/Neural Nets, Human/Computer Interfaces, Computer Graphics, Visualization, Pattern Recognition, Algorithms, Software Engineering, Robotics, etc.

CESDIS PROPOSED HPCC ACTIVITIES

FY 92

- Hire Associate Director for HPCC.
- Help manage Goddard NRA peer review.
- Staff and run evaluation activity for space and Earth science grand challenge problems on various high-performance test-bed architectures.
- Prepare and issue CESDIS call-for-proposals in HPCC research.

CESDIS PROPOSED HPCC ACTIVITIES

FY 93 - 97

- Build research activities for HPCC in:
  - Relative evaluation for high performance computers in space and Earth science applications.
  - Numerical techniques for parallel computation.
  - Management of massive amounts of data in distributed systems.
- Support education of Ph.D's in areas of HPCC research funded through:
  - peer reviewed projects
  - post-docs
  - graduate fellowships

OVERALL CESDIS PLANS

1992 - 2000

Build a community of computing science researchers who collaborate with space and Earth scientists on problems of interest to NASA, through peer-reviewed proposal research at universities, through collaboration with industrial researchers, and by building a small core of about 5 full time researchers at CESDIS, plus a similar size University of Maryland group of faculty and graduate student researchers.

CASIS BACKGROUND

Professor Michael J. Flynn
Departments of Electrical
Engineering and Computer Sciences
Stanford University
Stanford, CA
(415) 723-1450

APPLIED INFORMATIONS SYSTEMS
RESEARCH WORKSHOP

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CASIS
Background

Prof. Michael J. Flynn
Departments of
Electrical Engineering
and
Computer Science
Stanford University

Some special facilities/centers:

- Center for Integrated Systems
- Center for Telecommunications
- Center for Reliable Computing
- Center for Concurrency Studies
- Program in Manufacturing Science

⋮

CASIS — 1991

Supported faculty and research areas:

Telecommunications
 Professor F. Tobagi
 Professor J. Cioffi

Neural Nets
 Professor A. Peterson
 Professor T. Kailath

Concurrent Processors
 Professor M. Flynn
 Professor Monica Lam

Data Analysis & Management
 Professor G. Wiederhold
 Professor J. Vesecky
 Professor M. Levoy

Programming Environments
 Professor M. Linton

CASIS — Past

- 10 years
- Supports about 20 research students per year
  About 110 total
- About 5 supported students receive Ph.D. each year
  About 35 total
- Over 300 supported reports, publications, etc.

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Data Visualization

Data Recognition

Data Transmission

Data Processing

Data Visualization

Ice Flows Using SAR

Aurora

Terrain Elevation Mapping Using SAR

Basic Studies in 3-D

Data Representation

INFORMATION EXTRACTION FOR IMAGE DATABASES AND VISUALIZATION

1) Image analysis and computer vision tools may be used to extract information and parameters from image data.

2) The extracted parameters from the data may be used as automatically generated indeces of image databases.

3) The extracted information may be also used as automatically generated geometric primitives for visualization.

EXAMPLES OF CASIS RESEARCH IN INFORMATION EXTRACTION FROM DATA

1) Generating sea ice motion vectors from radar images.

2) Extracting area and boundary information from UV satellite images of aurora.

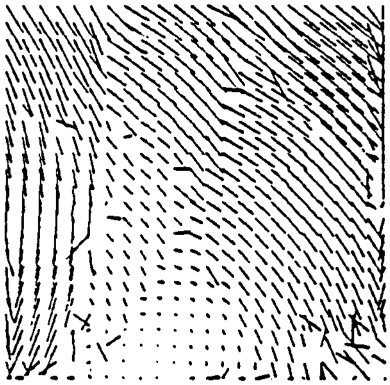
3) Finding curvilinear features in radar images.

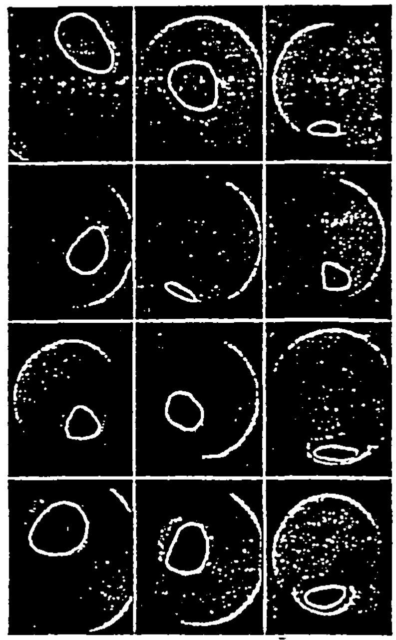
IEEE TRANSACTIONS ON

GEOSCIENCE AND REMOTE SENSING

JANUARY 1988 VOLUME 26 NUMBER 1 (ISSN 0196-2892)

A PUBLICATION OF THE IEEE GEOSCIENCE AND REMOTE SENSING SOCIETY



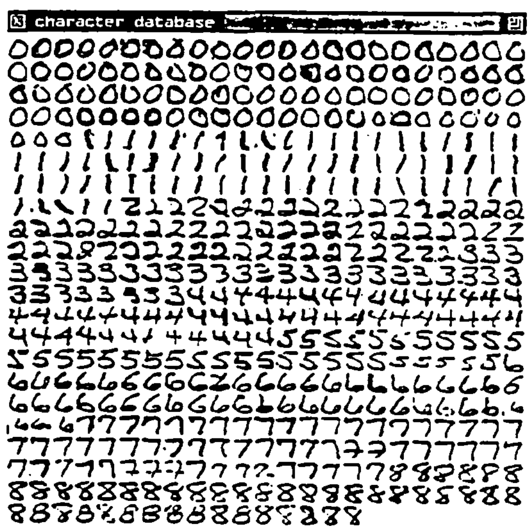


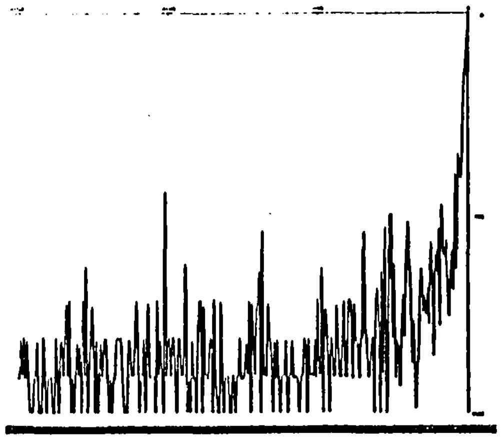
Automated

Data Recognition

Sparse Memory

Neural Nets





Data Transmission

Expressnet

High Speed Data Transmission

EXPRESSNET

A Unidirectional Broadcast Bus Local Area Network with A conflict-free round-robin Media Access Protocol

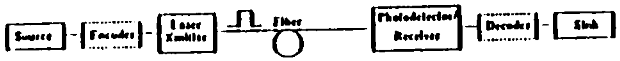
Basis for many network Concepts used in High Speed Fiber Optic Local Area Networks, including the *Metropolitan Area Network Standard DQDB* (IEEE802.6)

Described in Most Important Textbooks

Tanenbaum; Stallings; Gallager and Bertsekas; etc.

Telecommunication
- Fiberoptic Data Transmission
- Network Design

Fiber Optic Communications



- Impairment: Dispersion distorts pulses resulting in intersymbol interference (ISI)
- Goal: Find simple signal processing techniques to compensate for ISI, allowing for improved data rates and distances

Computing

Concurrency Studies

Optimizing Compilers
for Large Scale Multiprocessors

Parallel Architect's Workbench

Application Specific Systems Development

-avoiding the software bottle neck for key application

- gas dynamic/fluid flow
- pattern recognition/neural nets
- finite element analysis

Parallel Processor Software support

- GEM
- scheduling optimization

Architectures for Lattice Gas Cellular Automata

- Main application domain: fluid flow simulation
- Approach One
  - Until recently, most fluid flow models are based on partial differential equations (e.g. Navier-Stokes equations).
  - Solution usually involves numerical techniques with large numbers of floating point operations.
- Approach Two
  - Lattice gas cellular automata are new discrete models of fluids.
  - The fluids are made up of idealized particles that move according to simple rules.
  - Collections of large numbers of these particles can show overall continuum behavior which agrees with results predicted by Navier-Stokes equations.
  - This approach involves only logical operations and does not require floating point arithmetic.

The Computer Architect's Workbench

- The AWB is a set of software tools to predict the relative performance of alternative computer and system architecture features
  - Actual applications are used as benchmarks
  - High quality compiler support
  - Low requirements on hardware descriptions
- Trace Driven at basic block granularity

AWB: A General Research Tool and a Problem Solving Tool

- Research Tool
  - Architecture and Instruction Caches
  - Architecture and Data Buffering
  - Optimization and Instruction Architecture
- Design Tool
  - ASIC alternatives
  - Cost/Performance Analysis
  - Specific Workload Evaluation

Current Research

- The Effects of Programming Paradigms on the Instruction and Data Streams of a Shared Bus Multiprocessor
- Increasing the Performance of Shared Bus Multiprocessors
  - Effects of shared caches
  - Compiler techniques
    - Prefetch of Data
    - Write and Flush
    - Utilizing relationships between variables
  - Processor Architecture

APPLIED INFORMATION SYSTEMS RESEARCH PROGRAM WORKSHOP

PRINCIPAL INVESTIGATORS PRESENTATIONS (A.M. SESSION)

APPLIED INFORMATIONS SYSTEMS
RESEARCH WORKSHOP

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PRINCIPAL INVESTIGATORS PRESENTATIONS

PROGRAM PLAN FOR AN EXPERIMENTER'S LABORATORY FOR VISUALIZED INTERACITVE SCIENCE

Elaine R. Hansen/P. I.
Colorado Space Grant Consortium,
Univ. of Colorado
Boulder, CO
(303) 492-3141

Marjorie K. Klemp/Co.I.
Sally W. Lasater/Co.I.
Marti Szczur/Co.I.
Joseph B. Klemp/Co.I.

APPLIED INFORMATIONS SYSTEMS
RESEARCH WORKSHOP

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Program Plan

for an

Experimenter's Laboratory for Visualized Interactive Science

Applied Information Systems Research Workshop

July 22 — 24, 1991

Boulder, Colorado

Colorado Space Grant Consortium,
Laboratory for Atmospheric and Space Physics,
National Center for Atmospheric Research,
Goddard Space Flight Center,
University of California at Santa Barbara

Elaine R. Hansen

Program Plan for an Experimenter's Laboratory for Visualized Interactive Science

— Presentation Outline —

I. Goals and Objectives

II. Concept for Accomplishing Objectives

III. Building Blocks

— Features

— Key Players and Organizations

IV. Plans

I. Program Goals and Objectives

Goals

- Provide a capability that will help scientists of the '90's to interactively visualize data in order to better understand the *large, complex,* and *multidimensional data sets* of our future space missions
- Provide an Interactive Visualization Environment to support science research *within and across NASA science disciplines*
- Provide an Interactive Visualization Environment that can be *easily tailored* by the scientists themselves to best fit their individual research problems and display preferences
- Enable general members of the Space Science Community to use advanced visualization tools *at an affordable price*
- *Capitalize* on existing information systems techniques, technologies, and tools

I. Program Goals and Objectives

Objectives

- Provide a multidimensional, visualization capability based on the research needs of NASA scientists
- Support interactive, exploratory analysis
- Handle multiple, simultaneous, and diverse data sets (ingest, present, manipulate)
- Provide a user interface that is intuitive for and responsive to the needs of the general science user
- Provide software that will run on a variety of popular, affordable workstations

II. Concept for Achieving Objectives

— First and Foremost, product must have a suitable acronym! —

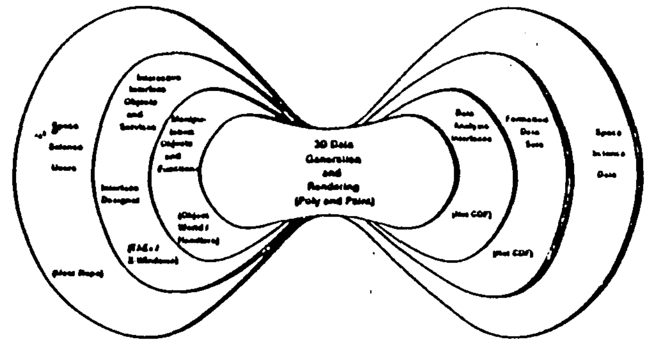
IVE (Interactive Visualization Environment)

IVAN (Interactive Visualization Analysis Node)

ELVIS (Experimenter's Laboratory for Visualized Interactive Science)

II. Concept for Achieving Objectives

— Product —



II. Concept for Achieving Objectives

— Process —

- Early and Continual Focus on the Science Users through interviews, observations, and participative design
- Parallel Design of all aspects
  - — The user interface design must start at the same time or before software design
- Early and continual user testing with prototypes to enable feedback to the design process
  - — User testing of user interface, functions and services, help, documentation, training, etc.

III. Building Blocks

1. 3D Data Generation and Rendering, "PolyPaint"
   - — Foundation system developed by NCAR
   - — Key individuals are Joseph Klemp (PolyPaint Originator and Lead), William Boyd, (Systems designer/programmer), Matt Irvin (Programmer, summer student, Physics grad at MIT in Academic Year)
   - — "Poly" Features
     - Polygon generation for contour surfaces within any specified subset of a three-dimensional grid volume
     - Contour surfaces that enclose either higher or lower values
     - Coordinate transforms for 3D data in non-Cartesian coordinates
     - Unit-normal vectors that are calculated either separately for each polygon vertex or averaged among polygons sharing that vertex
     - Polygon generation for planar surfaces cutting through the data domain
     - Polygon generation for surfaces defined by the values of a two dimensional data array
     - Polygon generation for two-dimensional contour lines (computed as ribbon surfaces) with a specified contour interval in any coordinate plane
     - Polygon generation to convert a three-dimensional curve into a ribbon-like surface

III. Building Blocks

— "Poly" Features (cont'd.)
- User-specified limitation on the maximum number of vertices in polygons
- Wire frame plots to preview the polygon data
- File storage for polygon data in formats that can be utilized within PolyPaint or other surface-rendering facilities

— "Paint" Features
- Either index color (8 bit) or true-color (24-bit RGB)
- Depth queuing using a z-buffer stored in memory
- Display of multiple objects that can be superimposed sequentially within the same view domain
- Polygon shading using either color (Gouraud) or surface-normal interpolation
- Reversal of unit-normal vectors to view the inner side or both sides of surfaces
- Display of 3D red/blue *stereo* objects
- Volumetric rendering of three-dimensional data
- Wire-frame rendering with shaded and anti-aliased lines
- Combined display of solid-surface, wire-frame, and volumetric rendering
- Procedures for storage and display of images to and from disk
- Multiple color-table partitions for displaying different colored objects on index-color systems
- Lighting options that include:
  — Up to 10 light sources

III. Building Blocks

— "Paint" Features (cont'd.)
  — Realistic rendering with a single light source using backscattered lighting
  — Colored light sources on true-color systems, with independent control of surface color
  — Light sources either at infinity or at a finite distance from objects (intensity diminishes with distance from light source
  — Diffuse or specular reflection (computed according to the Phong model) or combinations of the two for each light source
  — Independent color control of diffuse and specular reflection on true color systems
  — Ambient lighting
  — Haze
  — Transparent colors using either color mixing or other color combinations
- View-domain scaling with options for:
  — Automatically maximizing view domain within the specified window
  — Specifying various subscreens within the window
  — Relocating the location and direction of view
  — Altering the view angle (to zoom in or out)
  — Rotating objects about the direction of view
  — Rescaling the object in any coordinate direction
- Word packing options to reduce memory requirements

III. Building Blocks

2. Management of Data Objects, "Object World")
   — A software tool, developed at LASP
   Key individuals: Sally Lasater and Randy Davis
   — Manages data objects
   (store, retrieve, update, delete)

3. Interactive Interface Objects, Services and Designer-bench "Transportable Applications Executive — TAE+"
   — Developed by GSFC's Data Systems Technology Division
   Key individual: Marti Szczur
   — Enhanced for realtime applications by LASP at CU
   Key individuals: Margi Klemp and Eric Hills
   — Features
   - An easy to use workbench for design and layout of new user interfaces with "interaction objects"
   - Runtime Services to display and control workbench-designed user interfaces
   - A run-time interpreted command language to control an application's user interface

III. Building Blocks

4. Data Access Interface — Network Common Data Form (NetCDF)
   — Concepts originated by GSFC's NSSDC
   — Enhanced as general purpose tool by Unidata
   — Features
   - General tools for storing and retrieving range of science data types
   - Enables access software to treat all data types in the same way
   - Treats data as collection of self describing, network-transparent objects, accessed *through simple interface*
   - Supports random access of multi-dimensional variables, and direct access to single data values, to a hypercube of data, and to records

IV. Plans

- Plans have been reduced and stretched to fit available funding levels

(hoping for more funding!)

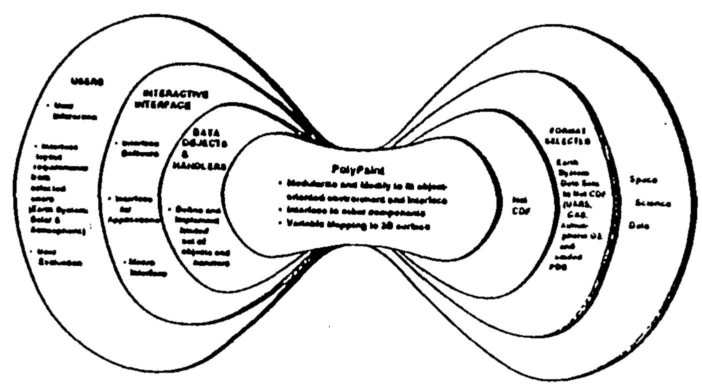
IV. Plans

- Integrate software components
- User interactions and evaluations

Milestones

- System data flow in 1 1/2 years
- Complete system with limited users, data types, handlers in 3 years

IV. Plans



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PRINCIPAL INVESTIGATORS PRESENTATIONS

GRID ANALYSIS AND DISPLAY SYSTEM (GrADS): A PRATICAL TOOL FOR EARTH SCIENCE VISUALIZATION

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APPLIED INFORMATIONS SYSTEMS
RESEARCH WORKSHOP

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THE GRID ANALYSIS AND DISPLAY SYSTEM (GrADS):

A PRACTICAL TOOL FOR
EARTH SCIENCE VISUALIZATION

JAMES L. KINTER III
BRIAN E. DOTY

CENTER FOR OCEAN-LAND-ATMOSPHERE INTERACTIONS
DEPARTMENT OF METEOROLOGY
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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
APPLIED INFORMATION SYSTEMS PROGRAM WORKSHOP
BOULDER, COLORADO

22-24 JULY 1991

SCIENTIFIC VISUALIZATION = 3:

I SEE

SCIENTISTS ⟷ DATA
- QUANTITATIVE
- INTERACTIVE
- VIEW + MANIPULATE

YOU SEE

RESULTS ⟶ JOURNALS
- QUANTITATIVE
- PUBLICATION QUALITY
  - LEGIBLE
  - INFORMATIVE
  - COMPARABLE

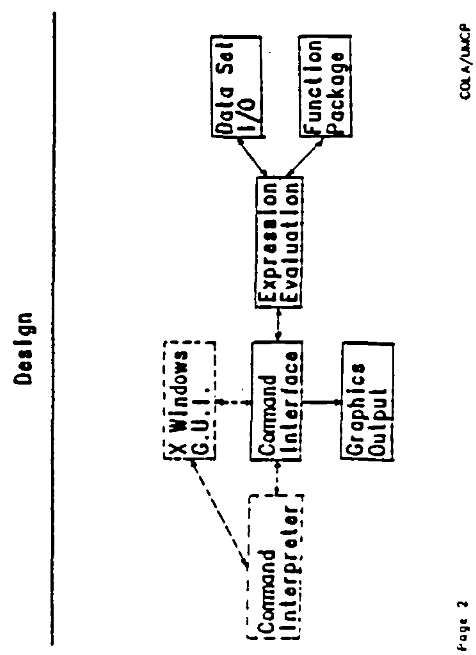
WE SEE

IMAGES ⟶ PUBLIC
- QUALITATIVE
- AESTHETIC

GrADS - Design Goals

- INTEGRATE [illegible]
  - ACCESS
    - [illegible]
    - [illegible]
  - MANIPULATION
    - [illegible]
  - DISPLAY
    - [illegible]

      [illegible]
      grid values [illegible]
      overlays
      [illegible]
    - [illegible]
- INTERACTIVE
  - [illegible]
  - User interface
  - Control of data/display characteristics
  - Scripting
  - Programmability
- EASE OF USE
  - Short learning curve
  - [illegible]
- HARDCOPY
  - Vector graphics output to hardcopy devices allows maximum device resolution, i.e., not limited to display resolution



ORIGINAL PAGE IS
OF POOR QUALITY

GrADS - IMPLEMENTATION

- PORTABILITY

  Coded in ANSII standard C

  Simple graphics interface to display: isolation of device specific graphics

  Datasets in standard Unix "stream" files writable from Fortran or C

- HIGH SPEED GRAPHICS

  Routines built in and optimized for rapid display

- NEW FUNCTIONALITY

  Ease of adding new graphical displays

  Ease of adding new data manipulation functions

GrADS Gridded Data Set

- The generalized view of the data is 4-Dimensional. Spacing may be non-linear except in time.
  - X,Y,Z,T = Longitude, Latitude, Height, and Time
  - Any number of variables
- Data resides on disk in binary format. Data sets are easily created or read by FORTRAN programs.
- X varies fastest, then Y, then Z, then each variable, then time.
  - Variables may have different numbers of levels, but must have same number of X, Y, and T elements
  - Use separate data set for different scaling

GrADS Station Data Set

- Each data element arbitrarily located in space and time.
- Data resides on disk in a structured format. Subroutines are provided for creating the data set from FORTRAN programs.
- A utility is run to create a 'map' of the station data set, allowing effecient I/O access for any data request.

