LECTURE 1
INTRODUCTION

CEEGR 4800/6965 - Special Topics
Geographic Information Systems and Hydrologic & Hydraulic Modeling
Uzair (Sam) Shamsi, Ph.D., P.E.
Adjunct Professor
Department of Civil / Environmental & Chemical Engineering

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DISABILITY STATEMENT

- YSU requires the following disability statement appear on each syllabi:
- "In accordance with University procedures, if you have a documented disability and require accommodations to obtain equal access in this course, please contact me privately to discuss your specific needs. You must be registered with CSP Disability Services, which is located at Wick House, and provide a letter of accommodation to verify your eligibility. You can reach CSP Disability Services at 330-941-1372."

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OUTLINE

- General
  - Student teacher introduction
  - Signup
  - Schedule
  - Textbook
  - Grading
  - Learning objectives
  - Course Web site
- Lecture No. 1 - Introduction to GIS
  - GIS definition
  - GIS history
  - GIS applications
  - GIS basics
    - Features
    - Raster vs. vector data
    - Topology
    - GIS Compared to CADD and AM/FM

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ABOUT YOUR PROFESSOR

- ☑ Technical Manager, Michael Baker Corporation, Pittsburgh, PA
  - Water and wastewater engineering
  - Hydrologic & hydraulic modeling
  - GIS
- ☑ Professor
  - University of Pittsburgh, GIS and Hydrology
  - Penn State University, Continuing Education
  - Youngstown State University, GIS and Hydrology
- ☑ 24 years of GIS and Engineering experience
- ☑ Education:
  - Ph.D. (Civil Engineering), University of Pittsburgh, 1988
- ☑ 90+ publications
- ☑ Books:
  - GIS Tools for Water, Wastewater, and Stormwater Systems, An ASCE Press Best-seller, 2002.
  - GIS Applications for Water, Wastewater, and Stormwater Systems, CRC Press, 2005.
- ☑ Professional Engineer in PA, WV, OH, GA
- ☑ 2007 Engineer of the year, ASCE Pittsburgh

Contact
sshamsi@mbakercorp.com
412-375-3076 Office
724-777-6909 Cell

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YOUR TURN

Please introduce yourself

- Your name
- Your program: undergraduate or graduate
- Your major
- Your organization (if employed)
- Your profession (if employed)
  - Civil engineer, TA, intern, etc.
- Your area of interest:
  - Water Resources, Transportation, Structures, Construction

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SCHEDULE

Week No.	Class No.	Date	Topics	Chapters
1	1	1/12/2009	Introduction	
2		*1/19/2009*	***Holiday: Martin Luther King Day***	
3	2	1/26/2009	GIS Software	
4	3	2/2/2009	ArcMap Overview and Exercises 3A, 3B, 3C, 4A, 4B, 4C (Opt.)	3, 4
5	4	2/9/2009	(1) GIS Data (2) Map Scales and Projections	5, 6, 7, 13
6	5	2/16/2009	Computer Lab: Exercises 5A, 5B, 6A, 6B, 7A, 13A, 13B,	5, 6, 7, 13
7	6	2/23/2009	(1) Spatial Analysis and Geoprocessing (2) Related Technologies	8, 10
8	7	3/2/2009	Computer Lab: Exercises 8A, 8B, 10A	8, 10
9		*3/9/2009*	***Spring Break***	
10	8	*3/16/2009*	***Lecture (Creating and Editing Data) + Mid-Term Exam***	14, 15, 16
11	9	3/23/2009	Computer Lab: Exercises 14A, 14B, 15A, 15B, 16A, 16B, 16C	14, 15, 16
12	10	3/30/2009	(1) Modeling (2) Model Builder	20
13	11	4/6/2009	(1) Introduction to EPANET (2) Introduction to SWMM	
14	12	4/13/2009	Computer Lab: Exercises 20A, 20B, 20C, EPANET and SWMM Ex.	20
15	13	4/20/2009	GIS and Modeling Integration 1: Theory	
16	14	4/27/2009	GIS and Modeling Integration 2: Tutorial & Exercise	
17	15	*5/4/2009*	***Final Exam***	

This course has approximately 50% lectures and 50% computer exercises

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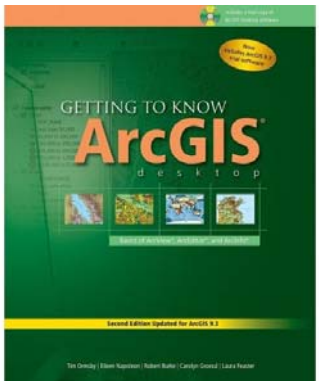
TEXT BOOK

- Title: Getting to Know ArcGIS Desktop
- Authors: Tim Orsby, Eileen Napoleon, Robert Burke, Laura Feaster, and Carolyn Groessl
- Publisher: ESRI Press
  store.esri.com/esri/showdetl.cfm?SID=2&Product_ID=1149&Category_ID=42
- Edition: Second (2008), Updated for ArcGIS 9.3
- Type: Paperback
- Pages: 600
- ISBN: 9781589482104
- Comes with two CDs:
  - Exercise data CD
  - Trial ArcGIS 9.3 software



