Managing Hazardous and Toxic Waste Information:

GIS Application

August 9-11, 1989
Denver, Colorado

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MANAGING HAZARDOUS AND TOXIC WASTE INFORMATION:
GIS APPLICATIONS

United States Army Toxic and Hazardous Materials Agency (USA-THAMA), United States Army Construction Engineering Research Laboratory (USACERL), and United States Army Waterways Experiment Station (USAWES) sponsored a symposium entitled "Managing Hazardous and Toxic Waste Information: Geographic Information Systems (GIS) Applications" on August 9, 10, and 11 in Denver, Colorado. The purpose of that meeting was for sharing ideas, systems and progress on the various GIS programs within the Corps of Engineers and the Army, with applications to the study and management of hazardous and toxic waste issues. The symposium provided a unique opportunity to develop synergy between the Corps of Engineers Laboratories, specifically in the area of GIS Research and Development and GIS implementation efforts. Discussions about these efforts proved very beneficial to all parties concerned.

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INTRODUCTORY MATERIAL

A. AGENDA

B. LIST OF REGISTERED ATTENDEES

C. MEETING NOTES BY MIKE YOEMAN
MANAGING HAZARDOUS AND TOXIC WASTE
INFORMATION: GIS APPLICATIONS
Denver, Colorado
August 8-11, 1989
MEETING AGENDA

Tuesday, August 8
6:00 p.m.-9:00 p.m. Registration Judy Zindors
7:00 p.m.-10:00 p.m. Icebreaker THAMA

Wednesday, August 9
8:30-8:45 Opening Remarks Mark Boulisky, William Moran, Sandy Stephens
8:45-9:15 Keynote Address
"GIS in the Corps: Process and Directions" Bill Kleach
9:15-10:00 THAMA
"THAMA Overview: Installation Restoration Data Management Information System (IRDMIS)" Mark Boulisky
"Geotechnical Applications Using Interactive Surface Modeling" Ina May
10:00-10:15 Break
10:15-11:00 CERL
"GIS Capabilities and Activities at CERL" William Moran
"GRASS: Development and Support" Jim Westervelt
11:00-12:00 WES
"Geotechnical Applications of GIS" Albert Williamson
"GIS/Image Processing Synopses" Jack Stoll
"CADD and GIS" Sandy Stephens
12:00-1:00 Lunch
1:00-1:45 CREEL
"Demonstration of PRISM and STELLA Software for use in the Corps of Engineers" Be McKim
1:45-2:30 ETL
"GIS Work at ETL" Bruce Opitz
2:30-2:45 Break
2:45-3:30 DMA
"DMA: CD-ROM Products" Mark Shellberg
3:30-3:45 Wrap-up Mark Boulisky
3:45-6:00 Corps Demonstrations

Thursday, August 10
8:30-8:45 Opening Remarks Sandy Stephens
8:45-10:15 Vendors' and Agencies' Presentations
DBA Dave Johnson
Dynamic Graphics Bill Hooker
Autometrics "MOSS and Autometrics" Bruce Morse
Purdue University "Evaluating Ground Water Pollution Potential using GIS" Kurt Buehler and Douglas Hickey
10:15-10:30 Break
10:30-12:00  Vendors' and Agencies' Presentations
          Intergraph Gary Lambert
          ESRI Jack McCarthy
          Concurrent Computer Corporation Daryl McDaniel
12:00-1:30  Lunch
1:30-5:00  Working Groups
3:00-3:15  Wrap-up Sandy Stephens
3:15-3:30  Break
3:30-5:00  Vendors' and Agencies' Demonstrations

Friday, August 11
8:15-8:30  Opening Remarks William Goran
8:30-9:00  Bringing it all Together: Data Interface Sandy Stephens
9:00-10:30 Round Table Discussion
10:30-10:45 Break
10:45-12:00 Round Table (cont.)
12:00      Adjourn
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MANAGING HAZARDOUS AND TOXIC WASTE
INFORMATION: GEOGRAPHIC INFORMATION SYSTEM (GIS) APPLICATIONS
August 8 -11, 1989
Meeting Notes prepared by Mike Yoemans

I. Introduction: Meeting was co-sponsored by USATHAMA and WES. Approximately 65 personnel attended the meeting. Primary focus was on coordinating/sharing GIS Lab activities with emphasis on finding ways to better serve the field. The meeting covered a variety of topics to include presentations by each laboratory (THAMA, CERL, WES, CREEL, and ETL). It also included a number of vendor presentations and break-out sessions, dealing with four (4) key GIS problem areas.

II. Key Note Speaker: Dr. Bill Klesch opened the conference by discussing the HQUSACE reorganization, which puts environmental functions into a single organization as a part of the Chief’s initiative to create a greatly expanded environmental mission. He also discussed the results of a Corps-wide GIS study he led. The study was completed in Oct 88 by 32 personnel from throughout the Corps. Personnel were divided into eight (8) sub-groups. Focus was on GIS applications. The Chief has approved the study findings, briefly described below:

A. Report recommended the creation of a technology transfer program and emphasized need for software sharing.

B. Headquarters needs to promote GIS. There will be a GIS coordinator at headquarters, located in the Civil Works Policy and Planning Division. A GIS steering committee will be established with counterparts at districts. District representatives will be given increased visibility.

C. Sub-group recommendations:

1. User Needs. GIS should promote professionalism -- technology must work and provide a high level of credibility. GIS must be practical and flexible. GIS costs must be accurately tracked and users must be trained on proper procedures for conducting cost/benefit analysis. Users and developers of GIS are cautioned to remember that data collection is the most expensive aspect of system operations, and its a long road to system benefits. A formal GIS education program should be created. GIS must be easily accessible to all who need them.

2. Scoping. There are many issues related to scoping: How much data is enough? Can we afford GIS for this project? How much time do we have? To deal with these and other scoping concerns, the sub-group recommended:

(a) Project managers should gather as much detailed information as early on in the project as possible. Data should be structured in a manner that takes into account future uses.

(b) Standard ways of collecting data should be developed.

(c) Share existing data to maximum extent.

1 - c1
3. Hardware capability. Sub-group recognized the need for standard hardware, but not in the immediate future. Organizations need to get their feet wet first. As of the study completion date, there were 48 existing systems with approximately half in the FOA and the half at the Labs. Requirements need to be defined. We need to define those applications that are routinely used. The lead district concept should be applied to facilitate GIS development. A GIS training program needs to be established.

4. Data quality. Data must be accurate! Need to develop multi-purpose data bases. To do this data will have to be structured independent of the applications that use it. Procedures need to be developed for tracking errors (Error Budgets). Data accuracy requirements need to be defined. Policies need to be established making data quality essential to all aspects of GIS to include the R & D community.

5. Technology transfer. We must create opportunities for sharing technology. Top management needs to be educated. We need to find ways to promote GIS.

6. Cost. This is a tough issue. $59 million spent to date. 9 districts are operational as of Oct 88. 26 districts were not operational. The study estimated that is would require $210 k per district to get started. There are currently 35 – 50 packages to be evaluated. The most important point about cost is to remember that data collection is the most expensive aspect of GIS.

7. Software Sharing. Methods and procedures need to be developed for sharing software and for encouraging open architecture vendor solutions.

8. Inter-agency coordination. GIS data and application requirements and capabilities must be coordinated with Federal, state, and local colleges. Everyone is doing their own thing. Benchmarks have to be developed for evaluating data base structures and hardware configurations. We need to manage between GIS, CADD, and remote sensing.

D. Bill Klesch closed his remarks by talking about how the Corps is going to deal with the toxic waste program. He indicated that the Chief thinks environmental engineering is our future. There will be a coalition between the engineering and environmental community. We are beginning to see how hazardous waste relates to civil works projects. Final word: Focus on GIS applications!! Use this information to influence vendor GIS products!!

III. Lab presentations. Mark Bovelsky opened this portion of the conference by talking about the fragmentation of the GIS program and the need to pull it all together. This was followed by a presentation from each of the Labs.

A. CERL. William Goran gave a good presentation on the Geographic
Resource Analysis Support System (GRASS), which has extensive land management capabilities. The software is public domain, and it is available at a cost of $1K per package. This presentation had lots of information showing hardware configurations and existing software programs (estimated at 180 programs). This looks like a very good system -- one that should interest all FOA. Other material distributed at the conference included a GRASS Newsletter and a GIS fact sheet. Personnel interested in obtaining copies of this material or more information on GRASS should contact CERL directly.

B. WES. Sandy Stephens lead off with the standard CADD briefing. He was followed by Al Williamson who gave a presentation on geotechnical applications. He indicated that there are 36 different applications with about 40 users. He briefly described the Computerized Environmental Resource Data System (CERDS). It was used to analyze data for 1,000 river miles. Data came primarily from existing maps. Al’s talk focused on developing GIS applications to solve specific problems. He stressed that GIS applications should not become software or hardware dependent. Jack Stoll was the final WES speaker. He talked about Image Processing. He indicated that WES was actively supporting NASA’s GIS upgrade. He also mentioned a specialized GIS hardware, which makes extensive use of the TCP/IP communications protocol. He emphasized the need to ensure image processing capabilities be included as a critical feature for future GIS.