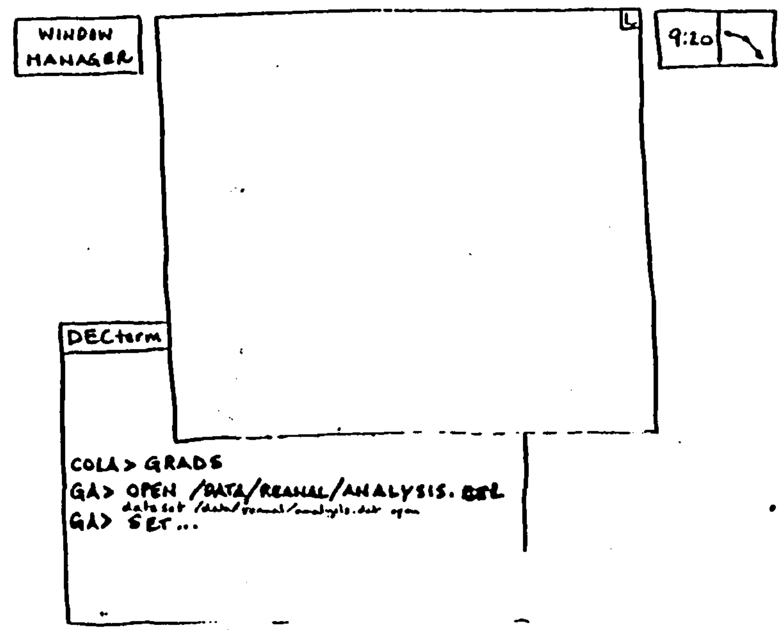
GrADS Data Description File

- Name of binary data set
- Defines scaling between grid coordinates and world coordinates
- Describes each variable
  - Abreviation to be used for the variable within expressions
  - Number of levels provided
  - Units value (not currently used)
  - Long name of variable

```
DSET /DATA/REANAL/ANALYSIS.DAT
UNDEF -9.99E33
TITLE REANALYZED GLOBAL FIELDS FROM DEC 82
*
XDEF 144 LINEAR 0.0 2.5
YDEF 73 LINEAR  -90.0 2.5
ZDEF 12 LEVELS 1000 850 700 500 400 300
               250 200 150 100 70 50
TDEF 20 LINEAR 00Z6DEC1982  6HR
*
VARS 5
Z     12   99    GEOPOTENTIAL HEIGHTS
U     12   99    U WINDS
V     12   99    V WINDS
RH     6   99    RELATIVE HUMIDITY
TV    12   99    VIRTUAL TEMPERATURE
ENDVARS
```



```
DSET /DATA/TMP/OBS.DAT
DTYPE STATION
STNMAP /DATA/TMP/OBS.MAP
UNDEF -999.0
TITLE RAWINSONDE REPORTS — RH, Z, TV
TDEF 4 LINEAR 00Z6DEC1982 6HR
VARS 3
Z  0  99  GEOPOTENTIAL HEIGHTS
TV 0  99  VIRTUAL TEMPERATURES
RH 0  99  RELATIVE HUMIDITY
ENDVARS
```

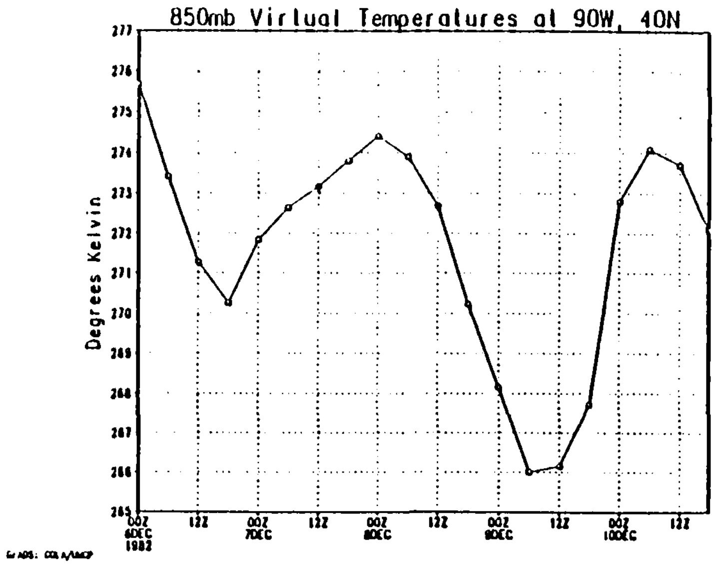



Example 1

Examples using the data sets from the descriptor files shown earlier (files have been opened).

```
SET LON -90
SET LAT 40
SET LEV 850
SET TIME 00Z6DEC1982 18Z10DEC1982
DISPLAY TV
DRAW TITLE 850mb Virtual Temperatures at 90W, 40N
DRAW YLAB Degrees Kelvin
```

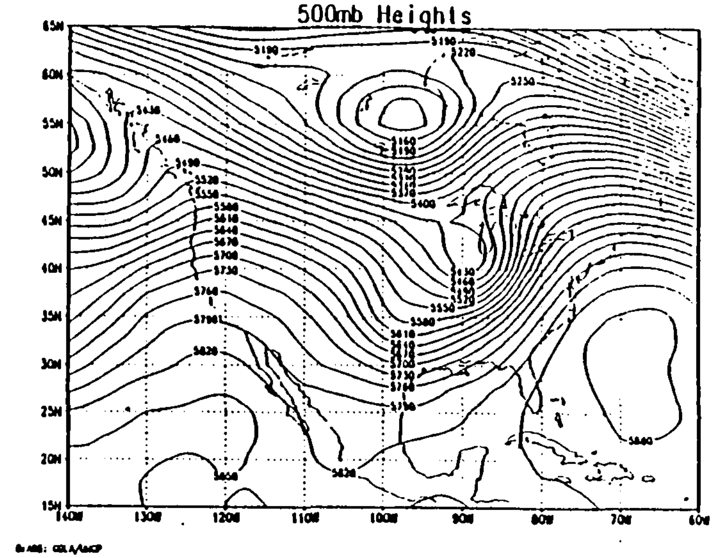
Notes:
- A 1-D 'slice' of TV (a basic variable) is being displayed
- We get a graph by default



Example 2

```
CLEAR
SET LON -140 -60
SET LAT 15 65
SET LEV 500
SET T 1
DISPLAY Z
DRAW TITLE 500mb Heights
DRAW XLAB 00Z December 6, 1982
```

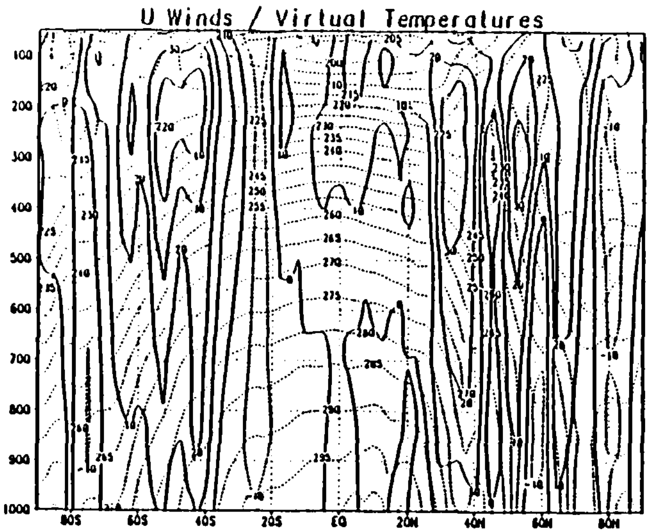
Notes: • If X and Y are varying, a map is automatically drawn.



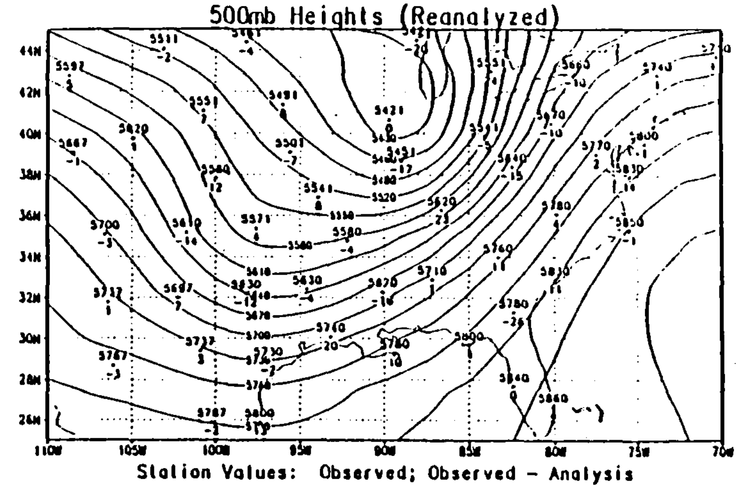
Example 3

```
CLEAR
SET LON -90
SET LAT -90 90
SET LEV 1000 50
SET T 1
DISPLAY U
SET CSTYLE 3
DISPLAY TV
DRAW TITLE U Winds / Virtual Temperatures
```

Notes: • Vertical Cross Section
• Multiple DISPLAYs without CLEARing result in overlaid contours

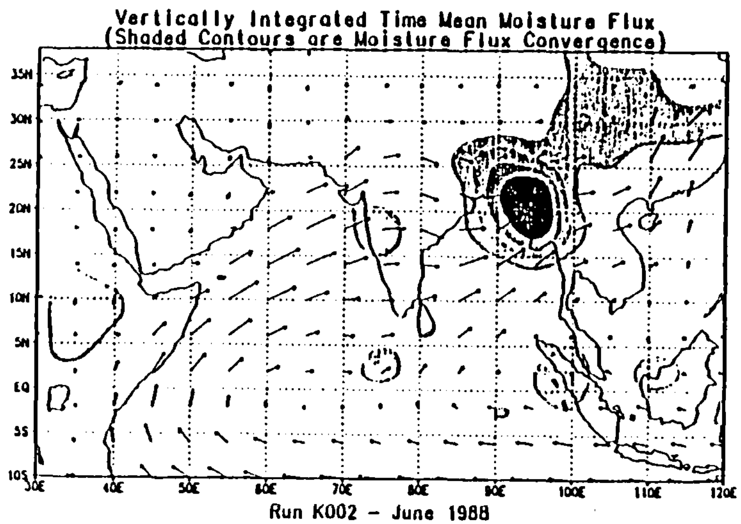


GrADS: COLA/IGES

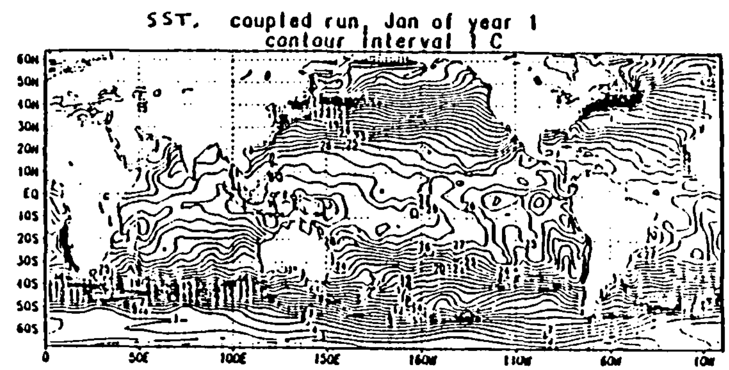


GrADS: COLA/IGES

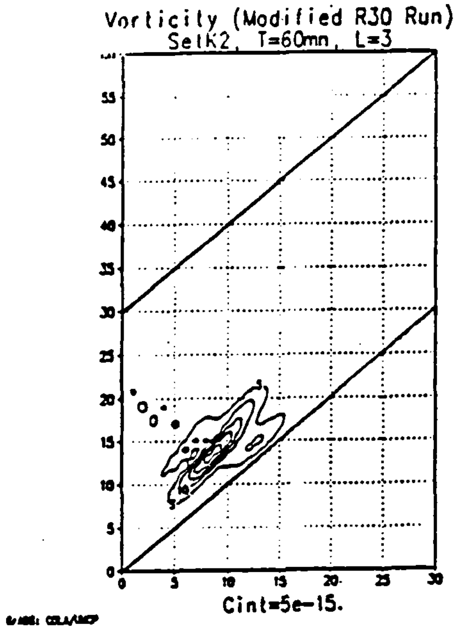
R15-OGCM.

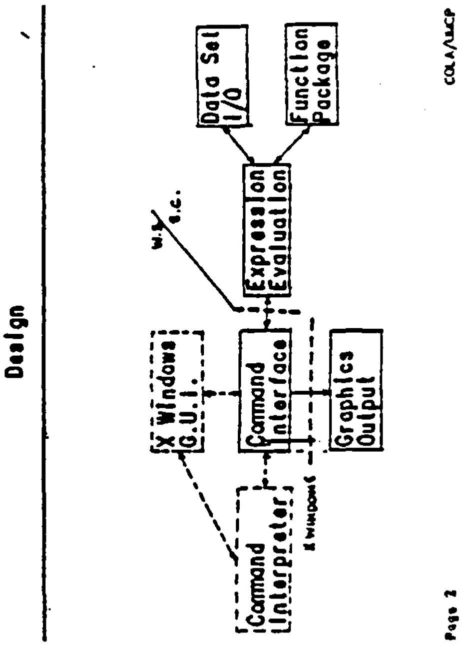


GrADS: COLA/IGES



GrADS: COLA/IGES


Vorticity (Modified R30 Run)
SelK2, T=60mn, L=3
Cint=5e-15.


Design
Data Set I/O
Function Package
Expression Evaluation
X Windows G.U.I.
Command Interface
Graphics Output
Command Interpreter
COLA/UMCP

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PRINCIPAL INVESTIGATORS PRESENTATIONS

A DISTRIBUTED SYSTEM FOR VISUALIZING AND ANALYZING MULTIVARIATE AND MULTIDISCIPLINARY DATA

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APPLIED INFORMATIONS SYSTEMS
RESEARCH WORKSHOP

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JPL

A Distributed System for Visualizing and Analyzing Multivariate and Multidisciplinary Data

Investigator Team:

Jet Propulsion Laboratory
Allan S. (Bud) Jacobson - Principal Investigator
Mark A. Allen
Ronald G. Blom
Lee S. Elson

San Diego Supercomputer Center
Michael J. Bailey

Silicon Graphics, Inc.

JPL

The Linked Windows Interactive Data System (LinkWinds)

1. A visual data exploration/analysis environment with data displayed in a series of interdependent windows. Interdependence is established at user's discretion by "linking" visuals and controls.

2. A standard graphical user interface with additional "linking" rules. Results in an intuitive interface accessible with a minimum of training.

3. A user accessible applications prototyping environment.

4. Implemented with an object-oriented programming model, with "links" establishing message flow path. There is an underlying command language (Lynx) based upon scheme.

5. A multi-user science environment (MUSE) requiring a minimum of network band-width.

JPL

A Distributed System for Visualizing and Analyzing Multivariate and Multidisciplinary Data

Program Objectives

1. Develop LinkWinds tools and controls specific to at least two science disciplines and demonstrate them in current research activities.

2. Adapt LinkWinds to X-Windows for execution in a network environment.

3. Use adapted LinkWinds to demonstrate cooperative and interactive televisualization and analysis by geographically separated science teams.

JPL

The Linked Windows Interactive Data System (LinkWinds)

Development Approach

1. Employ an incremental development process using rapid prototyping of applications.

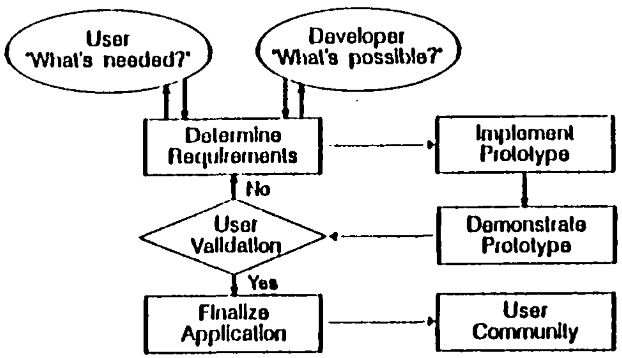
2. Work with users and developers in a tight loop throughout the process.

3. Provide software and workstations to users to stimulate product use in research activities.

JPL

The Linked Windows Interactive Data System (LinkWinds)

Application Development Cycle



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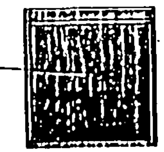
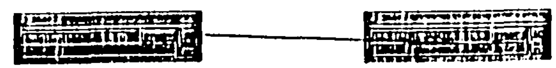
The Linked Windows Interactive Data System (LinkWinds)

Linking Rules

1. If an empty window appears, link a data object to it.



2. Link control symbols to other windows in order to manipulate them.

JPL

The Linked Windows Interactive Data System (LinkWinds)

User Interface Design Philosophy

1. Users are impatient and want to get started quickly on productive work. They are discouraged by large manuals.

2. Users learn from self-initiated exploration, making mistakes and correcting them.

3. Users refer to documentation only when the software doesn't conform to their expectations. Then they skip around in manuals or on-line help to find the answer to current problem.

(Ref: Marc Rettig, CACM, Vol 34, 19, July 1991)

JPL

The Linked Windows Interactive Data System (LinkWinds)

Future Plans

1. Port to X-Windows, using OSF Motif toolkit, for expansion to other platforms.

2. Implement an applications generator to support user application development.

3. Expand MUSE capabilities.
   Session Management, Floor Management, Telepointers, Network clipboard

4. Implement hardcopy and video output.

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PRINCIPAL INVESTIGATORS PRESENTATIONS

DATA REDUCTION EXPERT ASSISTANT

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Robert J. Hanisch/Co.I.

APPLIED INFORMATIONS SYSTEMS
RESEARCH WORKSHOP

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Data Reduction Expert Assistant

AISR Workshop

22-24 July 1991

Glenn E. Miller
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Data Reduction

The process of converting raw instrumental output into physical measurements

Data Analysis Systems

- IRAF - Image Reduction and Analysis System (NOAO)
- STSDAS - Space Telescope Science Data Analysis System (STScI)
- MIDAS - Munich Interactive Data Analysis System (ESO)
- IDL - Interactive Data Language
- .....Many other systems

Very successful approach

- widespread distribution of these systems
- systems written for one wavelength extended to serve others
- incorporation of independently developed packages

Philosophy of These Systems

- Modular operators which work on standardized types of data files
- Command Language to execute single commands or scripts of commands (in interactive or batch mode)

Advantages:

- Flexibility for the user:

  Individual commands can be chained (or "pipelined") to construct powerful, customized procedures
- Ease of development:

  Well-defined methods for adding new modules. Thus many programmers and scientists may independently contribute to the growth of a system.
- Standardization

Disadvantages

- Learning a system isn't easy

  Commands can be complex with many parameters and even experts don't know the entire system. Users may have to learn more than one system, especially if they work at different institutions or their work is multi-disciplinary/multi-spectral

- Difficult to capture expert knowledge

  Manuals, on-line help, local gurus have drawbacks

- Data management problem

  A few night's observations can result in hundreds of data files which must each pass through many reduction steps

Expert Assistant

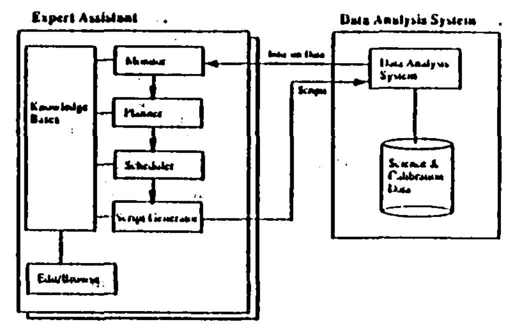
An alternative approach which builds on the foundation of these systems

- Gather information about the available data (typically from header information in the data files).
- Develop a plan for data reduction based on the user's goals, actual properties of the data and on limitations of available resources (e.g. disk space).
- Translate the plan into explicit reduction commands for a specific data analysis system.
- Monitor the plan and its execution for problems (e.g. missing calibration files) and alert the user.
- Be extensible to incorporate new types of data reduction, new analysis modules and new data analysis systems. The Expert Assistant will provide users with tools for this purpose.
- Present powerful and effective user interface including mouse-and-menu graphics (which is also found in non-expert systems) and natural language interface.

Useful Goals - But can it be done?

Yes:

- Expert systems/artificial intelligence technology in routine use at the STScI to support operations
- Prototype data analysis assistant developed by one of us in 1987
- Doesn't require specialized hardware - the same workstation which runs IRAF (e.g. a Sun 4) can run expert system software



Implementation Considerations

- Choose language suited to symbolic processing, expert systems, and other artificial intelligence paradigms
- Ability to construct powerful user interface
- Provide flexibility for porting to other workstations
- Low cost for our users (existing data analysis workstation, plus minimal if any software licenses)

Choices:

- Common Lisp

  Well-tested Lisp utility library at STScI
- Object Oriented (Common Lisp Object System)
- X-based window system

  Motif? CLIM? Gina?

How to Best Involve the Scientific Community?

Lead Users:

- Involve scientists in use and independent evaluation of expert assistant as soon as possible (in addition to scientific input of PI and Co-Is)
- We feel that it is important that this tool be used with real data reduction problems as early as possible.
- Even the initial versions of the Expert Assistant will be sufficiently powerful to pay back the Lead Users *for their investment of time.*

Summary

Expert Assistant will significantly enhance research by removing much of the burden of routine data reduction from scientists and freeing them to focus more attention on the physical interpretation of the results. It will also *alert the user to problems encountered* in the reduction process.

Technically feasible

Innovative in use of expert systems/AI technology but built on foundation of existing data analysis systems

Project oriented towards developing a useful tool that will run on commonly used systems

An explicit design feature of this work is independence of any particular scientific discipline or data analysis system, which allows it to be applied to multiple scientific disciplines.

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PRINCIPAL INVESTIGATORS PRESENTATIONS

OVERVIEW OF THE SYSTEMS OF EXPERTS FOR INTELLIGENT DATA MANAGEMENT (SEIDAM)

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Ko Fung/Co.I.
Joji Iisaka/Co.I.

APPLIED INFORMATIONS SYSTEMS
RESEARCH WORKSHOP

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SEIDAM

OVERVIEW OF THE SYSTEM OF EXPERTS FOR INTELLIGENT DATA MANAGEMENT (SEIDAM)

by

David G. Goodenough, Ko Fung, Joji Iisaka,
Mike Robson, Cornelius Kushigbor

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Boulder, Colorado

NASA CCRS PFC

SEIDAM

WHICH AGENCIES ARE INVOLVED?

ENERGY, MINES AND RESOURCES CANADA
- CANADA CENTRE FOR REMOTE SENSING

FORESTRY CANADA
- *PACIFIC FORESTRY CENTRE*

U.S. NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
- APPLIED INFORMATION SYSTEMS RESEARCH PROGRAM

INDUSTRY, SCIENCE AND TECHNOLOGY CANADA
- STRATEGIC TECHNOLOGIES BRANCH

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OUTLINE

- PROPOSAL SELECTED BY NASA IN NOV. 1990 THROUGH COMPETITION FOR THE APPLIED INFORMATION SYSTEMS RESEARCH (AISR) PROGRAM.
- INTRODUCTION
- MULTIPLE DATA SOURCES INTEGRATION
- SEIDAM STRUCTURE
- MACHINE LEARNING
- USER INTERFACE
- SPATIAL KNOWLEDGE EXPERT SYSTEM
- DIGITAL TERRAIN MODEL (DTM) AND SEGMENTATION EXPERT SYSTEMS
- SYSTEM VALIDATION
- TASKS AND PLANS

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SEIDAM

SEIDAM - OTTAWA TEAM

CCRS

David Goodenough - Principal Investigator
Ko Fung - Co-Investigator
Joji Iisaka - Co-Investigator
Michael Robson, Cornelius Kushigbor
Alain Menard, Jean-François Meunier, Karl Staenz

University of Ottawa

Stan Matwin, Dan Charlebois

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SEIDAM

SEIDAM OBJECTIVE

TO CREATE A SYSTEM OF EXPERTS FOR INTELLIGENT DATA MANAGEMENT (SEIDAM) WHICH WILL INTEGRATE REMOTE SENSING DATA FROM SATELLITES AND AIRCRAFT WITH GEOGRAPHIC INFORMATION SYSTEMS AND MANAGE LARGE ARCHIVES OF REMOTELY SENSED DATA FOR DYNAMIC SELECTION OF DATA SOURCES AND SENSOR CHARACTERISTICS FOR RECOGNITION OF FOREST OBJECTS APPROPRIATE FOR ENVIRONMENTAL FOREST MONITORING.

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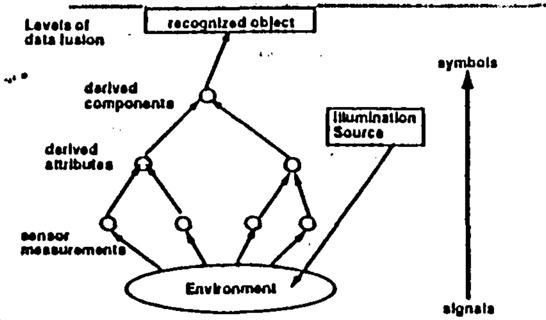
INTEGRATION OF INFORMATION



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SEIDAM

WHY USE MULTIPLE DATA SOURCES?

- A SINGLE DATA SOURCE MAY NOT BE ABLE TO CAPTURE ALL THE SIGNIFICANT CHARACTERISTICS NEEDED TO IDENTIFY AN OBJECT.
- A SINGLE DATA SOURCE MAY BE SUBJECTED TO SYSTEMATIC ERRORS AND NOISE.
- MULTIPLE DATA SOURCES MAY PROVIDE COMPLEMENTARY INFORMATION.
- REDUNDANT INFORMATION FROM MORE THAN ONE DATA SOURCE INCREASES THE ACCURACY AND CERTAINTY OF OBJECT IDENTIFICATION.
- ONE IS MORE LIKELY TO HAVE DATA AVAILABLE AT THE DESIRED TIME.
- HISTORICAL GIS INFORMATION CAN GUIDE RECOGNITION PROCESS.

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PROBLEMS WITH MULTIPLE DATA SOURCES

- COSTS OF ACQUISITION
- COMPLEXITIES OF HANDLING MULTIPLE SENSORS:
  - VARIABLE SPECTRAL CHARACTERISTICS OF SENSORS.
  - VARIABLE SPATIAL RESOLUTIONS OF SENSORS.
    - HIGH RESOLUTION SENSOR MAY RESOLVE CLOSELY SPACED OBJECTS, THUS GIVING TOO MUCH DETAIL.
    - LOW RESOLUTION SENSOR MAY NOT RESOLVE OBJECTS OF INTEREST.
    - OBJECTS WILL VARY IN SHAPE AND TEXTURE FROM SENSOR TO SENSOR.
- DIFFERENT SENSORS MAY HAVE DIFFERING VIEWING GEOMETRIES, MAKING MATCHING AND REGISTRATION OF SPATIAL OBJECTS DIFFICULT.
- VARIABILITIES DUE TO DIFFERENT RESPONSES TO THE ATMOSPHERE.
- VARIATIONS DUE TO DIFFERING RECORDING CRITERIA, FORMATS AND STANDARDS.

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Data Sources

Satellite:

- LANDSAT 5,6
- SPOT 3
- ERS-1
- JERS-1
- NOAA/AVHRR
- MOS-1A, B

Aircraft:

- CCRS SAR (X, C - polarimetric)
- CCRS MEIS (push broom scanner)
- CCRS AMSS
- NASA airborne SAR (X, L, P - polarimetric)
- AVIRIS, TIMS

Field Measurements:

- GIS information
- DTM
- Ground calls
- *Ecosystem chemistry*
- Meteorological data

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MISMATCHES BETWEEN GIS DATA AND REMOTE SENSING DATA

- SENSOR RESOLUTION MAY NOT BE SUFFICIENT TO RECORD SPATIAL FEATURES USED FOR POLYGON DELINEATION.
- GIS FEATURES MAY NOT BE VISIBLE IN IMAGES DUE TO NON-STATIONARITY OF OBJECTS (E.G. CROPS, WATER BOUNDARIES, BURNS, ETC.).
- GENERALIZATIONS USED FOR BASE MAP MAY CREATE SPATIAL DISPLACEMENTS WITH RESPECT TO IMAGE DATA.
- DIFFERENT GIS SOURCES MAY HAVE SPATIAL ERRORS BETWEEN THEIR RESPECTIVE BASE MAPS.
- IMAGE OBJECTS REFLECT SEASONAL VARIATIONS.

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SEIDAM

Object Recognition Approach

1. CONVENTIONAL STACK APPROACH
   - 1.1 maximum likelihood with or without prior probabilities.
   - OR 1.2 logistic classifier.
   - OR 1.3 feature selection followed by classification.
2. SYMBOLIC APPROACH
   - 2.1 derive attributes from the minimum number of data sources.
   - AND 2.2 object identification based on the attributes.
   - OR 2.3 dynamically select new data source if partially successful in object identification.