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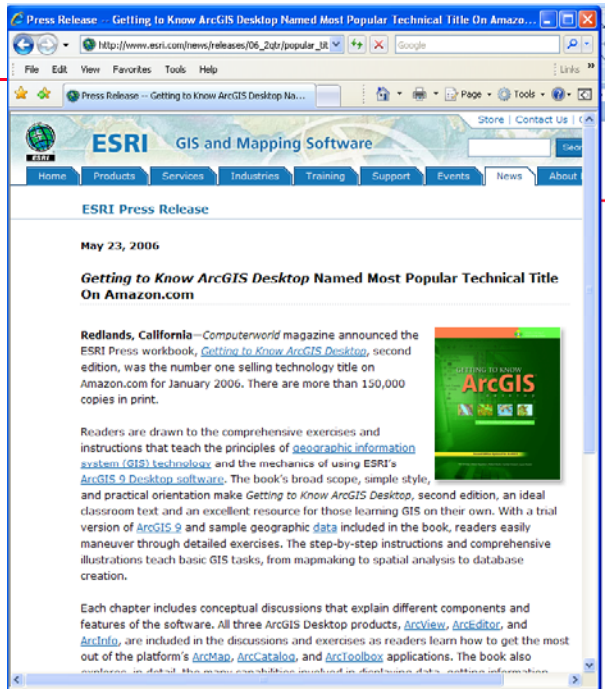
TEXT BOOK


Press Release -- Getting to Know ArcGIS Desktop Named Most Popular Technical Title On Amazo...

ESRI GIS and Mapping Software

Home | Products | Services | Industries | Training | Support | Events | News | About

ESRI Press Release

May 23, 2006

Getting to Know ArcGIS Desktop Named Most Popular Technical Title On Amazon.com

Redlands, California—*Computerworld* magazine announced the ESRI Press workbook, *Getting to Know ArcGIS Desktop*, second edition, was the number one selling technology title on Amazon.com for January 2006. There are more than 150,000 copies in print.

Readers are drawn to the comprehensive exercises and instructions that teach the principles of geographic information system (GIS) technology and the mechanics of using ESRI's ArcGIS 9 Desktop software. The book's broad scope, simple style, and practical orientation make *Getting to Know ArcGIS Desktop*, second edition, an ideal classroom text and an excellent resource for those learning GIS on their own. With a trial version of ArcGIS 9 and sample geographic data included in the book, readers easily maneuver through detailed exercises. The step-by-step instructions and comprehensive illustrations teach basic GIS tasks, from mapmaking to spatial analysis to database creation.

Each chapter includes conceptual discussions that explain different components and features of the software. All three ArcGIS Desktop products, ArcView, ArcEditor, and ArcInfo, are included in the discussions and exercises as readers learn how to get the most out of the platform's ArcMap, ArcCatalog, and ArcToolbox applications. The book also

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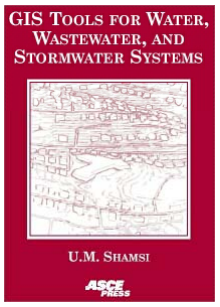
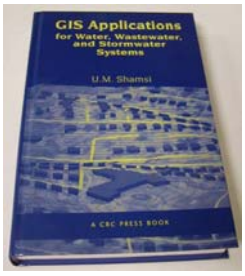
REFERENCES

- GIS Tools for Water, Wastewater, and Stormwater Systems, U.M. Shamsi, ASCE Press, 2002
  - GIS application basics
  - www.GISApplications.com
- GIS Applications for Water, Wastewater, and Stormwater Systems, U.M. Shamsi, Taylor & Francis / CRC Press, 2005
  - Advance GIS applications and H&H modeling
  - www.GISApplications.com
- EPANET Users Manual
  - http://www.epa.gov/ORD/NRMRL/wswrd/epanet.html
- SWMM5 Users Manual
  - http://www.epa.gov/ednnrmrl/models/swmm/index.htm
- Class handouts





GIS Applications

Mapping | Monitoring | Modeling | Maintenance

WEB RESOURCES

- Learn about GIS
  - Definition, components, data, related technologies, applications, etc.)
  - http://www.gis.com
- GIS Applications
  - Case studies and examples in various professions including civil and environmental engineering
  - http://www.esri.com/industries.html

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GRADING

- 20% Homework
- 40% Mid-Term Exam
- 40% Final Exam
- ***Homework will be due in the following class. Late homework will not be accepted or graded***

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LEARNING OBJECTIVES

1. Learn the theory and applications of Geographic Information Systems (GIS) in Civil & Environmental Engineering and Hydrologic & Hydraulic Modeling
2. Become proficient in using ArcGIS software
3. Learn the basics of EPANET model
4. Learn the basics of SWMM5 model
5. Become familiar with the GIS applications in computer modeling