C. ETL. Bruce Opitz gave an enlightening talk on ETL’s efforts to develop systems to support the soldier. He pointed out that it is quite a different problem to develop systems that must operate under battlefield conditions by soldiers who may not have graduated from high school. Bruce indicated that ETL will be purchasing large numbers of systems. They are looking to acquire off-the-self systems. Human engineering factors will play a heavy role in system selection.

D. DMA. Mark Shellberg presented Defense Mapping Agency’s initiatives to apply CD-ROM products to convert existing paper maps. They have an extensive information modernization program estimated at $2.6 billion. There is much the Corps can learn about CD-ROM technology from DMA. Moreover, there is an extensive amount of data sharing that can and should occur between the Corps and DMA. Mark said if you want information from DMA on data holdings, lessons learned, etc., you must go through ETL (Mark Bovelsky).

E. CRREL. Ike McKim talked about two systems: PRISM and STELLA. They feature image conversion and image processing. They seek to overcome the vector versus raster problem by allowing all data to be viewed as vector. STELLA is an object oriented program. It the first good example of object oriented programming I’ve seen! The system is capable of building extremely complicated models.

IV. Vendor Presentations. Six (6) vendors made presentations as follows:
A. DBA. Specialize in GRASS customization, data base generation, digital data input services, image processing, and image manipulation. They are establishing a Digital Cartographic Research Laboratory to look high technology for GEO-TECH.

B. Dynamic Graphics. A software development firm featuring large software library, interactive systems for surface modeling, and 3D modeling. Graphics were exceptionally good!

C. Autometrics. Provides on-call support for the Map Overlay Standard System (MOSS). This system was originally built in 1976. It is public domain software used extensively by the Omaha District. It is an analytical tool. It was largely redesigned in spring of 1989.

D. Intergraph. Gave standard CADD presentation with focus on data and software integration capabilities and third party porting products.

E. ESRI. Featured their integration tools. Good slides showing GIS integration requirements for both data and application.

F. Current Computer Corporation. They feature real-time systems. They sell hardware, but they provide a "GIS Bundled GRASS Based system, which is operational at Little Rock District.

V. Working Group presentations. Based on area of interest, attendees were divided into four working groups as follows:

A. Raster versus Vector. Group suggests:

1. Desire for concurrent processing of raster and vector data without having to convert back and forth.

2. More sharing of data. Open system architecture and standard interchange data model.

3. Procedures for acquiring existing data. Central Corps site for distributing data. Data acquisition policy.

4. Library of Corps GIS applications. Suggestion was made to use NTIS (?) and catalog of GIS software produced by USGS.

B. Single discipline task group. Recommend broad needs for GIS development:


2. Need to create GIS center similar to CADD center.

3. Technology transfer forums.

4. GIS standards -- Attribute schema and symbology and
weighting criteria.
5. Software development requirements need to be defined.
6. GIS R&D support for modeling/analysis.
7. GIS Training program and steering committee.

C. Planning and Marketing.

1. Establish GIS Center
   a. News Letter
   b. E-Mail
2. GIS Planning Guidelines
3. Educate Management/Need copy of cost/benefit analysis
4. Corps-wide GIS inventory of applications and platforms
5. Army Steering Committee to develop guidelines
6. Standards for sharing data
7. User Groups
8. Incorporate GIS planning into IMP sequence
9. IM architecture should include GIS
10. Include IRM Committee in GIS to extent possible
11. Definition: Terms
12. Policy on GIS: Should exist at planning and be funded
    through technical and indirect

D. Remote Sensing: How to get data that already exists. Lower
   costs. Lots of land, but no information on it, and no handbook on
   how to collect data. Responsibility should be placed in Real Estate
   section. Get ACE here in future! Newly created Environmental
   Division.

1. Need participation in R&D to insure money is spent in
   right way
2. Water quality factor.
SPEAKERS PRESENTATION

MATERIALS

A. NOTES FROM KEYNOTE ADDRESS
B. THAMA
C. CERL
D. WES
E. CRREL
F. ETL
G. DMA
NOTES OF KEYNOTE ADDRESS

The GIS Ad Hoc Committee: Corps of Engineers/Environmental Advisory Board, at its 1987 March Meeting on ENVIRONMENTAL DATA recommended that the Chief of Engineers select a specialist to focus on environmental data and GIS, addressing eight areas --

1. Scoping
2. Sensitivity to user needs
3. Inter-model hardware consistency
4. Software capability
5. Data quality
6. Technology transfer
7. Cost
8. Inter-agency coordination.

September 1987 - Kleesch appointed Chairman
November 1987 - Group of 32 selected and convened
Range of experience and familiarity with GIS among this 32 person
Focus on Application of GIS to Corps.
32 assigned to 8 subgroups.
Ad Hoc report completed 10/88 and forwarded to Chief of Engineers.

1. Chief has accepted and report will be printed.

RECOMMENDATIONS:
1. GIS Coordination at HQ OCE to reside in Policy and Planning Division.
2. Establish Steering Committee of Division Chiefs
3. GIS Coordinators at Districts/Divisions - but needs visibility to cut across Division activities.

SENSITIVITY TO USER NEEDS --

- Professional Credibility - tools actively support mission
- Practicality
- Flexible - lots of different professionals
- Accurate cost information
- Education & Accessibility - need training opportunities.

SCOPING - How much data is enough.
- Detail required tied to investigation
- Gather most detailed information needed as soon as possible.
- Development of standardized materials for data collection.

HARDWARE AND SOFTWARE CONSISTENCY

- Lots of discussion - compelling argument for standardization - but recommended that standardization be postponed - why - diversity of current use.
- Recommend - offices should develop multi-year plan for GIS implementation and use.
- Recommend - use expertise in place at certain districts, especially on regional basis, to respond to specialized or regional Corps needs.
- Recommend - training program.

2 - a1
DATA QUALITY -
Data is greatest cost - data quality is critical
- Anticipate future needs in developing data rather than short term.
- Procedure to tract error propagation.
- More involvement with Federal inter-agency committee

TECHNOLOGY TRANSFER -
- Need for effective communication
- Technology awareness within the Corps Senior Leadership - Match aware of this technology area.
- Timely and accurate information and systems acquisition
- Need program of GIS training to reach at least one at each site

COST -
- In 1988 -- 48 systems in place -- Cost = 5.6M
- Required to add other districts -- Cost = 5.7M (26 districts without capabilities)

INTERAGENCY - COORDINATION -
- Use of GIS grown dramatically in last four years
- Data exchange and system capabilities problems abound
- Need -- benchmarks for scale, quality.
- Draw together - Remote Sensing and GIS

Regarding Hazardous and toxic waste data management, the COE's Chief's emphasis is on water resource issues and environment. Corps as an environmental agency to seek solutions for the engineering and environmental community. GIS offers great applications for hazardous and toxic waste management as a tool for COE.
THE GRASS USER COMMUNITY

Federal Agencies
State & Local Governments
Educational Institutions
Private Firms
Foreign-based Organizations
FEDERAL ORGANIZATIONS USING GRASS

U.S. Army Installations
Corps of Engineers Districts, Divisions & Labs
Soil Conservation Service
National Park Service
U.S. Geological Survey
U.S. Navy
Department of Energy
National Aeronautic & Space Administration
National Oceanographic & Atmospheric Admin.
Defense Mapping Agency
U.S. Forest Service
U.S. Air Force
Agricultural Research Service
ARMY INSTALLATIONS USING GRASS

• Current:
  Fort Hood, TX
  Fort Lewis, WA
  Fort Carson, CO
  Yakima Firing Center, WA
  Hohenfels Trn'g Area, FRG
  Camp Ripley, MN
  Headquarters NGB, MD

• Planned:
  * Fort Belvoir, VA
    Fort Polk, LA
    Fort Bliss, TX
    Fort McClellan, AL
    Fort Chaffee, AR
    Fort Knox, KY
    Fort Sill, OK
    Fort Leonard Wood, MO
    Orchard Trn'g Range, ID
CORPS SITES USING GRASS

- **Current:**
  - Fort Worth
  - Little Rock
  - Rock Island
  - St. Paul
  - CERL
  - ETL
  - WES

- **Planned:**
  - * Chicago
  - Mobile
  - * New Orleans
  - Omaha
  - Portland
  - St. Louis
  - Tulsa
  - Vicksburg
  - Walla Walla
  - New England Division
  - Southwest Division
  - CRREL
GRASS DEVELOPMENT

- Government-developed, Public Domain
- Multi-Agency Participation
- Portable, Multi-Host
- Open Design Philosophy
# HARDWARE PLATFORMS RUNNING GRASS

