STATE OF VERMONT
CONCEPTUAL SYSTEM DESIGN

Final Report for Phase II of
Vermont's Comprehensive GIS Strategy Study

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EXECUTIVE SUMMARY

This Phase II Report is being submitted to the Vermont GIS Oversight Committee pursuant to a contract for preparation of a comprehensive strategy for development and use of a Geographic Information System for Vermont. This report continues the documentation of information collected by the Oversight Committee, PlanGraphics, and the Cavendish Partnership and contains recommendations, technical analysis, and issue identification necessary for the affordable and timely progress for GIS development in Vermont.

The Vermont Municipal and Regional Planning and Development Act, as amended by the Growth Management Act (Act 200), authorized the establishment of a Vermont Geographic Information System to provide maps and other decision support analytical tools to local and regional government agencies. Land use planning for appropriate development of Vermont's natural resources was defined in terms of legislative goals. The information sharing network anticipated for all units of government in support of these land use planning goals is best suited to a GIS solution, and the considerations presented in these reports provide a framework for that statewide information network.

The Phase I Report focused on the GIS "needs determination," and documented relevant experiences in other states, proposed GIS applications chosen and defined based on interviews with personnel from state agencies, and regional and municipal government that will be the ultimate supporters and users of the Vermont GIS. Initial work on the characterization of users, organizational issues, staffing, system configuration, and data quality standards were also presented in the Phase I Report. Interim support for the software selection process was provided to the Oversight Committee, including development of Guidelines for GIS Software Demonstrations. An interim report examining the issues raised by public access to the Vermont GIS was prepared. This report includes a proposed system for characterizing levels of GIS access, a cost model for establishing prices for commercial products and services that will be available from the Vermont GIS, and an analysis of legal issues that arise from efforts to control access and market government "owned" information processing services.

The Phase II Report covers the remaining tasks specified in the contract for services. It is focused on system design issues in three general areas: Organizational issues are examined and recommendations are made for a phased institutional development to support Act 200 information exchange, and to make the most distributed access to the Vermont GIS possible within budget and schedule limitations of Act 200. Next, database development is examined including discussions of mapping standards, data standards, and conceptual database design requirements for priority applications, data conversion methodologies, and cost estimates. Finally, the Phase II Report provides an analysis of computer hardware needs for the Vermont GIS, conceptual GIS configurations, and cost estimates.

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SECTION 1
INTRODUCTION

The Phase II Report (System Design) presents a conceptual design for the Vermont GIS based on system applications defined and grouped into priorities in the Phase I Report (Needs Determination). The Phase II Report includes discussion of three aspects of conceptual design: organizational and institutional development, database design, and hardware configurations. It is to be read in conjunction with the Phase I Report and the interim paper, "Providing Access to the Vermont Geographic Information System: Legal Framework, Functional Access, and Cost-Price Model for Sale of Products and Services," which included examples of interagency contracts and statutory formulations from other states addressing access to government data.

Many decisions remain as to specific choices regarding hardware, staffing, parcel mapping and conversion, investment choices among development of databases to support priority applications, and institutional relations and organization. The considerations presented in these reports do not constitute a final "cookbook" detailing every step to implementation of the Vermont GIS. One of many possible specific recipes could be proposed that meets all the requested applications, but would require inappropriate assumptions of available time and money. These reports provide the Governor, Oversight Committee, and other GIS policy makers a framework for the GIS implementation strategy without attempting to limit the necessary flexibility that funding, schedule, and institutional considerations among the cooperating government agencies still demand at this stage of project development.

The benefits go up as the distributed use of the system expands, spreading the initial investment in data conversion, hardware, and training as more applications are provided to more users. Before this cost effective payoff occurs, limited funds must be stretched to provide basic tools for land use planning at the town level. An interdependent relationship exists between several identified startup tasks. Critical policy decisions are required in the following areas to proceed with implementation:

- Number of users to initially receive on-line, batch, or service bureau access to the Vermont GIS
- Amount and timing of financial investment in cash from the GIS fund and other existing commitments of resources
- Individual agency dedication of staff and facilities supported by existing agency budgets
- Identification of alternative funding sources for parcel mapping, commercial databases, distributed hardware, software, staff, and data conversion
- Development of a GIS service capacity for users where current local or agency resources will not allow direct access to the system
- Schedule for implementation of Act 200 applications
- Schedule for implementation of other cost effective agency applications not directly connected to land use planning.

This report focuses on Vermont GIS implementation options within the known and anticipated constraints of funding, institutional cooperation, and deadlines established by Act 200. The large front end investments, primarily conversion of information into usable GIS data, could well exhaust the current funds allocated for support of Act 200. The current Act 200 time frame for implementation allows little time for further deliberation of alternatives. Initially, Vermont might choose to limit funding of hardware purchases at the regional level, forego certain priority applications in favor of others, or seek a bond issue or other source of funds sufficient to provide more applications for more users quickly. The recommendations in this report provide system design targets for solutions to Vermont GIS implementation goals, but necessarily leave many routes open to interim policy decisions to build a working GIS.

Methods of cost recovery and legal issues impacting proprietary use of the Vermont GIS were examined in an interim report, "Providing Access To the Vermont Geographic Information System." Both Act 200 impact fees and the opportunity to share development and operational costs of the system with private sector users will in time offset certain initial conversion, hardware/software, and staffing costs. Compromises between a more intensive front end investment for establishing the system or an extension of the deadlines for making all Act 200 applications available should be made between now and 1990. Based on the current information collected over the past five months by PlanGraphics and The Cavendish Partnership, this report presents an analysis of the system design issues that will impact necessary GIS implementation choices :

- Obtaining completed parcel mapping for the state (now 50 percent complete)
- Database standards (acceptable minimum levels of accuracy, quality, and format)
- Conceptual database design (for state and local applications)
- Database conversion and maintenance methods and general cost estimates (phased based on need to generate base maps and support of priority applications)
- Hardware configuration and general cost estimates (phased based on near and long term targets capable of meeting Act 200 goals)
- Organizational options and implementation strategies (conditional on interagency agreements and structure of a policy committee).

The initial strategic goal will be to provide base maps for towns and regions adequate to allow a consistent statewide platform for land use planning. Attribute information tied to the maps will come from state sources and be updated and maintained through a state/local partnership. Local planning information will be collected by the towns, and state and regional resources will be devoted to fitting such information into the system allowing spatial analysis that will greatly enhance the quality of planning. Towns with automated parcel maps and support from a Regional Planning Commission with independent GIS capabilities will be able to achieve the benefits of more GIS applications much sooner than towns considering preparation of their first area parcel map. Choices between providing for consistent statewide evolution of this decision support system, and quick results for a limited jurisdiction from the initial investment will be prevalent throughout the implementation of the Vermont GIS.

Along with the natural values of the state's land, air, and water; information about land is one of Vermont's most valuable resources. Accurate and timely information can assist all levels of government in making good decisions to maintain and improve the quality of life in Vermont. The distributed nature of government's land use decisions mandated in Act 200 demands that high quality data be made accessible to towns through an effective dissemination mechanism at reasonable costs.

The statewide implementation of GIS technology provides Vermont the opportunity to avoid the costs of redundant data collection, to provide for compatibility of information allowing for manipulation, display and analysis, and to provide for automated linkage between databases of different organizations. Vermont's GIS will provide a base for the capture of more useful data than has been practical in the past. It will allow the ability to see organizational impacts of land use decisions historically and to forecast future impacts. The system will allow for better assignment of costs and responsibilities for appropriate development in the state, and provide greater professionalism and efficiency in service delivery to the citizens and land use permit applicants. The requirement for GIS technology to support Act 200 planning will result in making use of Vermont's information resources for an overall improvement in the efficiency of providing government services for a much broader list of current and future programs.

SECTION 2
ORGANIZATIONAL ISSUES AND INSTITUTIONAL RELATIONSHIPS

INTRODUCTION

The Phase I Report, "Needs Determination", characterized GIS users and presented management issues, recommended a general organizational structure, and delineated GIS staff roles. In this section of the Phase II Report PlanGraphics discusses organizational interrelationships in greater detail, and relates them to GIS database development priorities and organizational structure needed to carry out priority GIS uses. PlanGraphics has defined the priority uses or applications, and the organization, hardware, and database to support those uses, as those required to implement Act 200.

This section will discuss a broad range or organizational issues and recommendations including:

- Present a range of possible GIS intergovernmental interactions
- Lay out a central GIS policy structure
- Outline GIS interagency agreement requirements
- Present criteria for formal agreements, such as memoranda of understanding, as a starting point to define major system participants' roles
- Discuss data maintenance and user access policies
- Define state agency, regional commission, and local government roles
- Define system development phases
- Recommend next organizational steps
- Evaluate the private sector role.

GIS INTERACTIONS BETWEEN STATE, REGIONAL, LOCAL, AND OTHER ORGANIZATIONS

Defining GIS interactions by type and agency will lay a foundation for defining organizational relationships. Many types of interactions require different relationships between users and the Policy Committee/GIS home. Interactions will occur among GIS participants in the following areas:

- *Policy decisions:* Establishment of a GIS organizational home, GIS contractual agreements, overall system funding, legislation, GIS user access policies, evaluation and selection of application development options

- *Technical decisions:* Mapping standards, data standards, GIS hardware/software selection, scheduling database updates

- *Communications:* Information exchanges about the GIS, additions to the database, advice on applications, procedures, service center requests

- *Data exchange:* Development/maintenance of the database, hard copy data sharing

- *System operation:* Training, staffing, quality control, standards enforcement, applications development, digital data exchange, hardware/software maintenance.

