Using GIS for Computer-Assisted Dispute Resolution

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ABSTRACT: GIS-based tools have been designed at the University of North Carolina for increasing the understanding of urban and regional planning problems, creating joint databases, and communicating possible solutions in conflict resolution training. Used in workshops and graduate planning courses, the tools include a pc ARC/INFO database of land use and environmental information for a Hypothetical City and a Land Suitability Model that enables participants to seek multiparty agreements through negotiating model values.

INTRODUCTION

Resolving land-use and environmental conflicts requires the parties to develop mutual understanding of the problem, shared databases, and potential win/win solutions (Fisher and Ury, 1981). Given the complex nature of the spatial issues involved, the parties to the conflicts need assistance in these tasks. At the University of North Carolina, we have designed a set of teaching tools that demonstrate how GIS can provide that assistance.[1]

These tools have been used effectively to teach computer-assisted dispute resolution to participants in professional workshops and graduate courses in city and regional planning. By creating macro commands and analysis procedures, we have been able to provide a compressed learning experience that allows participants to use computer models to negotiate solutions to difficult problems.

Our computer-assisted negotiation exercise takes six to eight hours to complete. Along with brief lectures and a GIS demonstration on IBM's Storyboard software, the training package consists of (1) a pc ARC/INFO database for a Hypothetical City, (2) a Land Suitability Model to test the acceptability of parcels for particular uses, and (3) a dBASE sorting and display program to identify inter-team parcels meeting acceptable criteria.

The structure of the negotiation exercise intersperses hands-on GIS analyses with brief lectures and demonstrations. First, the students are introduced to GIS-based land suitability analysis by means of a lecture and a computer demonstration of a prototype analysis shown on Storyboard software.[2] Then they are divided into groups of three to five persons, each with their own computer terminal, and provided with role descriptions. The three roles are a Development Firm, an Environmental Group, and a Planning Agency. Their goal is to come to consensus on a site for a development project. Each group is provided with a land suitability model, into which they must incorporate their role's values and weights. Following this initial round, exercise staff run the resulting suitability models and provide hard copy results to each group.

Next, a lecture on negotiating win/win outcomes is presented. Using guidelines from *Getting to Yes* (Fisher and Ury, 1981) and from *The Art and Science of Negotiation* (Raiffa 1982), the instructors discuss the value of problem-solving versus competitive approaches to conflict resolution. Then the groups compare the outcomes of their land suitability models and seek to negotiate a consensus solution by adjusting their preferred suitability scores. When they complete their negotiations, the consensus values are entered and the consensus model is run. A debriefing is used to explore the effects of bargaining styles and shared databases on the mapped outcomes.

LAND SUITABILITY ANALYSIS IN HYPOTHETICAL CITY

Land suitability analysis is a technique used to map the variation in relative suitability for a particular land use, such as industrial or commercial, over an entire planning area. Suitability is determined by site or parcel attributes, such as slope, soil type, and access to utilities.

Traditional land suitability analyses derive from the work of Ian McHarg (1969). These methods relied upon overlaying environmental characteristics drawn on tracing paper or other transparent media, and then estimating the cumulative values of the combined layers to derive a suitability score.

GIS-based land suitability analysis uses the traditional overlay concept, but adds the power and precision of the computer. With GIS, the land suitability analyst can rapidly calculate the ranks, weights, and scores of a suitability model. The resulting suitability values are readily mapped, including rescaling if necessary to zoom in on a particular area. The digital GIS maps are more easily preserved and duplicated than hand-drawn overlays. Furthermore, iterative recalculations to generate alternative suitability patterns are easily tested. This is especially important in a negotiation situation, where new scenarios need to be explored in order to generate joint gains for multiple parties. The utility of models to assist in resolving technically complex disputes, particularly when the "facts" themselves are in dispute, has been documented by a number of analysts (Straus and Clark, 1980; Susskind and McMahon, 1985; Ozawa, 1988; McCreary, 1989). Models provide a common basis for understanding policy consequences and dealing with uncertainty.

In order to teach land suitability analysis, as well as other land-use planning methods, we developed a simplified GIS database describing a city of 10,000 population with a typical central business district, industrial area, outlying shopping center,

[1]In addition to the GIS-based negotiation, we also use a computer spreadsheet model in another computer-assisted negotiation exercise, "Town Square," which involves negotiating a public/private development project (Godschalk, 1985). Our work with computer-assisted negotiation is only one part of a larger effort to educate practitioners and graduate students in the applications of geographic information systems to planning problems (Godschalk and McMahon, 1992).

[2]This Storyboard program was developed by us under contract with IBM for use in introducing government officials to GIS. It is part of a two-day training course.