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SYMBOLIC INTEGRATION APPROACH

- Knowledge-Based Methodology
- Object Oriented approach
- Objects are grouped into an hierarchy according to the ease of recognition from imagery
- Available data sources are ranked and selected automatically to derive attributes required for object recognition
- Attributes are derived from the optimum data sources on an as-needed basis
- Object instances are disambiguated by the use of derived attributes from selected data sources
- The search space is limited by pruning unlikely instances

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DATA SOURCE SELECTION

- Select data source with best coverage of the ground area.
- Select data source with lowest inherent errors such as geometric and sensor errors
- Select data source with optimum spatial resolution. We don't want too coarse a resolution so that desired objects can not be identified. Also, we don't want too fine a spatial resolution so that desired objects become too complex in the image.
- Select best wavelength intervals of the sensor measurements for the desired objects.
- Select data sources for which there exist implemented algorithms to derive the required attributes.
- Select data source with lowest cost pre-processing required.
- Select data source with the least computational cost of the analysis algorithms.

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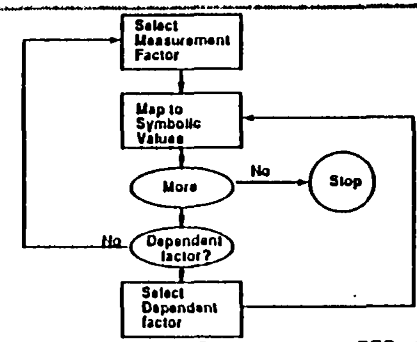
Selection of Measurement Factors



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COMBINATION OF ATTRIBUTES FOR OBJECT RECOGNITION

- Combination through weights on the attributes
- Heuristic Methods (e.g. majority voting)
- Bayesian Approach
- Dempster-Shafer rules of combination
- Fuzzy Logic
- Endorsement Methods

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CONFLICT RESOLUTION FOR THE ENDORSEMENT METHOD

Endorsements for	Endorsements against	Inferred	Remark
Definite	None	Definite Yes	
Definite	Definite	Unknown	Inconsistent
Definite	Contingent	Definite Yes	
None	Definite	Definite No	
Contingent	None	Weakly Yes	
None	Contingent	Weakly No	
Contingent	Definite	Definite No	
Contingent	Contingent	Unknown	Inconsistent

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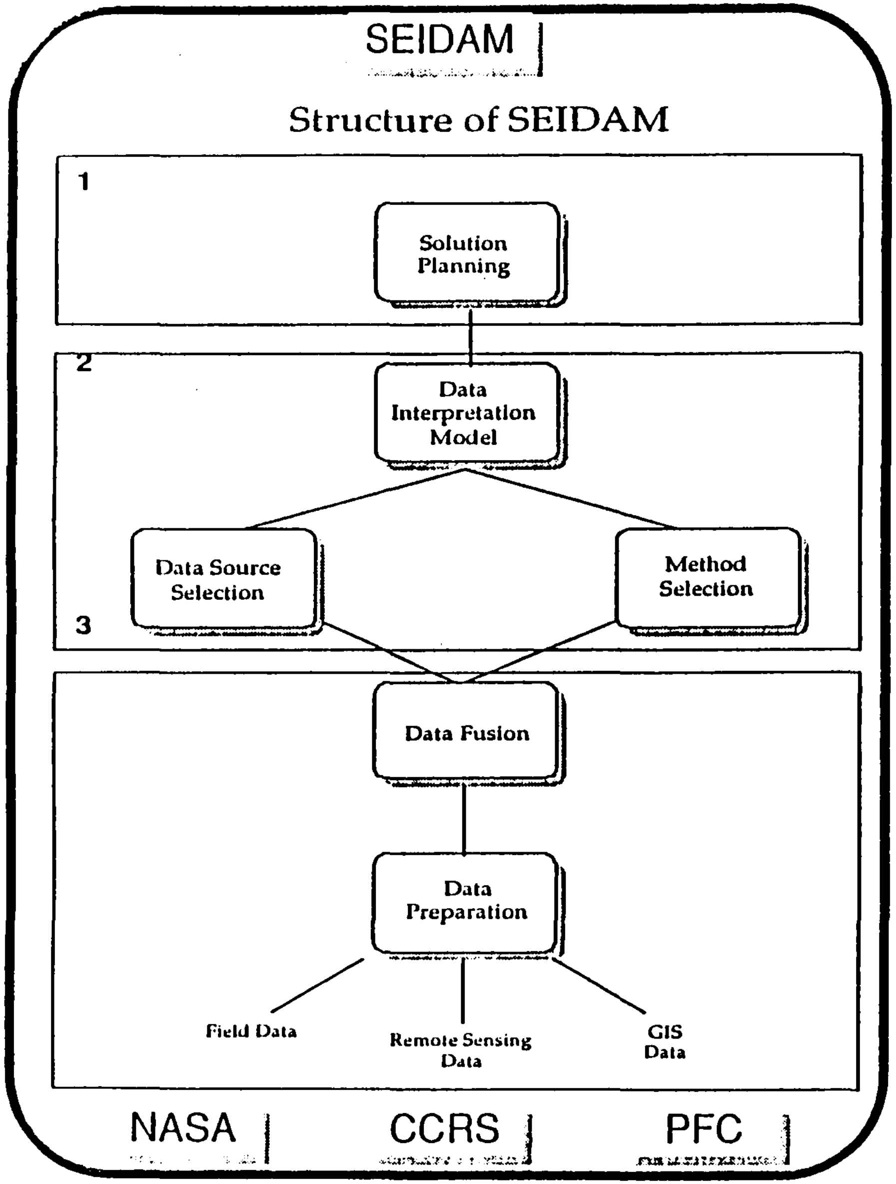
SEIDAM
Structure of SEIDAM
1
Solution Planning
2
Data Interpretation Model
Data Source Selection
Method Selection
3
Data Fusion
Data Preparation
Field Data
Remote Sensing Data
GIS Data
NASA
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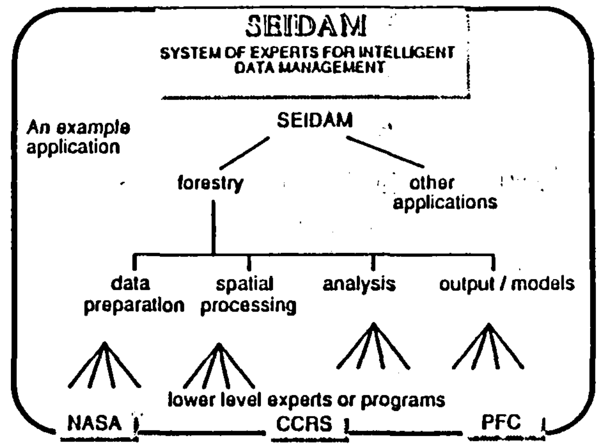
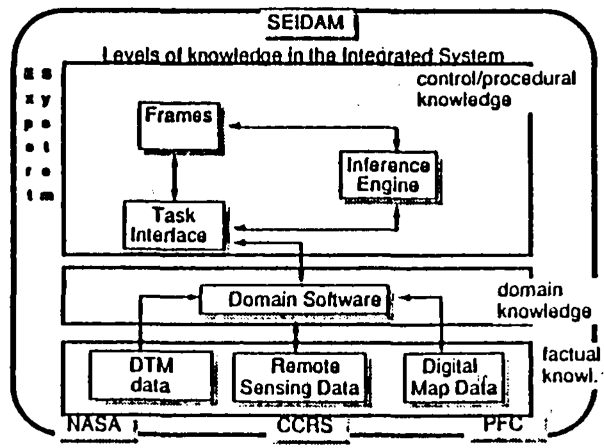

SEIDAM
SYSTEM OF EXPERTS FOR INTELLIGENT DATA MANAGEMENT
An example application
SEIDAM
forestry
other applications
data preparation
spatial processing
analysis
output / models
lower level experts or programs
NASA
CCRS
PFC


SEIDAM
Levels of knowledge in the Integrated System
control/procedural knowledge
Frames
Inference Engine
Task Interface
Domain Software
domain knowledge
DTM data
Remote Sensing Data
Digital Map Data
factual knowl.
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Objectives of work on applying learning and planning in SEIDAM:

- to facilitate the development of new experts
- to re-use previous designs, particularly in the areas requiring specialized AI-related expertise
- to evaluate usefulness of Machine Learning technology in deployment of Expert Systems, with a Remote Sensing focus

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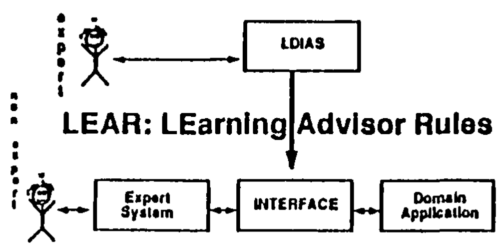
Programming-by-example helps build interfaces



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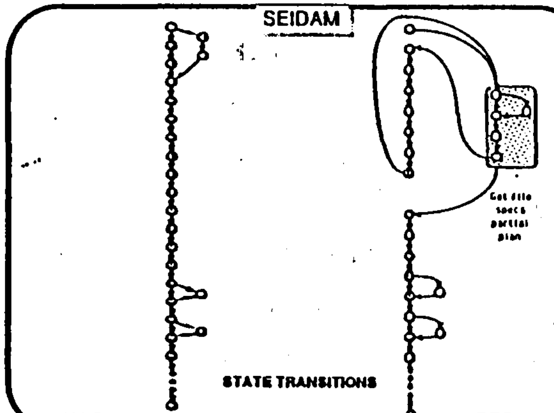

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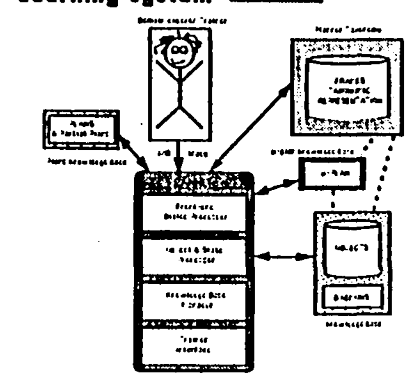
Learning System



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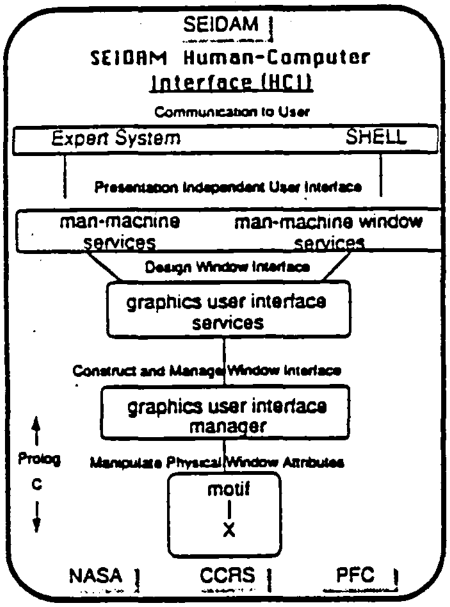

SEIDAM

Human-Computer Interface Considerations

Purpose of the HCI

- simplify prompt-intensive procedures
- generate level of knowledge
- organize the information on the screen
- "augment the capability of the worker"

Benefit of the HCI

- complex set of tasks become less intimidating by relating tasks to the goal and to other tasks
- communicate at the level of the users
  - adapt to the level of the user
- event driven dialogue rather than predictable

Development Considerations

- communication strategy
  - level of abstraction (target user)
  - consistent grammatical rules and terminology
  - consistent presentation
- amount of freedom available to the user
- inform the user
  - what has happened, what is happening

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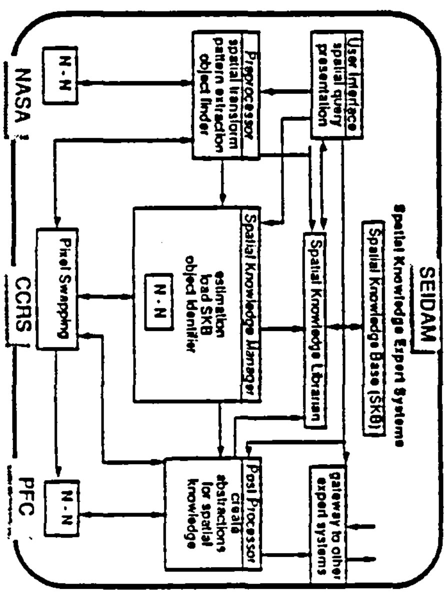
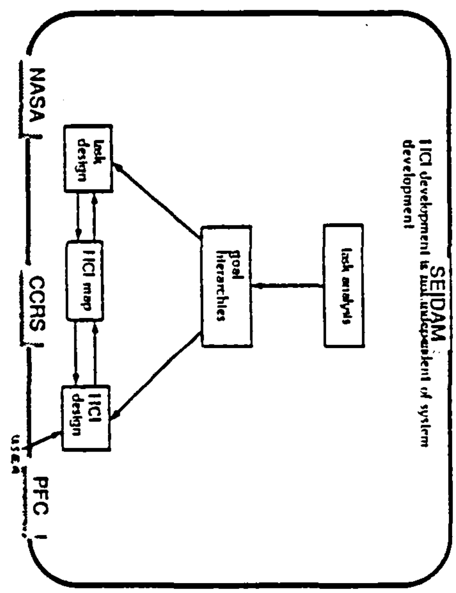
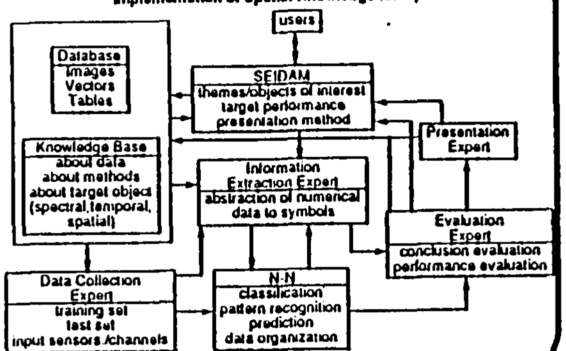




SEIDAM

Implementation of Spatial Knowledge for Operations



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SPATIAL KNOWLEDGE EXPERT SYSTEM

Background Demands:

Conventional Image Analysis for Remote Sensing:
little integration and utilization of spatial knowledge
Multi sensor data integration for different resolutions
Need more intelligent data abstraction

Emerging of supporting technologies:

Artificial Neural Network Computing

CCRS' developed method "Pixel Swapping" to treat image spatially and spectrally in a unified way.

Experience:

CCRS' long term experiences with image analysis and expert system development.

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Spatial Knowledge: OBJECTIVES

1. Develop spatial information acquisition methods and system:

   Investigation of Neural Networks capability:
   Spatial information extraction, Multi sensor data fusion
   Data abstraction methods for high resolution spectral data,
   Image indexing methods.

   Integration of Pixel swapping functions to image computing system.

2. Develop an expert system for spatial information analysis system embedding or linked with neural networks and pixel swapping functions.
3. Collect spatial knowledge observed in remote sensing data and create pilot knowledge bases.
4. Validate spatial knowledge acquired for remote sensing

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Spatial measurements knowledge

Geometrical measurement:

classical geometrical measurements:
Area sizes, moments, direction and ellipticity length, direction...
additional geometrical measures:
Fractal Dimension.
Statistical and Structural Texture measures

Geometrical shape characterization:
point like, line like, region like.

Spatial structure:
Tree-like, network like, spatially clustered...

Association:
Hit, overlapped, included...
Positively associated, negative associated or randomly associated.

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SPATIAL KNOWLEDGE EXPERT SYSTEM

Preprocessor
- Linked with N-N
- Feature conversion

Spatial knowledge acquirer
- Spatial measure estimation
- Spatial measure organizer
- Spatial knowledge manager

Interface manager:
- Spatial Query handling
- *Spatial knowledge presentation*

Knowledge librarian:
- Spatial knowledge description, indexing and retrieve

Post processor:
- classifier
- noise remover
- predictor

Interfaces to other expert system:
- Import and Export relevant information to other expert system.

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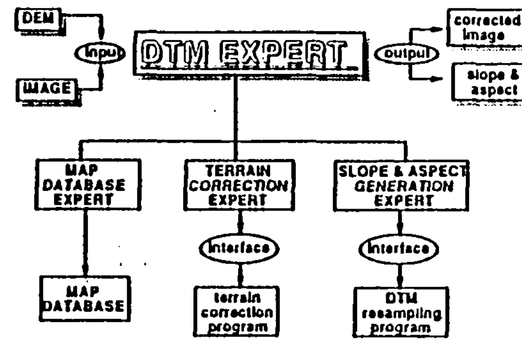
DTM EXPERT STRUCTURE



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DTM EXPERT FLOW

1- estimate the Terrain type

2- estimate Satellite image accuracy

3- estimate DEM accuracy

4- do Terrain Correction

5- Resample DEM

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CONCLUSIONS FOR DTM SYSTEM

- Elevation, slope and aspect from DTM improve significantly object recognition accuracies.
- *Expert system simplifies uses of DTM*
- Expert systems offer the possibility of distributed, national access to DTMs from provincial and federal sources.
- DTMs are essential for multisource integration.
- Expert prototype successfully tested with image and DEM of mountainous terrain in B.C.
- In the future: generate revised accuracy estimates for each point in the DTM

  Adaptive grid size with DEM for Slope & Aspect generation

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C-2

SEIDAM

SEGMENTATION Introduction

- SEGMENTATION is a complex process with knowledge distributed over several levels of the recognition procedure.
- Users are unfamiliar with the many issues to be considered in choosing the best edge operator, the best segmentation method, sensor characteristics and the most appropriate spatial and spectral features.

➡ Expert Systems can simplify access to this powerful but complex process!

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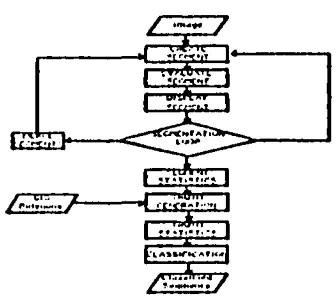
Prototype Flow Chart



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Segmentation Expert - IMPLEMENTATION

Prototype RULES: Example

```
suggest_action_based_on(NUMSEG,NUMPOLY,SIZE,SMOOTHING):-
  NUMSEG /= '-1',
  NUMSEG < NUMPOLY,
  rs_write("Suggestion: Resegment with a lower smoothing threshold."),
  rs_nl,
  rs_write("  Reason: The number of segments is less than the number"),
  rs_nl,
  rs_write("        of GIS polygons which suggests that too few"),
  rs_nl,
  rs_write("        segments were created."),
  rs_nl,
  rs_write("  Previous "),
  write_thresholds(SMOOTHING),
  halve_thresholds(SMOOTHING,NEWSMOOTH),
  rs_write("  Suggested "),
  write_thresholds(NEWSMOOTH),
  rs_nl,
  !.
```

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Segmentation Expert - IMPLEMENTATION

GIS polygons updates:

- Use labelled segments to update GIS polygons:
  - leave polygons that match segments
  - split polygons covering multiple segments classes
  - redraw polygon limits to match segments classes
  - update GIS database with new polygon attributes
- Difficult cases can be submitted to forest inventory experts and/or local foresters for human labelling.

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SEGMENTATION CONCLUSIONS

- The expert system simplifies and speeds up the segmentation process
- Great advantage over standard programming techniques:
- our prototypes being incorporated into an operational system for segmentation.
- 'Intelligence' of our expert is easily improved with new knowledge as soon as it becomes available

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CONCLUSIONS #2

- We still need to work on GIS updating process from segments of remotely sensed images:
  - Segmentation parameters?
  - Improve segment classification
- Establish RULES for labelling segment classes from GIS
- Rules to modify GIS polygons from classified image segments?
- Expert to be tested on several forest inventory maps

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WHAT RESEARCH WILL BE DONE?

WHAT METHODS SHOULD BE SELECTED TO ANALYZE REMOTE SENSING AND GIS DATA IN ORDER TO MONITOR A FOREST?

1) AUTOMATED METHOD:

- SEGMENTATION OF THE GIS
- INTELLIGENT SELECTION OF HISTORICAL GIS DATA AND ATTRIBUTES
- ESTIMATION OF GIS LABEL AND BOUNDARY ACCURACIES
- SEGMENTATION OF THE REMOTE SENSING DATA
- ENDORSEMENT METHOD LABELLING OF SEGMENTS TO CREATE NEW FOREST POLYGONS WITH IMPROVED ACCURACIES, MORE CONSISTENT LABELS, AND CHANGED AREAS IDENTIFIED

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WHAT RESEARCH WILL BE DONE? #2

2) IMPROVE EXISTING METHODS FOR FOREST INVENTORY:

- TOPOGRAPHIC CORRECTION OF SATELLITE DATA
- POINT TO AREAS OF CHANGE
- AUTOMATICALLY SEGMENT AREAS OF CHANGE
- ESTIMATION OF GIS LABEL AND BOUNDARY ACCURACIES
- INTERACTIVE CREATION OF NEW ROADS
- UPDATE GIS

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WHAT RESEARCH WILL BE DONE? #3

HOW DO THESE RESULTS GET COMBINED WITH FOREST CANOPY MODELS TO MAKE IMPROVED ESTIMATES OF FOREST STAND PRODUCTIVITY?

- CHARACTERIZATION OF LAND SURFACE FROM DTM AND ESTIMATION OF SITE QUALITY FROM SOILS, GEOLOGY, HYDROLOGY, AND DTM ANALYSIS
- INTEGRATION OF GIS - RS RESULTS WITH FOREST CANOPY MODELS FOR SHORT AND LONG TERM PRODUCTIVITY ESTIMATION ON A POLYGON BASIS
- EXPERIMENTATION WITH AIRBORNE IMAGING SPECTROMETER DATA FOR CHEMICAL INPUTS INTO MODELS

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WHAT RESEARCH WILL BE DONE? #4

- WHAT COMPUTING SCIENCE AND ENGINEERING RESEARCH WILL BE DONE?
  - CREATION OF EXPERT SYSTEM SHELL IN QUINTUS PROLOG WITH GUI (GRAPHICAL USER'S INTERFACE) FOR UNIX AND VMS
    - RETAIN EXISTING SOFTWARE INVESTMENT
    - DISTRIBUTED PROCESSING WITH INTELLIGENT AGENTS
    - OBJECT-ORIENTED (FRAMES)
    - ABILITY TO PAUSE AT USER'S CONVENIENCE
  - MACHINE LEARNING FOR CREATION OF EXPERT SYSTEMS TO CONTROL TASKS AND FOR LEARNING FROM EXPERIMENTS
  - ~150 EXPERT SYSTEMS WILL BE CREATED WITH WINDOW INTERFACE
  - DISTRIBUTED GIS AND RELATIONAL DATA BASE ACCESS

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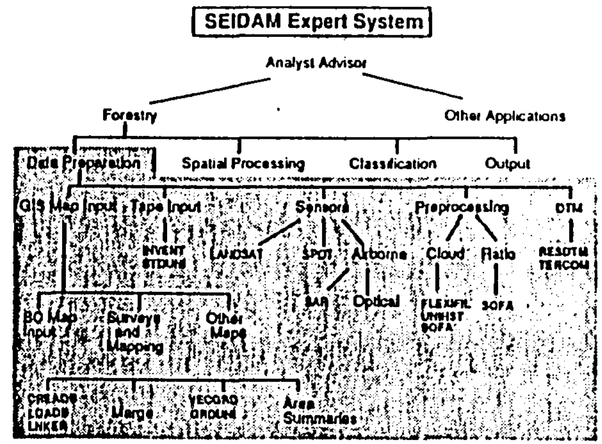
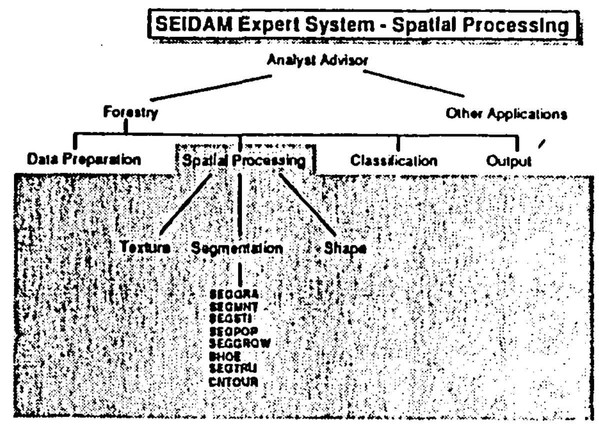
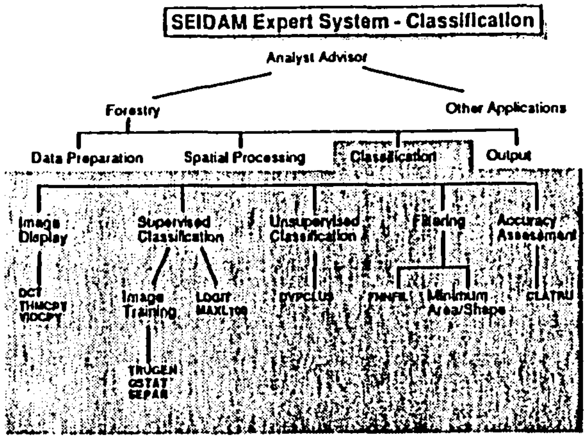
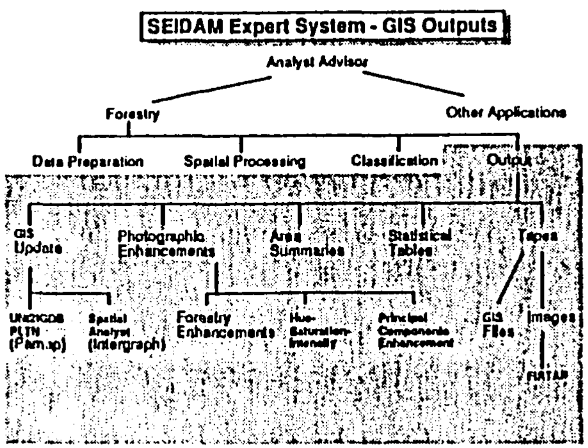
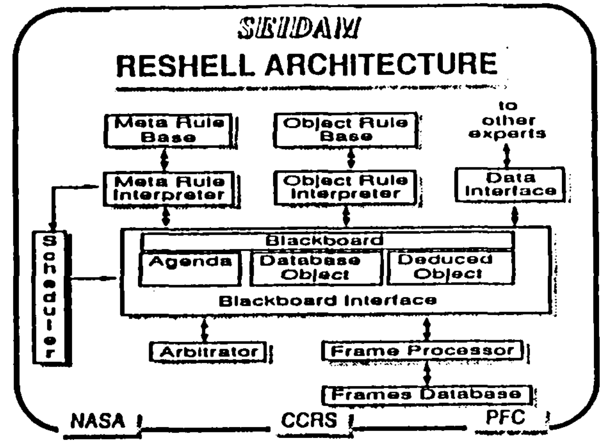
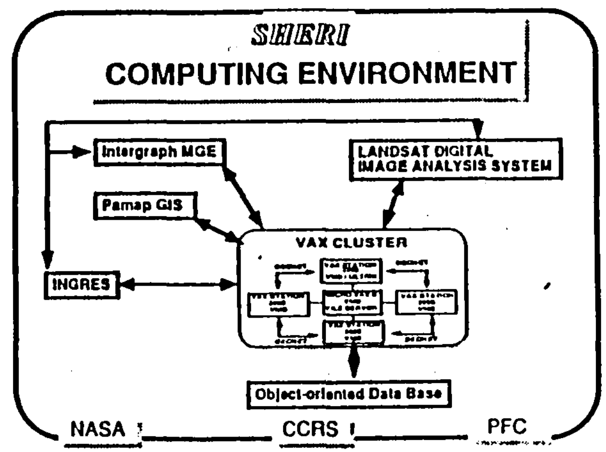





