

Systems Development for Geographic Information Systems: A Case-Study Analysis

James B. Pick

University of Redlands

Redlands, California, USA

james_pick@redlands.edu

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Organization of Talk

- Antecedents
- Systems development
 - GIS systems development
- Case study analysis of 20 companies
 - Findings of case study analysis
 - Influence of size of firm
- What does this study say about GIS systems development, versus IS?
- Practical implications of research
- Conclusion

Antecedents

- A GIS system must be conceived, planned, and taken through a series of analysis, design, testing, and implementation steps to actually reach the point that it is “turned on” and put into use.
- A major tenet coming from both the IS and business-planning disciplines is that of systems development phases.

Reasons use of the systems development methods and tools for GIS and spatial is limited in industry

- (1) The early history of GIS took place in the public sector which, was not as well versed in the techniques as business.
- (2) The spatial design teams often located in small independent groups with members coming from the public sector backgrounds of (1).
- (3) Fewer big- corporation design methods and techniques were utilized for GIS, since GIS is not yet very much in the visible profit centers of larger companies.

Systems development – 2 Major approaches

1. *Traditional Approach*

- Based on structured design and programming.
- Utilizes data flow diagrams and entity relationship diagrams. What is key are processes, data flows, and relational data-base structure.

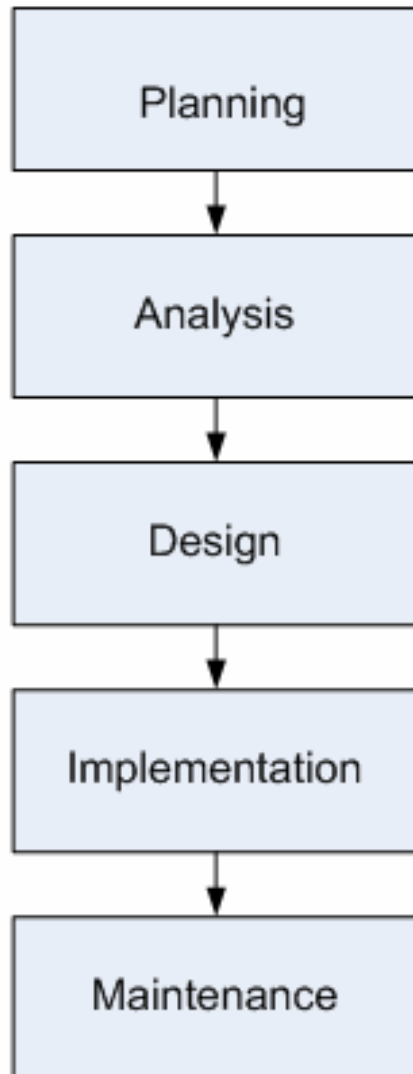
2. *Object-oriented Approach*

- a set of interacting objects is designed to work together to accomplish goals.
- The object replaces the processes.
- Has the advantage that the object is easier to think of as relating to the real world.