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and residential neighborhoods. Our Hypothetical City database includes 14 coverages for slope, soils, drainage, water resources, floodplains, topography, agricultural suitability, transportation, existing land use, zoning, sewer lines, and other planning features. Eight of these are used in the negotiation exercise.

To complete a land suitability analysis for Hypothetical City, students rank the intensities of the attributes that they select as important in determining suitability for a particular use, weight the attributes relative to each other, and combine them into a suitability model. For example, to locate sites suitable for industrial development the coverages for slope, Interstate Highway access, and sewer access might be selected. Then, the degrees or intensity (e.g., percent slope) of each attribute are assigned a ranking score, the overall attribute is assigned a weight, and the ranked and weighted attributes are combined into a suitability model, as shown in Table 1.

Model outputs are then combined into several categories of suitability (e.g., high, medium, low) depending on where their scores fell within the range of outcomes derived from running the model for each location. These outputs are plotted as maps and displayed in tabular format. If the participants wish to revise the models, new ranks or weights are readily substituted and the revised maps and tabulations can be compared with the original model outputs.

TABLE 1. ILLUSTRATIVE SUITABILITY MODEL FOR INDUSTRIAL DEVELOPMENT SITES

Attribute	Class/Intensity	Rank	Weight
Slope	< 5%	5	1
	5%–15%	3	
	> 15%	1	
Access to Interstate	< 0.5 mile	7	2
	0.5–1 mile	5	
	1–2 miles	3	
	> 2.0 miles	1	
Access to Sewer	< 500 feet	7	3
	500–2640 feet	5	
	2640–5280 feet	3	
	> 5280 feet	1	

Suitability Model:
Degree of suitability of each site for industrial development (assuming an additive model[3]):
(Slope × 1) + (Highway × 2) + (Sewer × 3)

[3]The model allows the use of various combinatorial procedures, multiplicative as well as additive. We chose to use the simpler additive procedure for this exercise, in order to make the calculations as transparent as possible for the users.

RESOLVING DEVELOPMENT DISPUTES IN HYPOTHETICAL CITY

Role playing exercises are a common tool in teaching environmental dispute resolution. Such exercises may involve two or three players attempting to resolve a simple land transaction, such as the farmland conversion exercise presented in Dotson *et al.* (1989, pp. F1–F10), or many parties seeking to resolve a complex environmental dispute, such as the low level radioactive waste siting exercise, Radwaste I and II (Susskind and Babbitt, 1987). Typically, these players have roles that readily define a certain set of interests, such as farmer, conservation group, and developer. In the more complex games, however, the particular circumstances of the exercise, along with the desire to strike a deal, can result in unanticipated alliances and coalitions.

What these games have in common are background information, shared by all participants in the exercise, and confidential information, which is unique for each of the exercise participants. The background information provides the players with a common understanding of the key issue or issues to be dealt with during the exercise, and often provides an indication of the interests motivating the various participants. The confidential information provides the details of these interests. If a game is scoreable so that various outcomes can be quantitatively compared, a player may receive a "bottom line" that must be equaled or exceeded in order to agree to a proposal from another player. Whether the games are scoreable or not, they are configured in such a way that it is possible to either reach or not reach an agreement, depending on the player's ability to communicate his or her interests and to represent these interests effectively.

Several features of these games make them effective teaching devices. Although they are written in a way that isolates one or a few issues from what might in real life be a very complex set of concerns, the fact that the issues are recognizable and credible helps students to engage in the exercise. The willingness to suspend disbelief is assisted by two tensions associated with doing these exercises in a classroom setting. Usually the size of a class dictates that several sets of teams play the game at the same time. No individual wants to be seen as doing much worse than the other players who have played the same role, and so there is a tendency to push for a "high" score, in a conventional sense. Players also, however, want to practice the guidelines of principled negotiation which, when game results are compared at the end of a class session, may mean that no one wants to run up too high a score at the expense of reaching a group consensus. It is interesting that even on the several occasions when the game described below was used with a single group of practicing environmental or development professionals in a non-classroom setting, there was no lessening of this willingness to suspend disbelief. Participants enjoy playing roles typically played by their counterparts in actual negotiations (that is, developers play environmentalists or planners), and are interested in using GIS as a negotiation aid.