SEIDAM Expert System - Classification
Analyst Advisor
Forestry
Other Applications
Data Preparation
Spatial Processing
Classification
Output
Image Display
Supervised Classification
Unsupervised Classification
Filtering
Accuracy Assessment
DCT
THMCPY
VIDCPY
Image Training
LOGIT
MAXL100
DYPCLUS
Minimum Area/Shape
CLATRU
TRUGEN
GSTAT
SEPAR


SEIDAM Expert System - GIS Outputs
Analyst Advisor
Forestry
Other Applications
Data Preparation
Spatial Processing
Classification
Output
GIS Update
Photographic Enhancements
Area Summaries
Statistical Tables
Tapes
Spatial Analyst (Intergraph)
Forestry Enhancements
Principal Components Enhancement
GIS Files
Images


SEIDAM
RESHELL ARCHITECTURE
Meta Rule Base
Object Rule Base
to other experts
Meta Rule Interpreter
Object Rule Interpreter
Data Interface
Scheduler
Blackboard
Agenda
Database Object
Deduced Object
Blackboard Interface
Arbitrator
Frame Processor
Frames Database
NASA
CCRS
PFC


SHIERI
COMPUTING ENVIRONMENT
Intergraph MGE
LANDSAT DIGITAL IMAGE ANALYSIS SYSTEM
Pamap GIS
VAX CLUSTER
INGRES
Object-oriented Data Base
NASA
CCRS
PFC

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HOW WILL SEIDAM BE TESTED?

THE PACIFIC FORESTRY CENTRE AND CCRS ARE SELECTING THREE TEST SITES, THREE NEAR INVERMERE, BRITISH COLUMBIA AND ONE ON THE WEST COAST. DATA COLLECTION FROM AIRCRAFT AND SATELLITES IS BEING PLANNED FOR THE SUMMER OF 1992.

CCRS HAS PREVIOUSLY COLLECTED DATA OVER THE INVERMERE SITES. THESE DATA HAVE INCLUDED SEVERAL YEARS OF TM, HRV, MOS-1, AND NOAA AVHRR. AIRCRAFT DATA PREVIOUSLY COLLECTED INCLUDE CCRS SAR, AVIRIS, MEIS, AND AMSS. MORE THAN 150 FOREST INVENTORY GIS FILES HAVE BEEN ACQUIRED. DTMS CORRESPONDING TO THE TEST SITES HAVE BEEN OBTAINED FROM FEDERAL AND PROVINCIAL SOURCES.

SEIDAM WILL BE TESTED AT CCRS, PFC, AND POSSIBLY NASA-ARC FOR THESE SITES AND FOR OTHER REMOTE SENSING DATA.

SOME INDUSTRIAL CONTRACTORS MAY ALSO CHOOSE TO EVALUATE THE SEIDAM METHODOLOGY.

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HOW WILL SEIDAM BE TESTED? #2

CCRS HAS CONDUCTED FIELD WORK IN THE ROCKY MOUNTAIN TRENCH PREVIOUSLY.

FOR AIRCRAFT CALIBRATION, OPTICAL MEASUREMENTS OF LAKES AND HOMOGENEOUS TARGETS ARE MADE AND SAR CORNER REFLECTORS AND ACTIVE RADAR CALIBRATORS ARE DEPLOYED.

A GRID OF MARKERS IS LAID OUT FOR MULTI-SENSOR REGISTRATION.

ECOLOGICAL SAMPLES WILL BE TAKEN WITH THEIR LOCATIONS DEFINED BY GPS GROUND EQUIPMENT. MEASUREMENTS WILL BE MADE OF CHLOROPHYLL, NITROGEN, LIGNIN, AND OTHER CHEMICALS. THE WEST COAST SITE HAS AN EXTENSIVE HISTORY OF ECOLOGICAL MONITORING.

WHERE POSSIBLE, GPS POSITIONING WILL BE USED TO DEFINE AIRCRAFT LOCATION.

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Artificial Intelligence Research Projects

SHERI	PIKES
(System of Hierarchical Experts for Resources Inventories)	(Photo Interpretation Keys Expert System)
(...until March 1993)	(April 1991 -- March 1994)

SEIDAM

(System of Experts for Intelligent Data Management)

(January 1991 - January 1995)

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SEIDAM SOFTWARE STATUS

- More than 44 expert systems created; implementing Motif interface for user interface
- Ported Shell and Expert Systems to Unix
- Ported Shell and Expert Systems to other platforms (Sun, Macintosh...)
- Research, develop and integrate new Expert Systems

  (Segmentation, Digital Terrain Model, Texture, Spatial Knowledge, Endorsement labelling with fuzzy methods, GIS input / output, intelligent land information system, forest productivity and monitoring, etc.)
- Interface Expert System and RDBMS (through INGRES, C, Prolog and SQL)
- Plan knowledge acquisition experiments for SEIDAM validation
- Integrate Object Oriented Database
- Use Machine Learning to accelerate the development of new Experts

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SEIDAM

TASKS AND MILESTONES

Project Approval by NASA	Nov. 1, 1990
Submit Preliminary Proposal to ISTC	Mar. 15, 1991
Submit Final Proposal to ISTC	June 28, 1991
SEIDAM Overall System Design	Sept. 30, 1991
Annual Report to NASA/CCRS	Dec. 30, 1991
Remote Sensing data ES	Apr. 30, 1992
GIS ES	May 30, 1992
Field Data ES	June 30, 1992
Airborne data acquisition	July , 1992
Data Fusion ES	Nov. 30, 1992
Annual Report to NASA/CCRS	Dec. 30, 1992
Data Source Selection ES	Feb. 1, 1993
Neural Network development for data fusion	Mar. 31, 1993
Method Selection ES	May 30, 1993
Data Interpretation Model ES	July 15, 1993
Solution Planning ES	Sept. 30, 1993
Final SEIDAM Validation	Nov. 1, 1993
Final Report to NASA/CCRS	Dec. 30, 1993
Project Completion for NASA portion	Mar. 31, 1994

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SEIDAM

FINAL REMARKS

WE ARE DELIGHTED TO HAVE THE OPPORTUNITY TO JOIN OUR COLLEAGUES IN THE APPLIED INFORMATIONS SYSTEMS RESEARCH PROGRAM.

PLEASE FEEL FREE TO CONTACT US AT THE NUMBERS GIVEN ON THE FIRST VIEWGRAPH.

IF YOU ARE INTERESTED IN INTERACTING WITH THE SEIDAM PROJECT, PLEASE CONTACT DR. DAVID GOODENOUGH.

WE THANK THE NATIONAL AERONAUTICS AND SPACE ADMINISTRATION FOR SUPPORTING THIS PROJECT.

WE ALSO THANK THE CANADA CENTRE FOR REMOTE SENSING, OF ENERGY, MINES AND RESOURCES CANADA, AND THE PACIFIC FORESTRY CENTRE OF FORESTRY CANADA.

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57-82

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p. 6

PRINCIPAL INVESTIGATORS PRESENTATIONS

THE SCIENTIFIC MODELING ASSISTANT: AN ADVANCED SOFTWARE TOOL FOR SCIENTIFIC MODEL BUILDING

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Michael H. Sims/P.I.
NASA Ames Research Center
Moffett Field, CA
(415) 604-3388

APPLIED INFORMATIONS SYSTÊMS
RESEARCH WORKSHOP

NOTES:

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The Scientific Modeling Assistant:
An advanced software tool for scientific model-building

Richard M. Keller
Michael H. Sims
Principal Investigators

David Thompson
Michal Rimon
Project Staff

Christopher McKay
Jennifer Dungan
Science Collaborators

NASA *Ames Research Center*
Artificial Intelligence Research Branch
Mail Stop 244-17
Moffett Field, CA 94035-1000
(415) 604-3388 keller@ptolemy.arc.nasa.gov

Funded by the Applied Information Systems Research Program
Administered by the Information Systems Division
of NASA's Office of Space Science and Applications

Methodology

- Study existing scientific modeling software
- Design tool to meet scientists' needs
- Reimplement models with our new modeling tool

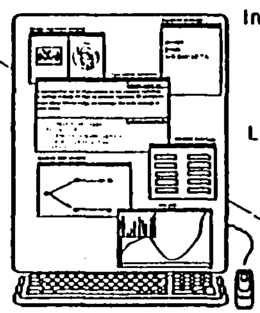
Initial Focus Areas

- **Planetary Atmospheric Modeling:**
  "Titan Greenhouse Model" (C.P. McKay, NASA Ames)
- **Earth Ecosystem Modeling:**
  "Forest BGC" (S.W. Running, U. of Montana)

Project Goal: Build a *specialized* software tool to assist in Scientific Model-building

FEATURES

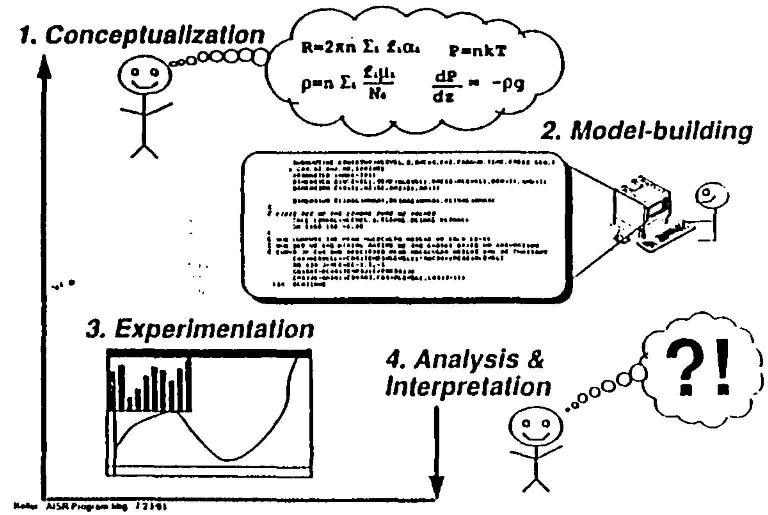
- Analysis & visualization facilities
- Interactive graphical interface
- Intelligent assistance
- High-level modeling language
- Libraries of data sets, equations, subroutines, physical quantites



TECHNIQUES

- Object-oriented programming
- Artificial intelligence
- Symbolic manipulation
- Visual programming

Overview of the Scientific Modeling Process



Outline

✓ 1. Project Introduction

☞ 2. Problem & Approach

3. Case Study:

   Modeling planetary atmospheres

4. Summary

Problems and Opportunities

Problems:

- Labor intensive
- Difficult to understand, share, and modify

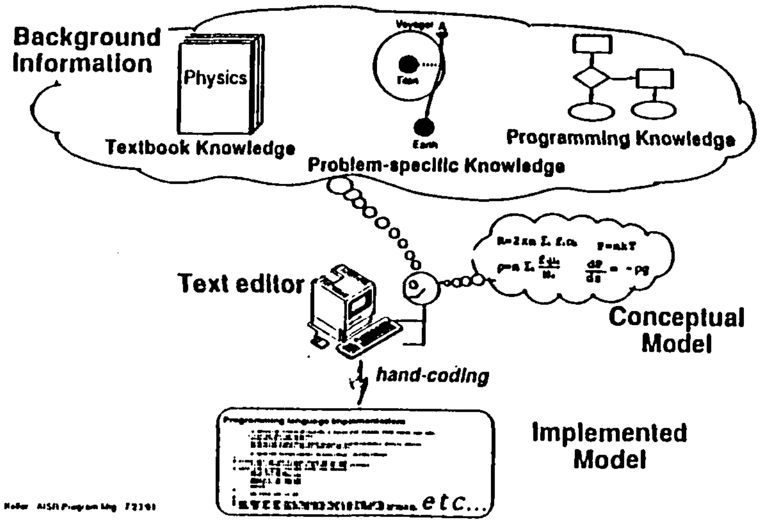
Root causes:

- Scientist ≠ programmer !!
- Wrong level of abstraction
- Implicit knowledge buried

Potential payoffs:

- Improve scientific productivity
- Foster scientific communication
- Disseminate modeler's expertise

Manual Approach to Model-building

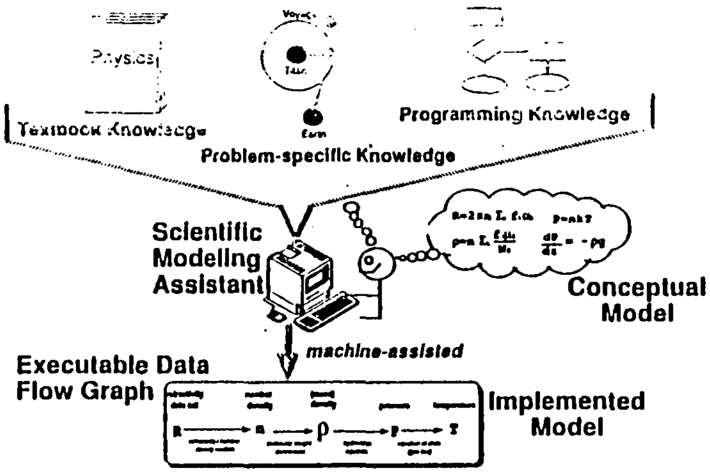


The scientists' plea: *"Spare me the programming details!"*

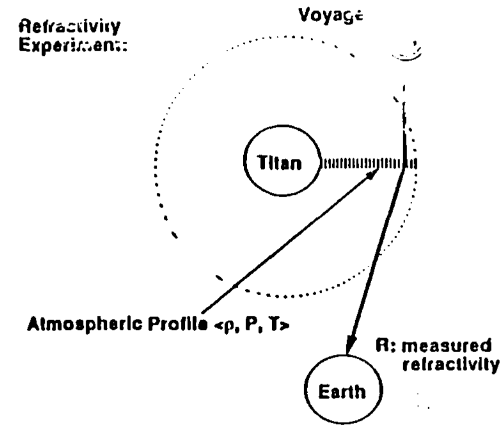
- Variable declarations, storage allocation
- Scientific units bookeeping & conversion
- Data structure manipulation & management
- Documentation
- Symbolic manipulation
- Interfacing with scientific datasets
- Numerical programming:

  ODEs, integration, interpolation, convergence

Intelligent Assistant Approach



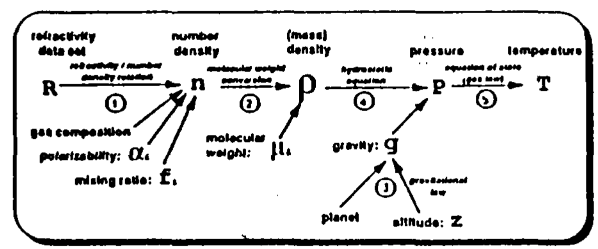
Titan Atmospheric Modeling: *The Voyager fly-by*



Outline

1. Project Introduction ✓
2. Problem & Approach ✓
3. Case Study: Modeling planetary atmospheres ☞
4. Summary

Data flow graph for computing atmospheric profile



Equations used:

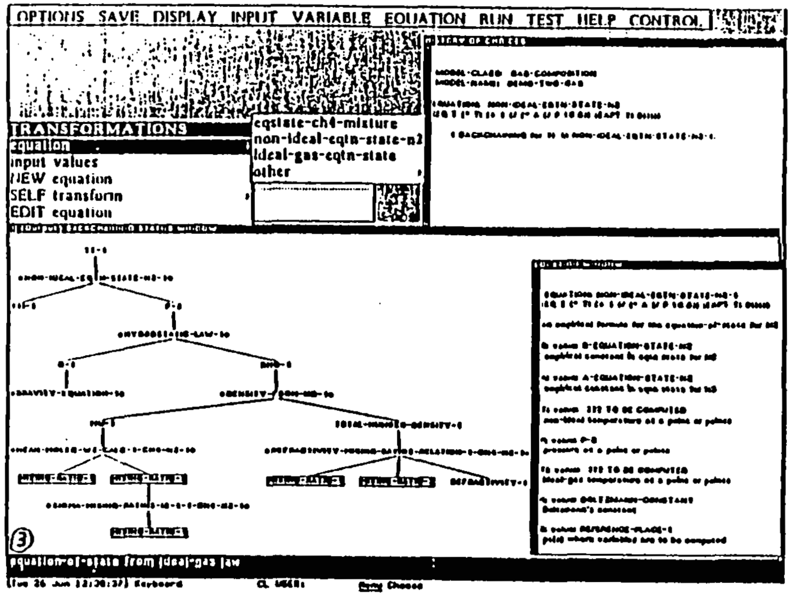
① $n = \frac{r}{\sum_i f_i \frac{r_{i,stp}}{L}}$

② $\rho = n \sum_i f_i \frac{\mu_i}{N_0}$

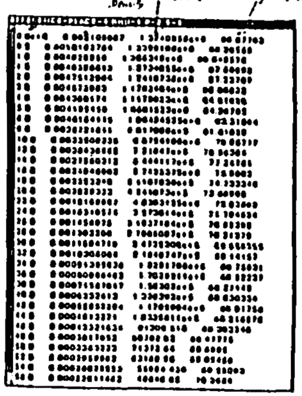
③ $g_z = g_0 \left(\frac{r}{r+z}\right)^2$

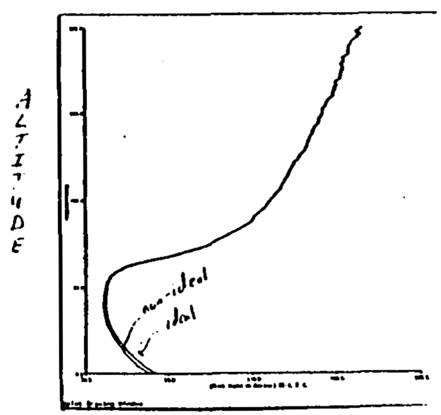
④ $\frac{dP}{dz} = -\rho g$

⑤ $n = \frac{P}{kT}$



Scientific Modeling Assistant
Data Display Screens





Prototype Modeling Tool Provides:

- Library of relevant:
  - data sets
  - physical variables
  - equations
- Mechanisms allowing user to select and apply equations to data and compute new physical variables
- Model/data display features:
  - data dependency network
  - plotting/graphing facility
  - tabular display
- Model management environment: multiple models and multiple scientists

Outline

✓ 1. Project Introduction

✓ 2. Problem & Approach

✓ 3. Case Study:

Modeling planetary atmospheres

☞ 4. Summary

Status

- Completing development and evaluation of first prototype
- Redesigning system interface and internals
- Adding additional domain knowledge
- Moving toward more portable system
- Investigating other domains:
  Ecosystem modeling

Major Milestones

- **FY 1991:** Completion and evaluation of initial "alpha" prototype
- **FY 1992:** Design and implementation of a "beta" version prototype that will be used by a small group of atmospheric scientist-users

  Begin development of ecosystem model
- **FY 1993:** Enhance system and make available to a group of Cassini Mission scientists who are involved in instrument design

  Make system available to ecosystem scientists

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PRINCIPAL INVESTIGATORS PRESENTATIONS

DATAHUB
KNOWLEDGE BASED ASSISTANCE FOR SCIENCE VISUALIZATION AND ANALYSIS USING LARGE DISTRIBUTED DATABASES

Thomas H. Handley Jr./P.I.
Jet Propulsion Laboratory
Pasadena, CA
(818) 354-7009

Donald J. Collins/Co. I.
Richard J. Doyle/Co.I.
Allan S. Jacobson/Co.I.

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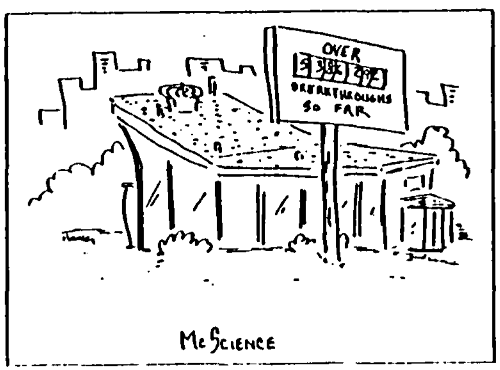
DataHub

Knowledge-based Assistance for Science Visualization and Analysis Using Large Distributed Databases

Team

Data Management	T. Handley (PI)
	P. Li
Science	D. Collins (CO-I)
	A. *Tran*
Expert Systems	L. Falcone
Visualization	B. Jacobson (CO-I)
	M. Wade
Research	T. Maddox (Summer Faculty)



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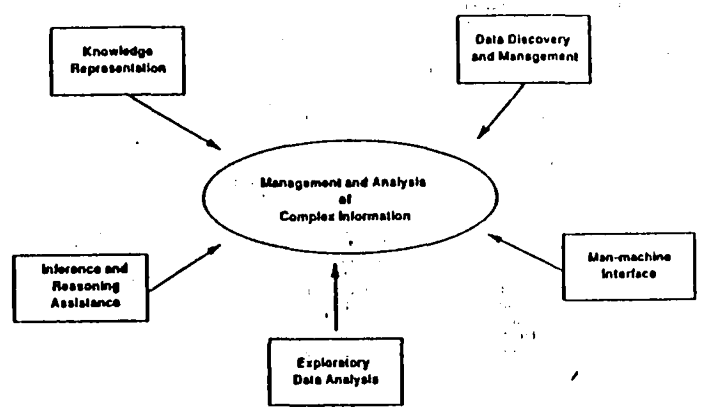
Applicable Technologies



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Objectives

- Scientific Data Models
  - Data driven analysis.
  - Data transformations
  - Data semantics
  - Analysis-related knowledge about data
  - Data discovery, ingestion, extraction, ...
  - Self-describing data structures
- Intelligent assistant system(s) with some knowledge of data management and analysis built-in.
- Use of mature expert system technology to aid exploratory data analysis, i.e. expert systems, neural nets, classification systems.
- Capture and encode knowledge about the data and their associated processes. Encode scientific knowledge into the routines, processes and procedures.
- Provide data management services to exploratory data analysis application(s) i.e. LINKWINDS.