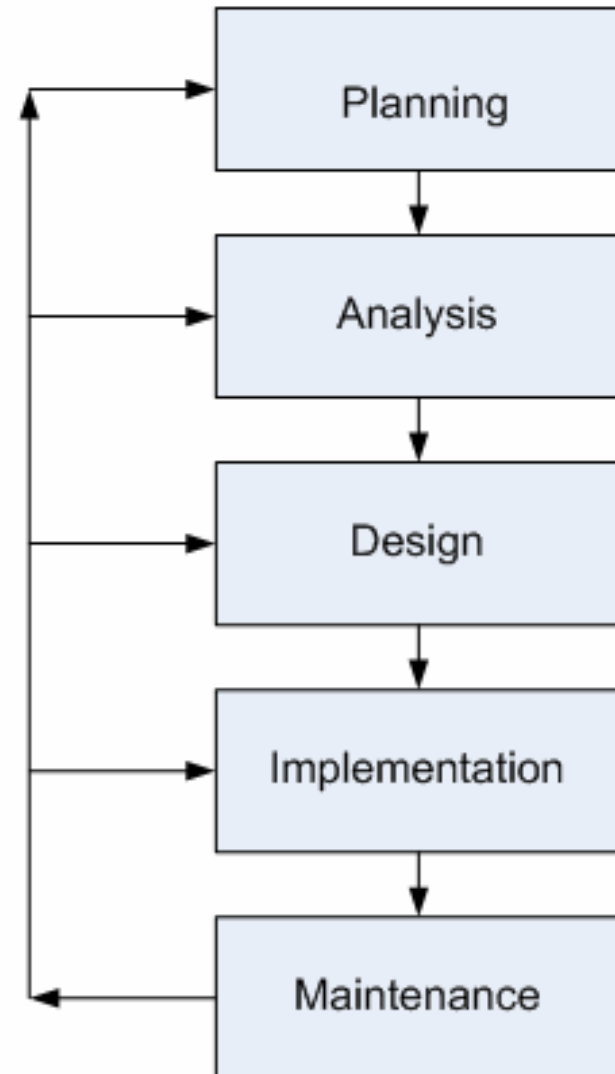
Phases in systems development

- Both traditional and OO approaches utilize phases in developing a system.
- Names and number of phases vary, but have almost the same components (Satzinger et al., 2006).
- The phases apply generally to any type of system. They are well accepted by larger companies.
- They are Planning, Analysis, Design, Implementation, and Maintenance. They can loop back fully or partly.
- The phases can be applied to developing GIS and spatial systems. For those systems there are some special aspects which are discussed by phase.

GIS Development Phases



GIS Development Phases, with Iteration



GIS systems development – what is different - Planning

Planning (The GIS problem to be solved is identified. Then its feasibility, budget, staffing, scheduled analyzed)

- *Staffing.* GIS has the problem of the “knowledge gap” (Tomlinson, 2003; Marble, 2006). When technology (spatial) is moving rapidly as for last five years, hiring and retaining of qualified GIS staff is a challenge.
- *Training.* There hasn’t been sufficient training to have knowledgeable staff and key-users to make the decisions of planning.
 - Solutions. Larger than the business, which can institute planning. Is a societal problem.

GIS systems development – what is different - Analysis

Analysis (information gathering, discovery, hearing the user, developing requirements, making a proposal to go ahead)

- *The systems development team.* It is assembled. In larger firms, the GIS department is usually much smaller and separate from IT. Thus the choice of team leader and team members is crucial, depending on nature of the problem and the organizational dynamics.
- *Prototyping.* (i.e. quickly creating and testing a small version of the full system). It is advocated for GIS development (Reeve and Petch, 1999; Tomlinson, 2003). It can push through the complexity of GIS projects and rapidly get results to users to critique.

What is different - Analysis (cont.)

- *Technology seminar.* Called early in analysis to provide training, increase GIS and spatial understanding, and have group of key GIS-user dept. heads come up with requirement suggestions. The group also has key systems development staffers, CIO, some middle managers, and several executives.
 - It's similar to what is usually known as RAD (Rapid Application Development)

GIS systems development – what is different - Design

Design (full design requirements are developed and detailed).

- *Spatial data model.* For GIS, design of the data model differs from traditional IT. Must account for spatial and attribute data. The alternatives include:
 - Relational data-base with table linking to geography
 - Object oriented database model
 - Spatially-enabled data warehouse
- *Acquisition of spatial data.* It differs (sources, etc.)
- *Spatial data conversions.* Needed because of differences in the standards that are in use.
- *Cartographic design.* The cartographic elements not present for standard IT or multimedia. Software has cartographic tools. For high-end applications, an in-house or consulting cartographer may be needed.

GIS systems development – what is different - Implementation

Implementation. (The system is built, tested, and put into use).

- *Coupling of technologies.* Spatial technologies may be coupled together, for instance GIS, GPS, and RFID. This adds complexity to construction and implementation.
- *Training.* There is an enhanced training challenge, because of the deficit in educated workforce and users (Marble, 2006). Users likely to be unfamiliar with spatial concepts.