<table>
<thead>
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<tr>
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<td>MASSCOMP</td>
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<tr>
<td>AT&amp;T 6386</td>
<td>OPUS PC-TEKTRONIX</td>
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<td>COMPAQ 386</td>
<td>PC CLIPPER</td>
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<td>DELL 386</td>
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<td>HP 9000</td>
<td>SILICON GRAPHICS IRIS</td>
</tr>
<tr>
<td>IBM-RT</td>
<td>SUN (3's, 4's &amp; 386i)</td>
</tr>
<tr>
<td>VAX</td>
<td>APPLE MACINTOSH II</td>
</tr>
</tbody>
</table>
INSTITUTIONAL STRUCTURES GUIDING GROWTH

- GRASS Inter-Agency Steering Committee
- Annual GRASS User Group Meeting
- GRASS Distribution & Support Centers
  - ITD/SRSC
  - DBA Systems
  - Central Washington University
  - USACERL
  - Soil Conservation Service
  - National Park Service
- GRASS Training Courses
- GRASS Software Documentation
- Quarterly GRASS Newsletter
DOCUMENTATION SUPPORTING
GRASS/GIS IMPLEMENTATION

GRASS USER'S REFERENCE MANUAL
GRASS PROGRAMMER'S MANUAL
GRASSCLIPPINGS NEWSLETTER

GRASS IMPLEMENTATION GUIDE
GRASS APPLICATIONS GUIDE
GRASS USER'S GUIDE - APPLICATION EXAMPLES
GRASS PROBLEM-SOVING MANUAL
METHODOLOGY FOR PERFORMING A RETURN
ON INVESTMENT STUDY FOR GRASS
THE LAND ANALYSIS GROUP

STAFF AND ORGANIZATION

**Subgroups**
- Software Design
- Cartography and Data Development
- Analysis and Applications
- Technology Transfer

**Technical Disciplines**
- Archaeology
- Computer Science
- Forestry
- Geography
- Landscape Architecture
- Mathematics
- Soil Science
- Urban Planning
THE LAND ANALYSIS GROUP

HARDWARE

Communications & Documentation  Pyramid 90x

GIS Equipment:  
- Sun 4/280  Masscomp 5450
- Sun 4/110  Masscomp 5500
- Sun 3/60 (6)  Masscomp 500
- Sun 386i (2)  Interpro 240
- Sun 150 (2)  Compaq 386/25
-  
- Compaq 386/16
- Apple Mac IIx

Digitizers:  Altek, Calcomp (2), Geographics (2), Kurta

Output Devices:  
- Calcomp 1043 (plotter)  Tektronix (ink jet)
- Imagen (laser printer)  Shinko (thermal)

All machines linked via NFS over ethernet.
THE LAND ANALYSIS GROUP

SOFTWARE

GRASS
- GIS and Image Processing

MAPGEN
- Cartographic Output

Intergraph
- Digital Terrain Model and CADD

ETIS
- Soils Information System
- Economic Impact Forecast System
- Environmental Legislative System
- Bulletin Boards (GISTALK, CRIBB)

TAE
- Transportable Application Executive

X
- Window/Graphics Interface

VICAR,
- Image Processing

ERDAS

S
- Statistical Package

CRIS
- Cultural Resource Mgmt

Dbase,
- DBMS

Empress,
- RIM, Oracle

AutoCAD
- CADD
THE LAND ANALYSIS GROUP

GRASS/GIS RELATED SERVICES

- Introductory Information on GRASS and GRASS Applications
- Distribution of Software and Documentation
- Hardware Configuration and/or Acquisition Information
- On-site Installation of Software and Hardware
- Telephone Support for Software
- Data Acquisitions Assistance
- Data Conversions between various Formats and Media
- Data Digitizing
- Applications and Data Analysis Assistance and Services
- New Drivers for Hardcopy Devices, Digitizers, and Display Devices
- Hardware System Management Support
- Networking Consultation and Guidance
GRASS ANALYTICAL FUNCTIONS

• **Analytical Tools:**
  - Boolean Overlays
  - Weighted Overlays
  - Inference "Rule-Based"
  - Grid Cell Math Calculations
  - Image Classification
  - Distance Zones
  - Neighborhood Filters
  - Mask Creation
  - Coincidence Tabulation
  - Raster/Vector Conversions
  - Area Calculations
  - Reclassification

• **Analytical Models:**
  - Trajectory Analysis
  - Watershed Dynamics
  - Noise Contours
  - Erosion Prediction
  - Site Evaluation
  - Damage Assessment
  - Corridor Selection
  - Site Allocation
  - Site Prediction
GRASS MAPPING FUNCTIONS

- Vector Digitizing, Edit & Display
- Raster 2-D and 3-D Display
- Site Display & Analysis
- Labeling & Legends
- Raster Hardcopy Devices:
  - Ink Jet
  - Thermal
  - Impact
  - Electrostatic
- Input of Data from:
  - DMA DTED
  - USGS DEM
  - USGS DLG
  - SPOT
  - Landsat MSS & TM
  - Commercial Formats
  - Hardcopy Maps
Subject: Managing Hazardous and Toxic Wastes - GIS Applications

SLIDE 1
INTRODUCTION

SLIDE 2
PROBLEM - MULTI-PLATFORMS

SLIDE 3
COMMON DATA BASE

SLIDE 4
CONTRACT COMPONENTS
SLIDE 5
APPLICATION SOFTWARE

SLIDE 6
CADD AUTHORITY

SLIDE 7
CADD FACTS

SLIDE 8
MAX RETURN / MIN TIME

SLIDE 9
CADD CENTER

2 - d2
SLIDE 10

OBJECTIVES

IMPLEMENTATION
COORDINATION
INTEGRATION
TRAINING

SLIDE 11

IMPLEMENTATION

IDENTIFY H/W & S/W FOR APPLICATIONS
H/W & S/W ADVANTAGES/DISADVANTAGES
PROMOTE ENHANCEMENTS/MODIFICATIONS
IDENTIFY STD H/W FOR DATA EXCHANGE/SUPPORT

SLIDE 12

COORDINATION

IDENTIFY AREAS OF EXPERTISE
PROMOTE SHARING OF LESSONS LEARNED
SOLICIT SUPPORT FROM MANAGEMENT
ENHANCE EXCHANGE OF DATA

SLIDE 13

INTEGRATION
SLIDE 15

INTEGRATION

AUTOMATE THE DESIGN PROCESS
ESTABLISH STD FORMATE FOR GRAPHICS/DB/OBJECTS
STANDARIDIZE DATA CONVERSION
(SURVEYS, MAPPING, & ANALYSIS)
DEVELOP INTERFACES TO OTHER PROGRAMS

SLIDE 16

TRAINING

ENHANCE EXISTING TRAINING
DEVELOP ADVANCED/SPECIALIZED APPLICATIONS

SLIDE 17

CADD CTR DIAGRAM
SLIDE 18

RELATIONSHIP OF CADD/GIS

DIFFERENCES
  OBJECT-ORIENTED
  SPATIAL ANALYSIS

SIMILARITIES
  GRAPHIC DISPLAY
  DATA BASE ATTRIBUTES
  DATA ANALYSIS

SLIDE 19

CADD/GIS USES

REAL ESTATE (LEASES/OWNERSHIPS)
TERRAIN MODELS
COORDINATE DATA/ANALYSIS
HYDROGRAPHIC BASIN ANALYSIS
LAND USE MODELING/ANALYSIS
EROSION & INFILTRATION ANALYSIS
URBAN PLANNING & ASSESSMENT
UTILITY LAYOUTS & PLANNING

SLIDE 20

KINGS BAY TITLE
SLIDE 35

CADD CTR SUPPORT (Conclusions)

APPLY ADVANTAGES OF CADD TO GIS
DIGITAL MAPPING CAPABILITIES
INTEGRATE EXISTING DATA BASES
ENHANCE OUTPUT DISPLAY OF DATA
MISSION
To enable the Corps of Engineers to achieve the best use of CADD within the shortest time frame.

PURPOSE
The CADD Center is the Corps vehicle for sharing information and development work and minimizing duplication of effort while retaining local automonies and decentralized organizational structures.

MODE OF OPERATION
The Center is an end-user driven, technology transfer oriented organization. Single-Discipline Task Groups (SDTG) are formed under headquarters guidance to get field office grass roots input into CADD activities. A Field Technical Advisory Group (FTAG) provides the guidance to the Center.