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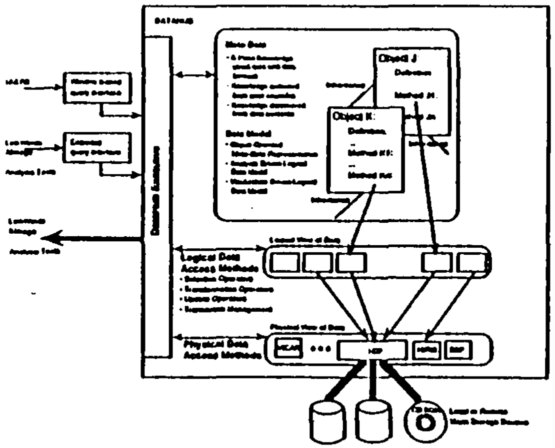
DataHub Functional Architecture



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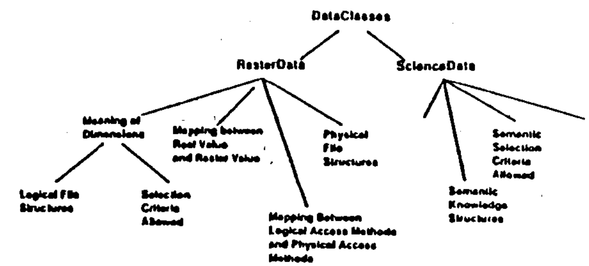
MetaData Representations



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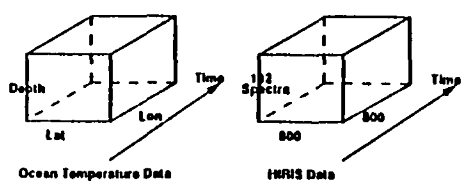
Data Representation

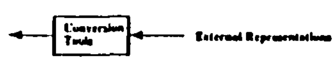
Logical View

- Uniformly gridded n-dimensional data
- Examples:



Physical View

- HDF
- VICAR
- FITS
- CDF



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Logical Access Methods
Selection Operators

- Range selection for one or more independent variables. Required conjunctive conditions for n-k dimensions (n-dimensional data, k-dimensional display).
  - d1 < Depth < d2, where Time = t1
  - t1 < time < t2, where Depth = d1
- Enumerated selection for one or more free variables
  - Time = { t1, t2, ... tn }
- Selection for the dependent variables
  - Temperature > 20 degree-C for Temperature Dataset
  - Frequency > 25 for Flag Dataset

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Logical Access Methods
Transformation Operators

- Data format conversion operator
  - MCSST DSP -> MCSST HDS SDS
- Raster conversion operator
  - MCSST HDF -> MCSST HDF Raster 8-bit
- Resampling operator
  - MCSST HDF Raster 8-bit Global -> MCSST HDF 360x180
- Mapping between collected data and known facts
  - Ocean data versus LandMask
- Filling in missing data
  - Use local data to fill
  - Use data selected from other time frame
  - Use data selected from other correlated dataset
- Dataset registration
  - Warping
  - regridding
  - Registration
- Other map projections

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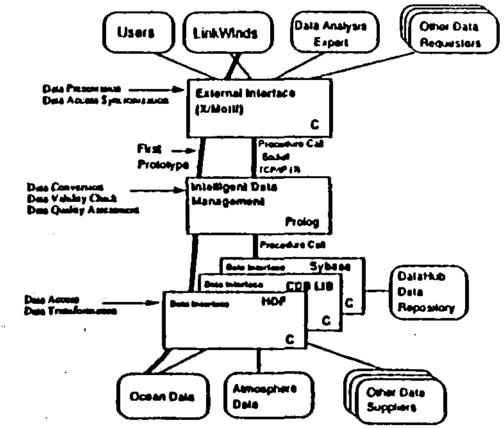
Preliminary Software Architecture



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Logical Access Methods
Update Operators

- Transaction
  - Atomic action
  - Traceable unit
  - Recoverable Unit
  - Result datasets stored in user area
- Example

```
Begin-Xtn
    DSP -> HDF SDS
    HDF SDS -> HDF Raster 8-bit
    HDF 8-bit -> HDF 360x180
End-Xtn
```


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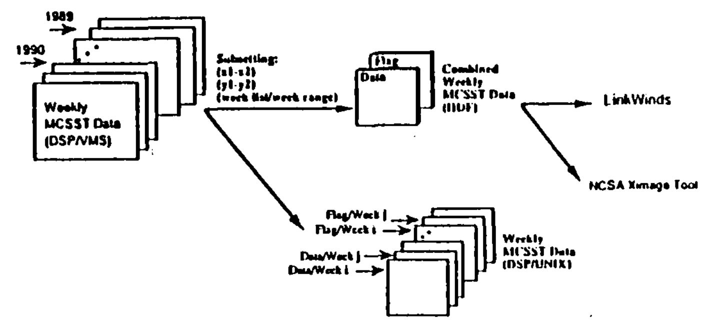
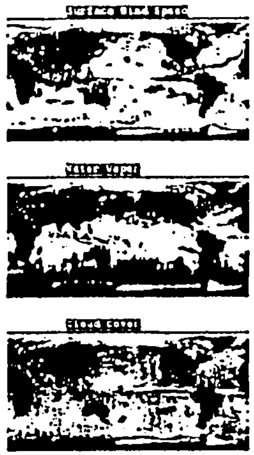
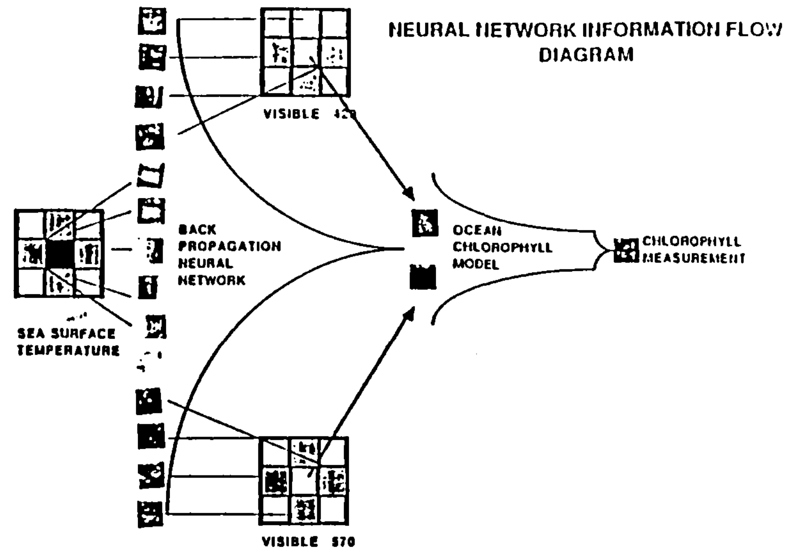
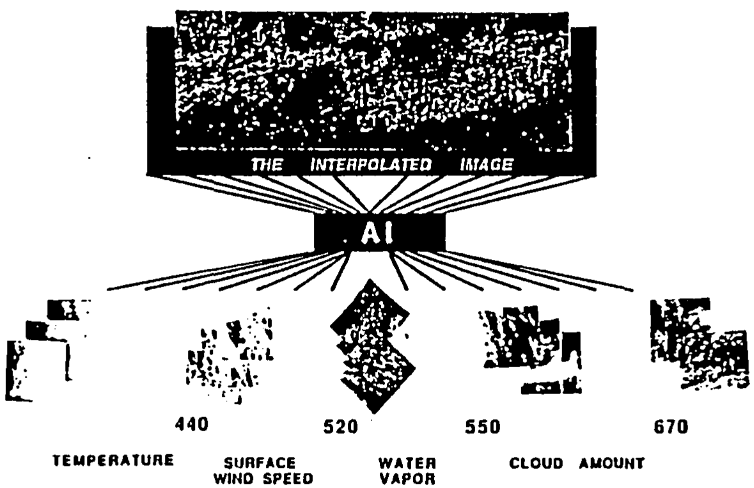
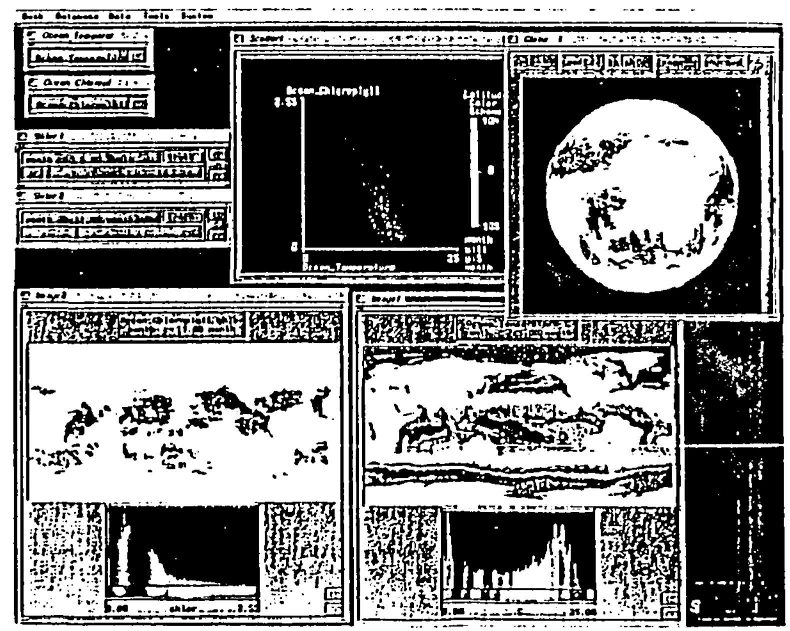
Today's Prototype

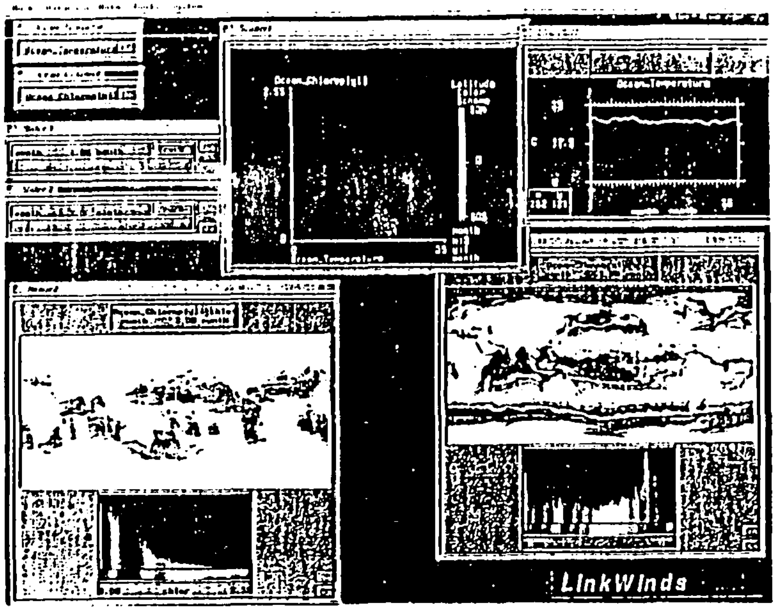





NEURAL NETWORK INFORMATION FLOW DIAGRAM
VISIBLE 420
BACK PROPAGATION NEURAL NETWORK
OCEAN CHLOROPHYLL MODEL
CHLOROPHYLL MEASUREMENT
SEA SURFACE TEMPERATURE
VISIBLE 570


THE INTERPOLATED IMAGE
AI
440
520
550
670
TEMPERATURE
SURFACE WIND SPEED
WATER VAPOR
CLOUD AMOUNT





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An Interesting Situation
(Summer Research Fellow)

- Exponential increase in volume of data.
- A reduction of domain specific analysis expertise.
- The loss of and/or delay in the discovery of knowledge.

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LinkWinds

- Modifications and additions to LinkWinds made in support of this activity.
  - Size limitation on ingested databases were relieved to accommodate the oceanographic data. All applications were affected.
  - An interface to NCSA's Hierarchical Data Format (HDF) was implemented. Methods were put in place to convert from other standard formats to HDF.
  - Design of databases exchange protocols and interface between LinkWinds and DataHub was initiated.

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An Intriguing Solution
(Summer Research Fellow)

- The development of intelligent assistant systems with some knowledge of data management and analysis built-in.
- LinkWinds: allowing users to select data sources and link them with various transformation procedures that analyze and display data.
- Graphical Representation of Knowledge (GROK): nodes and links (graphs) are a useful visualization of the grouping and ordering of general knowledge.
- Science Analysis Assistant (SAA): an embedded formalism for advising scientists about the salience of data.
- The goal is to reduce the difficulty of managing or exploring complex or large datasets or knowledge bases.

D-49

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Our Hypothesis
(Summer Research Fellow)

- A high level of satisfaction with LinkWinds: maybe because it is a comfortable *reflection of the data analysis skills and processes of its development team.*
- The combination of procedures linked by the user can lead to the identification of interesting features of the original dataset and the possible discovery of new knowledge.
- Emergent behavior seems to be a result of the linking process which is driven by the user's domain specific and general knowledge and experience.
- The process of data analysis is well-represented by a graph of connected data, analysis and display procedures

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Possible Outcomes
(Summer Research Fellow)

- Salience measures which are locally interesting (from data perspective) and *globally interesting (from the domain specialist's perspective).*
- Concurrent data exploration paths.
- Experimental trials to determine if algorithms faithfully represent user preferences and goals.
- Machine learning techniques used to generalize data analysis algorithms.

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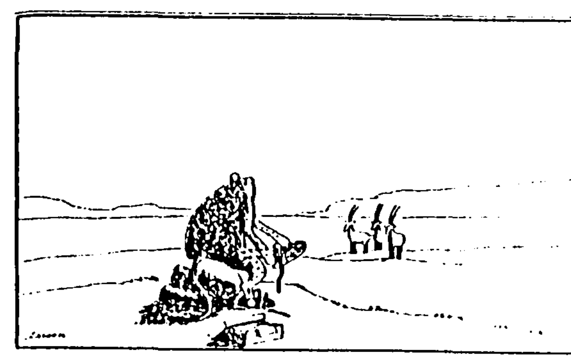
Research Objectives
(Summer Research Fellow)

- Investigate how information from 1) the original data, 2) analysis and display procedures and 3) the user may be combined to facilitate knowledge discovery in a dataset.
- Explore the development of algorithms which represent how information regarding analysis goals and hypotheses, transformation procedures, and metadata may be combined to facilitate the discovery of knowledge.
- Seek to develop dataflow representations of the information between these sources.
- Characterize interaction dynamics of information top-down in a goal-driven manner from the user towards the data and the analysis and display procedures and bottom-up in an event-driven manner.
- Use resulting metadata to characterize and classify the analysis and display procedures.
- Classify the cooperative or competitive information flow dynamics.



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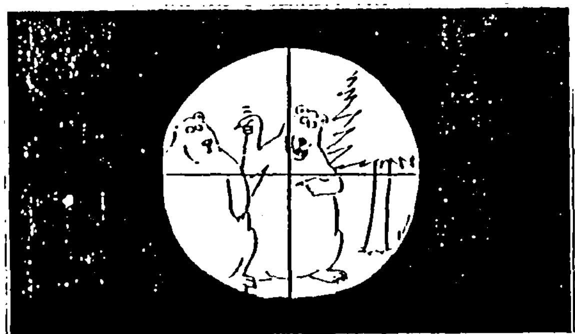

Backup

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Science

The primary productivity of phytoplankton in the ocean is largely responsible for the assimilation of carbon into the oceanic environment and thus in part the removal of carbon from the atmosphere. Because the ocean is thought to be a primary sink for atmospheric carbon, the basin wide and global distribution of oceanic primary productivity is of central importance in the global budget of carbon. To understand the global productivity of the oceans, the interactions between the physical and biological structures must be known. The biological population of the ocean is highly variable both spatially and temporally on all time and space scales. The global nature of this problem then requires the use of satellite instrumentation as the only platform capable of providing coverage on temporal and spatial scales that are appropriated to the assessment of carbon flux into the ocean. The goal of this research is to increase our understanding of the sources of variability in the sea to provide a more accurate assessment of oceanic productivity from ocean color imagery. The objectives of this research are the description of the spatial and temporal distributions and variability of the planktonic community in the sea and the primary productivity of that community. To achieve these objectives, remotely sensed data of the spatial and temporal distributions of pigment concentration, temperature and incident irradiance at the surface are used to provide a description of the seasonal variability of the water column primary productivity in the north Pacific Ocean and to explore the spatial and temporal distributions of phytoplankton biomass and primary productivity in the equatorial Pacific Ocean upwelling area and in the oligotrophic central Pacific gyre.

To provide an understanding of the global flux of carbon through the upper ocean into the ocean bottom sediments, the JGOFS Steering Committee has identified the need for both time-series and process oriented regional studies to examine the spatial and temporal distribution of the physical and biological parameters with determine that flux and have initiated regional studies of these processes. A regional study has been defined to describe the role of the north Pacific Ocean in the global flux of carbon. The equatorial Pacific has been selected for the intensive process oriented study upwelling processes in this region, and a time-series study of the oligotrophic central Pacific gyre has been initiated with the Hawaii Ocean Time-Series study at the ALOHA site.

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Science (cont'd)

The Pacific studies require a much broader context in which to interpret the measurements provided by the time-series and process oriented studies. To address the broader context, satellite imagery can provide a description of the spatial and temporal scales of the biological and physical processes and their variability, including changes in water mass, incident irradiance, nutrients and the consequent formation of blooms of differing species of marine phytoplankton and bacteria. We will use a time series of CZCS images of the atmospheric aerosol and pigment distributions for the north Pacific Ocean, defined to include the Equatorial region, extending to 20°S, to study the seasonal variability of primary productivity. This data will be combined with time series of the MCSST product form the sea-surface temperature and data of the distribution of surface wind speed and atmospheric cloud distributions to produce a local climatology of the equatorial and sub-artic north Pacific ocean. These time series will be examined to determine the spatial and temporal statistics of productivity, including the interannual variations that occur in the productivity caused by variations in the physical environment.

The regional imagery from the north Pacific will provide an historical context for the continuing study of this region. For the description of the seasonal patterns of primary productivity, composite maps will be generated from the individual scenes produced from the CZCS archives. The goal of the composites is to provide a seasonal description of the producivity of the region and to preserve the temporal character of data that is fundamentally episodic in nature. Two such maps will be produce, including maps of the total productivity, computed from the surface irradiance and the water column pigment content through a model described by Collins, et al., 1991, and of the carbon flux through a model under development by Mitchell, et al., 1991. The model of total productivity permits the computation of the total carbon assimilation by phytoplankton in the ocean, while the model for the carbon flux estimates the fraction of the total carbon assimilated that is removed from the surface mixed layer through processes which contribute to the uptake of CO_2 from the atmosphere.

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Science (cont'd)

This task will address the issue of the assessment of pigment concentration, and of the radiance leaving the sea surface, controlled by that pigment concentration, for a dataset that is fundamentally deficient of data in certain regions of space and time because of environmental and operational factors. To permit this assessment, data from the sea-surface temperature, surface winds and cloud amount will be used, together with the temporally and spatially adjacent pigment data to interpolate the CZCS data fields as a means of estimating the total pigment field. The interpolated pigment fields will then be used to provide time series estimates of the pigment and primary productivity fields in the study area.

It is essential to use artificial intelligence technology for the multidimensional interpolation and extrapolation of the pigment data fields because fundamental physical and biological descriptions of the data fields have been insufficient in the past to describe the development of these fields in space and time. The statistical description provided by the use of AI technology will enhance our ability to predict the development of these fields through the use of these techniques to assess the roles of each of the physical parameters in the development of the pigment fields in space and time.

With the development of properly interpolated and extrapolated fields, estimates of the net and total primary productivity will permit an assessment of the carbon flux in the equatorial Pacific ocean. These concepts will be extended to provide an assessment of the net flux of carbon from the atmosphere into the oceans on an annual basis. Our preliminary estimates of this quantity are 3.2 Gtons Carbon per year based on estimates of the water leaving radiance and a regression of water leaving radiance and carbon flux based on work by Mitchell, et al., 1991. These estimates will be refined through a better estimate of the pigment concentration and thus of the water leaving radiance.

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LinkWinds

The near term object is to ingest, at will, a large number of datasets related to two databases. These are the Multi-Channel Sea Surface Temperature (MCSST) *data which are global ocean* temperature measurements, and the Coastal Zone Color Scanner (CZCS) data which measure ocean biomass. Once these data are ingested into LinkWinds, its tools can be used to study the *correlations* between ocean temperature and biomass.

The oceanographic datasets which are the subject of our near-term studies are larger than datasets previously used in LinkWinds. The MCSST data is composed of two images measuring 2048x1024 pixels, with 16-bits *per pixel*. *One image is the data itself, and* the other image gives a measure of the quality of the data image on a pixel-by-pixel basis. These data exist on a weekly basis. The CZCS data is multispectral images in five channels, each of 8-bits range. These images also measure 2048x1024 and exist on a weekly basis, as well as in monthly composite form.

For ingestion, all data has been transformed to the Hierarchical Data Format (HDF) developed at the National Center for Supercomputing Applications (NCSA) at the University of Illinois. LinkWinds *will be modified to read* this standard data format.

Because of the larger size of these datasets, the ingestion process is taking place in two stages. For stage one, the data are being subsetted into 360x180 pixel images and put into HDF format. Preliminary design and coding *to read this data into the LinkWinds environment is underway now* by Philip Li, and is estimated to be done in about two weeks. Once this is accomplished, the tools and controls of LinkWinds can be immediately applied to the study of the data. In preparation for stage two, all tools and controls of LinkWinds are being redesigned and modified to accommodate arbitrarily large image sizes. The coding for these modifications is being done now by Mitch Wade. Concurrently, user interface modifications to allow the user to read arbitrary HDF files will be developed as a collaboration between Philip Li, Mitch Wade and Martin Orton. Once these tasks are completed, *and the data in its fullest form* can be read and studied, then we will concentrate upon modifying existing correlational tools, and developing new ones to extend the studies of these data.

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Summer Faculty Research - Data Knowledge Issues

One result of an exponential increase in volume of data and a reduction of domain specific analysis expertise is a loss or delay in the discovery of knowledge. Such delays or losses could mean performance degradation or critical system failure, which could be very expensive. Machines may be able provide some assistance in various data management and analysis tasks. The development of such intelligent assistant systems will require that some knowledge of data management and analysis be acquired or built-in to them. How should this knowledge be represented in a form that may be used by a machine?

An exploratory data analysis system, LinkWinds, has been developed at the Jet Propulsion Laboratory (JPL) of the California Institute of Technology to help scientists from various disciplines discover new knowledge from data. LinkWinds allows its user to select data sources and link them with various *transformation procedures that analyze or display data. LinkWinds is* one of at least two other efforts at JPL (Graphical Representation of Knowledge (GROK) and the Science Analysis Assistant (SAA) whose objectives are to reduce the difficulty of managing or exploring complex or large datasets or knowledge bases.

Scientists who have used LinkWinds are very satisfied with its flexibility. They can manipulate color maps and combine, or link, other features such as "sliders", crosshairs, and graphs to support *interactive manipulation of data for examination, thus easily changing the topology of data,* analysis and display windows and links. One reason for the high level of satisfaction with LinkWinds may be because it is a comfortable reflection of the data analysis skills or processes of its experienced development team. LinkWinds supports the iterative transformation of data through a search process where the results of each iteration are interpreted and the search stops or is redirected when some salience level is realized.

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Summer Faculty Research - Data Knowledge Issues (cont'd)

The visualization tools and analysis procedures in LinkWinds further help constrain the search by allowing data transformations to be represented by color, animation, or other visually perceptible features. The combination of procedures linked by the user can lead to the identification of interesting features of the original dataset and the possible discovery of new knowledge. This emergent behavior seems to be a *result of the linking process which is driven by the user's domain* specific and general knowledge and experience.

Some of these same ideas are embedded in GROK. Specifically, GROK's design asserts that nodes and links (graphs) are a useful visualization of the grouping and ordering of general knowledge. Grouping and ordering may be facilitated by "zipping" or connecting disparate knowledge elements upon which inferences may be made. This is similar to semantic networks where a graph with *specialized links represent the semantic relationships* between objects (nodes) of the graph. Such networks are hierarchical and class inheritance is often a characteristic of nodes in the graph. Much of the connectionist and artificial neural network research involves linking nodes that act as simple computing elements in a similar fashion. Research is in progress that will use the GROK architecture to connect distributed data sources and analysis routines within and between machine hosts on a shared computer network.

We assume that the process of data analysis is well-represented by a graph of connected data, analysis and display procedures. Our objective is to investigate how information from 1) the original data, 2) analysis and display procedures and 3) the user may combine to facilitate knowledge discovery in a dataset. The original data represents an event history of the spatial and temporal conditions *of the data acquisition environment. Partitioning the data into subsets on the* basis of spatial, temporal, or other physically or logically relevant grouping and ordering features is essential. The analysis and display procedures embody a priori transformation, reduction, and

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Summer Faculty Research - Data Knowledge Issues (cont'd)

abstraction information needed to reconfigure the original dataset. Combinations of these procedures can be more useful that they are independently. Again, this is an example of collective emergent behavior. The user has the experience necessary to link knowledge of domain dependent goals and hypotheses, *analysis and display procedures, and the source data to drive exploratory* data analysis. Visual feedback from the transformation processes allow the user to decide if the result satisfies relevant analysis goals and hypotheses.

Our investigation will explore the development of algorithms which represent how information regarding analysis goals and hypotheses, transformation procedures, and metadata may be combined to facilitate the discovery of knowledge. We believe that much of the users' domain knowledge *is embodied in the 1) dimensionality and 2) directionality of the links between the data* and various transformation procedures. The semantics of the users' domain knowledge is represented by these links. Often, the user is not aware of many of the analysis and display methods which may assist data analysis. We seek to develop dataflow representations of the information between these sources.

Another research objectives is to characterize the dynamics of the interaction of information. *Some information flows top-down in a goal-driven manner from the user towards the data and the* analysis and display procedures. Other information flows bottom-up in an event-driven manner. By using pattern recognition, information theoretic and other statistical methods, resulting metadata may help characterize the analysis and display procedures relative to the flow of information. Object-oriented software engineering techniques may allow us to classify these procedures as well as the cooperative or competitive information flow dynamics.