GIS systems development – what is different – Maintenance

Maintenance. (Support for smooth functioning of the systems for the years following implementation).

- *Rapid change.* Since 2000 and particularly since 2005 (advent of wide-scale consumer based mapping, business RFID, etc.), spatial technologies have been advancing rapidly, even more so than IT as a whole.
 - Change increases the maintenance need for maintenance.
 - It may force major upgrades or abandonment.

Research Study of the GIS Systems Development

- A interview research study was conducted over the past year and a half of 20 case firms, to determine prevalence, structure, and applications of GIS connected to enterprise systems
 - ESRI's help and support is acknowledged.
- The firms vary by industry, size and GIS maturity. Three of them requested anonymity.
- The person responsible for GIS at the firm was interviewed for 1.5 to 2 hours. A standard protocol of questions was followed. The interviews were taken down by hand notes and transcribed from tape.
- The sections of the interview concerned applications, users, enterprise GIS, systems development, spatial decision support, costs and benefits, and strategic GIS.
- There are many findings already published and presented, and others in process. This report is limited to the findings on GIS systems development.

Methodology

- The methodology for this research is case study (Yin 1994).
- The sample was selected as a convenience one, rather than random or stratified. The reason for a convenience sample is that many firms are proprietary and confidential about their GIS and spatial technologies
- For each firm, the protocol is to interview the manager or executive responsible for spatial technologies. The interviews utilized a standard interview protocol and set of general questions. They were transcribed in writing and tape recorded if permission was granted.
- This was supplemented with business materials from the firms and secondary sources.

Research Questions

The case-study research sought answers to the following questions:

1. Was systems development done in-house or mostly outsourced?
2. If in-house, were formal phases taken, or were information steps followed?
3. What was the composition of the systems development project team?
4. Was the system development approach traditional or object-oriented?
5. Were there differences by the size of company in the approach taken?

RQ1: Findings on whether systems development is outsourced

- Only two of the 20 firms conducted most of systems development by outsourcing.
 - *The Large Credit Bank (LCB)* had little GIS implemented, relative to its huge size. In its main credit bank unit, GIS development was outsourced entirely to a small firm that concentrated on market analysis for branches and mapping of headquarters campus. Some newly acquired smaller banks already utilized GIS – unclear if that would stay in-house or also be outsourced. Here outsourcing may represent “benign neglect.”
 - *Kaiser Permanente*. Outsourcing managed by the corporate head of GIS. GIS group energetic and limited intentionally in size. Outsourcing has been generally successful. GIS manager initiates development and brings projects through analysis at least, but then will often outsource larger projects to various specialized consultants.

RQ1: Findings on outsourcers

- Two respondent firms have a primary emphasis of outsourcer serving client firms.
- *Engineering Systems* (ES) is a small, LA-based GIS consulting firm that serves mostly county agencies in Calif. and Virginia. It servers as an outsourcer for multi-year projects, up to 10 years, with ES personnel located at the client. It emphasizes high accuracy in this work.
- *URS* is the world's largest environmental consulting company. It assigns a project team to develop requirements and specifications with the client. It emphasizes detailed using documents very early ("Quick and dirty straw man"). It then produces quickly Beta version prototypes, often implemented first on a URS server. It emphasizes speed and user consultation.

RQ2: What formal phases were taken, or were they informal steps

- Of 18 firms doing in-house development, 10 used formal approach and 8 informal.
- Of those doing formal, trends are noted:
 - The GIS group or team mostly leads the system development. For Southern, IT was the leader, which reflected a consolidation of subsidiary firms, some of which had separate GIS groups.
- Informal systems development for respondents involved brainstorming, informal idea exchange, and experimental ad-hoc procedures.

RQ3: What was composition of systems dev project team, formal approach?