The entities that will be involved in GIS interactions include the following:

- Policy Committee and subcommittees
- Other GIS related committees (i.e., State Agency Planning Implementation Committee, Council of Regional Commissions, etc.)
- GIS organizational home (i.e., AOA)
- Major state agencies (i.e., ANR, AOT, ADCA)
- Other state agencies
- Individual Regional Planning Committees
- Individual cities, towns, and villages
- Private sector and individuals
- University of Vermont.

Table 2-1 shows five broad types of interactions possible among the entities involved in the Vermont GIS. The types - policy, technical, communications, data, and system - are defined above. The table illustrates the complexity and the diversity of interactions possible between each entity once Vermont's GIS is fully implemented. Predictably, the greatest diversity of interactions can be expected to occur between the GIS organizational home and the other entities, with the Regional Planning Commissions and the University of Vermont also involved with multiple participants. Obviously, designated GIS service centers will be major participants in many facets of the GIS. They will be involved in two-way interactions with all participants. Other entities will have more narrowly defined roles.

The GIS organizational structure needs to enhance these interactions without creating too rigid a structure. It needs to provide for flexibility to meet Act 200 needs, yet serve other GIS applications at some future time. The rest of this section will discuss approaches to that structure and roles of the GIS participants.

GIS ORGANIZATIONAL HOME

For an effective GIS, Vermont needs a central organizational unit that can coordinate policies, standards, data quality control, and users' needs; as well as communicate with participants. Such a central unit will also serve as the clearinghouse and library for all GIS databases in the state. Formal contractual agreements among participants or legislation detailed by memoranda of understanding will need to specify which entity(ies) should run the GIS. This report recommends that an office in the Agency of Administration will become the GIS's organizational home, as discussed in the Phase I Report. Other suggestions for GIS organizational homes include a new GIS service bureau to be part of the Executive Department (in the Office of Policy Research and Coordination), a hybrid of a state agency and a for-profit organization (like the Vermont Industrial Development Authority), or an existing institution (specifically the University of Vermont).

TABLE 2-1
GIS INTERACTIONS AMONG VERMONT ORGANIZATIONS

Interaction Initiators ↓	GIS Organizational Home	Policy Committee	Technical Subcommittees	AA, AOT, ANR, ADCA	Other State Agencies	Regional Planning Commissions	Cities, Towns, and Villages	University of Vermont	Individuals and Private Sector Corporations
GIS Organizational Home		P	T, C, S, P	T, C, D, S, P	T, C, D, S, P	T, C, D, S, P	C, D P	T, C, P, S	T, C, D, P
Policy Committee	P		P	P	P	P	P	P	P
Technical Subcommittees	T, C, S	P		T, C, S	T, C, S	T, C, D, S	T, C	T, C, S	T
AA, AOT, ANR, ADCA	T, C, D, S	P	T, C, S		C, S	C, D	C, D	C, D	D
Other State Agencies	T, C, D, S	P	T, C, S	C, S		C, D	C, D	C, D	D
Regional Planning Commissions	T, C, S, D	P	T, C, S	C, D	C, D		T, C, D	C, D	D
Cities, Towns, and Villages	C, D	P	T	C, D	C, D	T, C, D, S		C, D	D
University of Vermont	T, C, D	P	T, C, S	C, D	C, D	C, D	C, D		D
Individuals and Private Sector Corporations	T, C, D	P	T	D	D	D	D	D	

Legend:

P = Policy Interactions
T = Technical Interactions
C = Communications Interactions
D = Data Interactions
S = System Interactions

The reason for choosing a new office within the Agency of Administration for the organizational home is based on many of the same reasons the authority to plan for GIS implementation was initially delegated to the Agency of Administration Secretary following passage of Act 200. The Agency of Administration has a utilitarian view of the need to provide balanced use of this decision support tool to all levels of government. It has in-house expertise in computer software and hardware and public records issues through the Department of General Services, expertise in mapping and the state orthophoto resources through the Department of Taxes, expertise in state procurements and financing tools through the Department of Finance and Management, and expertise in the establishment of new agency positions through the Department of Personnel. The Agency of Administration is not so directly involved with particular GIS applications that there would be even the appearance of improper emphasis when choosing between development of applications that inherently favor one agency over another or local needs over state agency needs.

PlanGraphics does not recommend the formation of an "authority" with more independent, private sector characteristics as an organizational home for several reasons. The Act 200 schedule does not allow for experiments, especially if they involve the creation and staffing of an entirely new institution. Many of the reasons for choosing a public/private platform for other state systems have proven unnecessary. In one example, this approach did not suffice to limit the impacts of public records law, and the opportunity to share costs with the private sector was not enhanced by the structure. Administrative control problems have been evident with such structures, and state and local agencies are likely to become one among many "clients" as the system matures. It is most important that Vermont retain proprietary control over the value of the database that will be established to support the Vermont GIS. This kind of structure at minimum brings data ownership into question, and at worst gives away the taxpayer's investment in the data for a small portion of its value. It may prove to be very appropriate to license distribution of commercially valuable aspects of the Vermont GIS in order to take government out of the role of marketer (as was done between Hennepin County, Minnesota and Ultimap, Inc. for sale of government developed software). The situation in Vermont may eventually call for the creation of an independent authority to account for some unanticipated development, but there is no current demand for creating an authority to deal with GIS implementation that merits the risk of loss of administrative control and database value. Government owned contractor operated or GOCO arrangements may be beneficial for support during the period of building a permanent staff. This is an option for consideration short of giving up the control of the system to a contractor.

The University of Vermont is one interim home option presented in the Phase I Report. The University should continue to provide GIS products and services to state agencies and those regional and local governments with no hardware. This interim approach to a central service center is attractive because GIS equipment, software, and trained staff are already available at the University. The University has had a major role in the current pilot projects, providing conversion and technical services statewide. The University's GIS development has been based on software that is compatible with connections to other systems already available in the state, and it is available for mainframe, mini, micro, and workstation based systems. The Oversight Committee recently chose the same GIS software now used by the University for the Vermont GIS.

The University is a major GIS implementation resource and should be used more extensively, however, current support requests (both within and outside of the pilot project scope) are already overwhelming the current staff's capacity. Plans for increased staff and purchase of improved hardware are underway, and the state Policy Committee should support building the University's GIS infrastructure to keep up with the demand. Such support would be most critical during a one to two year interim period, or until state or regional service centers were established. The University and the Policy Committee will need to develop this service bureau role further in a system implementation plan and budget. The plan should include consideration of the University as a conversion shop for statewide data layers and base map production; a training center for GIS personnel from the towns, regions, and state agencies; and could include lease arrangements for equipment targeted for the organizational home when purchase of equipment directly by the University is not possible. The University will provide the best source for professional GIS staff, in short supply nationally, for the service bureaus that will evolve throughout the Vermont GIS network.

CONSOLIDATED GIS OVERSIGHT

Policy Setting Group

One of the first organizational structure needs is a permanent policy committee, preferably established by legislation or executive order, that is empowered to make decisions concerning the GIS. GIS technology bridges disciplines of computer science, information management, cartography, and environmental management. GIS projects are multidisciplinary in nature and are most successful when developed by multidisciplinary teams. The current Oversight Committee provided an excellent framework for policy decisions to initiate Vermont's GIS. The Phase I Report recommended the next step requires a more formal, permanent policy group with express implementation authority. Such a group will approve major GIS direction changes and new focal points for the GIS, promote system use, resolve conflicts, and assist in long range system planning and financing.

As seen with the demands placed on the University, the Policy Committee will have a very substantial job during the first two years of the project where many of the policy decisions that will shape the GIS will be made. As the GIS organizational home comes into existence with trained staff and an approved multi-year implementation plan, the Policy Committee's work load will be significantly reduced to more limited areas of oversight and support. Building this complex system with a finite budget under the Act 200 deadlines will require a very businesslike approach, with both efficient decision making techniques and broad user representation built in. Recommendations for Policy Committee membership are based on Oversight Committee discussions, particularly the work of the Organization Subcommittee, combined with the recommendations made in the Phase I Report.

PlanGraphics recommends the following membership for the GIS Policy Committee:

- Secretary, Agency of Administration
- Secretary, Agency of Development and Community Affairs
- Secretary, Agency of Natural Resources
- Secretary, Agency of Transportation
- Two legislators - one representative and one senator
- Representative from the University of Vermont
- President, Vermont Association of Planning and Development Agencies
- Two representatives of towns and cities (designated by the Vermont League of Cities and Towns)
- One business representative (e.g., Vermont Business Roundtable).

PlanGraphics recommends that the University of Vermont be the designated representative of an institution of higher learning initially. The University has a key role in pilot projects and may be an interim central service center. Representatives from other institutions can be appointed to replace or augment the University of Vermont as the University's role evolves over time.

The Policy Committee will need to be able to make decisions effectively and efficiently. This requirement is quite difficult to meet since system development involves such a broad range of user types and needs, and the anticipated schedule demands a benevolent dictator to deal with the range and number of decisions identified for system implementation. A choice between large numbers of participants and highly placed decision makers representing broad subject areas, still requires choosing the formula with the more workable numbers. Although it is essential to represent the broad constituency of Vermont's complex, distributed GIS, the proposed 11 member Policy Committee of highly placed policy makers is still too cumbersome for efficient, rapid decision making. It will always be a problem to assemble a quorum on short notice given such a membership. Appointed representatives of these named members are anticipated, but such representative participation must be accompanied by a clear delegation of authority to make decisions on behalf of the agency Secretary.