OBJECTIVE
To integrate and implement CADD by:
- Furnishing technical advice
- Conducting training
- Evaluating products
- Providing advisory teams
- Initiating studies
- Promoting communications
- Distributing products

ORGANIZATIONAL CHART

FUNCTIONAL CHART

CADD Center
Points of Contact

Information Technology Laboratory
Chief, Dr. N. Radhakrishnan
Chief, Dr. Ed Middleton
CADD Center
Chief, Mr. Sandy Stephens
Mr. John Hood
Mr. Richard Bradley
CPT Mike Conrad

"GUIDED BY THE FIELD"

US Army Corps of Engineers
CADD Center
Information Technology Laboratory
Waterways Experiment Station
PO Box 631
Vicksburg, Mississippi 39181-0631

Office Symbol: CEWES-IM-DA
Mail Code: CEWES-IM-1A
(601) 634-4109
1-800-LAB-6WES

CEWES-IM-Z
(601) 634-2527

CEWES-IM-D
(601) 634-4020

CEWES-IM-DA
(601) 634-2945
(601) 634-3138
(601) 634-2286
(601) 634-2947
OBJECTIVES

- IMPLEMENTATION
- COORDINATION
- INTEGRATION
- TRAINING
IMPLEMENTATION

- IDENTIFY H/W & S/W FOR APPLICATIONS
- H/W & S/W ADVANTAGES/DISADVANTAGES
- PROMOTE ENHANCEMENTS/MODIFICATIONS
- IDENTIFY STD H/W FOR DATA EXCHANGE/SUPPORT
COORDINATION

- Identify Areas of Expertise
- Promote Sharing of Lessons Learned
- Solicit Support from Management
- Enhance Exchange of Data
INTEGRATION

- AUTOMATE THE DESIGN PROCESS
- ESTABLISH STD FORMATE FOR GRAPHICS/DB/OBJECTS
- STANDARDIZE DATA CONVERSION
  - SURVEYS, MAPPING, & ANALYSIS
- DEVELOP INTERFACES TO OTHER PROGRAMS
TRAINING

- ENHANCE EXISTING TRAINING
- DEVELOP ADVANCED/SPECIALIZED APPLICATIONS
CADD/GIS

(HAZARDOUS & TOXIC USES)

- REAL ESTATE (LEASES/OWNERSHIPS)
- TERRAIN MODELS
- COORDINATE DATA/ANALYSIS
- HYDROGRAPHIC BASIN ANALYSIS
- LAND USE MODELING/ANALYSIS
- EROSION & INFILTRATION ANALYSIS
- URBAN PLANNING & ASSESSMENT
- UTILITY LAYOUTS & PLANNING
CADD CENTER GIS SUPPORT

- APPLY ADVANTAGES OF CADD TO GIS
- DIGITAL MAPPING CAPABILITIES
- INTEGRATE EXISTING DATA BASES
- ENHANCE OUTPUT DISPLAY OF DATA
POTENTIAL GROUPS

- HYDRAULICS & HYDROLOGY
- REAL ESTATE
- OPERATIONS
- DEH
INTRODUCTION

CONCEPTS TO CONSIDER

FUNCTIONALITY
COSTS

COMPATIBLE DATA

MULTIPLE PLATFORMS
SLIDE 5

HARDWARE/SOFTWARE SUPPORT

SLIDE 6

ADDITIONAL CONCEPTS TO CONSIDER

EXISTING H/W & S/W
  INPUT/OUTPUT DEVICES
ADP PROGRAMMING SUPPORT
H/W & S/W SUPPORT
MAINTENANCE
TRAINING PERSONNEL

SLIDE 7

TYPES OF R&D PROJECTS

SINGLE APPLICATION
MULTIPLE APPLICATIONS
  HOW TO APPLY ANALYSIS
  FOA'S TECHNICAL ABILITIES
  PERSONAL AVAILABLE
  EXISTING EQUIPMENT
  DATA INPUT REQUIREMENTS
CONCEPTS TO CONSIDER

- FUNCTIONALITY
- COSTS
ADDITIONAL CONCEPTS TO CONSIDER

- EXISTING H/W & S/W
- INPUT/OUTPUT DEVICES
- ADP PROGRAMMING SUPPORT
- H/W & S/W SUPPORT
- MAINTENANCE
- TRAINING PERSONNEL
TYPES OF R&D PROJECTS

- SINGLE APPLICATION
- MULTIPLE APPLICATIONS
- HOW TO APPLY ANALYSIS
- FOA'S TECHNICAL ABILITIES
- PERSONNEL AVAILABLE
- EXISTING EQUIPMENT
- DATA INPUT REQUIREMENTS
LABORATORY PERSPECTIVE/OBJECTIVES

O BASIC RESEARCH

O APPLIED RESEARCH

O BALANCE

O PRESENT REQUIREMENTS

O 3-5 YEAR OBJECTIVES
Demonstration of Prism and Stella Software for the Corps of Engineers Toxic and Hazardous Waste Management Program

by

Alan Cassell, Perry LaPotin, Harlan McKim
Cold Regions Research and Engineering Laboratory
72 Lyme Road
Hanover, NH 03755-1290

Brief Description of presentation

given at

Meeting on

Managing Hazardous and Toxic Waste Information: GIS Applications
Denver, CO

August 8-11, 1989
The movement of toxic and hazardous materials through soil systems is a function of the pattern of water movement through the soil matrix and the physical/chemical interactions between the soil particles and the hazardous material itself. Given the spatially variable nature of soil systems, the dynamic transport characteristics of the waste material also vary spatially. The formulation and use of models to predict the spatially variable behavior of waste movement in such complex systems has been difficult and largely unavailable to operating agencies.

STELLA is an object oriented programming environment that operates on the Macintosh computer. STELLA is specifically designed to simulate dynamic systems and is well adapted to model interactive networks. STELLA is a commercially available software package in which the user creates structural diagrams on the screen that describes the dynamic system of interest. Thus models based on interacting differential equations with constant and variable coefficients are rapidly and easily created and tested. This demonstration shows a STELLA model that simulates the movement of a toxic and hazardous material through a spatially variable two dimensional soil system. The output from the STELLA model serves as input to additional software that provides high quality animation of the simulated movement of waste over time through the network. The total effort required to produce this complex model and sophisticated output was less than two days.

Figure 1 shows the structural diagram of the simplified spatial model. The rectangular structures accumulate the waste over time that flows into and out of each rectangle through the pipelines. The circular structures attached to each pipeline (controllers) contain the logic that regulates the flow-rate in each pipeline. In the model, each rectangle can be thought of as representing a pixel (or some unit of land area). Since each rectangle is attached (through the connecting pipelines) to adjacent rectangles, the condition in any one rectangle at any time is interactively reflected in adjacent rectangles (or areas). Thus a truly interactive two-dimensional system has been created.

The simulation is started by initiating water flow through the pipelines into the network from the left side of the network. High concentrations of waste was assumed to exist in rectangle 32 at time zero (i.e. a simulated waste site). Additionally, at times of 40 and
110 units into the simulation run, a slug input of waste was assumed to enter the system through controller IN 3.

Figures 2 and 3 show the dynamic simulations relationship of the relative waste concentrations in each rectangle (or for each area) versus elapsed time. Figure 2 shows the propagation of the waste through the system along the longitudinal axis, whereas Figure 3 depicts movement along the transverse axis. The model clearly shows the dynamic nature of both longitudinal and transverse dispersion as the waste moves through the system. While this unverified model is based on simple washout dynamics in two dimension, with additional research it will be possible to develop and verify such models that can operate in 3 dimensions while at the same time incorporating appropriate algorithms that describe unsaturated and saturated flow conditions and soil/contaminant interaction reactions.
Figure 1. Simplified Dynamic Spatial Model
Figure 2. Longitudinal Waste Propagation
Figure 3. Transverse Waste Propagation
ETL ACTIVITIES IN GIS

- GIS EVALUATION
- DTSS
- ALBE
ARMY GIS EVALUATION

STUDY PERFORMANCE CONSIDERATIONS OF OFF-THE-SHELF GIS'S

SYSTEMS LOANED TO ETL FOR R&D EVALUATION ON COST-REIMBURSABLE BASIS

CONCENTRATE ON ENGINEERING WORKSTATIONS & DESKTOP MICROS
Incur minimal costs •

"Smart Buy" statute

Enables government to maintain

Enhances government knowledge base •

Projects & applications

Provides support for numerous

Advantages to government

Army GIS evaluation
PROJECTS WITH GIS REQUIREMENTS AT ETL

Commander's Aid for Reasoning About Terrain (CARAT)  6.1
Expert System for Minefield Site Detection  6.1
Advanced Digital Radar Image Exploitation System (ADRIES)  6.1-6.2
*Army GIS Evaluation  6.2
*Soldier-to-GIS Interface Research  6.2
Brigade Integration of Digital Data  6.2
Computer Image Generation Facility  6.2
DTSS Softcopy Image Exploitation Research  6.2
Terrain Information Extraction System (TIES)  6.2
TAC Modernized Production Facility  6.2 - OMA
ALBE Terrain Demonstration System  6.3
Digital Topographic Support System (DTSS)  6.4
DMA Digital Data Demonstration System  OMA
ARMY GIS EVALUATION
PREREQUISITES