- For firms with a formal approach, the team is composed of IT group members, GIS group members, business users, and/or consultants. The structure and relationships vary.
 - At Rand McNally, GIS group leads for internal projects and IT programming group for commercial projects.
 - At Sears, CAM app done by GIS group, SST app by IT programming, and ESRI GIS apps to outside consultant.
 - At Southern, GIS development usually done by centralized IT, sometimes by GIS unit in a subsidiary, but IT “in the loop.”
 - At Sperry Van Ness, a small centralized IT unit does both IT and GIS development, consulting closely with key users.

RQ3: What was the composition of team for informal systems dev?

- Composition of systems development team less clear for informal approach. It is more spontaneous driven by parties that vary from firm to firm.
 - For Prudential Preferred and Lamar Advertising, GIS and business individuals lead in initiating ideas, some of which gather strength for development projects.
 - At Chico's, ideas comes from GIS group of four. "Get people's takes and let's go down the path."
 - At Motion-based, developers use "ad hoc" techniques in designing and programming. The use gut instinct to build what they believe is correct. Concept is "product roadmap" informed by customer ideas for improvement.
 - At Western Exterminator, there is not software programming, but rather a business analyst responsible for map web services, guides application development.

RQ4: Was the system development approach traditional or object-oriented?

- For firms using formal systems development approaches, they were all traditional.
- Motion-Based Technologies utilized informal steps for systems development but for implementation centered on the Java language, making use of its object-oriented features.
- One of the reasons for the dominance of traditional is that leadership in systems development came mostly from GIS groups, which largely lacked training or experience in OO development methods or languages.

RQ5: Were there differences by size of firm in the approach taken?

- The formal approach is far less common for small companies (1/3), compared to large and medium ones (60 percent).
- An explanation is that small firms are at earlier maturity stages, are hard-pressed from day to day, and are often short-handed, so the firm cannot afford the time and resources to support the formal procedures and controls.
- Also, the large firms are used to and often have in place mandated formal procedures in IT, accounting, and other areas, so it is consistent managerially to extend them to GIS.

What does this study say about GIS systems development, versus IS?

- The study implies that GIS systems development is mostly insourced. Outsourcing can be done with varying roles for the client firm.
 - Outsourcing is more common with IT
- Most companies for GIS utilize a traditional systems development approach, rather than informal. This is similar to IT.
- Large and medium-sized firms are more likely to adopt a formal approach for development. This is true for IT systems development as well.

What does this study say about GIS systems development, versus IS? (cont.)

- The GIS group if present usually plays a major or the lead role in development, although the associated IT group tends to conduct in-house programming and technical implementation. Key users are often included.
 - The issues are different from IT projects, where IT is typically in charge, but the extent of decentralization of IT is a significant factor.

Practical Implications for how a GIS manager plans and administers systems development

- *Outsourcing.* An early decision is whether some or nearly all of the systems development should be outsourced? This decision can be helped by thorough cost-benefit analysis? It also depends on the company culture and experiences.
- *How GIS IT groups inter-relate.* If done in-house, a key early decision is how the GIS and IT groups will inter-relate in spatial systems dev. Which group should be put in charge of what projects?

Practical Implications for a GIS manager (continued)

- *How formal an approach.* In deciding on the extent of formality of systems development, the manager should weigh the firm's standard practices, the size of the project (larger needs more formal), the amount of regulatory scrutiny (e.g. Hipaa or Sarbanes-Oxley), and the people on the team.
- *User training and education.* Since users involved in systems development may be less familiar with GIS and spatial, they may need to be trained and educated.
- *Rapid application development and prototyping.* They should be seriously considered, as they can help to involve users early, even ones less geospatially knowledgeable.

Conclusion

- Standard systems development approaches for IT need to be modified for GIS.
- A study of 20 firms indicates how spatial systems development is conducted in the real world.
- Factors such as outsourcing, organizational structure of development, team composition, extent of formality of approach, and firm-size differences are important.
- Many GIS and spatial development projects have failed. Ideas from well-known approaches and the experiences of firms implementing GIS can be helpful and hopefully lead to more success and better quality spatial systems.

Questions