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Summer Faculty Research - Data Knowledge Issues (cont'd)

Hopefully, the result of our work will be a Science Analysis Assistant within LinkWinds or GROK that may be capable of advising a scientist on ways to subset a large dataset on the basis of salience measures which are locally interesting (from a data perspective) and globally interesting (from the domain specialist's perspective). Future research issues include 1) the possibly suggesting physically or logically concurrent data exploration paths of interest to the user, 2) experimental trials to determine if our algorithms faithfully represent user preferences and goals, and 3) the application of machine learning techniques in an attempt to generalize our data analysis algorithms.

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Expert Systems

Interpolation problems present challenges across scientific disciplines. The oceanographic domain presents a rich set of data parameters that must be clustered and combined to build an interpolated image. The time required to construct the interpolation is inhibited by the computational resources needed to find a comprehensive correlation over the entire set. Artificial Intelligence *AI* will support this effort by combining the data sets using state of the art *machine learning* techniques. Leverage of this task is provided by the Scientific Analysis Assistant *SAA* funded under Code RC. Together these projects are investigating how machine learning techniques can assist scientists with efficient data ingestion.

Proof of Concept *Near Term Goals*

- Evaluate and Compare Machine Learning Techniques

  GID3
  Parallel Distributed Processing *PDP* Networks
  AutoClass
- Apply Selected Technique and Test Performance
  Apply the selected machine learning algorithm to two thirds of the data set and test the algorithm performance on the remaining one third of data.

Solution *Long Term Goals*

- Apply Proven Technique

  Produce the interpolated image using selected data parameters.

- Compare Performance
  Measure the performance of machine learning algorithm application to conventional techniques.

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Expert Systems (cont'd)

Neural network algorithms share a common feature that sets them apart from conventional techniques. They work well with non linear systems. The ocean science domain presents an interpolation problem that combines temporal and spatial considerations. Long known to follow non linear behavior these parameters are conventionally modeled with linear approximation techniques. We have isolated a problem and selected a technique to demonstrate the performance of advanced computational methods on the non-linear domain.

Problem: Determine the relationship between sea surface temperature and chlorophyll amount over the Hawaii ocean time series (HOTS) site. Use the derived relationship to infer chlorophyll measurements under cloud data given sea surface temperature measurements.

Technique: After comparison of classification algorithms such as GID3 and Autoclass, a back propagation neural net was chosen because it best supports continuous data types. The back propagation algorithm was modified to produce real-valued instead of binary output.

Experiment: Input to the neural net is a set of spatial and temporal temperature measurements. Outputs are two visible wavelength measurements used to calculate the chlorophyll measurement. Pixels from the image which are not obscured by clouds are selected for input to the network. Two thirds of the data set is used to train the network. The remaining one third is used to test the network performance. Once optimal network performance is achieved, the data originally obscured by clouds will be interpolated with the trained network.and spatial and temporal temperature measurements.

Status: Training and testing of the neural net is underway. The network has been trained to a 60% confidence level. To increase this confidence measure we will use principle component analysis techniques to filter the most informative data spatially and temporally. Addition of this this technique will minimize the number of input nodes and maximize the information content per node.

JPL

Data Management

Currently available database technology is largely designed for business data processing applications, and seems inadequate for scientific applications. This RTOP is addressing the following issues in scientific data management:

I. Scientific Database Models
   1. Data format (usage of meta-data embedded in dataset headers, data conversion that preserves data validity, data formats for different analysis methods, ...)
   2. Data semantics (meaning of data values, relationship between datasets, discipline-dependent data access/analysis methods, ...)
   3. Analysis-related knowledge about data
   4. Data quality assessment (identify and treat missing data, i.e., NULL value representation, evaluate data validity after data interpolation, data transformation, etc., ...)

II. Resource Sharing Environment for Science Databases
   1. Data exchange protocol to facilitate data ingestion and data visualization
   2. Data extraction and storage of extracted data
   3. Tracking, logging, and synchronization of data access activities

Figure 1 depicts today's world of science data management. There are many data format from the data suppliers in different science communities. There are many data conversion tools available to convert from the suppliers' formats to the data formats desired by the data consumers. One of the objectives of the ongoing project is to build a resource sharing environment depicted in Figure 2. A system, named *DataHub*, will be a server between the data suppliers and the data consumers to facilitate data exchanges, to assist science data analysis, and to provide a systematic approach for science data management.

JPL

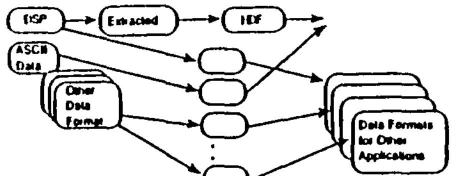

Figure 1. Science Data Management: Today

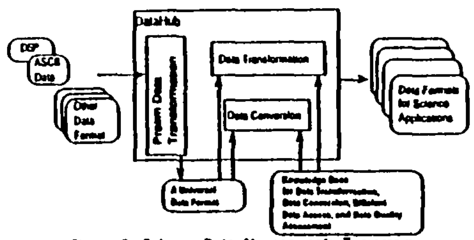

Figure 2. Science Data Management: Tomorrow

KNOWLEDGE-BASED ASSISTANCE FOR SCIENCE VISUALIZATION AND ANALYSIS USING LARGE DISTRIBUTED DATABASES

(NRA: UPN 656-65 21, T. Handley)

GOAL / OBJECTIVES

PROVIDE AN ENVIRONMENT FOR SUPPORTING DEVELOPMENT, DEMONSTRATIONS AND TESTING

APPLY MATURE EXPERT SYSTEM TECHNIQUES TO DATA MANAGEMENT, DATA ANALYSIS AND VISUALIZATION

APPROACH / BUDGET

DESIGN AND DEVELOP THE DATAHUB ALONG WITH THE INITIAL DATA SETS FOR A DATAHUB/LINKWINDS BASED SYSTEM

USE THE DATAHUB TO PROVIDE AN ENVIRONMENT FOR SUPPORTING DEVELOPMENT, DEMONSTRATIONS AND TESTING BY IMPLEMENTING "DUMMY SERVERS" FOR EACH OF THE OTHER DOMAINS I.E., SOFTWARE THAT PROVIDES DATA AND INTERACTIONS

ESTABLISH THE WORKING INTERFACE BETWEEN LINKWINDS AND THE DATAHUB

DEMONSTRATE THE INTERFACE WITH DATA SETS AS DETERMINED BY THE SCIENCE CO-INVESTIGATOR

	FY91	FY92
TOTAL $	$200K	$720K

FY91 ACCOMPLISHMENTS

INITIAL EXPERT SYSTEM DOMAIN	3/91
OCEAN DATA SETS SELECTED AND ACQUIRED	4/91
PROTOTYPE DATAHUB/LINKWINDS DATA INTERFACE	5/91
KNOWLEDGE ENGINEERING USING ANALYSIS RESOURCES	5/91
WORKSTATION ENVIRONMENT AND INTERFACES DEFINED	6/91
DATAHUB SHELL	9/91
DEMONSTRATION	10/91

FY92 MAJOR MILESTONES

ANALYSIS ASSISTANT	11/91
DATAHUB REMOTE DESIGN	12/91
ADDITIONAL DATASETS (GEOLOGY, ATMOSPHERIC) SUPPORT	1/92
DATA MANAGEMENT KNOWLEDGE ENGINEERING	3/92
DATA MANAGEMENT ASSISTANT	7/92
DEMONSTRATION	10/92

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PRINCIPAL INVESTIGATORS PRESENTATIONS

MULTI-CHANNEL HOLOGRAPHIC BIRFURCATIVE NUERAL NETWORK SYSTEM FOR REAL-TIME ADAPTIVE EOS DATA ANALYSIS

Hua-Kuang Liu/P.I.
Jet Propulsion Laboratory
Pasadena, CA
(818) 354-8935

J. Diep/Co.I.
K. Huang/Co.I.

APPLIED INFORMATIONS SYSTEMS
RESEARCH WORKSHOP

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JPL

Presentation To

APPLIED INFORMATION SYSTEMS RESEARCH WORKSHOP

July 22-24, 1991
Boulder, Colorado

MULTI-CHANNEL HOLOGRAPHIC BIRFURCATIVE NEURAL NETWORK SYSTEM FOR REAL-TIME ADAPTIVE EOS DATA ANALYSIS

Hua-Kuang Liu

Jet Propulsion Laboratory
Pasadena, Ca. 91109

OUTLINE OF THE TALK

OBJECTIVE

TECHNICAL APPROACH

FUNDAMENTAL PHYSICAL CHARACTERISTICS

IMPORTANCE

PROGRESS SUMMARY

FUTURE RESEARCH WORK PLAN

OBJECTIVE

To research and develop a novel optical bifurcating neuromorphic pattern recognition system for making optical data array comparisons and to evaluate the use of the system for EOS data classification, reduction, analysis and other applications.

IMPORTANCE OF THE WORK

The bifurcating optical data and pattern recognition and classification system is based on the theory of the nonlinear wave scattering and interaction in photorefractive crystals and the nonlinear neuromorphic interconnection and activation. Theoretical understanding of the system is important to nonlinear science and technology.

The system combines advanced spatial light modulator technology with holographic and photorefractive material and devices. These elements function together to allow massively parallel processing at the speed of light. Experimental results of the system can lead to inventions important for technology breakthrough.

The multi-channel version of the system allows the input of data simultaneously from many different sensor sources and thus offers sensor analysis and fusion capability with high capacity and throughput. The system has important potential applications include parallel database search, image and signal understanding and analysis, natural language processing, in addition to real-time multi-channel adaptive EOS data analysis.

TECHNICAL APPROACH

- Use free-space holographic interconnection and optical parallel processing capabilities with multi-channel input capacity.
- The multi-channel input is realizable by holographic optical elements(HOE) and high speed updatable SLM's.
- Photorefractive crystals will be used for the formation of the bifurcating decision making process.
- Input data are applied via optical spatial light modulators into the optical system.
- Output are naturally classified into multiple channels of pairs of branches.
- Separately-controlled or integrated and organized decisions of the out information can be made based on the output.

PROGRESS SUMMARY (Fy91 Accomplishments)

(1) Completed a simplified model for the dynamic beam fanning phenomenon via inhomogeneous scattering centers in photorefractive crystals.

(2) Developed collaborative analysis activities with JPL colleagues including J. Grimes, W. Tai, W. Fang, and Prof. K. Hwang of USC.

(3) Found interrelationship and areas of potential applications of the system in data format standardization program of NASA.

(4) Investigated basic neuromorphic associative retrieval processing that include the terminal attractor based Hopfield model in the aspects of the data format and optical implementation challenges.

PROGRESS SUMMARY (Fy91 Accomplishments)

(Continued)

(5) Investigated hardware issues including key holographic optical elements and new electronically addressed spatial light modulators.

(6) Recent theoretical and experimental results on the spatial and spectral effects on noise fanning for photorefractive bifurcating process was submitted for publication at the OSA annual meeting in Nov., 1991.

H. K. Liu

(7) Presented an invited talk on nonlinear photorefractive optical processing at the Electrical Engineering Department of the City College of New York on June 24, 1991. He also discussed the projects on the new wavelet theory and its optical implementations with the researchers led by Prof. Y. Li at CCNY. They explored the wavelet RADAR signal processing. The technique may be important to NASA's SETI program.

PROGRESS SUMMARY (Fy91 Accomplishments)

(Continued)

(8) A U. S. patent No. 5,005,954 entitled "Method and Apparatus for Second-Rank Tensor Generation" was received. This invention is useful for the generation of neural net interconnection matrices in real time and is important for future optical computer networking applications. The photorefractive crystal used in the patent was the same as the one used in the current NASA RTOP work. The invention is useful to the current project.

H. K. Liu

(9) Attended the Gordon Research Conference in the week of June 16, 1991 at the Plymouth College, Plymouth, NH. He presented a talk on the topic of self-amplification in optical pattern recognition. The talk was well-received by about 100 invited experts in the field of holography and information processing from various countries including Japan, France, Israel, Canada, German, USSR, China, Sweden, and USA. Many interesting and important techniques were discussed in a very informal atmosphere.

FUTURE RESEARCH WORK PLAN (Fy92 Major Milestones)

(1) Experiment with the photorefractive crystals including $BaTiO_3$ and $KNbO_3$ on their capabilities of bifurcating diffraction via the studies of beam polarization, incidence angle of the input beam, crystal orientation, and spatial light modulator characteristics.

(2) Investigate the analogy between the neuromorphic processing and the nonlinear dynamic wave coupling phenomenon in the photorefractive crystals for gaining a deeper understanding of the fundamental building block of the system.

(3) Investigate the data format requirement and the output utilization algorithm of a multichannel system for the preparation of the design of an application-oriented architecture design.

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APPLIED INFORMATION SYSTEMS RESEARCH PROGRAM WORKSHOP

PRINCIPAL INVESTIGATORS PRESENTATIONS (P. M. SESSION)

APPLIED INFORMATIONS SYSTEMS
RESEARCH WORKSHOP

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PRINCIPAL INVESTIGATORS PRESENTATIONS

NATIONAL CENTER FOR SUPERCOMPUTER APPLICATIONS

Matthew Arrott/P.I.
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RESEARCH WORKSHOP

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NCSA TEAM

Scientific Research and Development
- Atmospheric Science Group

Computational Environment and Application Development
- Visualization Development Group

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PROJECT STRATEGY

Prototype

Investigate the issues and mechanics for possible intergration of atmospheric data across scales and use of modelling and observational data

- Divide and conquer
  - Storm (supported by NCSA and NSF)
  - Regional (supported by NASA)
  - Global
  - Ocean
- Computational Application Model
  - Data Generation
    - Observation
    - Modelling
  - Analysis
  - Inspection

Develop

Integration of successful prototype efforts into a series of robust applications

NASA Meeting

NCSA Goal

NCSA Team

Project Strategy

Computational Research Environment

NCSA Goal

To develop comprehensive computational research environments through the use of evolving software technology

COMPUTATIONAL RESEARCH ENVIRONMENT

Base criteria
- Interactive
- Visual
- Distributed
- Extensible
- Vendor supported

Silicon Graphic's "Explorer" Software

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PRINCIPAL INVESTIGATORS PRESENTATIONS

COLORADO CENTER FOR ASTRODYNAMICS RESEARCH (CCAR)

William Emery, P.I.
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RESEARCH WORKSHOP

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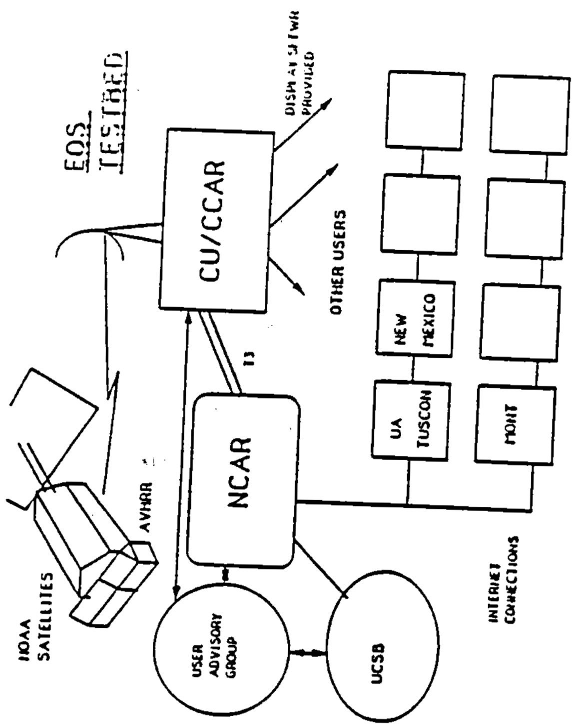


COLORADO CENTER FOR ASTRODYNAMICS RESEARCH (CCAR)

A RESEARCH CENTER OF THE ENGINEERING COLLEGE OF THE UNIVERSITY OF COLORADO BOULDER, COLORADO

LONG-TERM GOAL:

TO DEVELOP A WORLD-CLASS TEACHING AND RESEARCH PROGRAM IN EARTH APPLICATIONS OF SATELLITE REMOTE SENSING; TO PARTICIPATE IN GLOBAL CHANGE AND EARTH SYSTEM SCIENCE RESEARCH AND TO TRAIN NEW SCIENTISTS TO FURTHER WORK IN THESE RESEARCH AREAS.

STAFF:

5 FULL-TIME FACULTY
2 RESEARCH FACULTY
3 ADMINISTRATIVE ASSISTANTS
3 PROGRAMMERS/RESEARCH ASSOCIATES

45 GRADUATE ASSISTANT RESEARCHERS
14 UNDERGRADUATE ASSISTANTS

RESEARCH AREAS OF EMPHASIS:

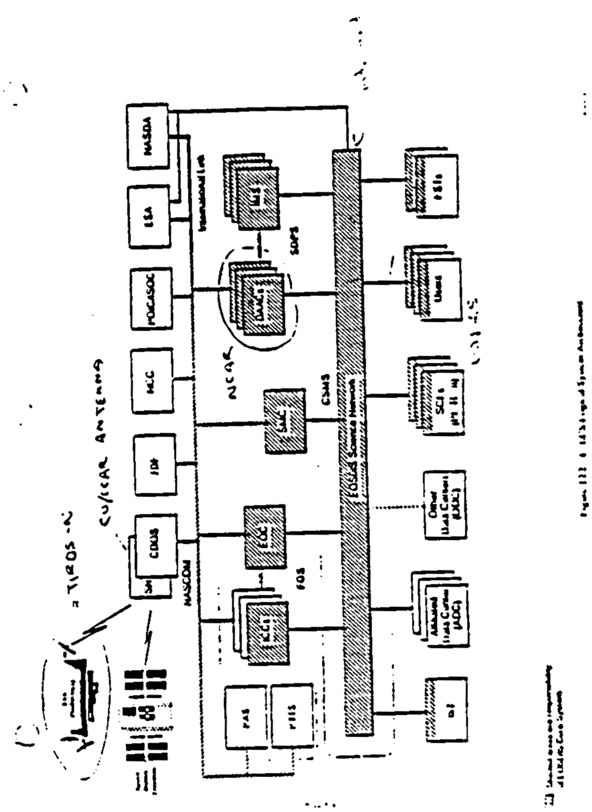
SATELLITE MISSION PLANNING AND DESIGN
PRECISION ORBIT DETERMINATION
ANALYSIS OF SPACE DEBRIS
SATELLITE SENSOR ALGORITHM DEVELOPMENT
SATELLITE DATA ANALYSIS AND IMAGE DISPLAY
DEVELOPMENT OF SATELLITE DATA RECEIVING SYSTEMS

EOSDIS TESTBED: AN AVHRR DATA SYSTEM FOR SNOWPACK AND VEGETATION STUDIES

BILL EMERY, JEFF DOZIER, AND PAUL ROTAR

OBJECTIVE: TO PROVIDE AN END-TO-END DATA SYSTEM FOR THE COLLECTION, PROCESSING AND ANALYSIS OF AVHRR DATA FOR TWO SPECIFIC DISCIPLINES

1. COLLECT AND PROCESS AVHRR IMAGERY OF THE WESTERN U.S. AT CU/CCAR
2. STORE PROCESSED DATA AT NCAR ON MASS STORE
3. MAKE DATA AVAILABLE TO RESEARCH USER COMMUNITY ON OR OFFLINE AS REQUIRED
4. DEVELOP USER COMMUNITY INTERESTED IN AVHRR APPLICATIONS IN SNOW COVER AND VEGETATION
5. DEVELOP APPLICATIONS SOFTWARE ON MAC'S AND UNIX FOR THIS USER COMMUNITY; DISTRIBUTE SOFTWARE TO USERS (I.E. IMAGE PROCESSING, IMAGE NAVIGATION, IMAGE CALIBRATION, ETC.)



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SATELLITE DATA PROCESSING SOFTWARE AT CU/CCAR

IMAGE PROCESSING SOFTWARE

1. SHO: A generic image processing program that runs on SUN workstations under SUNTOOLS/SUNVIEW (also on DEC X10)

2. DECSHO: A version of SHO that runs on DECWINDOWS

3. MOTIFSHO: A version of SHO that runs on any X11 workstation

4. IMAGIC: A similar image processing program that runs on the MACINTOSH-II family of computers

AVHRR DATA COLLECTION AND HANDLING

a. Antenna Operation (scheduling, tracking, ingest, archival)

b. Image Navigation and IR Calibration

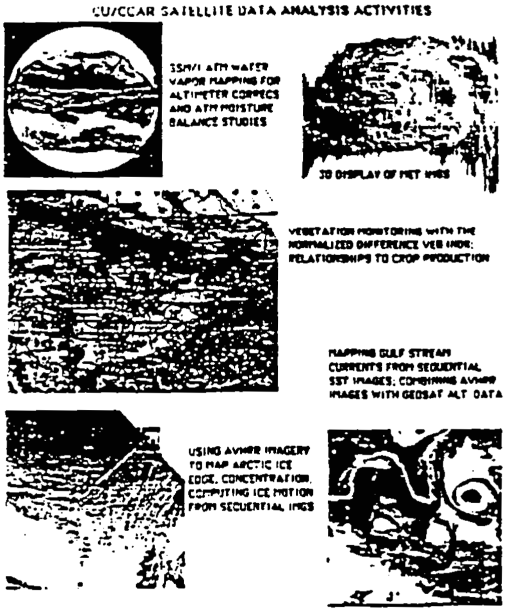
c. TOVS profiles (ITPP or 3I)

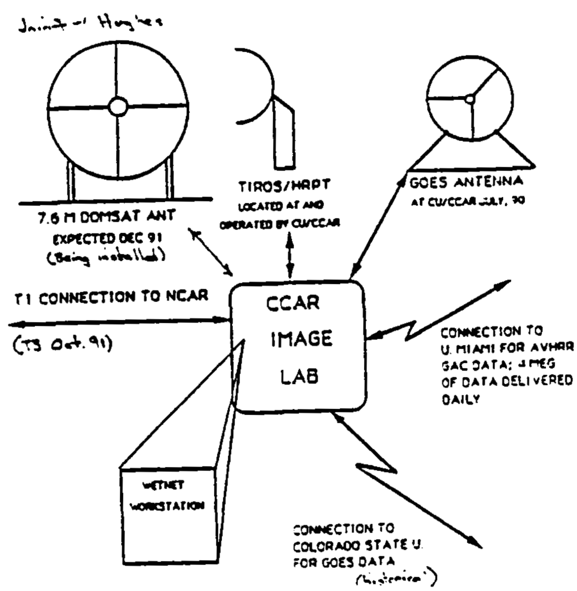
d. Applications (skin SST, SST motion, ice edge and concentration, ice motion, vegetation, cloud top temperature, cloud height, 3D perspective, etc.)

OTHER SATELLITE DATA HANDLING

a. SSM/I (ice and water vapor), LANDSAT & SPOT (3D mapping), SAR (ice mapping)

CU/CCAR SATELLITE DATA ANALYSIS ACTIVITIES





SATELLITE DATA CONNECTIONS

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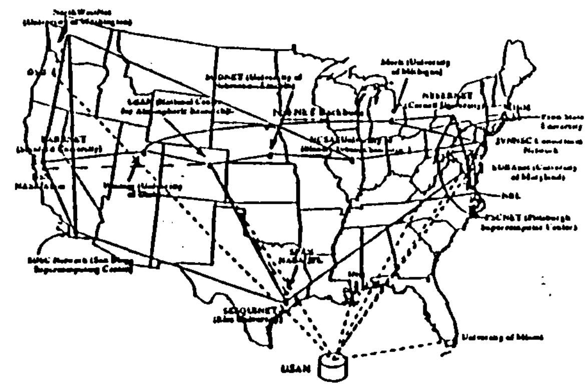
NCAR Mass Storage Systems (MSS)

Usage Data

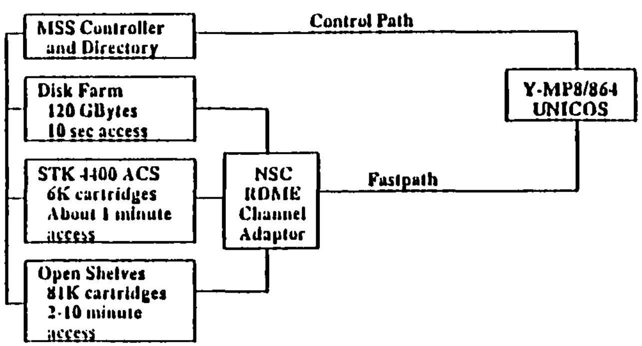
- 105,000 tape cartridges in use
- Total data stored 19 Tbytes
- Over 722,000 files
- Average file length 26.3 MB
- < two-minute delivery

Wide Area Network Connections at NCAR



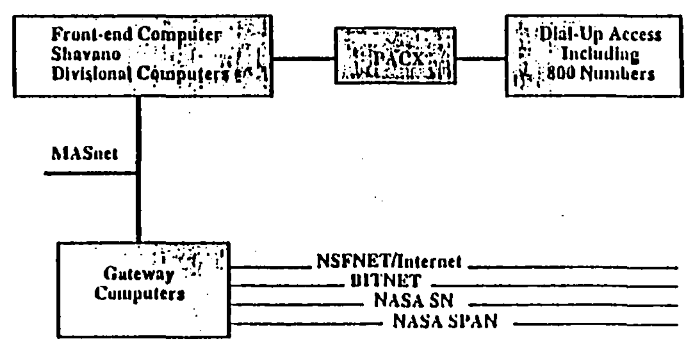
NCAR Scientific Computing Division
Supercomputing • Communications • Data

Mass Storage System Hierarchy



NCAR Scientific Computing Division
Supercomputing • Communications • Data

Remote Access



NCAR Scientific Computing Division
Supercomputing • Communications • Data

University of Colorado AVHRR Images On Line @ NCAR

As of this date, there are 499 days of data starting on March 3, 1989 -- July 18, 1991. The first images consisted only of channels 1 and 2. Now all channels are being archived.