DEVELOPMENT OF PRELIMINARY (BASELINE) REQUIREMENTS

FORMULATION OF PERFORMANCE STANDARDS FOR REQ'S

DEVELOPMENT OF EVALUATION CRITERIA - BENCHMARKS

ACQUISITION OR SYNTHESIS OF GIS DATA BASES FOR TESTS
GIS PERFORMANCE STANDARDS

ACCURACY
- Map Accuracy Standards
- Data Quality Requirements

FUNCTIONAL COMPLETENESS
- Consistency of Results

TIME
- Skill Development Time
- User Speed of Performance

UTILITY
- User Satisfaction
- Usefulness of Product Generated

EFFICIENCY OF SYSTEM OPERATION
GIS BENCHMARKS

USER INTERFACE
SKILL ACQUISITION TIME
REVERSABILITY OF OPERATIONS

DISPLAY & PRODUCT GENERATION
ACCURACY OF PLOT / SCALING
TIME TO ASSIGN & PLOT
CORRELATION BETWEEN DISPLAY & PLOT

DATA BASE CREATION /
DATA ENTRY
TIME / STEPS TO SET UP
TIME TO DIGITIZE
ERROR DETECTION

SYSTEM/ DATA BASE MANAGEMENT
DATA BASE UPDATE PROCEDURES
QUERY CAPABILITY EASE & LIMITS
ATTRIBUTE LOADING & EDITING

ANALYSIS & MANIPULATION
TERRAIN MODELING SIMULATIONS
BOOLEAN OVERLAY ACCURACIES & TIME
EASE OF WRITING/ IMPLEMENTING MACROS
ACCURACY OF MEASUREMENTS
GENERATION OF BUFFER ZONES
ABILITY TO CONVEY RELATIONSHIPS BETWEEN FEATURES & ENTITIES
PROJECTION TRANSFORMATION ACCURACIES
UNIT CONVERSION ACCURACIES
GIS PROBLEM AREAS

USER INTERFACE
SKILL ACQUISITION TOO LENGTHY
OVER RELIANCE ON USER'S MEMORY
LIMITED SENSE OF LOCUS OF CONTROL
LACK OF FORGIVENESS IN OPERATIONS

SYSTEM/ DATA BASE
MANAGEMENT
INTEGRITY OF DATA BASE NOT GUARDED
QUERY CAPABILITY LIMITED
ATTRIBUTE HANDLING INADEQUATE
LINKS BETWEEN GRAPHIC & ATTRIBUTES
CUMBERSOME

DISPLAY & PRODUCT
GENERATION
CARTOGRAPHIC CAPABILITIES CRUDE
LIMITED SUITE OF OUTPUT DEVICES

DATA BASE CREATION /
DATA ENTRY
DATA BASE CREATION TOO TIME CONSUMING
EDITING PROCESS CUMBERSOME
DATA QUALITY CHECKS LIMITED

ANALYSIS & MANIPULATION
COMPLEX MODELS DIFFICULT TO IMPLEMENT
EXECUTION TIMES TOO LONG
INCONSISTENT RESULTS IN SPATIAL ANALYSIS FUNCTIONS
DIGITAL TOPOGRAPHIC SUPPORT SYSTEM

SPECIAL PURPOSE PRODUCT BUILDER (SPPB)

1. AD HOC (SPECIAL) PRODUCT GENERATION
   Airstrip Site Selection
   Potential Bivouac Sites
   Bridge Bypass Potential
   Lines of Communication
   River Crossing
   Air Avenues of Approach
   Others

2. SYMBOLIZATION/ATTRIBUTE MODELING/PROXIMITY ANALYSIS

3. COMBINATION PRODUCTS (STACKING)

   **FOREGROUND**
   Masked Area Plot
   Target Acquisition
   Flight Line Masking
   Path Loss/Line of Sight
   SPPB

   **BACKGROUND**
   Cross Country Movement
   Concealment
   Drop Zone
   Helicopter Landing Zone
   SPPB
ALBE TECHNOLOGY DEMONSTRATIONS

DESCRIPTION: Army Technology Demonstration Program
              P.E. 0603734A, Project DT08

MANAGED BY: U.S. Army Corps of Engineers

EXECUTED BY: U.S. Army Engineer Topographic Laboratories

PARTICIPANTS: Atmospheric Sciences Laboratory (AMC/LABCOM)
              Cold Regions Research and Engineering Laboratory
              Engineer Topographic Laboratories
              Waterways Experiment Station
# ALBE GIS

<table>
<thead>
<tr>
<th>GOALS</th>
<th>DESIGN DECISIONS</th>
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<tbody>
<tr>
<td>Provide required functions to TDA Programmers</td>
<td>Library of GIS subroutines callable from Fortran, C</td>
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<tr>
<td>Consistent user interaction and graphics standards across all ALBE components</td>
<td>Use of ALBE User Interface and Graphic (GKS) libraries throughout the GIS</td>
</tr>
<tr>
<td>Avoid tying up workstation during lengthy computations</td>
<td>Optional batch utilities for time-consuming GIS functions</td>
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</table>
GOALS

Ability to query and retrieve data related to GIS objects from a DBMS

DESIGN DECISIONS

GIS "loosely coupled" to DBMS databases via a relation to associate GIS object IDs to DBMS record keys

Ability to create and operate user-defined GIS databases in self-contained mode (without a DBMS)

1) Optional storage of up to 63 GIS attributes per vector object in GIS data structures

2) Attribute dictionary to define and describe attributes
<table>
<thead>
<tr>
<th>GOALS</th>
<th>DESIGN DECISION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rapid response to most map query, manipulation, and display requests</td>
<td>Capacity to load and maintain large map data sets in internal data arrays</td>
</tr>
<tr>
<td>Ability to manipulate and display vector and cell data (incl. raster images) concurrently</td>
<td>Concurrent internal vector and cell data storage structures and logical overlay software</td>
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<tr>
<td>Ability to change level of display detail based on scale of display</td>
<td>Automatic map decluttering capability with user-selectable parameters</td>
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<tr>
<td>ALBE GIS INTERNAL DATA</td>
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<td>------------------------</td>
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<tr>
<td>VECTORS</td>
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<tr>
<td>OBJECT TYPES:</td>
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<tr>
<td>POINT</td>
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<tr>
<td>NODE</td>
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<td>ARC</td>
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<td>POLYGON</td>
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<td>COMPLEX OBJECT</td>
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<td>INFORMATION CONTENT:</td>
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<td>SPATIAL</td>
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<td>TOPOLOGICAL</td>
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<td>GRAPHICAL</td>
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<tr>
<td>DESCRIPTIVE</td>
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</tbody>
</table>

| CELL/RASTER           |
| ONE ATTRIBUTE PER FILE|
| CELL OR RASTER (GRID) |
| REPRESENTATION        |
| DATA TYPES:           |
| DICHTOMOUS            |
| DISCRETE CATEGORICAL |
| DISCRETE ORDERED      |
| CONTINUOUS            |
| STORED IN COORDINATES|
| OF SPECIFIED MAP      |
| PROJECTION            |
ALDE GIS 2.0

* STATE-OF-THE-ART TECHNOLOGY

* HYBRID OF AMS, MOSS, MAPS, AND BATTELLE DIOGART FUNCTIONALITY

* CONCURRENT VECTOR AND CELL PROCESSING

* RELATIONAL DATABASE

* DYNAMIC DISPLAY OF SPATIAL DATA
DEFENSE MAPPING AGENCY

MARK SHELBERG
DEFENSE MAPPING AGENCY SYSTEMS CENTER
ST. LOUIS, MISSOURI

OPTICAL DISC INITIATIVE
PROJECT LEADER

(314) 263-4486
WHO IS THE DEFENSE MAPPING AGENCY

- Enhance national security and support our strategy of deterrence by producing and distributing to the Joint Chiefs of Staff, Unified and Specified Commands, Military Departments and other DoD users, timely and uniquely-tailored mapping, charting, and geodetic products, services, and training

- Insure our war-fighting forces have available to them effective mapping, charting, and geodetic support should our strategy of deterrence fail

- Provide nautical charts and marine navigational data to worldwide merchant marine and private vessel operators

- Employs nearly 9,000 people in more than 50 locations around the world
OPTICAL DISC GOALS

Assistant Secretary of Defense Latham’s Guidance

- "... develop a standard data specification in response to [Aircraft] Moving Map Display information requirements ..."

- "... take the lead in establishing a DoD optical disc standard ..." for Mapping, Charting and Geodetic (MC&G) data

- "... explore which additional MC&G information sets are appropriate for exchange via optical disc ..."
DIGITAL RASTER MAP DATA SPECIFICATION

ARC Digitized Raster Graphics (ADRG)

- 250 lines per inch (100 microns)

- 24 bits color (8 bits Red, Green, Blue)

- Data on Equal Arc-Second Raster Chart/Map (ARC) Projection System

- Status of Specification - Final Version: April 1989
OPTICAL DISC STANDARD

DMA'S Decision In Selecting CD-ROM Was Based On:

- Available standards
  Physical - ECMA and Yellow Book
  Logical - ISO 9660 (High Sierra)

- Non-proprietary technology

- Cost and availability of media and hardware

- Excellent mass distribution media
PROTOTYPE DEVELOPMENT

ADRG Production Prototype
- Contains:
  Disc#1 - JOG-As # NI 11-2,3,5,6
  over China Lake
  Disc#2 - TLMs # 6446 I,II,III,IV
  over the Fort Hood area
  Disc#3 - TPC G-18B over China Lake

- Distribution Schedule
  Disc#1 - 31 October 1988
  Disc#2 - 15 November 1988
  Disc#3 - 14 April 1989
ADRG PRODUCTION PLANS

- FY 89 Production about 1800 map sheets
  (460 CD-ROMs)