To streamline decision making in the initial implementation stages, PlanGraphics recommends a core executive committee be formed, and the lead GIS staff person (once available) be given broad authority to make decisions subject to the Policy Committee's ratification. An executive committee could be consulted by phone or in specially convened meetings. If broad decision making authority is exercised by the lead GIS staff person, it should be pursuant to an approved plan and subject to ratification by the Policy Committee. Broad delegation of authority should only occur subject to a long range plan with incremental updates, and regular reports on progress towards established goals. GIS implementation must proceed with a balance between broad participation of users and a structure that does not slow down day-to-day business decisions.

In the early stages of GIS implementation the committee will confront the need to make many decisions of a diverse nature on matters such as interagency relations, equipment and software purchases, GIS education and training, GIS standards, GIS applications development priorities, and the like. One of the first actions should be to establish a GIS Manager staff position and other support staff for the Committee. If practical, the Committee should continue to make arrangements for the "loan" of staff from the Office of Policy Research and Coordination, State Information Systems, Property Valuation and Review, and the Agency of Transportation familiar with the history and technical issues of the project. Such substitutions for permanent staff, however, should be specific and formal so as to allow the borrowed staff to concentrate on this project, and not be a add-on to existing duties.

Technical Subcommittees

Technical subcommittees will link GIS users, the Policy Committee, and the GIS organizational home. They will review and advise on issues as requested by the Committee and GIS home. These subcommittees will evolve over time as the GIS is developed and issues change. Some will be standing subcommittees, while others will be ad hoc to deal with new, short term issues. The Subcommittee on Organization has proposed the following technical subcommittees to advise a Policy Committee:

- Organization
- Hardware/Software
- Data Evaluation and Entry/Standards
- Natural Resources
- Regional and Local Community
- Private Sector

PlanGraphics generally concurs with the Oversight Committee's recommendations. We offer the following comments on the roles of each subcommittee and the order of development, and suggest an additional subcommittee focused on GIS education and outreach:

- The Organization Subcommittee will be important initially as the GIS framework is established, and subsequently as transitions between GIS phases are planned. This subcommittee will be involved in long range GIS planning and will provide expertise in identifying and arranging sources of system funding. One of the earliest responsibilities of this subcommittee will be to develop the memoranda of agreement and other contractual agreements with system participants.

- The Hardware/Software Subcommittee, more appropriately called the Hardware/Software/Telecommunications Subcommittee, will coordinate ongoing acquisition of compatible hardware and software and help develop workable local and remote communications links. It may assist agencies with equipment contract negotiations, establish specifications, recommend a standard procurement contract, establish lists of pre-qualified conversion vendors, and help negotiate large purchases. The Department of Libraries should be represented on this subcommittee to assist with communications links. Their award winning system for networking the state through local libraries with automated information involved many of the same policy decisions, and some of the same technology that the distributed access to the Vermont GIS will require. Representatives from the Department of General Services will also be critical to this subcommittee. The Vermont Telecommunications Agreement (VTA) order by the Public Service Board should be examined as part of the review of cost effective communication links through the various telephone service companies in the state.

- The Data Evaluation and Entry Subcommittee (or Standards Subcommittee) will be concerned initially with two major groups of tasks. One involves data standards development, conversion decisions for graphic and attribute data, and data quality. They will make recommendations to the Policy Committee concerning an approach to data conversion needed for state and local base map production, which applications will best serve land use planning and cross-agency needs, and data collection and conversion needed to support these applications. The second set of tasks concerns development of parcel mapping standards and methods to fill the gap for those local governments where parcel maps do not yet exist, and where existing parcel maps are insufficient for conversion to a GIS base map. Key members of the State Mapping Advisory Committee should be involved in the second task as "staff" to or members of the subcommittee. Later, this subcommittee will most likely expand its scope and become a database maintenance procedures and standards subcommittee. Appendix D of the Phase I Report and Section 3 of this report describe the different kinds of standards issues that must be addressed in the initial GIS implementation phases.

  This subcommittee must lead the way to obtain statewide parcel maps, and would deal with parcel mapping standards, development of a publication to instruct towns on parcel mapping techniques suited to GIS and town planning purposes, and delineating appropriate state and local funding roles for the process. The existing work accomplished by the Mapping Advisory Committee and staff for the Division of Property Valuation and Review provides a significant base to attack the need for consistent statewide parcel maps, and this subcommittee should be built around the current State Mapping Advisory Committee expertise.

- The Natural Resource Subcommittee will be important in early phases of GIS implementation because the primary state level data related to Act 200 will come from the Agency of Natural Resources (ANR), and that agency is the potential user of the largest number of priority GIS applications driven by Act 200 requirements. Because of the need for conversion of existing ANR data for Act 200 purposes, and because ANR has the most to gain from utilization of GIS technology among the many state level users, this project will involve more staff and budget impacts on ANR than any other state agency. These impacts will be both good and bad depending on the time frame considered. In the near term, the need to analyze existing databases, rebuild certain databases, and change procedures for gathering information will require funding and staff commitments from both the agency budget and other sources to provide the attribute data needed for Act 200 purposes. In the long term, ANR will see the most benefits from automation of many procedures and analyses involving land, air and water resources. It will be critical to keep ANR involved in the GIS implementation planning, and to utilize the agency resources in a mutually beneficial development of applications. This subcommittee may broaden to include other primary state agency data sources as more applications become available, and adopt a different name as appropriate.

- The Regional and Local Community Subcommittee will assist with development of regional service centers and local GIS capabilities. It will serve as the link between the local land use planners and the organizational home, and work with the Organization Subcommittee in long range planning. Although several Policy Committee members represent local governments, this subcommittee should be used to maintain clear communications with the Regional Planning Commissions (RPC), especially during the initial organizational stage, and as the particular RPC develops its service bureau capabilities. There will be a need to deal fairly with the different levels of service that can be made available to different towns throughout Vermont during the development stage. There is a wide discrepancy between starting points - some have automated parcel maps today and are anxious for state attribute data, others lack any form of parcel map and are not ready to consider base map conversion issues. This subcommittee must provide guidance to the Policy Committee on who do we help first with limited funds, and what is the appropriate level of self-help for towns similarly situated.

- The Private Sector Subcommittee will explore opportunities for future mutually beneficial arrangements between government and individuals, corporations, and utilities for GIS products and services. The various possible types and levels of interactions described later in this section and in the interim report on access issues provide a starting point for the subcommittee. Eventually this subcommittee may focus exclusively on marketing selected, commercially valuable GIS services and products. Much of this subcommittee's work will be premature at early stages of GIS development because the subcommittee's responsibilities will not serve Act 200 purposes directly. Its first undertaking should be to develop a plan for generating supplemental financing and identifying sources of private sector data with Act 200 uses. Representatives of the two major electric utilities and gas and telephone utilities should be included on the subcommittee.

- PlanGraphics suggests that an additional subcommittee on GIS education and outreach be formed. This subcommittee will be especially important in developing ways to inform regional and local governments about the GIS and its relation to Act 200, and to make GIS services easily accessible. It can help maintain enthusiasm for the planning process while offsetting unrealistic expectations, assist with planning, arrange training, and market GIS services and products. The last activity would be coordinated with the Private Sector Subcommittee. Some ideas for outreach activities include a GIS speakers bureau, a video that explains the GIS, ongoing GIS demonstrations around the state, and a visiting GIS assistance unit.

GIS AGREEMENTS

One of the first tasks of Vermont's Policy Committee will be to develop and put in place some form of agreements, such as memoranda of understanding, among state, regional, and local GIS participants. Agreements should be flexible tools used to network all levels of Vermont government in using the GIS to carry out Act 200. A standard base agreement will need to be customized to fit the resources and needs of each participant. Most likely several different agreements will be needed for the RPCs, depending on the availability of parcel maps, hardware, staff, and other factors that will evolve at different rates for each RPC. Initially, there will be a need to identify responsibilities for conversion of appropriate state maintained information between the custodial agency and the Policy Committee. Even in cases where private commercial vendors are used, the question remains what costs should be born by the agency budget vs. the fund managed by the Policy Committee for Act 200 purposes. These agreements, which should have different provisions tailored appropriately for the level of government and its particular capabilities, will need to contain the following essential elements:

- Definition of participant. In the first phase, participants will be those governmental entities named in Act 200. As the primary purposes of the Act are met, the GIS participants can be expanded to include other public and private participants that can help support the system with funding or like-kind contributions of data, staff, or equipment.

- Participant responsibilities, such as database maintenance, adherence to standards established by the Policy Committee, and servicing regional or local governments as appropriate.

- Financial requirements for services. Every effort should be made to other user services relating to Act 200 without charge. The costs of services not related directly to Act 200 should be based on fees developed from system cost models. Act 200 services available to all regional and local governments would be free. The Policy Committee will need to develop financing policies and guidelines for GIS equipment, software, data compilation and conversion, and staff not related directly to Act 200.

- Decision making structure. Delegation of authority between the Policy Committee and the GIS organizational home should be specified. For example, the GIS organizational home manager will generally make day-to-day management decisions concerning the system within guidelines set by the Policy Committee and appropriate technical subcommittees.

- Other agency specific requirements and responsibilities. These will be developed on a case-by-case basis.