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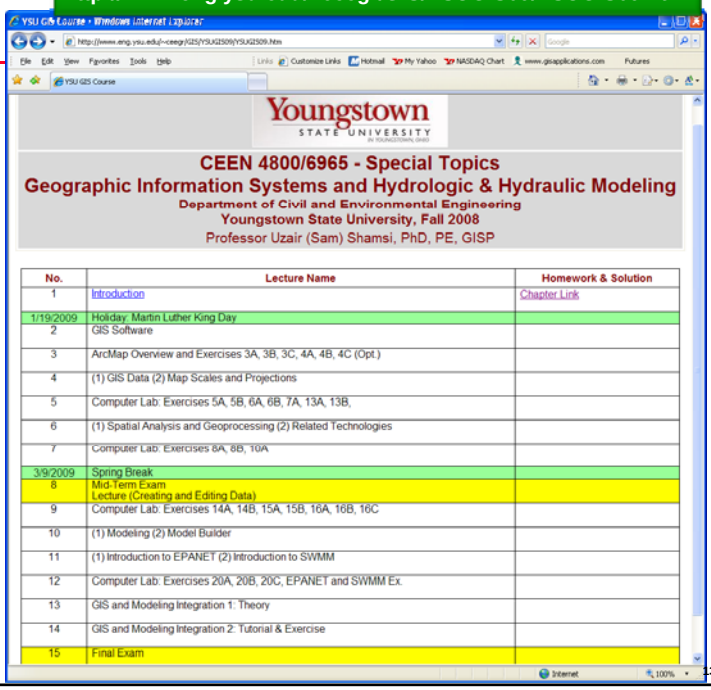
COURSE WEB SITE

http://www.eng.ysu.edu/~ceegr/GIS/YSUGIS09/YSUGIS09.htm



Youngstown STATE UNIVERSITY

CEEN 4800/6965 - Special Topics
Geographic Information Systems and Hydrologic & Hydraulic Modeling
Department of Civil and Environmental Engineering
Youngstown State University, Fall 2008
Professor Uzair (Sam) Shamsi, PhD, PE, GISP

No.	Lecture Name	Homework & Solution
1	Introduction	Chapter Link
1/19/2009	Holiday: Martin Luther King Day	
2	GIS Software	
3	ArcMap Overview and Exercises 3A, 3B, 3C, 4A, 4B, 4C (Opt.)	
4	(1) GIS Data (2) Map Scales and Projections	
5	Computer Lab: Exercises 5A, 5B, 6A, 6B, 7A, 13A, 13B,	
6	(1) Spatial Analysis and Geoprocessing (2) Related Technologies	
7	Computer Lab: Exercises 8A, 8B, 10A	
3/9/2009	Spring Break	
8	Mid-Term Exam Lecture (Creating and Editing Data)	
9	Computer Lab: Exercises 14A, 14B, 15A, 15B, 16A, 16B, 16C	
10	(1) Modeling (2) Model Builder	
11	(1) Introduction to EPANET (2) Introduction to SWMM	
12	Computer Lab: Exercises 20A, 20B, 20C, EPANET and SWMM Ex.	
13	GIS and Modeling Integration 1: Theory	
14	GIS and Modeling Integration 2: Tutorial & Exercise	
15	Final Exam	

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COURSE WEB SITE

- Or click YSU GIS Course link from www.GISApplications.com

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LITERAL GIS DEFINITION

- GIS = Geography + Information Systems
- Geography: A discipline that looks at features within their spatial content.
- Information System: A sequence of operations that takes us from planning and collection of data, to storage and analysis of the data, to the use of the derived information in some decision-making process.
- A GIS is an information system designed to work with data referenced by spatial or geographic coordinates.

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COMMON GIS DEFINITION

- **A GIS is an organized collection of computer hardware, software, geographic data, and personnel designed to effectively capture, store, retrieve, update, manipulate, analyze, and display all forms of geographically referenced information.**

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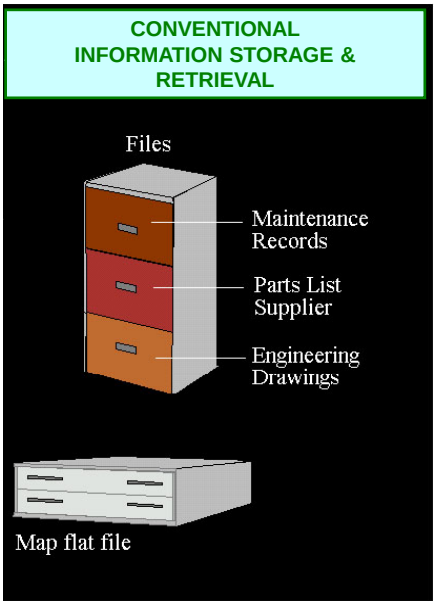
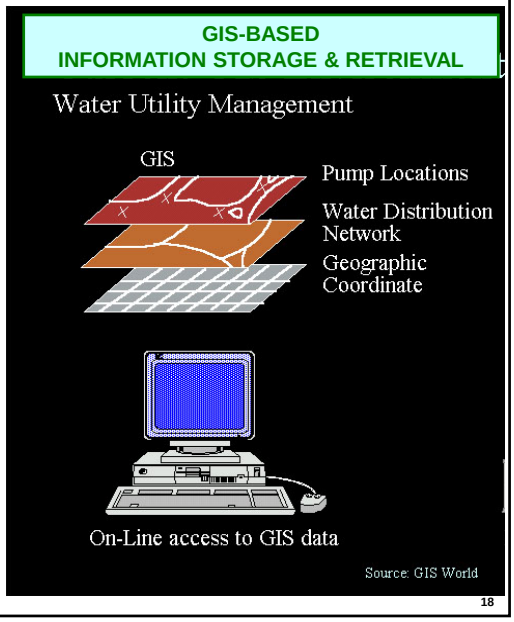
DATA STORAGE AND RETRIEVAL





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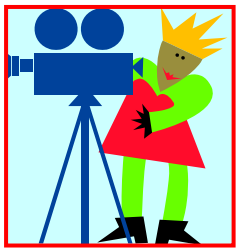
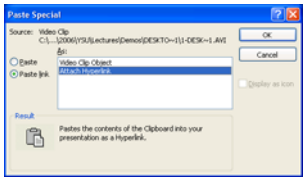
GIS MOVIE NO. 1

- What's GIS?
- From ESRI
- 2:15 minutes





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ANOTHER GIS DEFINITION

GIS is a computer system capable of assembling, storing, manipulating, and displaying geographically referenced information, (i.e., data identified according to their location) as well as operating personnel.