- Post FY 89 Production about 1200 to 2000 sheets per year

- FY 89 Production areas:
  ONCs, TPCs and JOGs over the U.S.
  JOG-Gs and TLMs over Germany

- Planned FY 90 Production areas:
  Complete the ONCs and TPCs worldwide
  Limited JOGs and TLMs
  Maybe GNCs and JNCs
DIGITAL TERRAIN ELEVATION DATA (DTED) ON CD-ROM

- DTED consists of a uniform matrix of terrain elevation values spaced every 3 ARC seconds

- CD-ROM will contain DTED, Digital Mean Elevation Data (a more coarsely spaced elevation matrix) and a gazetter

- Two prototypes issued and evaluated

- Production implementation in process

- All DMA data on CD-ROM by middle of 1990
WORLD VECTOR SHORELINE

- Vector data base format
- Shoreline at 1:250,000
- Political boundaries from 1:1,000,000 chart source
- Prototype produced in May 1989
ADDITIONAL DIGITAL DATA ACTIVITIES

- Digital Feature Analysis Data (DFAD)
- Digital Chart of the World (1:1 million fully attributed vector data base)
- Electronic Chart Update Manual
- Tactical Terrain Data
THE FUTURE

- DMA is committed to CD-ROMs for distribution of most of its digital product data

- CD-ROM is a good potential for other products eg. DMA catalogs and DMA product specifications

- DMA continues to track other media for use when appropriate such as WORM and erasable optical disks
CD-ROM IMPLEMENTATION STEPS

- Feasibility study
- System design
- Data requirements
- Product specification
- Data creation and preparation
- System simulation
- Premastering
- Mastering and replication
- Packaging, documentation, marketing and distribution
LESSONS LEARNED

- Use available standards
- If you are not an expert, get someone who is
- Know your users and their systems
- Develop a good data structure
- Use/Copy examples
- Generate prototypes, release data early on magnetic tape if possible
- The mastering/replication phase is the easiest except if your artwork is not on time or it is wrong
VENDORS & UNIVERSITY
PRESENTATION
MATERIALS

A. DBA
B. AUTOMETRICS
C. PURDUE UNIVERSITY
D. ESRI
DBA GIS EXPERIENCE

GRASS GIS
AIRLAND BATTLE ENVIRONMENT/GIS
GEO-INTEL
GRASS GIS SUPPORT SERVICES

DBA GRASS WORKSTATION SUPPORT
- SUN 3, SUN 4, SUN 386i
- TEKTRONIX 43xx
- TURNKEY SYSTEMS

SOFTWARE DISTRIBUTION
- INSTALLATION
- TRAINING

TECHNICAL SUPPORT
- GRASSNET CONNECTION
- TELEPHONE CONSULTATION
- CUSTOM ENHANCEMENTS
DATA BASE GENERATION

DATA INPUT - HARDCOPY TO RASTER

IMAGE SCANNING
DBA DESIGNS AND MANUFACTURES HIGH RESOLUTION IMAGE SCANNERS
- 20K CCD LINEAR ARRAY SENSORS
- RESOLUTION - 11 MICRONS AT 12 BITS/PIXEL
- ABILITY TO SCAN 20K X 20K IMAGE IN LESS THAN TWO MINUTES
- ACCOMODATES ROLL AND FLAT FILM - BARCODE SCANNER
- 9" X 9" FORMAT

DBA MANUFACTURES MEDIUM RESOLUTION IMAGE SCANNERS
- 5K SINGLE CCD CHIP LINEAR ARRAY
- 35 AND 70 MICRON RESOLUTION
- 7" X 17" AND 14" X 17" FORMATS

MAP SCANNING
DBA SCANS HARDCOPY MAPS AND IMAGERY AT VARIOUS SCALES AND RESOLUTIONS
- 25 - 250 MICRONS
- COLOR COMPRESSION
- DATA WARping
DATA BASE EXPLOITATION

IMAGE MANIPULATION
- DATA INCLUSION
- DATA EXCLUSION
- DATA EXTRACTION
  - TERRAIN DATA/MICRO RELIEF
  - HIGH RESOLUTION FEATURE DATA

DATA EDIT/ENHANCEMENT

APPLICATION SOFTWARE

DATA BASE MANAGEMENT
## DIGITAL CARTOGRAPHIC RESEARCH LABORATORY

### CAPABILITIES DEVELOPMENT OVERVIEW

#### PRODUCTION

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<td>Feature Attributing</td>
<td>Inclusion</td>
<td>AI Techniques</td>
<td></td>
<td>Tailored Output</td>
<td>Hardcopy</td>
</tr>
<tr>
<td>New Sources</td>
<td>Exclusion</td>
<td></td>
<td></td>
<td>Functional Use</td>
<td></td>
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<tr>
<td>Multi-Spectral</td>
<td>GIS Functions</td>
<td></td>
<td></td>
<td>AI Techniques</td>
<td></td>
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<tr>
<td>SAR</td>
<td>AI Techniques</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
MOSS Family

- MOSS (Map overlay Statistical System)-point, line, polygon analysis
- MAPS (Map Analysis and Processing System)-cell/raster analysis
- AMS (Analytical Mapping System)-data entry and edit
- COS (Cartographic Output System)-automated hardcopy output
- UTILITY-Misc. Utility Programs
- REFORM-Data Reformatting Programs
Federal Agencies Using MOSS

- U.S. Corps of Army Engineers
- National Park Service
- Soil Conservation Service
- Bureau of Indian Affairs
- U.S. Geological Survey

- U.S. Forest Service
- Los Alamos and Sandia National Laboratories
- Bureau of Land Management
- U.S. Fish and Wildlife Service
Milestones in the Evolution of MOSS

- 1976 - AMS developed as first arc/node data entry system
- 1977-8 - Initial development of MOSS
- 1979 - AMS and MOSS used in production environment
- 1980 - Integration of AMS and MOSS
- 1982 - Integration of MOSS and MAPS
- 1983 - First MOSS User's Conference
- 1986 - DOI hardware procurement for MOSS
- 1988 - Fortran 77 version of MOSS
- 1989 - 32-bit version of MOSS
The Evolution of MOSS

DG 32-bit
Tek WS
Prime 32-bit
VAX-UMS
HP-UX
ATT-382
DG 16-bit
<table>
<thead>
<tr>
<th>Significant Features of the Spring 1989 MOSS/MAPS Release</th>
</tr>
</thead>
<tbody>
<tr>
<td>• FORTRAN 77</td>
</tr>
<tr>
<td>• Virtual Memory</td>
</tr>
<tr>
<td>• Consistency</td>
</tr>
<tr>
<td>• Reliability</td>
</tr>
<tr>
<td>• Primatives</td>
</tr>
<tr>
<td>• Color</td>
</tr>
<tr>
<td>• Precision</td>
</tr>
<tr>
<td>• Data Conversion</td>
</tr>
<tr>
<td>• Map Files</td>
</tr>
<tr>
<td>• Directory Structure</td>
</tr>
<tr>
<td>• Projection</td>
</tr>
<tr>
<td>• Active maps</td>
</tr>
<tr>
<td>• System Parameters</td>
</tr>
<tr>
<td>• Raster MOSS</td>
</tr>
</tbody>
</table>
DATABASE RETRIEVAL

- SELECT ENTIRE MAP
- SELECT SINGLE FEATURE
- SELECT FEATURES WITH CERTAIN SUBJECT AND ATTRIBUTE CODES
- APPLY BOOLEAN LOGIC INVOLVING MULTIPLE ATTRIBUTES
- RETRIEVE BY SIZE OR LENGTH CRITERIA
- RETRIEVE SEVERAL MAPS
- SELECT FEATURES IN A GIVEN AREA
- SELECT BASED ON A PROXIMITY OR CONTIGUITY
- RANDOMLY SELECT FEATURES
MULTIPLE ATTRIBUTE ANALYSIS

- Generic Interface to Flat File
- Specific Interface to SQL Database
- Create and Edit Attributes
- Summary Reports to Screen or File
- "Spreadsheet" Functionality
- Graphic Query
- Retrieve Using Map and Attribute Data
MOSS Multiple Attributes

MOSS Map

Multiple Attribute File

<table>
<thead>
<tr>
<th>Subject</th>
<th>Area</th>
<th>Tree Type</th>
<th>SI</th>
<th>Planted</th>
</tr>
</thead>
<tbody>
<tr>
<td>052F</td>
<td>320</td>
<td>DF</td>
<td>55</td>
<td>1947</td>
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<tr>
<td>195A</td>
<td>295</td>
<td>PP</td>
<td>90</td>
<td>1938</td>
</tr>
<tr>
<td>172B</td>
<td>332</td>
<td>DF</td>
<td>70</td>
<td>1968</td>
</tr>
<tr>
<td>362C</td>
<td>390</td>
<td>LP</td>
<td>65</td>
<td>1972</td>
</tr>
</tbody>
</table>