DATA MAINTENANCE AND USER ACCESS POLICIES

The Policy Committee needs to address how communication is to occur and set policies and procedures for data maintenance and user access. As distinguished from communications options presented in Section 6, Conceptual GIS Configuration, this discussion of data maintenance and communication will address, generally, who will maintain the database and how updates can be transferred to those authorized to enter changes. Detailed data maintenance policies need to be established by the Policy Committee and specified in written agreements with the appropriate agency. Data quality is everyone's concern. The worst thing a decision maker can do is to think an information system is working well when it isn't. Inappropriate or incomplete data problems increase in significance as the confidence of the user increases in a system that does not give the data quality or timeliness that is required. User access policies are straightforward, but procedures may become administratively complex because the initial support available for staff, data, hardware, and software will vary widely among RPCs, local governments, and state agencies.

Data Maintenance

As now envisioned, only the GIS organizational home (potentially the Agency of Administration) will actually be authorized to change the "official" state GIS base map and identified attribute layers that serve multiple users, although many other agencies at different levels of government will be involved in developing and maintaining it. The paths for conveying database changes to the GIS organizational home will follow the organizational structure for individual users and service centers generally. State agencies and local governments with GIS capabilities will send updates directly to the organizational home; while state agencies, regional and local governments without any in-house GIS capabilities will route updates through the appropriate GIS service center.

Not all data developed by Vermont's GIS users will be part of the state GIS database. Each user with system capability will be free to develop databases of local interest that are not a necessary part of the state system. For example, a town may develop an address range database for police and fire department applications. It is recommended that the GIS organizational home be notified of such databases and serve as a clearinghouse to maintain listings. Such reporting requirements should be specified as a procedural standard for system participation. The data catalogue developed for Vermont and explained in the Phase I Report should serve to maintain this information. It was designed as an automated database. This provides a dynamic list which will serve future needs, allow for current additions to the catalogue, and searches for information by subject or custodial agency. It will become a valuable resource for state and local use if maintained as the Vermont GIS matures.

User Access

The Policy Committee can address user access to the Vermont GIS according to the levels of transactions presented in the Phase I Report - interactive, high priority batch, low priority batch, and service bureau requests. Access will be determined in part by whether users want to purchase their own software and equipment, and develop staff capability for onsight analysis and data maintenance. Interactive, high and low priority batch transactions will require an in-house GIS capability. However, all users will be able to access the GIS indirectly through regional or state service centers. They will write or call the central or regional GIS service nodes or submit requests through a GIS "circuit rider". As mentioned in the earlier discussion of the Regional and Local Community Subcommittee, a visiting GIS assistance unit could travel to local governments on a set schedule to collect GIS requests and deliver products and services. Present technology does not allow a practical method for near real-time responses to requests from a traveling unit, but such a unit could still make GIS services more accessible to local governments, and provide an invaluable opportunity for GIS education.

PlanGraphics recommends the basic access policy be that Act 200 users get first priority for access, with exceptions possible for GIS uses that will benefit Act 200 implementation over the long run. For example, utilitarian arrangements can be made that serve Act 200 applications overall or generate funding or data maintenance for the system that will enhance Act 200 response capability. A general hierarchy for system use is government agency uses that serve Act 200, followed by government agency uses that do not serve Act 200, and then individual and private uses. Ultimately, the GIS manager will work with the Subcommittees to recommend use priorities to the Policy Committee.

STATE AGENCY ROLES

As Vermont's GIS develops, state government agencies, departments, and offices involved will need to define their roles. The roles of the major participating state agencies considered here are database maintenance responsibilities, in-house and external GIS communications facilitation, and system funding.

Overview

State agencies will have a crucial role in GIS database development and maintenance. At least 19 of the database layers tied to priority applications support, as discussed in Sections 4 and 5, will require state agency input. Of those 19, at least 12 database layers will draw exclusively from state level data. PlanGraphics recommends that agencies be assigned responsibility for preparing specific data layers for conversion, and then maintaining/updating those layers.

The rationale for database maintenance assignments is not complex. Generally, each agency will maintain those data layers which it is already assigned by statute or for which it now has lead responsibility. Section 4 details specific database update responsibilities. For example, the Agency of Natural Resources should be responsible for maintaining the groundwater features database layer. More difficult organizational issues involve each agency's role in converting old information into a usable format, changing procedures to collect new data in a GIS compatible format, and financing these activities. Some guidance will come from each agency's "assigned responsibilities" for Act 200 support. These assignments will be addressed by the committee work pursuant to the Growth Management Act Executive Order #68. Negotiated costs and benefits for establishing particular applications will generate terms for agreements between the participating agency and the Policy Committee. A division of costs and labor should be established by the procedure that will spread the GIS startup costs in an acceptable manner.

Example: Transportation Centerlines

A specific case in point that has been the focus of some debate by the Oversight Committee is the appropriate assignment of the generation and maintenance of the statewide roads layer (i.e., transportation centerline file). The automated roads information currently maintained by the Agency of Transportation (AOT) was developed to meet their statutory duties that require knowledge of linear distance by class of road in each town or district. The automated map was developed from a different base than the state orthophotos. Even if the positional accuracy were the same (i.e., ± 10 feet), the road file will not necessarily line up with parcel maps developed on the orthophotos due to the use of different base maps. A plot that combines the two files may put roads through watercourses and parcels where they do not belong. The current AOT road centerline files are generally considered to lack sufficient control points to tie them to surface features so as to meet Act 200 purposes, in spite of the fact that Intergraph files and ARC/INFO files are translatable and transferrable. The solution lies in digitizing the roads from the same base on which the parcel maps will be mapped, and from which the information will be converted to GIS data (i.e., on the orthophotos). This is a great deal of work and there are several possible solutions.

The Policy Committee could decide to await a complete small scale road layer until all parcel maps are completed and converted, which will take several years by most estimates. In the interim, large-scale "DLG" files that include roads will be available for the "state" database, and could be made available to the towns. They are inappropriate for most town planning purposes with positional accuracy limited to the 7 1/2' USGS quads from which DLG files are compiled. Since Act 200 expressly requires, "A transportation plan, consisting of a map and statement of present and prospective transportation and circulation facilities showing existing and proposed highways and streets by type and character of improvement, ...", this will probably be deemed an inadequate solution. This leaves the question of who pays for the creation and maintenance of a GIS roads layer, and whether it should be done in-house or contracted to a private vendor.

Certain transportation applications defined in the Phase I Report can be accomplished for the agency purposes using the current road files, but not those that require overlay of the other data layers, like soils or parcel information, being developed on the orthophoto base. The Agency of Transportation can perform additional agency specific applications if this new road layer is developed, and the Policy Committee needs the same work accomplished. This is the kind of situation that merits shared responsibility for the cost and labor of building this database layer, following a more detailed examination of the current transportation files and final choices among possible GIS transportation applications.

All database activities will have to follow mapping and data standards approved by the Policy Committee. Database development and maintenance funding will have to be negotiated as trade offs between agency budgets and the GIS fund. In many cases, joint funding for a particular database layer will be appropriate if it will serve Act 200 and agency-specific uses. Data maintenance that serves only an individual agency's application should not require financial support from the GIS fund. Interagency agreements should focus on shared financial impacts of data conversion and maintenance.

Database Updates

If data updates from regional and local governments pertain to a layer for which a state agency has contractual responsibility, the GIS home will consult with the state agency to ensure quality control, and then enter the data in the GIS. An alternative recommendation is to have data layer updates go first to the lead state agency, if there is one, and then to the GIS home. This might be deemed appropriate for specific data layers, but it would take control of timing and knowledge about the data layer's status away from the GIS home. In either approach, the state agency should participate in a review of the update contents.

Formal contractual agreements between the GIS home and each agency will spell out specific database responsibilities.

Shared System Funding

As to system funding, each agency should examine its existing hardware/software budget, and allocate part of it to the GIS proportional to the agency's GIS use. The Policy Committee or appropriate subcommittees should work with the Department of General Services, State Information Systems (SIS) to coordinate this examination. Long range development plans and budgets for the GIS are a likely coordination vehicle. Each agency will also need to facilitate communications pertaining to the GIS internally and with other state agencies, regional commissions, and local governments. If every state database conversion cost and equipment purchase is born by only the funds administered by the Policy Committee, the available funds will be quickly exhausted and not be sufficient to provide the Act 200 decision support anticipated.

Interagency Organization

Another role of each major participating state agency with significant GIS applications (i.e., ANR, AOT, AODCA) will be development of its own GIS organizational home. Each agency has various options available for its internal GIS home. For example, an agency's computer services division, director's office, line division, or a newly created GIS division could serve as the GIS focal point. At least two realities will influence each agency's choice. First, most agencies will have little GIS equipment in the early stages of implementation. Second, even if they purchase GIS query and output equipment, most agencies will lack trained GIS staff. These and other factors make it likely that most agencies will use whichever division or office maintains computer staff and equipment as their initial GIS homes.

Once the initial GIS implementation stage is complete and equipment and staffing issues are resolved, each agency will need to determine whether it should have all GIS requests handled by a central shop or distribute GIS responsibilities to individual divisions or offices. Whether a centralized or decentralized approach is chosen, each agency will need to appoint a central contact person to manage the organization's GIS activities, supervise on-site hardware, and represent the agency's interest with the GIS manager and GIS technical subcommittees. One or more additional people in each organization will be designated to operate the system for the organization and trained in system use, as defined in the Phase I Report's staffing discussion (Section 8).