Current Number Of Images

Images on line: 1,200
Size of Image: 1 Megabyte
Storage Size: 1.2 Gbytes

Monthly Number Of Images

Images processed per month: 120/mth
Processed Data Size: 120 Megabytes/mth

Daily Number Of Images

Images Processed Per Day: 4/day
Size of Image: 1 Megabyte
Storage size: 4 Megabytes/day
Channels 1, 2, 3, 4, 5

Image Projection

Images at End Of Project: 4,200
Image Storage Size: 4.2 Gbytes

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PRINCIPAL INVESTIGATORS PRESENTATIONS

GEOGRAPHIC INFORMATION SYSTEM FOR FUSION AND ANALYSIS OF HIGH-RESOLUTION REMOTE SENSING AND GROUND TRUTH DATA

Anthony Freeman/P.I.
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Pasadena, CA
(818) 354-1887

Pascale Dubois/Co.I.
Franz Leberl/Co.I.
L. Norikane/Co.I.
JoBea Way/Co.I.

APPLIED INFORMATIONS SYSTEMS
RESEARCH WORKSHOP

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JPL

GEOGRAPHIC INFORMATION SYSTEM FOR FUSION AND ANALYSIS OF HIGH-RESOLUTION REMOTE SENSING AND GROUND TRUTH DATA

A. Freeman, J. Way and L. Norikane (JPL)

F. Leberl (Vexcel Corp.)

F. Davis and Y. Wang (UCSB)

JPL

SCIENTIFIC OBJECTIVES

Confronted with the potentially massive volumes of data from remote sensing instruments and ground data collection for this site, the applications scientist might ask the following questions:

i) How do I manipulate such a large data set?

ii) How do I assess its information content?

iii) How do I find the optimum combinations of data to study changes in a given biogeophysical parameter?

iv)) How do I visualize the results?

v) How do I validate my models relating in-situ measurements to the remotely sensed data?

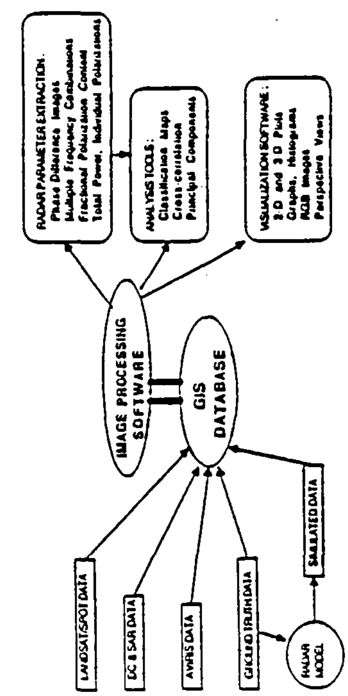
vi) What scientific generalizations can be made from this study, even though there are only two case studies?

vii) What important issues emerge which would impact EOS DIS and Forest/Natural Resources research with highly multi-dimensional data?

viii) To what extent do the GIS and Image Processing systems, both of which were designed to work with scientific data in raster format, and which are essentially state-of-the-art, show *significant weaknesses in handling large volumes of high-resolution data*? This is a practical issue of great importance to the remote sensing community.

JPL

Information Flow Diagram



JPL

SCHEDULE

Task	Completion Date
1. Install VICAR/IBIS on SPARCs Workstation (JPL):	9/91
2. Data Preparation:	
Identify SEASAT, LANDSAT Spot scenes (JPL)	6/91
SAR data Geocoding (Vexcel, JPL)	10/91
Generate simulated radar data for models (UCSB)	9/91
3. Data Entry into GIS Database (JPL)	
SAR data	10/91
Data from other sensors	9/91
Ground Truth Data	10/91
Simulated Radar data	11/91
4. Integration of GIS and Specialized Image Processing S/W (JPL, VEXCEL)	
Identify required S/W	3/91
Install on SPARCs	6/91
Set up GIS and Image Processing S/W Interface	5/91
Integrate	7/91
5. Development of New Algorithms (JPL,UCSB)	
Distance Measures	6/91
Multi-dimensional Classification Algorithms	?
6. Data analysis for case study I (JPL, UCSB)	
Extract radar parameters from data	12/91
Cross-correlate data sets	1/92
Principal Components analysis	2/92
Produce Classification Maps	3/92
Determine sensitivity of radar parameters	4/92
Validate radar models	5/92
Optimize visualization approach	6/92
Write report/journal paper on results	8/92

JPL SCHEDULE (CONT.)

Task	Completion Date
7. Data Preparation for Case Study II	
SAR data Geocoding (Vexcel)	07/92
AVIRIS data (JPL)	08/92
Ground Truth data formatting (JPL)	09/92
Simulated radar data generation (UCSB)	09/92
8. Data Entry (Case Study II) (JPL)	10/92
9. Data Analysis (Case Study II) (JPL, UCSB)	
Extract radar parameters from data	11/92
Cross-correlate data sets	12/92
Principal components analysis	1/93
Produce Classification maps	2/93
Sensitivity analysis	3/93
Radar Model Validation	05/93
Optimize visualization	08/93
Report/journal paper	10/94
10. S/W Documentation (JPL, VEXCEL)	
Write S/W Description Document	11/94
Write User's Guide to S/W	12/94

JPL DELIVERABLES:

1. Case Study I: Report/Journal Paper
2. Case Study II: Report/Journal Paper
3. S/W Description Document
4. User's Guide

JPL GEOGRAPHIC INFORMATION SYSTEM

- STATUS OF UNIX VICAR/IBIS S/W:
  - STARTING POINT WAS A SET OF UNIX VICAR ROUTINES TRANSLATED BY ARIZONA STATE UNIVERSITY
  - CURRENTLY HAVE 45 VICAR APPLICATIONS PROGRAMS RUNNING
  - 8 OF THEM ARE IBIS ROUTINES (NEED ~30 IBIS ROUTINES IN TOTAL)
  - CURRENT CAPABILITIES:
    - CAN READ RADAR IMAGE DATA INTO THE VICAR FORMAT
    - CAN SET UP - IMAGE FILES (RASTER)
      - GRAPHICS FILES (VECTOR)
      - I/F FILES (TABULAR)
    - PERFORM IMAGE ROTATION, STRETCHING
    - IMAGE RUBBER-SHEETING (FOR REGISTRATION)
    - DRAW POLYGONS ON DISPLAY AND CONVERT TO IMAGE FILES
    - FILL POLYGONS WITH DATA ATTRIBUTES

JPL GEOGRAPHIC INFORMATION SYSTEM

- IBIS GEOGRAPHIC INFORMATION SYSTEM

- OVERLAYING POLYGONS ON RADAR IMAGE

- FILLING POLYGONS WITH DATA ATTRIBUTES

JPL

GEOGRAPHIC INFORMATION SYSTEM

- DATA PREPARATION
  - CASE STUDY I: BONANZA CREEK EXP.'TAL FOREST, AK
    - 2 SEASAT IMAGES
    - 2 SPOT IMAGES
    - 10 AIRSAR FRAMES (==> 50 IMAGES)
    - 1 DIGITAL ELEVATION MODEL (USGS)
    - GROUND TRUTH SURVEY DATA
    - AERIAL PHOTOS
    - FURTHER AIRSAR DATA (5/91), GROUND TRUTH DATA AND ERS-1 SAR DATA WILL BE RECEIVED IN NEAR FUTURE
  - CASE STUDY II: BELIZE RAIN FOREST
    - 9 AIRSAR FRAMES (==> 45 IMAGES)
    - AVIRIS DATA
    - SOME GROUND TRUTH DATA

JPL

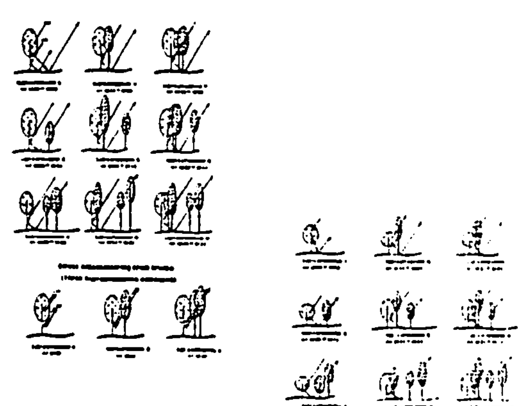
GEOGRAPHIC INFORMATION SYSTEM

- UCSB RADAR MODEL
  - UCSB RADAR MODEL(S) ARE INSTALLED ON THE SPARCS STATION AT JPL
  - MODELS WERE DEVELOPED FOR STUDIES OF MT. SHASTA FORESTS
  - CURRENT EFFORTS ARE FOCUSSED ON:
    - ENSURING THAT THE CONTINUOUS AND DISCRETE FOREST CANOPY MODELS AGREE IN THE LIMIT
    - ADAPTING THE MODEL FOR THE TYPE OF TREES FOUND IN ALASKA
    - GENERATING SIMULATED RADAR MEASUREMENTS FROM BONANZA CREEK GROUND TRUTH DATA
  - SIMULATED RADAR MEASUREMENTS FROM THE MODEL WILL BE USED TO FILL POLYGONS IN THE GIS TO GENERATE SIMULATED IMAGES

JPL

GEOGRAPHIC INFORMATION SYSTEM

- UCSB RADAR MODEL - BACKSCATTER COMPONENTS



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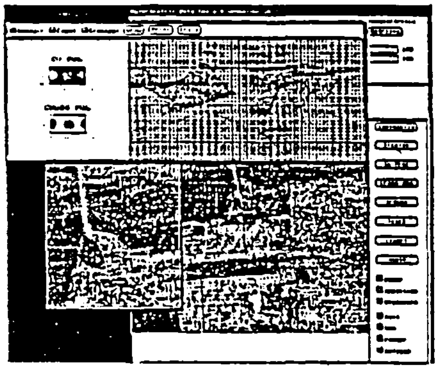
- CLASSIFICATION ALGORITHMS (FOR RADAR DATA)
  - FIRST STEP IS THE REDUCTION OF POLARIMETRIC RADAR IMAGE DATA TO FIVE BASIC QUANTITIES FOR EACH FREQUENCY (HH, HV, VV, ARG(HHVV*) AND |HHVV*|)
  - THIS GIVES 15 'CHANNELS' FOR EACH RADAR IMAGE SET
  - THEN USE LINEAR DISCRIMINANT ANALYSIS TO COME UP WITH A SUPERVISED CLASSIFICATION OF THE IMAGE
  - APPROACH WAS TESTED ON AN AIRSAR IMAGE OF AN AGRICULTURAL TEST SITE IN THE NETHERLANDS WITH 15 DIFFERENT CLASSES OF TARGET

- VISUALIZATION S/W AND ANALYSIS TOOLS
  - PVWAVE IS INSTALLED ON THE SPARCS STATION (GRAPHICS, RGB, PERSPECTIVES, ETC.)
    - NO I/F WITH VICAR YET
  - POLTOOL S/W - FOR POLARIMETRIC RADAR DATA ANALYSIS HAS BEEN INSTALLED. ALLOWS PLOTS OF POLARIZATION SIGNATURES, SYNTHESIZED IMAGES OF ARBITRARY POLARIZATIONS
    - NO I/F WITH VICAR YET
  - 'LIGHT TABLE' S/W DEVELOPED BY VEXCEL - ALLOWS USER TO 'ROAM' THROUGH LARGE IMAGES USING MOUSE

- POLTOOL S/W:



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PRINCIPAL INVESTIGATORS PRESENTATIONS

SAVS
A SPACE DATA ANALYSIS AND VISUALIZATION SYSTEM

Edward Szuszczewicz/P.I.
SAIC
Laboratory for Atmospheric and Space Science
McLean, VA
(703) 734-5516

Charles C. Goodrich/Co.I.
Alan Mankofsky/Co.I.

APPLIED INFORMATIONS SYSTEMS
RESEARCH WORKSHOP

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SAVS

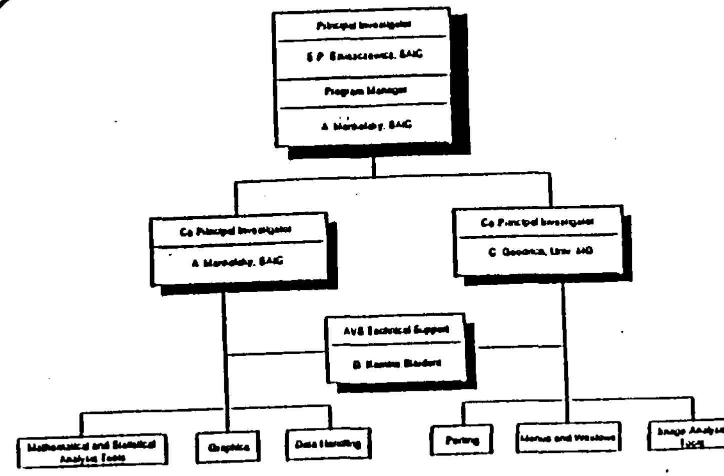
A SPACE DATA ANALYSIS AND VISUALIZATION SYSTEM

Presented by

E. P. Szuszczewicz

Laboratory for Atmospheric and Space Science
Science Applications International Corporation
McLean, VA

Applied Information Systems Workshop
July 22-24, 1991



SAIC Laboratory for Atmospheric and Space Sciences McLean, Virginia 22102

CONTRIBUTING ORGANIZATIONS

SAIC
Laboratory for Atmospheric and Space Science

STARDENT
Computer Inc.

UNIVERSITY OF MD
Department of Physics and Astronomy

SAIC Laboratory for Atmospheric and Space Sciences McLean, Virginia 22102

SAVS : A DATA ACQUISITION, MANIPULATION, ANALYSIS AND VISUALIZATION SYSTEM

<u>MAJOR COMPONENTS</u>:

INNOVATIVE VISUALIZATION SOFTWARE (AVS)

ADVANCED DATABASE TECHNIQUES (DAVID)

SET OF MATHEMATICAL, STATISTICAL, ANALYTICAL AND IMAGE PROCESSING TOOLS

STRONGLY DEVELOPED SENSE OF THE SCIENTIFIC REQUIREMENTS

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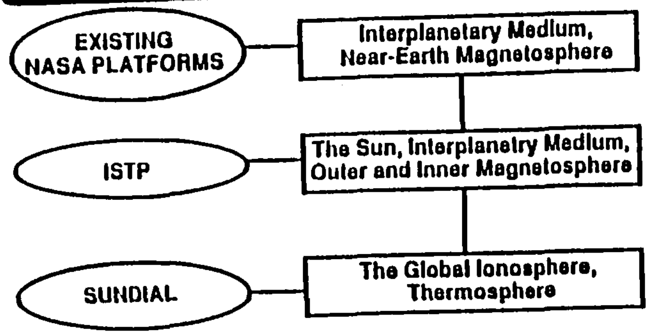
THE SAVS FOCUS:
The multi-disciplinary databases designed to understand the cause-effect relationships in the solar-terrestrial system, and their extrapolations to other planetary bodies



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THE NASA VISION FOR THE COMING DECADE

The vision: This vision includes a comprehensive attempt to understand the flow of energy into and through the geospace environment, with the goal that "*quantitative study of the geospace environment, created by the interplay of solar and terrestrial processes, will be progressing toward a full-scale predictive stage*" [from OSSA'sStrategy Document (1989)]

Implementation: Coordinated multi-spacecraft missions (e.g. ISTP) to collect "in situ" plasma and field measurements throughout the magnetosphere, the ionosphere and the interplanetary medium.

Requires imaging of the thermosphere, the ionosphere and the Sun, and coordinated ground-based magnetometer, ionosonde, radar, and photometric observations

Requires interactive database handling and visualization and analysis techniques

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STATEMENT OF THE PROBLEM

Increased focus on large-scale system phenomena

The cross-disciplinary nature of many investigations

Higher data rates and projections of increased volumes of data

Enhanced measurement capabilities (need for cross-correlation of global images with "in situ" and ground-based observations)

Increasing number of large-scale 3-D numerical codes available as analytical tools for data synthesis and interpretation

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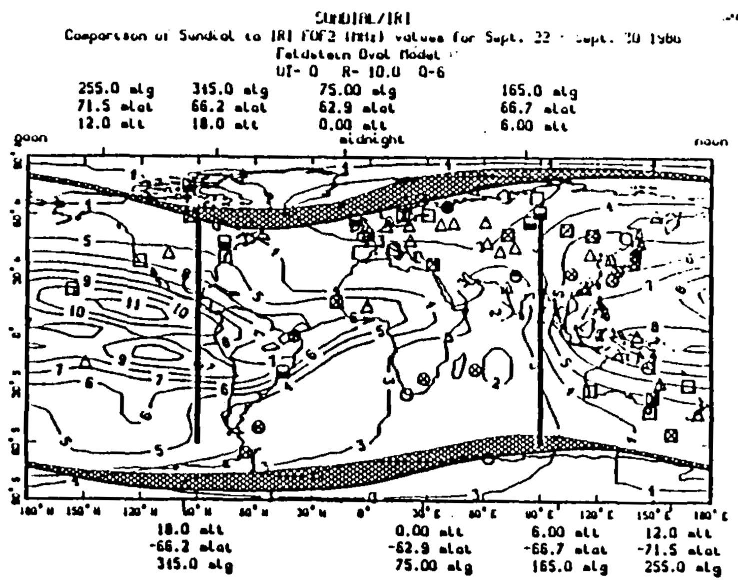

NEEDS OF THE PRACTICING SCIENTIST

Interactive data analysis and graphics *environment*

Ability to cross disciplinary boundaries with ease and understanding

Ability to "compress" data into a visually-organized form optimized for analysis and interpretation

Easy-to-use mathematical statistical and image processing tools

Tools to *obtain data sets from remote archives*

Access to empirical and numerical *model results* to correlate with the data and assist in data anlysis and interpretation

An *integrated* user-friendly *system they can afford*

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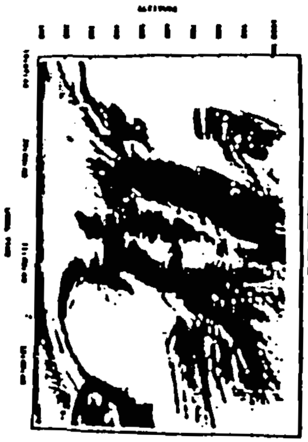

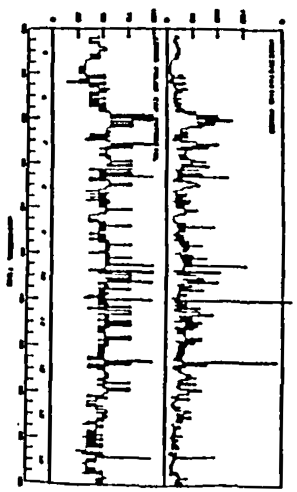

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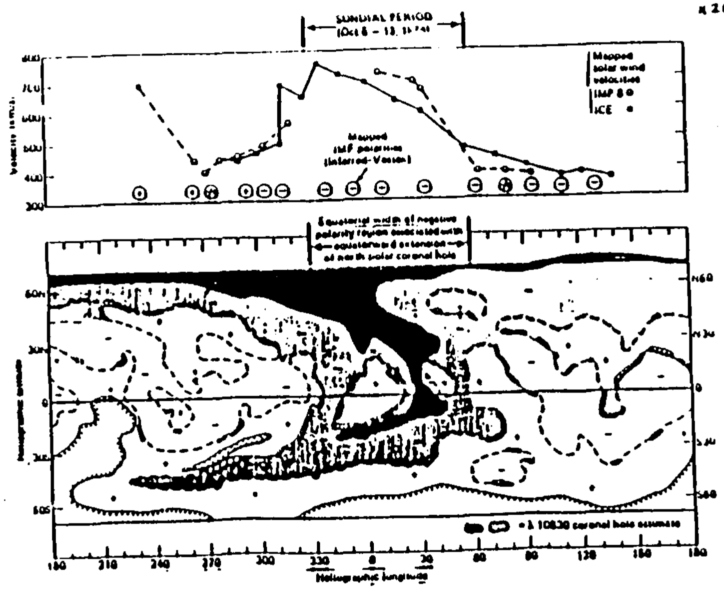

THE VISUALIZATION SYSTEM (AVS)

AVS IS DESIGNED FOR A DISTRIBUTED NETWORK ENVIRONMENT...SINGLE SYSTEM OR A NETWORK OF SYSTEMS

COMPLETE IMAGE DISPLAY CAPABILITIES:
- ...REAL-TIME PAN AND ZOOM
- ...ROTATION AND TRANSFORMATION
- ...FLIPBOOK ANIMATION
- ...SUPPORT FOR 8-BIT, 24-BIT AND FLOATING POINT IMAGES

IMAGE FILTERS INCLUDE:
- ...LOOK-UP TABLE OPERATIONS (PSEUDO-COLORING, HISTOGRAM BALANCING, DATA RESIZING INTERPOLATION, CROPPING AND SAMPLING)

PROVIDES A VARIETY OF TOOLS FOR RENDERING VOLUME DATA; A REAL-TIME ISO-SURFACE GENERATOR; ETC.

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PROJECTED CAPABILITIES

Visualization: 1-, 2- AND 3-DIMENSIONAL DISPLAYS, ALONG WITH ANIMATION, COMPRESSION, WARPING AND SLICING

Analytical Tools: GENERIC MATHEMATICAL AND STATISTICAL TECHNIQUES ALONG WITH THE ABILITY TO USE LARGE-SCALE MODELS FOR INTERACTIVE INTERPRETATION OF LARGE-VOLUME DATA SETS

Platforms: IMPLEMENTED ON SUN AND DEC UNIX WORKSTATIONS AND ON THE STARDENT GRAPHICS SUPERCOMPUTER

Immediate Application: SOLAR, HELIOSPHERIC, MAGNETOSPHERIC, IONOSPHERIC AND THERMOSPHERIC PHYSICS, WITH EXTENSIONS TO A BROADER RANGE OF PLANETARY, INTERPLANETARY AND ASTROPHYSICAL ENVIRONMENTS

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SAVS NEAR-TERM ACTIVITIES

Start customization of the AVS interface

Address the porting issues

Adapt AVS to NASA applications of 1-, 2-, and 3-D displays

Implement basic mathematical and statistical functions

Support locally-resident NASA data sets

Begin remote data handling capabilities

Implement relevant large-scale numerical models

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PRINCIPAL INVESTIGATORS PRESENTATIONS

A PLANETARY VERSION OF PC-McIDAS

Sanjay S. Limaye/P.I.
Univ. of Wisconsin-Madison
Madison, WI
(608) 262-9541

Mike Martin/Co.I.
R. S. Saunders/Co.I.
L. A. Sromovsky/Co.I.