052F
195A
172B
362C
ELEVATION (X, Y, Z) ANALYSIS

- IMPORT DEM DATA
- CONVERT CONTOUR LINES TO DEM
- CONVERT VECTOR MAPS TO CELL MAPS
- POINT-TO-GRID INTERPOLATION
- CREATE CONTOUR LINES
- AUTOMATICALLY LABEL LINES
- DISPLAY CROSS-SECTION OR PROFILE
- CALCULATE SLOPE, SLOPE LENGTH, ASPECT
- DETERMINE VISIBILITY
- DISPLAY A 3-D PERSPECTIVE
Autometric Software Subscription Service

ON-CALL SUPPORT

- Magnetic Tapes
- Software Problem Reports
- Phone Correspondence
- Software Correction Reports
- Field Office Trips
MOSS and MAPS System Interfaces

- MOSS
  - ADS
    - ADS2MOS
    - MOSS2ADS
    - MOSS2LGS
    - PARCEL
    - CNVADS
    - EMACS
    - REV6TO7
    - PCCS
  - ADS REV 6
  - Edited Ads File
  - CNVADS
  - EMACS
  - REV6TO7
  - PCCS2ADS
  - PCCS
  - PCCS2LGS
- MAPS
  - CONTOUR AND POLYCELL
  - SPSS
  - MOSS2LGS
- COS
  - COS Main Menu 13
  - Text File of Cell Data
- IDIMS
  - IMPORT (HAPS)
- USGS DEM DMA DEM
  - POINT AND POLYGON DATA
    - XYSUBJECT
- IMPORT/EXPORT FORMAT
  - DLG3
  - MOSS2LGS
  - MOSS2ADS
  - ADS2MOS
  - ADS TO DLG
  - DLG OPTIONAL FORMAT, ASCII
- DLG STANDARD
  - DGSTO
- PI
  - PITO
  - PITOCHL
  - PCCS2ADS
- PI
  - PITO
  - PITOCHL
  - PCCS2ADS
- MOSS Interfaces
  - HAPSTOIIDIMS
  - IMPORT (HAPS)
Evaluating Groundwater Pollution Potential
Using Geographical Information Systems

by

Douglas D. Hickey

School of Civil Engineering
Purdue University
West Lafayette, Indiana

Outline

☐ Overview of GIS (GRASS)
☐ Groundwater Applications of GIS
☐ Pollution Potential Mapping (DRASTIC)
☐ Model Integration and Results
Definition of GIS
Data Representation

(*Raster vs. Vector*)
Map Overlays in a Grid-cell GIS:

*Each layer contains data for one attribute of interest*
# Common Spatial Analysis Capabilities of GIS

<table>
<thead>
<tr>
<th>OPERATION</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arithmetic</td>
<td>Add, subtract, multiply, and divide existing map layers</td>
</tr>
<tr>
<td>Boolean combinations</td>
<td>Combine groups of attributes from different map layers to form a new map</td>
</tr>
<tr>
<td>Weighting</td>
<td>Assign weights to attributes of several map layers, thereby signifying relative importance</td>
</tr>
<tr>
<td>Coincident tabulation</td>
<td>Chart the mutual occurrences of attributes between two map layers</td>
</tr>
<tr>
<td>Neighborhood</td>
<td>Enhance or subdue an attribute value by considering surrounding values</td>
</tr>
<tr>
<td>Distance proximity</td>
<td>Produce a map layer based on distance from an attribute of an existing map</td>
</tr>
<tr>
<td>Clumping</td>
<td>Group physically discrete areas into a unique attribute value</td>
</tr>
<tr>
<td>Surfacing</td>
<td>Fit a smooth surface by interpolating between known values</td>
</tr>
<tr>
<td>Morphologic operations</td>
<td>Determine characteristics of a given area's shape or form</td>
</tr>
<tr>
<td>Slope</td>
<td>Generate a slope layer from elevation data</td>
</tr>
<tr>
<td>Aspect</td>
<td>Generate an aspect layer from elevation data</td>
</tr>
</tbody>
</table>
The Geographical Resources Analysis Support System

GRASS

1. Grid-Cell Data Analysis
   a. Coincident tabulations
   b. Map overlay tool
   c. Weighted map overlay tool
   d. Neighborhood operations tool
   e. Distances analysis tool

2. Graphical Analysis
   a. Monitor display routines
   b. Hard-copy production routines
   c. Three dimensional display routines
   d. Image enhancement routines (his)

3. Map Generation
   a. Area masking features
   b. Regrouping features
   c. Reclassification features

4. Sites Analysis
   a. Site location tools
   b. Site DBMS tools

5. Map information management
   a. Report preparation utilities
   b. Mapset query utilities
Data Layer Reclassification

<table>
<thead>
<tr>
<th>Original layer</th>
<th>Reclassed layer</th>
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</thead>
<tbody>
<tr>
<td>category</td>
<td>attribute</td>
</tr>
<tr>
<td>0</td>
<td>no data</td>
</tr>
<tr>
<td>1</td>
<td>1 feet</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>30-50</td>
</tr>
<tr>
<td>499</td>
<td>499</td>
</tr>
<tr>
<td>500</td>
<td>500</td>
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<tr>
<td>5</td>
<td>30-50</td>
</tr>
<tr>
<td>6</td>
<td>15-30</td>
</tr>
<tr>
<td>9</td>
<td>5-15</td>
</tr>
</tbody>
</table>
Goals of GIS in Groundwater Engineering

- To provide a comprehensive database of necessary environmental information
- To provide a means for easily updating time-dependent information
- To provide decision support that would otherwise be infeasible or unavailable
- To obtain a conceptual understanding of the groundwater system and the spatial relationships associated with it
- To improve interagency and/or interdepartmental cooperation in the capture, storage, and use of digital geographic data
- To provide a means for producing publication quality illustrations for reports and presentations that can be understood by decision makers
Applications of GIS in Groundwater Engineering

Protection Planning
- Water QualityClassification
- Water Quality Monitoring
- Pollution Potential Mapping
- Relationships Between Quality and Public Health
- Identification of Well Capture Zones
- Identification of Recharge Zones
- Land Use Control

Groundwater Management
- Resource Identification
- Public Well Site Selection
- Water Use Monitoring
- Input and Output for Flow Models
- Remedial Investigations and Feasibility Studies
- Evaluate Impacts of Contamination Incidents
- Quantity Assessment
- Aid in Landfill Site Selection
Empirical Assessment Methodologies.

<table>
<thead>
<tr>
<th>Method</th>
<th>Primary Use</th>
<th>Reference #</th>
</tr>
</thead>
<tbody>
<tr>
<td>EPA</td>
<td>monitoring prioritization</td>
<td>12,32</td>
</tr>
<tr>
<td>Decision tree</td>
<td>waste site selection aid</td>
<td>32</td>
</tr>
<tr>
<td>Criteria list</td>
<td>waste site selection aid</td>
<td>32</td>
</tr>
<tr>
<td>Water balance</td>
<td>landfill assessment</td>
<td>32</td>
</tr>
<tr>
<td>LeGrand</td>
<td>waste site assessment</td>
<td>32</td>
</tr>
<tr>
<td>Hagerty</td>
<td>hazardous waste assessment</td>
<td>32</td>
</tr>
<tr>
<td>Phillips</td>
<td>waste-soil-site combination</td>
<td>32</td>
</tr>
<tr>
<td>DRASTIC</td>
<td>regional protection aid</td>
<td>1</td>
</tr>
<tr>
<td>Canter</td>
<td>oil and gas field activities</td>
<td>12</td>
</tr>
<tr>
<td>G.O.D.</td>
<td>rapid regional assessment</td>
<td>18</td>
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<tr>
<td>LeGrand</td>
<td>waste site evaluation</td>
<td>28</td>
</tr>
<tr>
<td>Stack maps</td>
<td>regional or site assessment</td>
<td>26</td>
</tr>
</tbody>
</table>
DRASTIC
A Standardized System for Evaluating Groundwater Pollution Potential

Function:
\[ D_r D_w + R_r R_w + A_r A_w + S_r S_w + T_r T_w + I_r I_w + C_r C_w = \text{INDEX} \]

Where:
- \( r \) = Rating
- \( w \) = Weight
- \( D \) = Depth to Water
- \( R \) = Net Recharge
- \( A \) = Aquifer Media
- \( S \) = Soil Media
- \( T \) = Topography (Slope)
- \( I \) = Impact of the Vadose Zone
- \( C \) = Hydraulic Conductivity

\text{INDEX} = \text{Pollution Potential Index}
Developing DRASTIC Maps in a GIS Format

AVAILABLE MAPS AND FIELD DATA
DATA CAPTURE

D R A S T I C
D R A S T I C
RECLASSIFICATION

MAP ADDITION MULTIPLICATION

INITIAL POLLUTION POTENTIAL MAP
NEIGHBORHOOD FILTER
SMOOTH POLLUTION POTENTIAL MAP
RECLASSIFICATION NATIONAL COLOR CODE
FINAL POLLUTION POTENTIAL MAP
A presentation on a state-of-the-art geographic database model designed for open architecture and industry standard hardware platforms. Presentation to include discussion of the distributed computing environment, open database architecture, a user interface/application approach, and integration to other related geographic technologies.
Environmental Systems Research Institute
GIS is a Tool
GIS Characteristics