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GIS INCLUDES PEOPLE

- People are an integral component of a GIS
  - The most sophisticated GIS with the best quality data cannot survive if it lacks a team of trained and skilled professionals to manage and maintain it.
- This is where many GIS programs fail
  - Many failure stories and examples

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ESRI's GIS Definitions

- ESRI: Environmental Systems Research Institute. Worlds largest GIS software company that makes ArcGIS software.
- GIS.com: GIS is a collection of computer hardware, software, and geographic data for capturing, managing, analyzing, and displaying all forms of geographically referenced information.
- A GIS is a computer-based tool for mapping and analyzing things that exist and events that happen on earth.
- GIS technology integrates common database operations such as query and statistical analysis with the unique visualization and geographic analysis benefits offered by maps.

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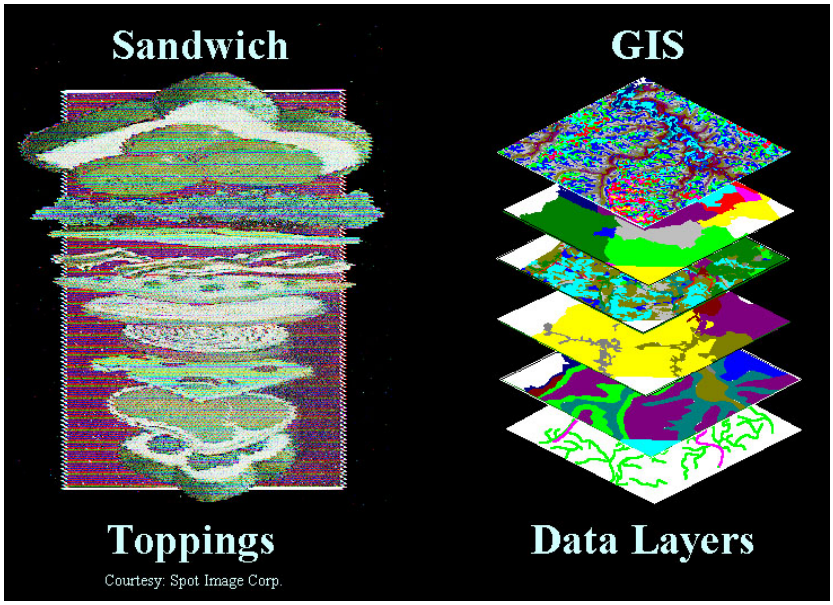
GIS AS LAYERS OF DATA



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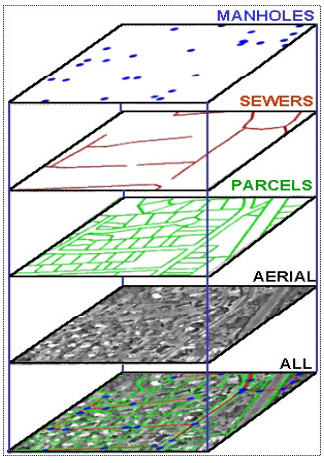
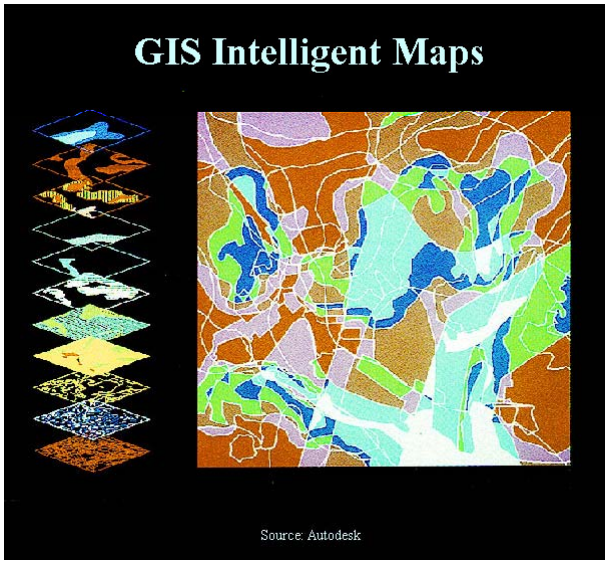
GIS AS LAYERS OF DATA