The Hypothetical City Development Dispute exercise is a pc ARC/INFO-based exercise. In the general instructions players are told that Hypocity needs to expand its taxbase and is interested in development proposals that will address this need. An out-of-town developer has given preliminary indications of an interest in developing a light manufacturing facility, perhaps on the edge of town, near the new interstate highway. The local environmental organization, which has appeared before the council on previous occasions to oppose what it thought to be ill-considered development proposals, appears to recognize the town's fiscal plight, particularly as it affects the town's ability to make supplemental payments to aid the local schools. Whether this organization will actually support a development proposal is unknown. The council's development decisionmaking is supported by the town's planning department, which has a reputation for being pro-environment in carrying out its development review responsibilities.

Game participants are told that the town has recently purchased a geographic information system (GIS) and has digitized a number of maps that should prove useful in evaluating potential development sites. These maps include SLOPE, WATERBUF (indicating the distance of any individual land parcel from the closest waterbody); FLOOD (indicating land parcels within the 100-year floodplain); SEWERBUF (indicating distance of land parcels to existing sewer lines); COMMBUF (the distance of parcels from the closest commercial center); CBDBUF (parcel distance from Hypocity's central business district); HYWBUF (parcel distance from the new interstate highway); and DEVELOP (indicating if a parcel is vacant or developed).

The town council is hopeful that this new technology may prove useful in identifying a development site with which everyone can live, without feeling that they have shortchanged their basic interests. After consulting with the town's finance director on the consequences of potential development options, the council would prefer that the parcel that is developed is at least three acres in size.

Each of the parties – developer, environmentalist, and planner – has access to the same GIS database for use in evaluating alternative proposals in terms of their own interests. These interests are described in confidential briefing papers, which include a list of optimal ranking and weighting scores for each of the eight input maps and a bottom line score for any parcel to be designated as acceptable to that party. For any parcel to be acceptable to all parties, it will have to be at least minimally acceptable to each of the parties in terms of these interests. Participants are instructed that it is unlikely that the council will support any proposal not agreed upon by all three parties.

After reading their general instructions, the three groups meet separately to develop an initial presentation of their development-related interests. Parties make use of the confidential instructions in conjunction with the Hypocity Land Suitability model described earlier. In the initial round of the game, participants usually rely on the rankings and weights provided in their instructions. The products of this initial effort, for each of the three teams, is both a list and a map of suitable parcels and a list of parcels, if any, that are acceptable to more than one team. This last list is created by a dBASE program operated by the game manager in between rounds of the game.

The programs written in pc ARC/INFO's macro language produce ordered lists of individual sites deemed acceptable to each party. These lists are submitted to a dBASE III Plus program which assembles them into a summary. The summary lists each parcel's identification number, its acreage, and the teams which found it suitable in their individual analyses. Additional lists are distributed to each team showing the parcels they found acceptable and how far above their minimum point threshold each parcel was found to be.

Armed with these tabular lists, the three parties then have the necessary information to determine how many parcels their initial models found in common, and a first indication of steps they might take to establish consensus. Some teams seek to reduce their minimum score to garner support, others look to specific weights and attributes to gain agreement, and others use spatial assessments to find adjacent parcels which together yield the minimum acreage required.

The dBASE program can then be used to assist individual teams that wish to cross-reference the parcels which their models found unsuitable. This allows them to consult the pc ARC/INFO macros to display maps and other attribute information about the parcels, and to begin associating neighboring acreage. It is apparent from teaching this exercise that a free-form negotiation about land use and development would be less realistic and satisfying. The ability to tie together spatial displays with tabular databases is invaluable in the process of "getting to yes" over a complex, multi-objective conflict.

If this initial effort does not identify any parcels agreeable to all parties, the parties may choose to negotiate about the weights assigned to one or more of the maps, in an effort to identify a parcel that all parties can agree upon. One or more parties may even decide to lower the "bottom line" with which they entered the negotiation. Diverging from an initial, preferred position regarding weights or a bottom line is voluntary, and parties may expect that requests for a change in someone else's weights or bottom line may be met by a similar request directed toward themselves.

Negotiations subsequent to the initial round are aided by several features of the Hypocity model. Once the players have a list of parcels that are acceptable to more than one team, the macro-driven Hypocity program allows them to utilize the GIS to identify the location and list the attributes of these parcels.

Several features of this negotiation exercise are noteworthy. The first is that completion of the game relies on an actual GIS, pc ARC/INFO. The use of this GIS is possible because of an extensive, interconnected set of macro programs that allow game participants to utilize the power of GIS without having a command line mastery of the software. The exercise only uses a portion of the coverages available in the Hypocity Suitability model, reflecting a balance between a credible game and the time limitations of working with more than eight coverages in a real-time exercise. Other coverges could be added or substituted to reflect a different game focus or different instructional goals.