REGIONAL COMMISSION ROLES

The twelve Regional Planning Commissions (RPCs) have roles mandated by Act 200 as GIS users, data maintenance coordinators, and GIS services deliverers. The last two roles are on behalf of the local governments in each commission's area. In the recommended scenario, the Regional Planning Commissions, as data maintenance coordinators, will collect data compiled by local governments that pertain to the GIS data layers, check it against minimum standards for that data layer, and convey it to the GIS administrative home or responsible state agency. Regional Planning Commissions may serve the service bureau role providing updates for data compiled by towns that do not have necessary equipment and staff.

The RPCs also will distribute GIS data prepared by the state and themselves to local governments. As GIS service deliverers, the commissions will function as regional service bureau nodes to varying degrees, depending on staff expertise and equipment. This approach is designed to prevent the confusion and delays that will result from over 250 local governments requesting GIS assistance from one central state level service bureau. As Vermont's GIS evolves, it is recommended that each RPC will become a GIS service center, at a level appropriate to the number and characteristics of its client local governments. We anticipate varied service center levels will develop among the twelve RPCs based initially on the status of parcel mapping in their area and the demand level for services from their local governments.

Finally, the RPCs will use the GIS in carrying out their responsibilities under Act 200 and other state legislation. This role will be assumed gradually as RPCs acquire the necessary equipment and staff expertise, and expand GIS applications to fit their regions' Act 200 needs. In 1989, only three of the twelve RPCs will have equipment and software, and they will still be learning about GIS technology and uses. The RPC role should grow as quickly as possible. Encouraging rapid growth of the RPCs' role should be a major Policy Committee goal.

LOCAL GOVERNMENT ROLES

Act 200 maps require land use, transportation, utilities, solid waste and related service facilities, schools, hospital, and other elements critical to planning which are not expressly listed in the legislation. Much of the GIS information critical to Act 200 will reside with local governments. Substantive input from citizens and local officials is required to maintain and supplement these data layers in the GIS. Central and regional resources can provide support for compiling the data layers, and a base map as a starting point, but they cannot supply the changes, detail, and accuracy that will allow for detailed local land use planning in future years. For example, conversion of the orthophoto maps will provide only certain planimetric features as they existed on the most recent overflight. Local governments will need to supplement these with greater detail as to new streets, utility lines, zoning, and the like. Decisions to use existing orthophotos or to provide updated orthophotos for a starting point will have a significant impact on the initial work a particular town will require for the production of a useful base map for planning.

Towns, villages, and cities need to focus on getting parcel maps on updated orthophotos and seeing this information for their jurisdiction converted into GIS data. Towns with hardware and automated parcel maps today should soon be able to add valuable attribute data from state agencies. They need to take the lead in working with other towns that have gotten along wihtout a parcel map to date, and show the GIS in action. There are not enough funds to make every town a pilot project, and there is no consideration of forcing cooperation from local government. The main role for the towns is to help each other find the most efficient way to take advantage of GIS.

Local governments will need to take the lead for preparing and maintaining several layers of the GIS database, either because they are the source or the major user of the layer in GIS applications. Local governments will need to be involved in both the initial creation and most of the maintenance of data layers for property lines; political/administrative boundaries; zoning; detailed land use/cover; detailed soils; water, sanitary sewer, stormwater, and other infrastructure facilities; and septic systems. Local governments will create additional data layers pertinent to their individual GIS application needs. These layers most likely will not be transferred to the state's central database, but will stay at the local level. The state's database clearinghouse will receive listings of such local data layers, but will not store the data itself.

UNIVERSITY OF VERMONT ROLE

Like the other major players in Vermont's GIS implementation, the University of Vermont will find its role evolving as the GIS expands. Initially, the University may serve as an interim GIS home and one of the early service centers along with other government agencies that have GIS equipment and available staff. This role is feasible as the software selected by the Oversight Committee is compatible with the University's.

After the development of the permanent organizational home, the University should have a significant continuing role in providing conversion services, applications development, GIS training and education, and specialized technical assistance. For example, the University could develop a GIS student intern program, conduct beginning and advanced GIS training programs for government GIS staff, and prepare and run a GIS education outreach program for local governments. In addition, the University could foster the use of new GIS database development techniques such as scanning, and continue to have a lead role in data conversion work or other GIS pilot studies. In the latter role the University's existing pilot projects now funded by the State would be continued and expanded.

A long range GIS plan and budget should lay out the financial relations between the GIS organizational home and the University, and present options for funding activities like those suggested above. Possibly some like-kind exchanges can be negotiated for activities of mutual benefit. For example, State, regional, or local agencies could fund a GIS student intern program that would provide short term or part-time staff assistance. The University could also supply specialized short term technical assistance to new users in exchange for equipment access or data.

ORGANIZATION DEVELOPMENT PHASES

To prevent Vermont from spreading its GIS development funds and efforts too thinly, PlanGraphics recommends that system organizational development occur in at least two broad phases.

Interim Phase

In an interim phase, which could encompass two or more stages, Vermont would:

1) Establish a GIS organizational home and staff

2) Charter a Policy Committee and establish subcommittees to develop baseline database standards, access policies, etc.; review candidate standards for non-state databases

3) Develop a long range plan for development and implementation of the GIS and a budget that reflects system and database development funding needs for a five year period, and which contains the following elements:

- A service center or centers to provide GIS assistance to all state, regional, and local entities without in-house GIS capabilities

- Plans for development of each regional service center based on available data and facilities to support applications, training programs, and hardware/software/ telecommunication links

- Development of state level databases of greatest use to GIS applications for regional and local entities and for cross-agency applications

- Development of the parcel map database at the local and regional levels

- Coordination of regional and local database development to ensure minimum mapping and data standards are met

- Provisions for monitoring the results of pilot GIS projects

- A GIS education and service program through the service centers that includes face to face contact with local governments

- A list of compatible software and minimum hardware needed to develop state level databases and run the service center

- Identification of agency GIS representatives and local contacts

- A training program in software, data collection, and applications.

Final Phase

In the final phase, Vermont would:

1. Complete major hardware purchases and install equipment in state and regional agencies

2. Add service centers, complete establishment of regional service nodes

3. Complete state level database development, giving priority to Act 200 related applications.

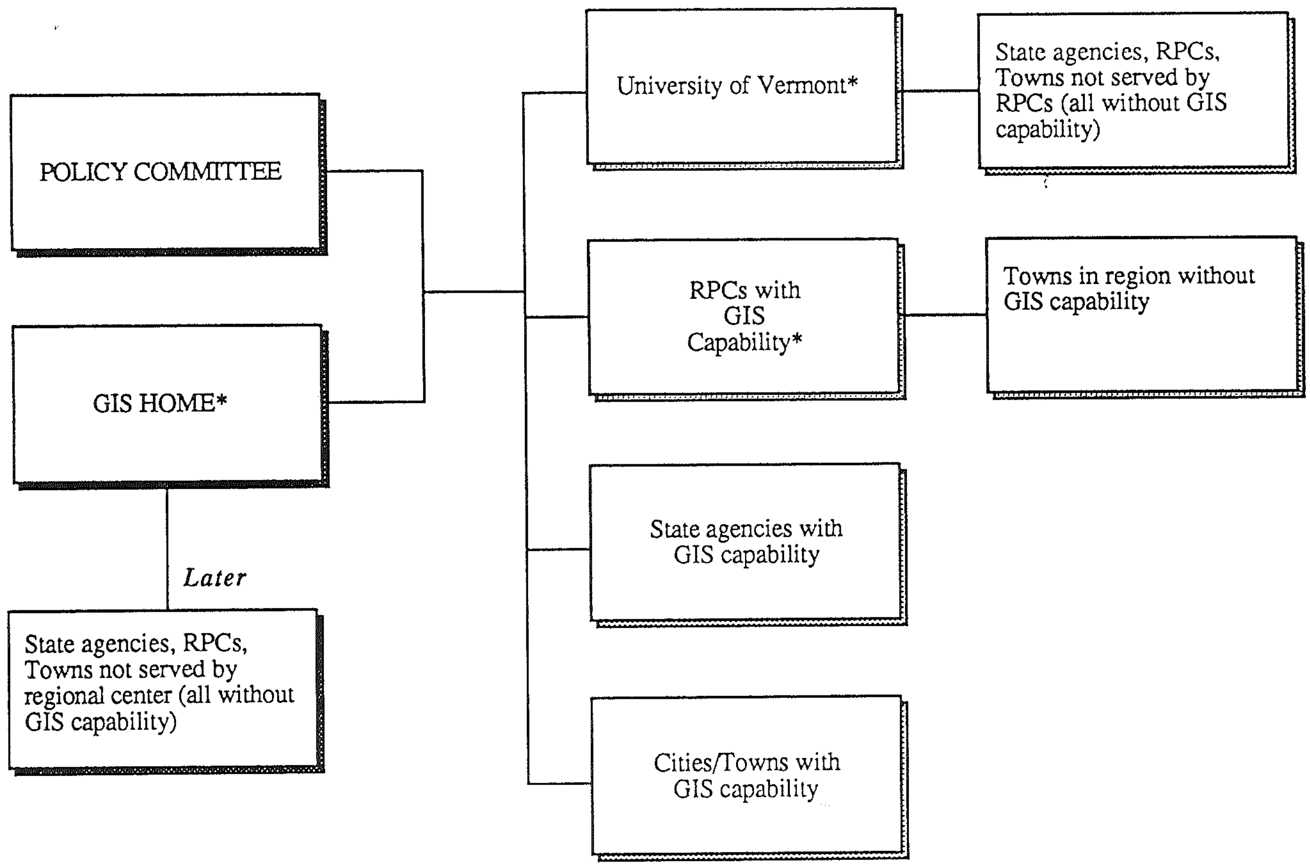
4. Continue to work with local governments to create local level base maps (principally conversion of parcel maps and addition of planimetric detail to database)