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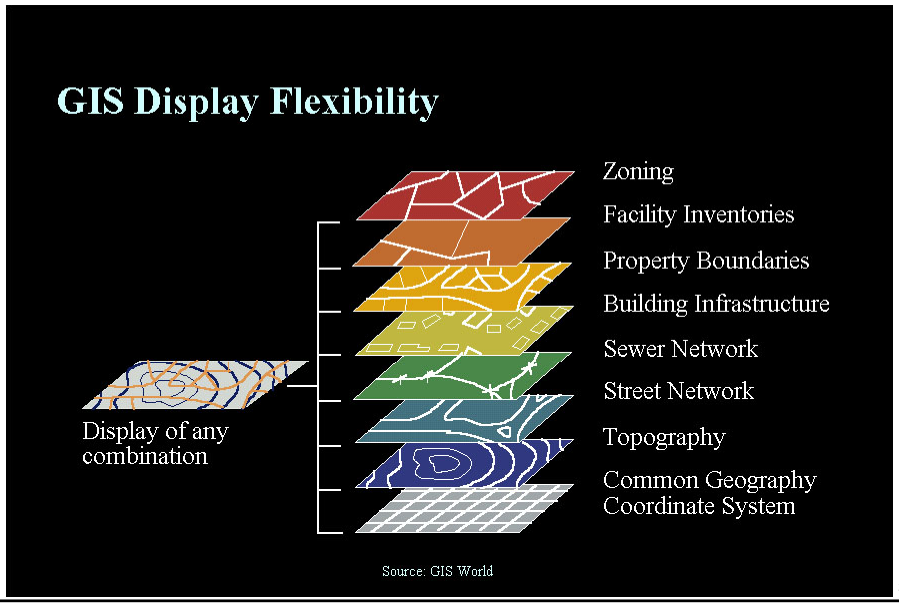
GIS AS LAYERS OF DATA



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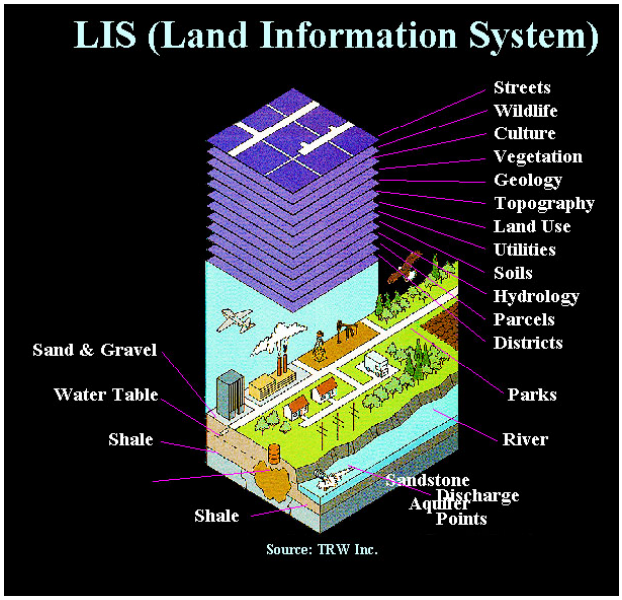
GIS AS LAYERS OF DATA



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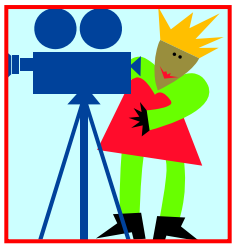
GIS MOVIE NO. 2

- Layers of Our world
- Created using ESRI ArcGlobe software
- 8:30 minutes



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MY GIS DEFINITION

- GIS = Database + Maps
- The GIS map is more than graphics - It is a database
- Every map element (point, line, area) has database attributes as well as graphic properties.
- A GIS map is a view of a spatial database

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GIS IS A LINK

- GIS is a link between a map and a database.
- A GIS takes the numbers and words from the rows and columns of databases and/or spreadsheets and displays them on a map.
- GIS allows users to view, understand, question, interpret, and visualize data in ways simply not possible in the rows and columns of a spreadsheet.

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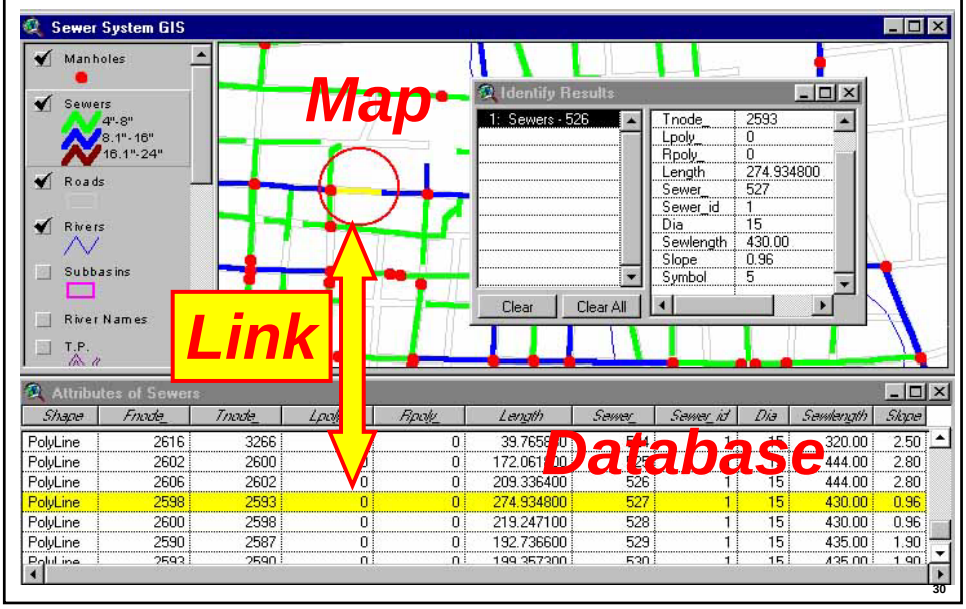
GIS IS A LINK



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JACK's GIS DEFINITION

Jack Dangermond, President, ESRI (User Conference, 1998)

- Geography: is the science of GIS.
- GIS
  - is an instrument for implementing geographic thinking
  - is a visual language
  - is the power of seeing
  - shows context and content
  - provides the framework for studying complex systems
  - integrates our knowledge about places
  - helps us better organize our institutions
- Jack's definition has an application focus.

