Spatial Decision Support (SDSS) and GIS
Using GIS

- GIS and computers can synthesize data and perform analysis and modeling
- But PEOPLE make decisions!
- How can GIS be used as part of the decision-making process?
- Decisions can be top down (managers) or bottom-up (public participation)
Spatial Decision Problems

The main characteristics of spatial decision problems include:

- Many alternatives,
- Consequences of the decision alternatives are spatially variable
- Each alternative is evaluated on the basis of multiple criteria,
- Some of the criteria are qualitative others quantitative
- More then one decision maker (or interest group) involved in the decision-making process
- Decision makers have different preferences on evaluation criteria and decision consequences
- Decisions are often surrounded by uncertainty
- NIMBYism etc.
Historical Background

• Decision Support System (DSS) based on work by Herbert A. Simon in 1950s and 1960s (Simon 1960);
• DSS evolved during the 1970s and 80s
• SDSS concept has evolved in parallel
• IBM's Geodata Analysis and Display System 1970s earliest large DSS
• SDSS has been associated with the need to expand the GIS capabilities for complex, ill-defined, spatial decision problems
• Major growth in research, development, and applications of SDSS in the last 10 years
• Many threads with different, but related names, such as collaborative SDSS, group SDSS, environmental DSS, spatial knowledge based and expert systems, PPGIS
GIS and Decision Support

- GISystems have limited capabilities to support the design and choice phases of the decision-making process.
- GIS provides a static modeling environment, reducing their scope as decision support tools.
- Especially so in the context of problems involving collaborative decision-making.
What is SDSS?

- SDSS is an interactive, computer-based system designed to support a user or group of users in achieving a higher effectiveness of decision making while solving a semi-structured spatial decision problem;
- The three terms (semi-structured spatial problems, effectiveness, and decision support) capture the essence of the SDSS concept
Components of SDSS

- *Data Base Management System* contains the functions to manage the *geographic data base*;
- *Model Base Management System* contains the functions to manage the *model base*;
- *Dialog Generation and Management System* manages the interface between the user and the rest of the system.
DSS Tools

- Procedural programming languages and code libraries (e.g., VB, AML, Avenue, TransCAD - Caliper Script macro language, MapInfo - MapBasic);
- Visual programming language (e.g. STELLA, Cantata and Khoros);
- Inter-application communication software (e.g. dynamic data exchange (DDE), object linking (OLE), open database connectivity (ODBC));
- Simulation languages and software (e.g. SIMULINK, SIMULA);
- Application programming interfaces (API) (e.g. the IBM's geoManager API, Java Advanced Imaging API, TransCAD's API);
- Applets (e.g. GISApplet, Microsoft Visual J++),
- Visual interfaces, graphics and color subroutines (e.g. graphical user interfaces – GUI, OpenGL, SVG, etc.)
DSS Generator

- Package of related hardware and software which provides a set of capabilities to quickly and easily build a specific SDSS
- GISystems (e.g. ARC/INFO, ArcView, ARCNetwork, Spatial Analyst, MapObjects LT, GRASS, IDRISI, MapInfo, TransCAD)
- Database packages (e.g. dBase, Access, Paradox);
- Decision analysis and optimization software (e.g. LINDO, EXPERT CHOICE, LOGICAL DECISION);
- Statistical and geostatistical software (e.g. S-PLUS, SPSS, SAS);
- Simulation (e.g. Spatial Modeling Environment)
Specific DSS

- Systems devoted to the analysis of a particular set of decision problems
- Support decision makers in tackling semi-structured problems
- Active Response Geographic Information System
- IDRISI Decision Support
- GeoMed
- Spatial Group Choice
- winR+GIS Spatial Decision Support
- CommunityVis
50 years of decision-making

• 1957 NRC report recommended burying the waste in a permanent repository
• Need a “safe” site for 77,000 tons of highly radioactive waste
• Safe means stable for at least 10,000 years as measured by radionuclides in surface and ground water downstream
• Need a stable place, free from hazards
• Storage-movement-disposal issues
• No solution in spite of 1982 act (DOE by 1998).
• Single site eventually chosen
Problem 1: The journey to Yucca Mt.
Problem 2: Burial
What is the radionuclide travel time from the repository to the water table?

Question addressed through modeling
Conceptual model selection
Calibration
Predictions
UZ Travel Time Predictions: 1995-2003

Effective Continuum
- Fractures and matrix assumed to be in pressure equilibrium
- Calibration yielded water perc. rates of 0.01 to 0.1 mm/y, dry fractures
- Travel times to water table of about 350,000 years

Dual Permeability
- Fractures can flow even when matrix is unsaturated
- Calibration could be attained with more reasonable perc. rates of 5 mm/y
- Travel times to water table of 10’s to 100’s of years possible!

Conceptual model uncertainty is critical to assessment of overall system uncertainty
Cl-36 Observations Confirm Rapid Transport Pathways

Atmospheric fallout from nuclear weapons testing (1950’s and 1960’s) is present in fluid 200-300 m below ground surface. Fault zones appear to be the pathway.

Source: Fabryka-Martin et al., 1997, YMP Milestone SP2224M3
Key Attributes of Repository Safety Strategy

1. Limited Water Contacting Waste Package
2. Long Waste Package Lifetime
3. Slow Release From Waste Package
4. Low Concentration of Radionuclides in Groundwater

The Yucca Mountain Decision Model Framework

1. Climate Precipitation
2. Infiltration
3. Unsaturated Zone Flow
4. Seepage
5. Waste Package Degradation
6. Radionuclide Mobilization Through Engineered Barrier System Transport
7. Unsaturated Zone Flow and Transport
8. Saturated Zone Flow and Transport

The figure illustrates the various components and processes involved in the repository safety strategy, including climate and infiltration, unsaturated zone flow, seepage, waste package degradation, radionuclide mobilization, and transport through unsaturated and saturated zones. The figure also highlights the biosphere affecting water, plants, animals, and people.
Many unknowns

• Will there be new faults and fractures in the next 100,000 years?
• Will the local tectonics remain inactive?
• Who will be there to notice in 12,005AD?
• What language do you write the warning notice in?
• [etc]
Can such a model be “understood” by anyone besides the developer?
Summary

• SDSS has been defined as an interactive, computer-based system designed to support a user or group of users in achieving a higher effectiveness of decision making while solving a semi-structured spatial decision problem.

• The SDSS concept is based on the DDM (dialog, data, model) paradigm; a well-designed SDSS should have balance among the three capabilities.

• There are three sets of technologies for building an SDSS: the DSS development tools, the DSS generators, and specific SDSS.

• The DSS tools facilitate the development of specific SDSS or they can be configured into a DSS generator which in turn can be used to build a variety of specific SDSS.