- Geographic & Tabular Data
- Integrated & Shared Data
- Limited Redundancy
- Transactional Updates
- Analysis
- Maps, Reports & Queries
ARC/INFO Data Model

- Geographic
- Tabular
- Topology
Geographic Features

- Points (labels)
  - +1
  - +2
  - +3
  - Wells, Poles
  - Address Location

- Lines
  - Streams, Roads, Pipes, & Spans

- Areas (Polygons)
  - Parcels, Lakes, Counties, Soil Units
Distributed Computing

A Collection of Resources Shared Across a Network
The Integration of Spatial Information Technology

The Next Step
To Analyze and Manipulate Spatial Data

- To Manage Large Spatial Data Sets
- To Analyze Imagery
- To Automate Map Making

Four Distinct Needs
GIS Technology Evolved From
To Meet These Needs Three Kinds of Systems Emerged

- Computer Assisted Drafting (CAD)
- Image Processing
- Geographic Information Systems (GIS’s)
CAD Systems

- Digitally Assist in Drafting & Cartography
- Interactive Graphics
- Data Stored As
  - Sets of Graphic Primitives
    (Lines, Circles, Curves, etc.)
  - Layers
Image Processing Systems

- Digitally Process Remote Sensing
- Image Classification, Analysis, Interpretation
- Data Stored As
  - Image Planes
  - Rasterized Sets
Geographic Information Systems

- Manage Large, Spatially Referenced Databases
- Provide Tools for Spatial Analysis and Modeling
- Data Stored As
  - Spatially Referenced
  - Cartographic Reference Plus Attributes
It is Becoming Possible to Integrate these Three Kinds of Systems and Integrate Their Functions.
The Interrelated Technologies

- Document Scanning Systems
- Image Processing
- Raster GIS
- Vector GIS
- DBMS
- CADD Systems
- Video Image Data
Integration Tools

- GIS–DBMS (Feature/Record)
- GIS–CADD/Image (Feature/Image)
- Visual Integration (Raster/Vector Overlay)
- Data Conversion (Switchyard)
Trends in GIS

Technology is Rapidly Advancing

- Data Structures
- Software Functionality
- User Interfaces

3 - d25
Trends in GIS

Professionals and Managers are becoming more technically oriented
Trends in GIS

Institutions are Beginning to Cooperate and Share Data
WORKING GROUP

REPORT

A. REMOTE SENSING IN HAZARDOUS & TOXIC WASTE
B. PLANNING AND MARKETING GROUP
C. RASTER/VECTOR INTEGRATION
D. SINGLE DISCIPLINE TASK GROUP
WORKING GROUP REPORT

a. Remote Sensing in Hazardous and Toxic Waste

DISCUSSION:

1. Problems with acquiring data from 20-40 years ago - Warehouse of uncataloged aerial photos are located countrywide - Our mission has changed to Environmental work. Data from NIKE/Ammunition plants, landfills is not readily available.

2. When aerial photos are obtained they are done by various entities. The problem results in different scales. There exists a need to make aerial photos more usable.

3. A need exists to digitize aerial photos and form a database so that present and future acquisition time is lessened.

4. Need exists for thermo-emissivity remote sensing data to determine problem areas. Would probably be useful on large areas (ammunition/ordnance plants - 25,000+ acres).

5. Place responsibility to acquire aerial photos in real estate section since responsibility rests with them to dispose of data.


RECOMMENDATION:

1. Thermo-emissivity pilot project on a large area to see what can be learned.

2. Cost-sharing Corps-wide for data collection, etc.

3. Use of indirect engineering overhead for data acquisition.

b. Planning and Marketing Group

Recommendations:

1. OCE should establish a GIS Center of Expertise.

2. The Center should be responsible for a bulletin board and newsletter.

3. The Center should (probably) develop a set of GIS planning guidelines.

4. The Center should (on request) review GIS plans, establish long-range plans and recommend future direction.

5. Management should be educated, as was done with CADD, on the utility of GIS's especially about return-on-investment or cost/benefit issues.

6. A Corps-wide GIS inventory should be done and made available.

7. Establish a central point to acquire data to eliminate duplicate buys.

8. Establish GIS user's groups at a sub-national geographic level (SE, SW, NE, etc.) to meet, exchange information/expertise, etc.

9. Incorporate GIS guidance and plans into District- and FOA- level Information Management Plans (IMPs); this could reinforce GIS approval and give it visibility.

10. Make sure GIS is included in the organizations' IM architecture.

11. Include the organization's Information Steering or Coordinating Committee in GIS decision-making.
Recommendations:

1. Desire expressed to have software available to perform concurrent processing of vector and raster data. Information was presented to the group that ETL/ALBE and software from Delta Data Co now perform concurrent processing.

2. There needs to be more sharing of data and interchangeability of data between various commercial or Federal systems. Recommend an open data structure which would allow interchange between CADD and GIS.

3. Recommend a corps voice be present at ANSI to assist in development of interchange standards for GIS data.

4. Need exists for a central Corps site for obtaining and distributing digital mapping and imagery data. A library would be an appropriate central point for existing data.

d. Single Discipline Task Group

Discussions on Formulation of a CADD Center (USAWES)

One topic of the break-out sessions, at the USATHAMA/USACERL GIS Information Exchange Meeting held in Denver, CO, was to discuss interest in formulation of a GIS-SDTG under the USAWES CADD Center.

Mr. Sandy Stephens, Chief, CADD Center, discussed the role of the SDTG's in meeting the CADD Center's charter, that being to enable the Corps to optimize use of CADD technology quickly. The SDTG's are the vehicle for grass roots input from the field offices to Corps-wide CADD Activities, particularly those which involve technical considerations related to the consolidated procurement contract with the Intergraph Corporation.

SDTG's have either already been formulated or are in the process of being formulated for ten application areas, including: civil/site design, structural design, electrical, mechanical, architectural, geotechnical, surveying and mapping, hydraulics and hydrology, systems management, and DEH support. SDTG's are normally formed with up to 12 active members, with a general functional and geographic sampling of users of Intergraph-based systems, including lab and field representatives, along with an OCE proponent and CADD Center representative.

Mr. Stephens stated that Army Installations to date have not been explicitly represented on the SDTG's. HQ discussions will likely lead to the Directorate of Engineering and Housing (DEH) representation on a number of the SDTG's or creation of a SDTG specifically dealing with CADD utilization at the Installations.

The role of SDTG's are primarily to identify advancements needed in software development through the Intergraph consolidated contract and to promote information exchange among users. The SDTG's also address needs for software certification within the agency for standardization of analysis and modeling.

Discussions during the break-out session focused primarily on the need for formulation of a SDTG to address the needs of GIS applications on Intergraph hardware/software systems. A second major focus of the proposed GIS-SDTG was to act as a technical forum for CADD/GIS transportability issues between Intergraph systems and other hardware or software systems. Issues related to porting of the Corps' GRASS software system on Intergraph platforms would also be included. Specific needs and activities of the proposed SDTG are outlined below.

The specific needs for formulating a GIS-SDTG were presented to the conference body. Considerable concerns was voiced that this proposed group not be represented as the only body discussing Corps-wide GIS developments, particularly covering those offices not involved in the Intergraph procurement. The findings contained in the Ad-Hoc GIS Committee report were reiterated that it was not recommended that the Corps standardize GIS developments around a...
single vendor's system, but rather promote broader implementation across the agency. Until much broader issues outlined in the Ad Hoc GIS committee report are resolved, considerable debate will naturally continue. A listing of broader Corps-wide GIS development needs and concerns were drawn up and are presented below.

Specific Needs for Single Discipline Task Group (SDTG) for GIS Under the USAWES CADD Center

- Data Exchange / Transportability / Porting Support between CADD and GIS
- Evaluate standards for Intergraph GIS Mapping / Analysis / Modeling for: Attribute Schema, Symbology, Weights, Fonts, QA/QC, Genealogy, Error Budgeting, etc.
- Promote Information Exchange (i.e., Newsletters, EMAIL, etc.)
- Identify GIS / Technical Contacts
- Software Evaluations / Needs for new or Improved Intergraph Modules
- Software and Translator Certification of Intergraph Modules
- Recommend CADD Contract Modifications / Pricing Strategies
- Training Needs Assessments / Information Exchange
- Interface to Other SDTG's

Broad Needs for Corps-Wide GIS Development

- Develop a functional GIS infrastructure within the Corps
- Develop field-level working groups for input to OCE GIS Steering Committee
- Promote field level GIS database / analysis / modeling coordination
- Evaluate needs for the formulation of a Corps GIS center(s)
- Evaluate needs for GIS regional support centers / data repositories
- Develop Corps-wide GIS mapping /analysis / modeling standards for: attribute schema, symbology, weighting, QA/QC, genealogy, error budgeting, etc.
- Assess Corps-specific GIS software development needs
- Create a R&D program for GIS modeling /analysis
- Assess GIS training needs / offerings
- Promote technology transfer forums