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GIS HISTORY

- Phase 1. 1960-75: Individual dominance (research)
  - Mainframe computers
- Phase 2. 1973-early 80s: National Agencies
  - Mainframe and mini computers
- Phase 3. 1982-90: Commercial dominance
  - Workstations and PCs
- Phase 4. 1991-2000: User dominance
  - Workstations and PCs
  - 1991: Universities (Geography Departments)
- Phase 5. 2001-Present: Enterprise dominance
  - Centralized data storage
  - Servers, Internet, and wireless technology
    - Google Earth
  - Mobile GIS (link field workers with enterprise systems)

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GIS HISTORY

- The GIS technology was conceived in 1960s as a digital layering system for co-registered overlays.
  - The Internet was started in the 1970's by the U.S. Department of Defense to enable computers and researchers at universities to work together. The GIS technology was conceived even before the birth of the Internet.
- Started in the mid 1960s, Canadian GIS is an example of one of the earliest GIS developments.
- The civilian GIS in the United States got a jump start from the military and intelligence imagery programs of the 1960's.
- More on History: in GIS Applications for Water, Wastewater, and Stormwater Systems (The Blue Book)

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GIS APPLICATIONS

- Are numerous!
- Potential municipal applications alone are:
  - Permitting and code enforcement
  - Building inspections
  - *Asset management*
  - *Water / wastewater / stormwater operations*
  - Comprehensive planning
  - Zoning
  - Hydrologic and hydraulic modeling
  - Facility design
  - Construction / project management
  - Parcel mapping
  - Tracking citizen complaints
  - Routing
  - Regulatory compliance
  - Public information
  - … and more

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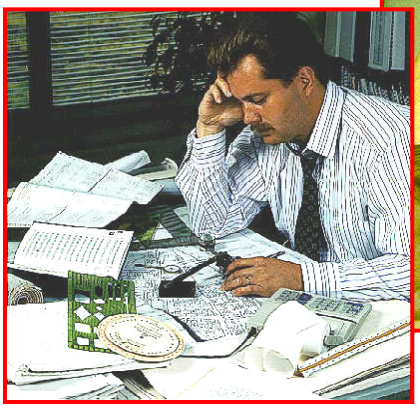
GIS APPLICATIONS CAN TAKE YOU FROM HERE …

More than 80 percent of all the information used by local governments is *geographically referenced.*



Some actual sewer maps

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… TO THERE

GIS applications make the things easier to do, which increases productivity, which saves time, which translates into saving money!

BENEFITS OF GIS APPLICATIONS

1. GIS applications make things easier to do
    1. Increase worker productivity
    2. Improve efficiency
    3. Save time
    4. Save money
2. GIS applications provide the power of integration
3. GIS applications offer a decision support framework
4. GIS applications provide effective communication tools

Detailed discussion in Chapter 1 of GIS Applications book.

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BEYOND MAPPING

- Mapping is the most common application of GIS. However, map making alone cannot sustain a GIS.
- GIS emphasis is shifting from map making to enterprise-wide mission critical applications.

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TOP 10 GIS APPLICATIONS

1. Landbase model
2. Work management
3. Facility model analysis / planning
4. Operations and maintenance
5. Document management
6. Customer information systems
7. Workforce automation
8. Regulatory reporting
9. Environmental testing
10. Marketing

Source: Third (January 2001) Geospatial Technology Report
Geospatial Information and Technology Association (GITA), (Geospatial Solutions, Feb. 2001)

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GIS APPLICATION BENEFITS
CASE STUDY No. 1

- City and County of San Diego, California
- One of the nation's largest county jurisdictions covering more than 4,200 square miles.
- SanGIS spent approximately ***$12 million*** during a 14-year period from 1984 to 1998 to collect the GIS data. The conventional surveying approach would have cost them about ***$50 million***. The GIS/GPS approach saved the City and the County of San Diego millions of dollars (The San Diego Union-Tribune, 1998). .
- Saving Factor = ratio of conventional approach (non-GIS) cost (or time) to GIS approach cost (or time).
  = 50/12 = 4.2 = 420%

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GIS APPLICATION BENEFITS
CASE STUDY No. 2

- The City of Charlotte and Mecklenburg County, North Carolina
- One of the fastest growing metropolitan areas
- Developed a watershed information system called WISE that integrates data management, GIS, and standard stormwater analysis programs like HEC-HMS and HEC-RAS.
- Using the GIS based integration method, the existing hydrology and hydraulic (H&H) models were updated at a fraction (less than ***$100,000***) of the cost of developing a new model (more than ***$1 million***) (Edelman et al., 2001).
- Savings factor = 1,000,000/100,000 = 10 = 1000%

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GIS APPLICATION BENEFITS
CASE STUDY No. 3

- The planners in the City of Dover (New Hampshire) used GIS from Intergraph to determine where and how much solid waste needs to be collected and removed.
- Without GIS, collecting this information would have taken approximately six months. Using GIS, it only took a few weeks.
- This information was provided to bidders to help them base their bids on facts rather than assumptions. This application resulted in lower-priced bids (Thompson, 1991).
- Savings factor = 12 = 1200%

More examples in Chapter 1 of GIS Applications book.