APPLIED INFORMATIONS SYSTEMS
RESEARCH WORKSHOP

NOTES:

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A Planetary Version of PC-McIDAS

Applied Information Systems Workshop

July 22-24, 1991, Boulder, Colorado

Sanjay S. Limaye (UW-Madison), Principal Investigator
L.A. Sromovsky (UW-Madison), R.S. Saunders (JPL), Mike Martin (JPL), Co-Investigators

- WHAT IS PC-MCIDAS?
  - A COMPACT SYSTEM FOR ANALYSIS OF ATMOSPHERIC IMAGING DATA
- WHY A PLANETARY VERSION?
  - THE NATURE AND VOLUME OF THE PLANETARY DATA AND UNIQUENESS
- HOW?
  - UNIX AND OS/2 VERSIONS
- WHEN?
  - UNIX EFFORT UNDERWAY. PROGRESS ON OS/2
- WHO?
  - INITIAL DEVELOPMENT AT SSEC. TESTING AT JPL FOR MAGELLAN APPLICATIONS
- FUTURE: COULD SUPPORT MARS OBSERVER AND CASSINI MISSIONS

McIDAS and PC-McIDAS

MAN COMPUTER INTERACTIVE DATA ACCESS SYSTEM

AN ANALYSIS TOOL FOR INTEGRATION OF WEATHER DATA FROM SATELLITES AND CONVENTIONAL SOURCES. HARDWARE AND SOFTWARE COMPONENTS DEVELOPED AT SPACE SCIENCE AND ENGINEERING CENTER (SSEC) INSTALLED GLOBALLY IN OPERATIONAL ENVIRONMENTS. EFFORT BEGAN IN EARLY 1970'S

- HARRIS DATACRAFT 6024/5 VERSION
  - 384 Kb memory, 45 Mb Peripheral Disk Storage
  - 1 800/1600 bpi tape drive
  - 2 user image display terminals
  - used during Mariner 10 Venus Fly-by
- HARRIS /6 NETWORK VERSION
  - 2 Database Managers and 6 Applications Computers
  - 768 Kb core memory on each
  - 1 Gb peripheral storage on "MUM" and "DAD"
  - 160 Mb peripheral storage on each "son" or "daughter"
  - 2 800/1600 tape drives
  - 1 1600/6250 tape drive
  - 2 [illegible] display terminals on eac[illegible]cal as well as Remote)
  - us[illegible] during the Voyager Fly-bys of Jupiter and Saturn
- IBM MVS [illegible]
  - Vir[illegible] Memory, 32 Mb real mem[illegible] Gb peripheral storage
  - [illegible]6250 tape drives
  - [illegible] tape drives
  - [illegible] communication support
  - [illegible] terminals globally
  - used during Uranus and Neptune [illegible] encounters

McIDAS Workstations

- INTEL 8085 based "dumb" terminals
  - used on the Harris versions
  - Analog disk and digital ram display memory
- McIDAS MS-DOS Version - first "smart" terminal
  - Dual mode operation- Local mode and Host Mode
  - Digital image display memory
- McIDAS-OS/2 Version - first multitasking implementation
  - EGA/VGA support for local display
  - used during the Voyager Neptune encounter
  - portable for field work
- Wide Word Workstation (WWW) support
  - Additional Image Display Memory
  - 16 bit display memory
  - dual channel video support
- McIDAS-AIX Version - X-Windows support

McIDAS Hardware Developed at SSEC

SATELLITE DATA INGESTORS

WIDE WORK WORKSTATION

DIGITAL CASSETTE ARCHIVE FOR GOES DATA

Real Time Data Available on McIDAS

GOES satellite images 24 hours/day

METEOSAT visible and infrared images

NOAA-10 polar orbiter AVHRR ar[illegible]P data (HIRS, SSM)

NOAA-11 polar orbiter AVHRR [illegible] data (HIRS, SSM)

GMS Infrared full disk image[illegible] resolution

[illegible]

[illegible]

[illegible]

[illegible]

[illegible] and [illegible] numerical [illegible] forecast products

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Archived Data available on McIDAS

Continuous GOES digital imagery data going back to 1977, some to 1974

Mariner 10 images of Venus

Voyager 1 and 2 images of Jupiter, Saturn (Digital Tapes)

Voyager 2 images of Uranus and Neptune (Digital Tapes)

McIDAS Installed Base

MAINFRAME FACILITIES INSTALLED AT:

- NASA/USAF facilities (AFGRL, KSC, JSC, MSFC, VAB) for shuttle operations
- NOAA (NHC, NSSFC, NMB)
- Private Companies (Federal Express, WTVT)
- Universities (FSU, UC-Chico)
- Weather Services facilities in Spain, China, Australia, EUMETSAT

REMOTE WORKSTATIONS

SUNY-Albany

UW-Milwaukee

UNIDATA PC-McIDAS at ~ 100 atmospheric science departments at colleges and universities

PLANETARY PC-MCIDAS

- MANY DIFFERENT KINDS OF DATA AND SPACECRAFT ORBITS
- NATURE OF ANALYSIS DIFFERENT FROM OPERATIONAL WEATHER SATELLITE DATA
- DIFFERENT RESEARCH GOALS AND DISCIPLINES
- * NOT A SOLUTION FOR ALL PLANETARY DATA *
- BUILD ON THE CORE MCIDAS APPLICATIONS AND UTILITIES
- DIFFERENCES BETWEEN MCIDAS AND OTHER SIMILAR SYSTEMS

ENHANCEMENTS/MODIFICATIONS

- BRIDGE TO SPICELIB KERNELS FOR PLANETARY NAVIGATION
- DIRECT SUPPORT OF CD-ROM DATABASE
- IMPROVED PROGRAM PRODUCT DERIVATION REPORTING
- NEW APPLICATIONS FOR GEOLOGIC DATA ANALYSIS FROM PLANETARY IMAGES
- MULTICOLOR COMPOSITES AND ANIMATIONS
- DOCUMENTATION OF PLANETARY PROGRAMS/ALGORITHMS
- USER GUIDE

COMPARISON OF MCIDAS AND VICAR

- DIFFERENT OPERATING ENVIRONMENTS
- MULTITASKING VS. SINGLE APPLICATION MODE
- MULTIFRAME VS. SINGLE FRAME DISPLAY
- DIFFERENCES IN HANDLING OF USER FILES (NATIVE OPERATING SYSTEM VS. MCIDAS OPERATING ENVIRONMENT)
- USER APPLICATIONS TYPICALLY BUILT MODULAR RATHER THAN MONOLITHIC
- USER PROGRAMMABLE CHAINING OF OPERATIONS ("MACROS")
- USER APPLICATION "PROFILING" FOR APPLICATION PROGRAM INPUTS
- DIFFERENT SYSTEM ARCHITECTURE PHILOSOPHIES
- SIMPLIFIED FILE STRUCTURE ("LW" FILES)
- GRIDDED DATA STRUCTURE ("GRID" FILES)
- SCHEMA DATA STRUCTURE ("MD" FILES)
- UNIFIED IMAGE DATA NAVIGATION ACCESS

SSEC

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PRINCIPAL INVESTIGATORS PRESENTATIONS

INTERACTIVE INTERFACE TO NCAR GRAPHICS

Robert Lackman, P.I.
NCAR
Boulder, CO
(303) 497-1224

APPLIED INFORMATIONS SYSTEMS
RESEARCH WORKSHOP

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Interactive Interface

to

NCAR Graphics

Bob Lackman
Scientific Visualization Group

NCAR Scientific Computing Division
Supercomputing • Communications • Data

NCAR Graphics Features

- Standards conforming
  - ANSI C and FORTRAN 77
  - GKS and CGM
- Portable
  - UNIX and VMS
- Scientifically oriented
- International distribution
  - University, government, and industry
  - Since 1971
  - Approximately 1500 sites
- Evolving
  - UNIX Version 3.1.1

NCAR Scientific Computing Division
Supercomputing • Communications • Data

NCAR Graphics Current State

- Features
- Components
- Interface

NCAR Scientific Computing Division
Supercomputing • Communications • Data

NCAR Graphics Components

- Test drivers for all utilities
- Over two dozen high-level utilities
- An intermediate interface library (SPPS)
- NCAR GKS-0A (Optional)
- Fortran and C translators (Optional)
- Miscellaneous tools and utilities
- Documentation

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NCAR Graphics Utilities

- **Contouring**
  - Regular and irregular grids
  - *Various quality levels*
- **Maps**
  - Outlines or filled
  - Ten popular transformations

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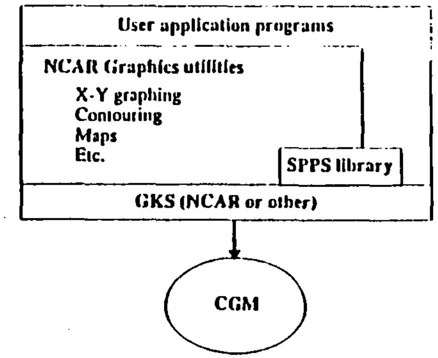
Supercomputing • Communications • Data

NCAR Graphics Programmatic Interface



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NCAR Graphics Utilities
(continued)

- X-Y plotting
- Surfaces and isosurfaces
- Streamlines and velocity vectors
- Histograms
- Stroked-character generators
- Others

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NCAR Graphics

NASA Proposal Enhancement

An Interactive Interface

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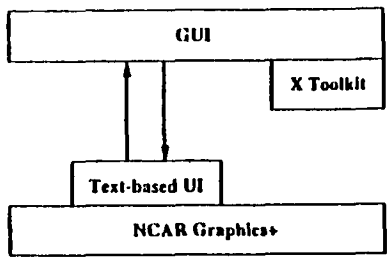
A Typical Application



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Supercomputing • Communications • Data

Design Considerations

- Ease-of-use
- Portability
- Enhanced functionality
- Standards
- Interoperability
  Module compatibility with AVS, apE, khoros, IDL, ...
- Distribution and support

  :

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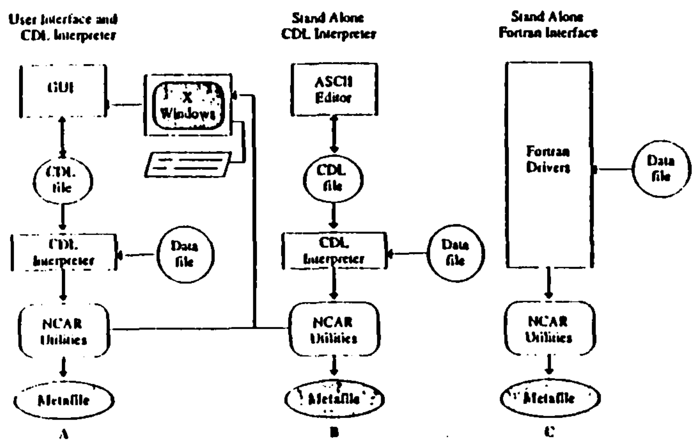
Supercomputing • Communications • Data

Overview of NCAR Interactive



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CDL = Command Description Language

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PRINCIPAL INVESTIGATORS PRESENTATIONS

VIEWCACHE: AN INCREMENTAL DATABASE ACCESS METHOD FOR AUTONOMOUS INTEROPERABLE DATABASES

Nick Roussopoulos/P.I.
Univ. of MD
College Park, MD

Timoleon Sellis/Co.I.

APPLIED INFORMATIONS SYSTEMS
RESEARCH WORKSHOP

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VIEWCACHE: AN INCREMENTAL DATABASE ACCESS METHOD FOR AUTONOMOUS INTEROPERABLE DATABASES

Principal Investigator:
Nick Roussopoulos

Co-Principal Investigator:
Timoleon Sellis

Department of Computer Science

and
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University of Maryland
College Park, MD 20742

July 5, 1991

Submitted to the First Workshop of the
Applied Information Systems Research Program
Boulder, Colorado
July 22-24, 1991

PROJECT SUMMARY

The objective of this work is to illustrate the concept of incremental access to distributed databases. An experimental database management system, ADMS, which has been developed at the University of Maryland, in College Park, uses VIEWCACHE, a novel database access method based on incremental search. VIEWCACHE is a pointer-based access method that provides a uniform interface for accessing distributed databases and catalogues. The compactness of the pointer structures formed during database browsing and the incremental access method allow the user to search and do inter-database cross-referencing with no actual data movement between database sites. Once the search is complete, the set of collected pointers pointing to the desired data are dereferenced.

One of the most attractive features of VIEWCACHE is its versatility in providing *External Multi Gateway Access* to commercial database servers, such as INGRES, ORACLE, and SYBASE, supporting existing and independently maintained databases. We have designed and implemented a Client-Server Database Management System Architecture which utilizes powerful workstations for managing inter-database queries and cached data. The workstation environment provides the "glue" for interoperating otherwise foreign environments. Gateway database access methods are enhanced by the incremental techniques of VIEWCACHE for caching local subsets of useful data.

VIEWCACHE is especially suited for distributed scientific databases maintained on commercial database systems. Scientist, who search such large catalogued databases, cannot write complete queries because search is defined during browsing. Current computer and database technology allows a user only to browse a single database at a time. It is, however, extremely useful to be able to browse and correlate data sets from multiple data servers. During browsing, there is no need to move data from one database to the next to compare and do cross-referencing; instead, VIEWCACHE creates a working set of pointers to the data sets or records that are candidates for the final retrieval. The working set is continuously refined until the user finds the exact data sets he needs. Furthermore, VIEWCACHE allows the creation of *mixed breed* views from several data sets and caching of them onto the users workstations. Such new data sets provide value added to the exiting data.

Another feature that ADMS supports is spatial search on image data sets. This capability is not offered by commercial DBMS but it was absolutely necessary for searching for objects in a giver "view field." Spatial search is based on R+-trees, an established access method. The indexing technique we are planning to support, provides for very efficient search over large databases of spatial objects.

The concept of VIEWCACHE has been demonstrated with the various traditional database benchmarks (like the Wisconsin benchmark); we propose to investigate and develop extensions to ADMS to make our system suitable for accessing very large space data sets. Clearly, NASA's huge numbers of distributed data sets collected from space and ground stations cannot be supported by existing distributed commercial distributed database systems because they require unnecessary and bulky data movements. VIEWCACHE, on the other hand, provides an inexpensive processing without interrupting the independence of existing and autonomous databases.

TECHNICAL OBJECTIVES

Our objective is to illustrate the potential of the incremental access of VIEWCACHE in a real NASA environment of distributed databases, in particular on a collection of Astrophysics databases. The compactness of the VIEWCACHE pointer structures formed during database browsing and the incremental access method allow the user to search and do inter-database cross-referencing with no actual data movement between database sites. Once the search is complete, the set of collected pointers pointing to the desired data are cached. This will provide a uniform user interface to a large number of databases using the VIEWCACHE concept, and the Client-Server Architecture. We will also examine ways to interface VIEWCACHE with the DAVID system and its library-based access methods for providing access to Heterogeneous and Distributed Databases.

In more detail, the following technical objectives will be sought during the next three years:

(1) An extension of the physical pointer structure of VIEWCACH to a logical one. This will permit VIEWCACHE to do inter-machine pointer referencing across a communication network (Local or Wide Area Networks). Access of heterogeneous DBMSs will be done by gateway software based on the SQL language.

(2) Investigate features and characteristics of various Client-Server DBMS architectures and measure their performance under a wide variety of key parameters, including speed of the storage media, speed of the CPUs, network transfer rates.

(3) Incorporate a spatial access methods and accordingly extend the SQL query language to include spatial search and operators which deal with imagery databases.

(4) Design and develop a user interface and the appropriate tools to facilitate handling and distribution of data sets and documents. The Astrophysics environment will be the first to target this interface. Other environments will also be investigated and appropriate tailoring of the interface will be attempted.

(5) Investigate ways to interface VIEWCACHE with DAVID, the Distributed Heterogeneous Database System developed at Goddard.

Work on this projects has already started on the items 1, 2, and 3 from above. We have been experimenting with Oracle DBMS on the subject of logical pointers. We have also developed simulation packages for evaluating alternative Client-Server Architectures for DBMSs. Experiments are currently being contucted with very large simulation runs.

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PRINCIPAL INVESTIGATORS PRESENTATIONS

SPATIAL ANALYSIS AND MODELING SYSTEMS (SAMS)

Charles Vermillion/P.I.
Univ. of Chicago
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Paul Chan/Co.I.
John Hill/Co.I.
Robert Jaske/Co.I.
Gilbert Rochon/Co.I.
Fran Stetina/Co.I.

STATUS REPORT

SPATIAL ANALYSIS AND MODELING SYSTEM (SAMS)

P.I. - Charles Vermillion, GSFC, Code 970.1
Co.I. - Fran Stetina, GSFC, Code 970.1
- Paul Chan, Science Systems & Applications, Inc.
- John Hill, Houston Advanced Research Center

The objective of this project is to develop a uniform environmental data gathering and distribution system to support a) emergency management for environmental disasters, and b) the calibration and validation of remotely sensed data. Initial activities will be to select a data test site and to demonstrate multi-discipline applications using simulated or satellite data in a non real-time mode.

The investigators have arranged collaboration with the CERL Laboratory of the Corps of Engineer (COE) in integrating its Geographic Information System (GIS), the Geographic Resources Analysis Support System (GRASS), into SAMS. CERL will also provide hydrological models (HEC-I and II) to be integrated into SAMS. The collaboration with the Federal Emergency Management Agency (FEMA) will allow this project to tap into FEMA's resources in GIS and emergency management tools.

We choose to use rainfall and flooding as the testbeds for the SAMS concept because of the abundance of data and the availability of models. We will integrate into SAMS (in a UNIX, GRASS and X-Windows environment) capability to display and process GOES data and analyze GOES generated rain-rate maps. GRASS is compatible with the majority of the data to be input to the selected hydrologic model (i.e. topography, land-use, soils, rainfall, stream gauge, etc.). The choice of the data test site has been narrowed down to West Virginia or Galveston, Tx, based on the availability of test data.

The expected results in six months are:

a) Design concept of SAMS,
b) Demonstration of a pilot module, and
c) Project implementation plan based on the pilot demonstration.

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PRINCIPAL INVESTIGATORS PRESENTATIONS

INTRODUCTION TO CADET
CENTER FOR ADVANCED DATA EVALUATION TECHNOLOGY

Cathy Schulbach/P.I.
NASA Ames Research Center
Moffet Field, CA

C. Jorgensen/Co.I.

APPLIED INFORMATIONS SYSTEMS
RESEARCH WORKSHOP

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INTRODUCTION TO CADET

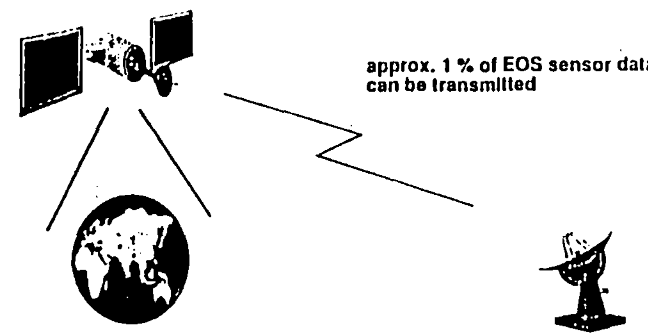
Center for Advanced Data Evaluation Technology

Cathy Schulbach /c Jurgensen
7/25/91

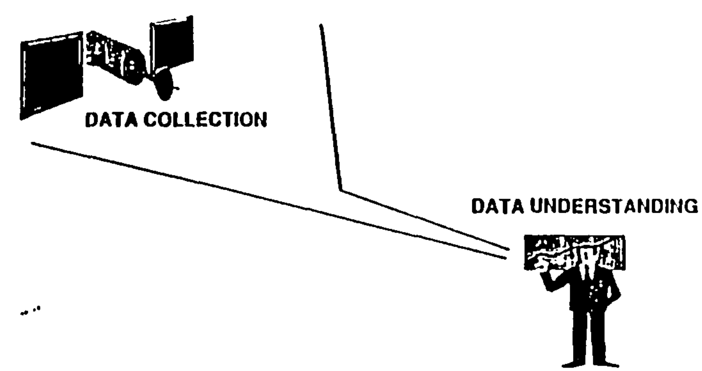
OUTLINE

- INTRODUCTION
- GOAL
- CADET OVERVIEW
- OBJECTIVES
- APPROACH
- KEY CADET FOCUS
- FUTURE MILESTONES

TECHNOLOGY PROBLEM



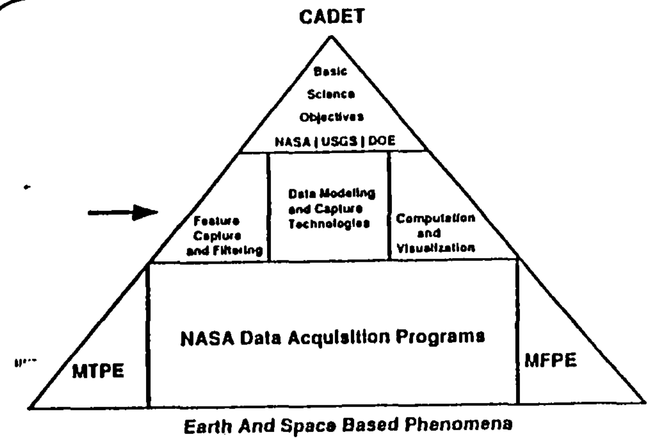
HUMAN PROBLEM



IMPLICATIONS

- The "BRUTE FORCE"method of trying to collect, save, and analyze "everything" is intractable and may not produce the best science.
- Smarter and more automated approaches are required.

NASA Ames Research Center | CADET | Information Sciences Division CHS 7/25/91 p.6



NASA Ames Research Center | CADET | Information Sciences Division HS 7/25/91 p 7

GOAL

- DEVELOP AND DEMONSTRATE IMPROVED METHODS OF HANDLING LARGE SCIENTIFIC DATA FLOWS RESULTING FROM CURRENT AND PLANNED NASA MISSIONS.
  - Real-time
  - On-board

NASA Ames Research Center | CADET | Information Sciences Division CHS 7/25/91 p 5

OBJECTIVES

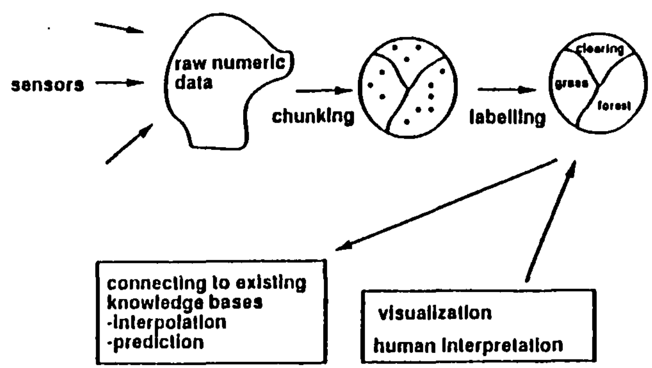
- Integrate existing work in neural networks, photonics, parallel processing, and dependable systems.
- Develop, test, and evaluate new concepts for model-capturing and novelty detection mechanisms (e.g. neural net learning).
- Implement advanced data analysis technology using advanced processors (e.g. optical processors, IWARP, ES-KIT).

NASA Ames Research Center | CADET | Information Sciences Division CHS 7/25/91 p 8

APPROACH

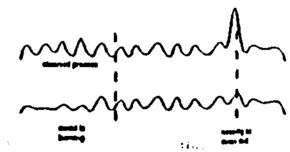
- Focus on common problems of importance to major NASA missions (e.g. MTPE, MFPE).
- Demonstrate technology advancements first with ground-based systems and then move to on-board, real-time platforms.
- Capitalize on existing capabilities and programs: Ames Advanced Data Systems and Software Test Facility (includes DARPA testbed) and the High Performance Computing and Communication Program.
- Coordinate with NASA and non-NASA agencies.

KEY CADET FOCUS: Translating Data Into Usable Form



ELEMENTS OF THE MODELLING PROCESS

- Developing a model from data
  - numerical analysis
  - Bayesian estimation
  - neural network learning
- Applying a model
  - expectations vs. observations--prediction
  - novelty detection--Δ, change
- Developing algorithms
  - mapping to computer architectures
  - optimizing performance



FUTURE MILESTONES

FY92

- Use the Failure Environment Analysis Tool (FEAT) to model a sensor system.
- Demonstrate the use of sensor overlays to display earth science data.
- Demonstrate the ability of a neural network front end to automatically capture underlying regularities in a real-world sample of spectrographic sensor data.

FY93

- Develop parallel code implementing a novelty filter to redirect a data recording device to dynamically respond to changes in measured, earth science phenomena.

FY94

- Validate the above concepts on the Ames Advanced Data Systems and Software Test Facility.

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APPLIED INFORMATION SYSTEMS RESEARCH PROGRAM WORKSHOP

PROGRAM PRESENTATIONS

APPLIED INFORMATIONS SYSTEMS
RESEARCH WORKSHOP

NOTES:

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FLIGHT PROJECTS OFFICE INFORMATION SYSTEMS TESTBED (FIST)

PatriciaLiggett
Jet Propulsion Laboratory
Pasadena, CA
(818) 357-4619

APPLIED INFORMATIONS SYSTEMS
RESEARCH WORKSHOP

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JPL

Flight Projects Office Information Systems Testbed (FIST)

P. Liggett

Goal

JPL

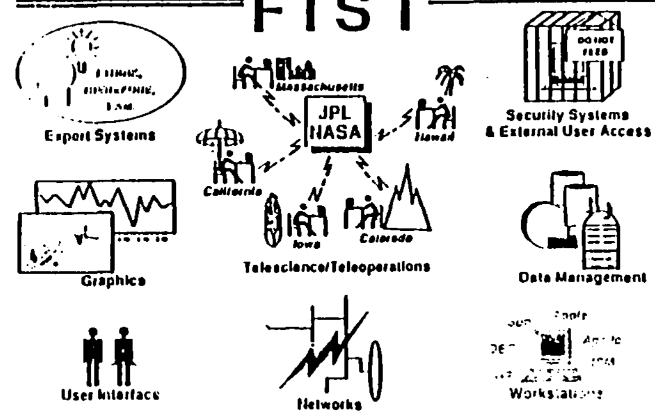
- FIST reduces risk by providing support for:
  - Requirements Clarification
  - Design Validation
  - Design Evolution

Goal

JPL

To perform technology evaluation and prototyping of information systems to support SFOC and JPL flight projects in order to reduce risk in the development of operational data systems for such projects.

FIST



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Criteria

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- Applied research and development using commercially available products and systems.
- Results of prototypes and evaluations are reported in the FIST Quarterly Report and presented during demonstrations.
- FIST guidelines are provided by SFOC compatibility requirements.

Quarterly Reports

JPL

- FIST Quarterly and SFOC Prototype Interim Reports are available through:

  FPSO Library
  Mail Stop T-1607
  Jet Propulsion Laboratory
  4800 Oak Grove Drive
  Pasadena, California 91109

JPL

SYSTEM BUILDING BLOCKS

- Open Systems Architecture
- Server/Client Model
- Iterative Design and Development
- Commercial and Public Products

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OPEN SYSTEMS ARCHITECTURE

- Limited Constraints
- Well Defined Interfaces
- Data Format Agreement
- Soft Serve versus Hard Freeze

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SERVER/CLIENT MODEL

- Limited and Well Defined Interdependance
- Loosely Coupled
- Services Provided to Requesting Client
- Role Reversal

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ITERATIVE DESIGN AND DEVELOPMENT

- Provides Users with Early View of System
- Adaptive to Changing Technology and Requirements

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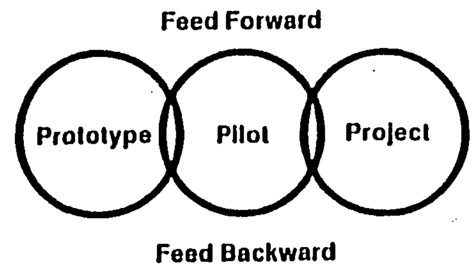
Technology Transfer

JPL



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RESEARCH WORKSHOP

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