5. Transfer major state level service center responsibility to the GIS home (if the University of Vermont or another similar institution is a central service center in the interim phase)

6. Involve the private sector through product and service development, marketing and data exchange

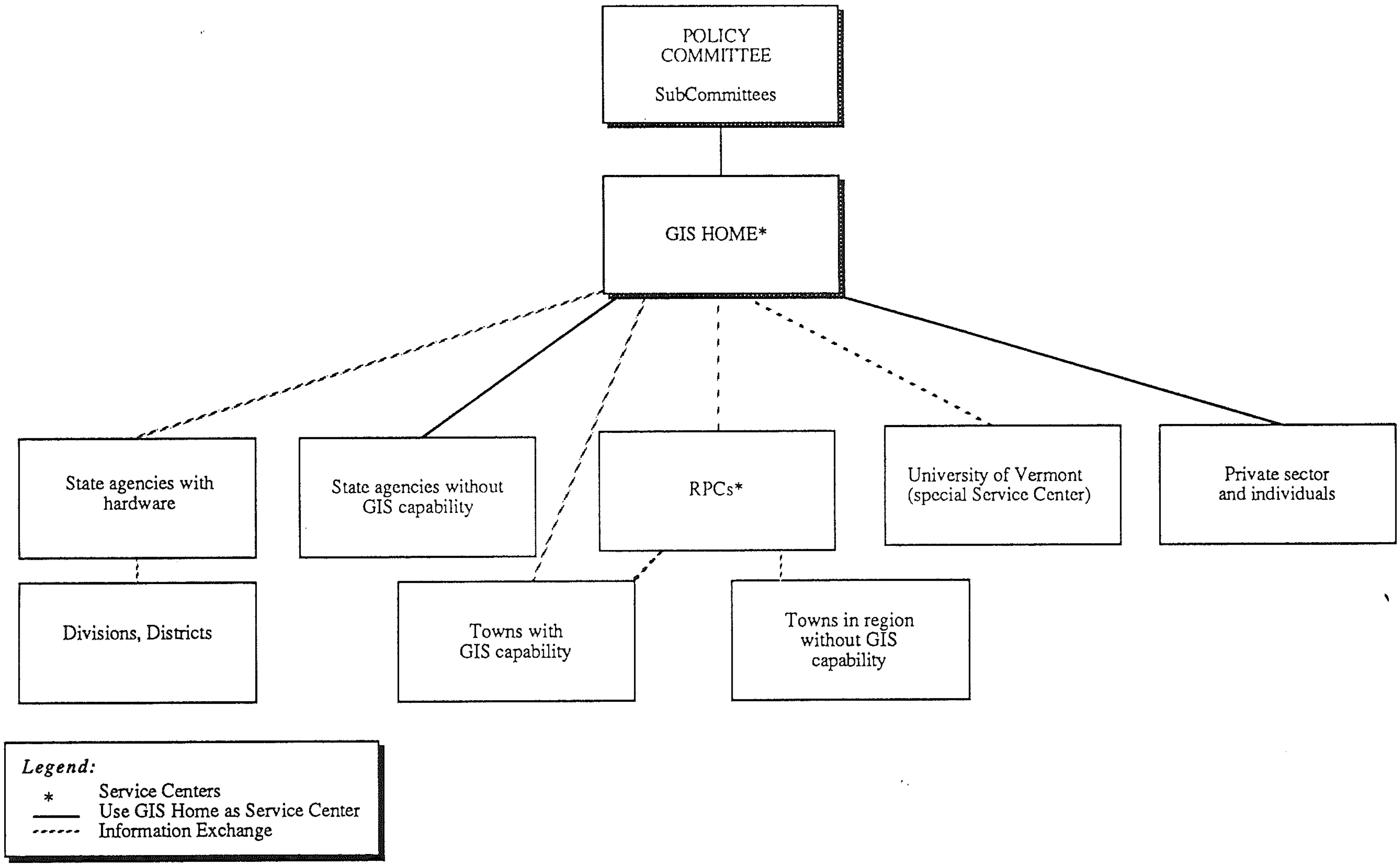
7. Establish user networks among state, regional, and local governments to exchange applications programs and share GIS experiences

FIGURE 2-1
VERMONT GIS ORGANIZATIONAL STRUCTURE - INTERIM PHASE



*Service Centers

FIGURE 2-2
VERMONT GIS ORGANIZATIONAL STRUCTURE - FINAL PHASE



This report defines the time frame of the interim GIS phase as 1989 to 1992, and the final phase as 1993 on. Proposed hardware configurations will be presented as "stages" on a slightly different time line as explained in Section 6. Figures 2-1 and 2-2 outline broad organizational structures for an interim and a final phase that complement the system configuration stages in Section 6. The progression provides access to GIS products and services for all government levels that do not have GIS capabilities through a growing network of service centers. As indicated in the figures, the centers will be located at the GIS administrative home, the University of Vermont, and Regional Planning Commissions equipped to produce GIS products (presently three of the twelve). In the earliest implementation stage, the operating service centers will be the University of Vermont and some Regional Planning Commissions. The RPCs will serve the local governments in their region, while the University will serve other RPCs, local governments, and state agencies.

In later stages of the interim phase, the GIS organizational home and more Regional Planning Commissions will become service centers as they acquire capability. The GIS organizational home will become the service center for state agencies without direct GIS links for both Act 200 and related applications. The University could continue to serve RPCs, and local governments not served by their RPC. State agencies that purchase their own equipment and software will serve their divisions and districts.

The final phase's organization shown in Figure 2-2 reflects continuing hardware acquisition by state agencies, Regional Planning Commissions, and local governments. More local governments will have their own capability or be served by their Regional Planning Commission rather than the University or the State. The GIS administrative home will continue to serve state agencies that lack direct access, but will provide more services to the private sector and individuals. State agencies with GIS capability will serve their divisions and districts. PlanGraphics recommends the University of Vermont's role be expanded to a specialized service center, supplying system technical assistance, applications development, training, education, and short-term staffing.

NEXT ORGANIZATIONAL STEPS

The initial issues the GIS Manager and Policy Committee will face involve hard choices that will need to balance limited funds, diverse demands from different GIS users, and an extremely short time frame for accomplishing Act 200 information distribution requirements. These issues include:

- **Identification of funding for data collection and conversion, hardware, software, staff, and training for local governments.**

  The state will not have sufficient funds to accomplish everything at once, so it needs to focus its spending and explore nontraditional funding approaches. A revolving loan fund developed from state bonds could assist local governments in their data collection and conversion and hardware/software acquisition efforts. Alternatively, the State could hire a single vendor to convert parcel maps prepared on state orthophotos once a threshold number of contiguous parcel maps are available from local governments. This will result in horizontal support of parcel mapping among local governments within a designated region. Such an approach has the advantages of single-source quality control and more control over edge-matching individual maps, and should provide opportunities for more cost efficient arrangements with commercial conversion vendors.

- **Selection and purchase of system hardware and software.**

  The development of specification for RFPs, contract negotiations, and installation, training, and bench mark testing constitute a significant body of specialized work for staff. It will not lend itself to part-time attention or a committee approach.

- **How to make best use of existing hardware that is inefficient in the GIS network because of translation expense, lack of speed, or limited capabilities.**

  A similar problem may exist with incompatible data architecture from past automation and conversion efforts. PlanGraphics suggests the Policy Committee not view existing automation investments as constraints that unduly limit the State's GIS choices. It would be inefficient to allow the inconsistent decisions of the past to drive system direction at the expense of an efficient, effective GIS.

- **Dealing with competing state/regional-local options.**

  This is the greatest challenge presented by Act 200. It would be true whether or not GIS implementation was part of the land use planning process. The equitable division of GIS application development focuses the need to resolve the state/local emphasis question on expenditures. More than 250 local governments, 12 RPCs, and 50 state agencies can use GIS technology if information sharing and start up expense problems can be solved.

- **Funding the service center to provide Act 200 related services to regional and local governments.**

  Based on the result of the initial pilot projects, the Policy Committee must provide a strategy for service center funding. Some applications should require regional and local governments and private users to pay for products and services, particularly if they are not Act 200 related. The Policy Committee and GIS Manager will need to sort requests for building databases and providing GIS access based on a balance between generating needed revenue and fulfilling the information requirements of Act 200. The large front end investment in the system will make more elaborate applications and analysis available at increasingly efficient rates as the system matures.

RECOMMENDATIONS FOR LOCAL, REGIONAL, AND STATE ACTIONS

Local Level

- Work with Regional Planning Commissions to develop/refine/update parcel maps, and then digitize the maps, with direction from the Policy Committee on vendor selection and minimum standards.

- Utilize a parcel mapping guidance document based on the initial work of the State Mapping Advisory Committee and supplemented with existing standards from other programs such as Minnesota, North Carolina, and Utah, as described in Section 3.