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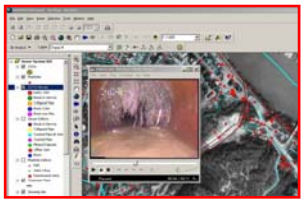
FUTURE GIS APPLICATIONS

- Location-based services (LBS) and wireless technologies will provide "on-demand" GeoSpatial information.
- Integration of computer, video camera, and GPS referred to as "video mapping" will be used to document field inspections:
  - TV inspection of sewer pipes.



- The Desktop-oriented network architecture will be replaced by a Web-based network
  - No need to store data on your computer
  - Web servers will query and transfer the information from data servers to desktop clients

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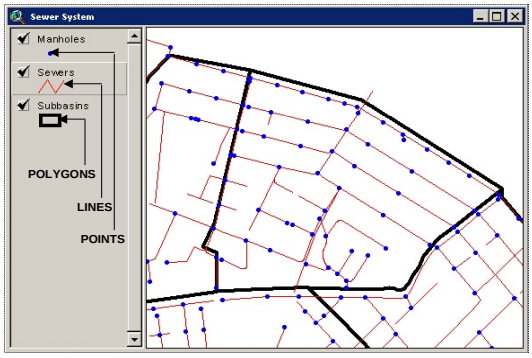
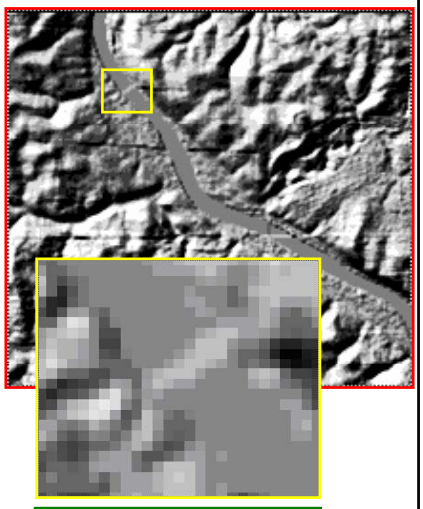
GIS BASICS

RASTER VS. VECTOR GIS



VECTOR GIS: LINEAR FEATURES (POINTS, LINES, POLYGONS)



RASTER GIS: GRID CELLS OR PIXELS

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VECTOR GIS FEATURES

A vector GIS layer (or map) is generally made up of 3 types of features:

1. **Point**

   Example: manholes, wells, outfalls, hydrants

2. **Line (arc)**

   Example: sewers, streams, streets

3. **Polygon**

   Example: watersheds, lakes, buildings

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SPATIAL RELATIONSHIPS - TOPOLOGY

- A mathematical procedure for explicitly defining spatial relationships between features.
- Spatial relationships can determine
  - Connectivity (what is connected to what)
  - Adjacency (what is next to what)
  - Containment (what is enclosed by what)
  - Proximity (how close is one object to another).
- Example: Which inlets are connected to an outfall?

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GIS VS. CADD

- CADD: Computer Aided Drafting and Design (CADD)
  - Example: AutoCAD, Microstation
- CAM: Computer Aided Mapping (CAM)
  - A CADD application to produce maps
  - An alternative to the traditional manual cartographic maps
  - Layers organize data by
    - theme (streams vs. roads)
    - type (linework vs. text)
- CADD / CAM programs do not have a linked database
- No spatial relations (topology) among layers
- New Trend: Integrated CADD/GIS applications (e.g., AutoCAD Map 3D)

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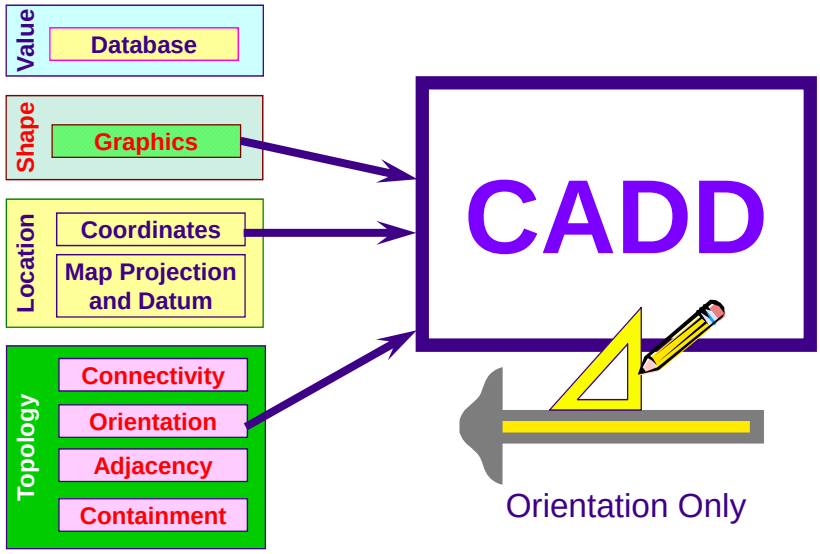
CADD AND CAM