Although the game is designed for players without any GIS background, the game can be structured so that one or more teams can utilize a GIS expert. In this situation, an instructor knowledgeable in ARC/INFO is available as a consultant to the teams, so that they have additional flexibility beyond that allowed by the macros. Parenthetically, each time the game has been played, participants have requested data query or presentation capabilities not in the current version of the game. When new macros are added, the same thing happens the next time the game is played. This situation can be addressed in real time by allowing a GIS expert to sit in with the team asking the question, and utilize the eight coverages in a nonstructured ARC/INFO session. In each game where one of the teams has requested such assistance, that team has ended up controlling the direction of the negotiation. This seems largely to be due to the ability of the group working with an expert to make more intuitive use of the GIS and its data than is possible with the macro driven version of the program. This team typically ends up recognizing that several adjoining parcels in the vicinity of a single small parcel acceptable to all parties can be assembled into a package that works for everyone. Although this same conclusion can be reached using the macro version of the program, the group using the expert tends to arrive at this insight first.

LESSONS LEARNED TO DATE

Using the Development Dispute Resolution exercise has been instructive for us as well as for the participants. Among the lessons learned have been:

- Providing parties with a common database facilitates negotiation and reduces ungrounded, self-serving claims. At the same time, the complexity of the database tends to make parties somewhat uncertain as to how to understand the potential of their own bargaining space and, hence, somewhat tentative in discussing options with other parties before they generate consensus internally about their strategies. Balance is critical here. Too little information limits the negotiation possibilities; too much information can overwhelm participants.
- If the technical demands of the exercise are too great, then the parties have less time and energy to focus on the substantive negotiation. Absolving participants from technical details of operating ARC/INFO and the suitability model through macros, dBASE programs, and user-friendly game procedures allows them to be more creative in their bargaining and more active in their attempts to form coalitions.
- A combination of tabular data and spatial analysis and display is ideal for negotiation in this context. The ability to look at a parcel of land on the screen and match it to a list of attributes gives participants an understanding that is missing with either option by itself. Participants take advantage of computer capabilities in analyzing the problem and in searching for joint gains. Thus, they make use of interactive graphics more than plotted, static maps.
- Professional planners and students with little knowledge of GIS, suitability analysis, or negotiation can be provided with enough expertise in a very short time to be able to undertake an exercise

involving all three skills. Due to the user-friendly computer structure of the exercise, participants gain a sense of empowerment and accomplishment they rarely achieve in workshop settings.

- Workshops of this type are extremely computer-intensive, and place great burdens on the computer labs where they are taught. To carry off this exercise takes four 80386-based computers with at least 1 Mb of RAM, 40 Mb of hard disk storage available, and math coprocessors installed. Plotters capable of generating page sized color plots as well as conventional printers are also necessary.

The bottom line for us has been discovering the fascinating opportunities opened up by combining negotiation training with GIS and land suitability analysis. We believe that the potential of these *GIS application areas* is extremely promising and only just beginning to be tapped.

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ASPRS Staff Voice Mail Extension Directory

The ASPRS Headquarters has a new phone system! Daytime calls will continue to be answered and routed by our receptionist, Thelma Sturdivant, between the hours of 8:30 a.m. and 5:00 p.m. If the person you're calling is unavailable, you will be asked to leave a message in our voice mail.

After regular business hours, the Automated Attendant System will immediately put your call into voice mail. You will be given the option of direct dialing the staff member's extension, or leaving a message in a "departmental" mailbox. It takes about 15-20 seconds for the system to transfer the call to the extension you wish to reach. Staff extensions and departmental mailbox extensions are listed below.

Staff Extensions—Alphabetical by FIRST Name

28 Anne Ryan, Sustaining Member/Region Services
16 Arlen Reimnitz, Asst. Executive Director
18 Bill French, Executive Director
23 Cheryl Stratos, PE&RS Advertising
25 Don Hemenway, Publishing & Public Information
24 Ellie Eldredge, Manuscript Coordinator
27 Joann Treadwell, Editorial-PE&RS/Proceedings
20 Judy Peesel, ISPRS
21 Julie Hill, PR—Exhibits & Marketing
12 Karen Davenport, Accounting
14 Marc Raffel, Finance Manager
17 Mindy Saslaw, Certification/Awards
29 Scott Scherrer, Membership
26 Sokhan Hing, Membership & Subscriptions
10 Thelma Sturdivant, Book Sales

Department Voice Mail Extensions

3 Membership & Subscriptions
4 Book Sales
5 Editorial Information
6 PE&RS Advertising
7 Meetings & Conventions
8 Certification/Awards
9 Executive Director Office
12 Accounting
20 17th ISPRS Congress
0 General Mailbox
15 Inst. for Land Information
19 IGIF