Regional Level

- Develop in-house service bureau capabilities - train staff, purchase software compatible with that selected by the state, and lease or purchase hardware to digitize, analyze, and produce products.

- Serve as the coordinator and repository of digital data for the region's cities and towns.

- Where feasible, convert local government data to digital form.

- Serve as regional service bureaus for their region's cities, towns, and villages without in-house capability. Provide supplemental data and assistance to those local governments with a GIS capability.

State Level

- Put a moratorium on further hardware purchases until the Vermont GIS hardware/software needs have been defined and a GIS budget prepared. Spend the funds on local data conversion and state databases AFTER defining common data standards and analyzing the benefits and costs. It will be less expensive to create a database from scratch, rather than transfer low quality or incomplete existing databases that cannot support the intended applications and attempt to "correct" them.

- Hire or begin retraining staff to work on the GIS in the agencies for Administration, Transportation, Natural Resources, and Development and Community Affairs.

- Choose the RPCs with the greatest number of completed local parcel maps and most completely outfitted with staff and hardware as the initial regional service centers. Once those service centers are in place, develop a demonstration program for other RPCs and local governments to maintain enthusiasm for the GIS and promote parcel mapping investments by other local governments.

- Use a central service center to supplement regional service centers. This could be the University of Vermont since the system the state selected is compatible with the University's. The University has provided services within the strict limitations of current capabilities to date, and will be essential for many short term needs as the system develops and expands until a separate state organizational home is operative. The division of labor between the two will shift based on capacity as the system matures. Neither should be chosen as the sole service center resource at the present time. It is probable that shared duties will develop to meet growing demands that neither can fulfill alone.

- Continue work on the updated brochure, and generate a "how to participate" publication with more detailed information on standards, hardware, service bureaus, and contacts. Construct a GIS education program for cities and towns that includes a PC GIS demonstration that can go on tour. This program can also deliver on-site GIS services to local governments. Use libraries and educational TV to provide general education materials and system demonstrations. Consider use of several techniques, including videos, brochures, and a speaker's bureau for technical and user aspects of GIS.

- Make lists of pre-qualified conversion vendors available to cities and towns through the service bureau and, where possible, negotiate better prices for services through statewide managed contracts for conversion services, equipment purchases, training, and maintenance. The negotiation of site licenses for software provides the first opportunity to "purchase" specialized training and maintenance services.

PRIVATE SECTOR ROLES

Vermont's GIS effort has consciously involved the state's private sector in its planning. Vermont wants to leave the door open to private sector participation in the GIS. Inclusion of the private sector on the proposed GIS Policy Committee and in the GIS feasibility study is intended to emphasize the role of the private sector as required by Act 200. The private sector is affected by Act 200 but, more importantly, has call for much of the same data, and spatial analysis that will be available from the Vermont GIS. This section will discuss how the Vermont GIS can best work with the private sector and at what phases in system development. It will expand on the concepts presented in the interim report on access issues, and examine private sector GIS activity from the perspective of: (1) participation, (2) system access, and (3) commercial products and services.

Potential Private Sector Roles

The first duty of Vermont's GIS will be to assist RPCs and local governments with Act 200 related issues. Accordingly, the private sector will not be a major player in the early stages of GIS implementation. However, once certain state and regional level GIS database layers are available in digital form, Vermont will have potential products and services to market to the private sector. Thus, one of the private sector roles is to be a GIS customer. Other possible roles range from full "participant" with direct system access to data provider.

Status of Geographic Information Use in the Private Sector

The responses received to a survey of private sector representatives examining use of geographic information in Vermont indicate the two electric utilities (Green Mountain Power and Central Vermont Public Service Corporation), Vermont Gas and the various telephone service companies are the major private industry groups with the greatest short term potential for participation in Vermont's GIS. All these utilities need regional or state level geographic data such as soils, land use, and roads that will be available in the early years of GIS development. In the longer term, the utilities could benefit from local parcel map and street databases, and can serve a role in maintaining parcel ownership data that will serve property taxation and assessment needs (utility hookups are often the only records that keep up with mobile homes in a given area).

More complex applications will be efficiently available to utility companies through participation in the Vermont GIS over time. Several typical utility applications were listed in the Phase I Report, but a detailed analysis of utility applications is outside the scope of this report. One good example results from the recent federal statutory requirements for mapping underground pipelines. Mapping standards for buried pipelines will be established this summer by Federal Department of Transportation regulations. States can receive significant funding if situated to enforce and monitor these regulatory requirements, and Vermont has existing and proposed cross-state systems to deal with, both in the regulatory and Act 200 planning context. By meeting Act 200 needs, the Vermont GIS will also provide the basis for developing the maps and plans the utilities will require to meet federal regulations, and management of the same information will provide the basis for Vermont to receive federal authorization and funding to administer the program.

Most of the nine private companies that responded to private sector survey provided general information about their company's geographic information. Many of them maintain maps and data sets for their own property, but not beyond that area. Few reported they now have CAD or GIS capabilities. Those that do, rely on the automated mapping services of their firm's headquarters and do not have local capability. For example, Cyprus Minerals is probably the largest landowner in the state, and has a significant need to track surface ownership and contiguous ownership and development for their property base. They use very site specific aerial photography for their base map, and could benefit greatly from the ability to see the broader area development plans and the ability to update their "frozen" information.

Although many firms do not use geographic information extensively at present, they may see its advantages once the GIS is implemented and products, services, and various levels of direct access are available. This means that a GIS education and marketing effort will need to be directed to the private sector. There is not necessarily an existing market for GIS products and services merely because there are useful applications that reveal there is a potential market. The recognition of the resource will expand over time, but it is critical to establish access control over the system through a planned course of conduct for commercial use that precedes private sector access at a level that involves actual cost recovery for system operation and maintenance.

Private Sector Participation in the GIS

Possible private sector participants include transportation firms, newspapers, realtors, title companies, cable TV, phone company, contractors and engineers, and businesses with an interest in demographic analyses. Other potential, but more difficult to reach markets are advertising agencies, architecture and construction companies, package delivery and courier services, moving companies, franchises, distributors, vending services, food delivery services, car rental firms, and solid waste hauling companies. Some of these markets exist primarily at the local or regional level. Almost all would have to be educated about the GIS.

Several levels of GIS participation by the private sector are possible. They are not necessarily mutually exclusive levels; hybrids of the levels described below are feasible. Illustrations of general levels of GIS participation by the private sector include:

1) Direct participation

   This role is often assumed by major utilities in multiagency, distributed systems. The private sector would be on equal footing with the major state agencies and other entities with direct, independent access to the GIS. It would have specific system obligations for database maintenance, standards adherence, and system funding like other participants that sign contractual agreements with the GIS. The utility could have a communications link with the GIS home for real-time access, and would lease or own its own equipment, software, and staff.

2) Separate acquisition and implementation of compatible hardware/software and semi-independent operations with database sharing

   The private sector could acquire its own compatible GIS equipment, software, and staff and use part or all of the state's database; but still not have a real-time link with the state's GIS. It might be responsible for its own database layer maintenance, but is more likely to contract with the state for updates through a subscription agreement. This is similar to the level of database maintenance activities recommended for local governments.

3) Purchase of products and services as needed from service centers

   The private sector would not have its own GIS capability, but would rely on one of the service centers to develop products and services on request for a fee. The products and services with potential appeal for this level of participation are further illustrated later in this section.

<u>Private Sector As Data Source for the GIS</u>

Based on survey returns, the Vermont GIS may derive useful private sector information on easements for electric and gas lines, solid waste facility locations, and underground utility locations, such as pipelines. Such data will be of greatest interest to municipalities and RPCs, and it will supplement certain state agency functions. Data exchange and data maintenance are like kind services that can be substituted for access fees. The benefits and costs of this expansion of system users require careful consideration.

<u>Approaches to the Private Sector</u>

Approaches to the private sector range from low key to proactive. They vary in the amount of GIS staff time required to carry them out, in the risks involved, and in their costs. PlanGraphics believes that a comparison of the potential pitfalls with the potential gains shows that Vermont should, with a few significant exceptions, hold off approaching the private sector until the base maps and priority applications are in place. The exceptions are the electric, gas, and phone utilities.

Two important caveats apply to any effort to involve the private sector, whether the effort is low key or proactive.

- First, every level of outreach uses up resources. An indirect cost (opportunity cost) is time lost for GIS development and implementation activities. The Policy Committee needs to consider how much staff time it is willing to trade off for marketing activities.

- Second, successful outreach must be backed up with a tangible and marketable product or service. Care must be taken not to market a product, as distinct from marketing the system, before it can be provided. Products and services available before 1991 will be limited. System access will be the first major service available. Vermont's GIS can then add standard map and database products, and custom services and products to its private sector offerings.

The products and services most likely to have the broadest appeal to the private sector are system access (see the defined levels of system access in the interim report on access issues), standard products, and custom services and products.

System Access

System access includes a broad range of potential GIS services Vermont can make available to the private sector. System access can be marketed at several levels with costs varying based on total staff time and system access time involved. Possible levels of system access track the discussion of "participation" and include full participation with access to data and processing capabilities, more targeted subscription to limited subject and jurisdictional coverage of the database with updates, and casual (one time or episodic users) for a particular product or analysis.

Access can be "purchased" through becoming a GIS participant and paying for a share of total system costs, as well as one time payments for products or services rendered. GIS participation is a long-term commitment that entails entering a contractual agreement with the system. A GIS subscription entails a contractual agreement for specific services. Casual system access would be purchased on a time and materials basis. All participation levels and specific products can be defined in terms of functional access to the GIS. A discussion of the actual products that might be marketed to sell "levels of access" follows.