CH2M HILL

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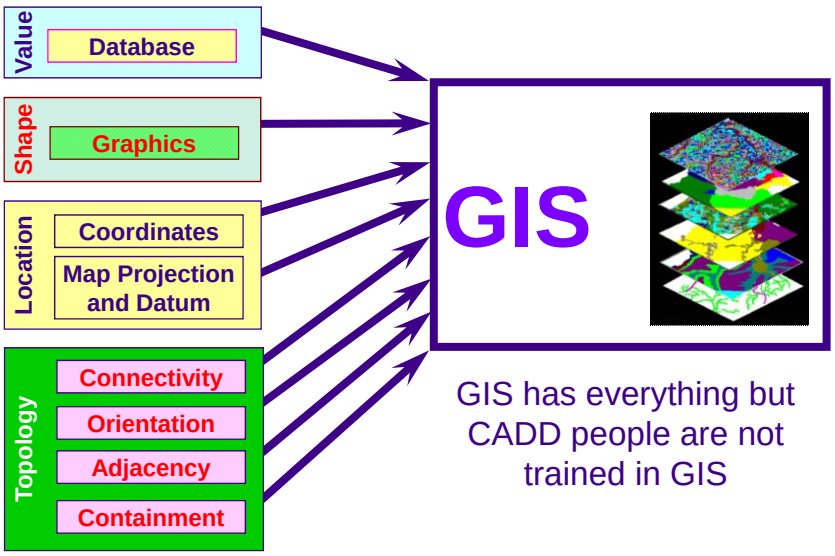
GIS



GIS has everything but CADD people are not trained in GIS

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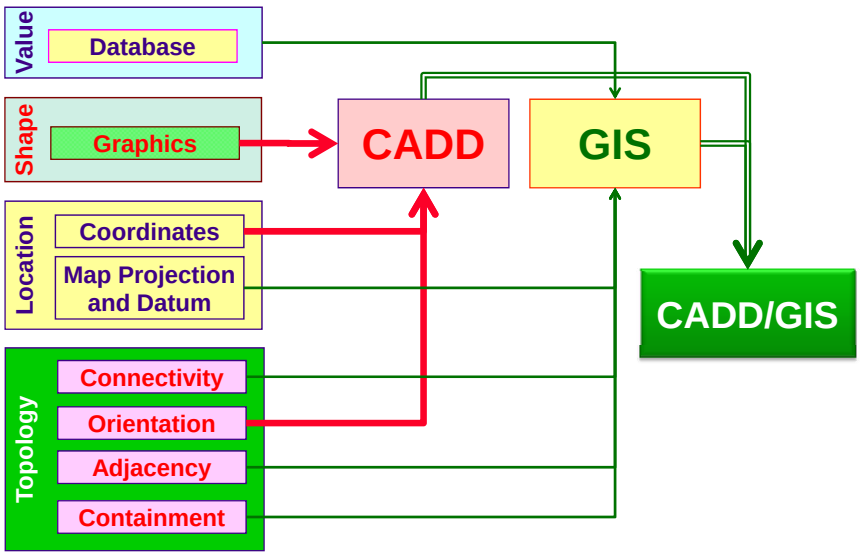
CADD/GIS



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CADD/CAM VS. GIS

Feature	CADD/CAM	GIS	CADD/GIS
Layers	Y	Y	Y
Topology (spatial relations)	N	Y	Y
Network analysis	N	Y	Y
Lines	Y	Y	Y
Nodes	N	Y	Y
Polygons (areas)	N	Y	Y
Attributes	N	Y	Y
Actual locations	Y/N	Y	Y
Map intelligence	N	Y	Y

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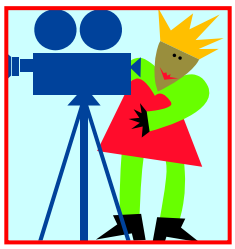
GIS MOVIE NO. 3

- GIS Primer: Desktop GIS
- 6:05 minutes



..\..\..\..\2008\YSUGIS08\Lectures\Demos\Desktop Primer\1-Desktop GIS.avi

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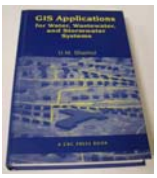
HOMEWORK No. 1



- Study Chapter 1 (Page 25) of Dr. Shamsi's book "GIS Applications for Water, Wastewater, and Stormwater Systems."
- A draft (unedited) version of the chapter can be downloaded from the Course Web site (Homework
- Answer the five questions at the end of Chapter 1.
- Limit each answer to one page (single spaced). The entire homework should not exceed 5 pages.
- Submit the printed homework in the next class.

CEEN 4800/6965 - Special Topics
Geographic Information Systems and Hydrologic & Hydraulic Modeling
Department of Civil and Environmental Engineering
Youngstown State University, Fall 2008
Professor Uzair (Sam) Shamsi, PhD, PE, GISP

No.	Lecture Name	Homework & Solution
1	Introduction	Chapter Link
1/19/2009	Holiday: Martin Luther King Day	
2	GIS Software	

HOMEWORK No. 1

Chapter 1 Questions

1. What are GIS applications and how are they developed?
2. What are the pros and cons of GIS applications? How can you avoid potential pitfalls of GIS applications?
3. What technologies are fueling the popularity of GIS applications?
4. List your ten most favorite GIS applications.
5. How will your current GIS needs benefit from potential future GIS applications?

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