A GIS service center would perform all the work for a client and deliver a finished product for a fee. Such products can range from custom rearrangement of existing data layers to a merger of user supplied data with GIS data. Initially, the GIS organizational home should be the only commercial outlet for products and services. Once all legal and policy issues are settled, broader delegation to regional and local service centers will occur. Such issues include public records, copyright, antitrust, equal treatment, and products liability discussed in the interim report on access issues.

Standard Products

Standard products are those developed as part of the system's foundation - planimetric and nonphotogrammetric databases. No additional work beyond reproduction is needed to prepare these products for sale once the original is created. All standard map products have set size, scales, and content.

GIS products that seem "sellable" to the private sector, based on survey responses, are updated aerial photos, updated orthophotos, 1:24,000 scale orthos, maps of highways, soils, land use/cover, political boundaries, and land ownership. Municipal land ownership maps coupled with owner names and addresses may be especially appealing to utilities for work order management.

Examples of Possible Standard Products

- Limited detail planimetry with major features such as street names, and hydrography

- Full detail planimetry

- Property boundaries (lots and parcels) with street names and limited planimetric information

- City, Town, and Village maps of major streets and water bodies, major storm and sanitary sewer lines, major streets, water bodies, and districts (zoning, political, etc.), and zoning boundaries.

Custom Services and Products

Custom services and products are requests for specialized or customized information products - maps, database updates, and reports. In general, custom services would result in the creation of custom maps with a nonstandard scale, attributes, or features; cover an area other than a map grid section; or using nonstandard feature symbols. They would selectively use the available data layers, with new data provided by the client in some cases, to meet particular needs. Typically, they would require consultation, research, and programming to produce. Service center-type activities would fall under this category.

As Vermont's GIS matures, it can offer utilities and associations contracts for database maintenance and a specified amount of assistance each year. With this approach private sector users would need their own equipment, and specialized applications software. Alternatively, the private sector may not want to bring their GIS uses and resources under state management through direct system participation, in which case their interest would concern the database only.

Services with potential appeal to the private sector are database maintenance and updating for all layers except those that pertain directly to the client's business, and baseline applications development (applications developed for other public sector users). Prices could be based on actual use or up front development funding. The GIS will need to have a functioning database before such services can be offered to the private sector.

Examples of Custom Services

- Routing, distance computation, area analysis
- Translation of selected geographic areas to AutoCAD files
- Hydrology modeling - stormwater, rainfall-runoff

Examples of Custom Map Products

- Unique combinations and spatial analysis of graphic and nongraphic data layers from the GIS and the user that respond to the end product desired by user. Examples are:

  - Properties that fall in the 100 year floodplains.

  - A map of roads with a certain level of vehicle traffic. This analysis would use the road centerline file, with the number of vehicles per hour added. Similar products are traffic volume/impact studies required for new development.

- Unique combinations of map layers, over standard base map features, chosen from a list, such as:

  - Soil types and geology
  - Census, neighborhood boundaries (w. associated tract, block numbers)
  - Land use
  - Watershed boundaries
  - Solid and hazardous waste disposal site locations
  - Administrative districts (EMS, police beats, fire, school, tax, service areas, etc.)

Examples of Custom Report Products

- List of property owners or appraised property values within "x" feet of a proposed construction project
- List of all user-defined attributes within a special area of a city, town or village. For areas with detailed attribute data development, attributes can include facilities such as utility poles, manholes, etc.; property values, owner, use; land use and zoning
- Census data
- Property ownership by name, address, acreage, record number

Schedule for Private Sector Cost Recovery: Considerations

It is recommended that cost recovery, cost sharing, and data exchange with the private sector be broadly pursued after the system development reaches a level of maturity determined by the Policy Committee to meet the primary Act 200 needs for information distribution. This opportunity is a tangible benefit of GIS implementation, but is not yet quantifiable. The world of information economics is in a formative stage, and it would be unwise to establish minimum cost recovery standards for the system in the absence of market information unavailable today, and in the absence of resolution of the issues raised in the analysis of the legal setting (see the interim report on access issues). Private sector participation should be pursued at all levels deemed to provide a mutually beneficial result for the client and the Vermont GIS. Control of system access still remains a condition precedent to the development of this independent funding source for the Vermont GIS. GIS technology provides the basis for a separate "information utility" that provides information products to all sectors of society for standard rates regulated by the Public Service Board. The development of public sector partners for Vermont's GIS will set the stage for the evolution of the information utility of the future.

SECTION 3
GIS DATABASE STANDARDS

INTRODUCTION

The key to developing a uniform, statewide database with both local level and state level information and uses, is the introduction of comprehensive mapping and data standards. These standards should cover procedures for the design, creation, and maintenance of the database. Standards add rigor and consistency to the process of collecting, creating, and maintaining computerized geographic information, and therefore are essential in establishing a usable GIS database for the variety of users in Vermont.

Many of the current problems associated with the updating and use of geographic information reflect the problems that standards are intended to address: consistency and coordination. It is essential to understand that **implementing a GIS without standards will simply create a computerized version of current geographic information problems.** Only by implementing standards can the full benefits of data integration and sharing across a broad spectrum of local, regional, state, and private organizations be realized. Because of its requirements for integration of state and local level information, standards will particularly impact the effectiveness of a GIS for implementing Act 200.

Data Standards

Data standards guide the construction of the database. As graphic and nongraphic information is converted to digital form and linked based on common linkage codes, standards guide the process. They ensure that the digital information will be compatible with information to be added to the system later, as well as with information already added. Standards systematically describe a variety of characteristics of a GIS database including the following:

- Content
- File format
- Coding and classification schemes
- Map accuracy
- Applicability and reliability of sources.

Developing GIS database standards requires a well-planned, up-front effort. The effort required will pay off in the form of vastly improved capabilities for data sharing and integration. In addition, the process of creating standards will bring issues, such as data exchange between local agencies and state agencies, to the fore. If these issues are resolved before significant data conversion and mapping resources have been expended, it will help in avoiding false starts and loss of faith by the user community. Time invested in creating standards will save time in the future.

Organizational Overview

This section establishes the framework for discussion in the next two sections of the various aspects of developing a GIS database. This section will review approaches taken to standards in other states, define what data standards are, why they are necessary, and describe the logical content of standards for both local- and state-level GIS data. In Section 4, GIS database concepts are introduced, a conceptual database design is presented, and the procedural aspects of maintaining the database are addressed. Finally, in Section 5, techniques for computerizing geographic information are introduced, specific approaches are described for individual map layers, and budgetary cost estimates for the data conversion effort are listed.

DATA STANDARDS IN OTHER STATES

In the process of identifying the necessary contents of data standards for the Vermont GIS initiative, PlanGraphics examined the standards and specifications for several large-area geographic information systems and/or property parcel databases in other states.

The following states are noteworthy with regard to their efforts in developing and implementing data standards: Minnesota, Florida, Utah, and North Carolina. For each of these states, we have summarized the responsibilities of the agency involved and summarized printed information on standards supplied by that agency.

Minnesota

The Land Management Information Center (LMIC) of the Minnesota State Planning Agency serves as a central clearinghouse for natural resource and property related digital data. The LMIC has created data standards which comprise their "data compatibility guidelines." They receive digital data from various local projects partially funded by the Legislative Commission of Minnesota Resources and overseen by OMIC staff. They have recently initiated a program whereby they will also acquire data from source agencies at the regional and state level. All data is integrated into the Minnesota Land Management Information System (MLMIS). The LMIC has developed Data Integration Guidelines as standards for creating databases, at the local, regional, or state levels, which can be integrated with MLMIS. The LMIC data standards are summarized as follows:

- The cost of integrating an independently developed database to MLMIS is borne by the creators of the database. If, to achieve integration, corrections and extra effort must be undertaken by LMIC, the extra costs are billed to the database creators.

- Standard geographic coding and classification schemes are required to properly enter and maintain the graphic data. For example, these coding schemes might insure that parcels are encoded as polygons rather than as a chain of line segments. The Data Integration Guidelines make reference to the standard coding techniques specified in such documents as the USGS Digital Cartographic Data Standards, the MLMIS Geocoding Procedures, and the ARC/INFO User's Manual. Procedures are suggested by LMIC for standardization of nongraphic attributes as well.

- Part of the MLMIS procedures define precision as the accuracy with which map features, such as areas, lines, and points, are recorded. To meet the precision qualifications, the data must be recorded accurately enough to easily locate the feature and to allow comparison with other needed data elements. The precision requirements are intended to be flexible so as not to add a great deal of effort and cost to the database creation. Specific guidelines are not included in this document for positional or relative accuracy of graphic elements.

- The LMIC staff reviews data collection and database construction as progress is made. Participating projects are required to complete the Preliminary MLMIS Data Integration Worksheet for review of the nature of data to be collected. During the data collection effort, but before database construction, the MLMIS Data Compatibility Worksheet must be submitted. This describes in more detail the data elements, method used for integration, method of data collection, data sources, data resolution, and computer software and hardware used.

Florida

The State's Growth Management Data Network Coordinating Council was established in 1985 by statute to coordinate sharing of data and information required to respond to growth management issues in Florida. The Council is primarily concerned with establishing a state level database. As part of their effort to establish a strategic direction for a statewide database, the Coordinating Council has created data standards. The following is a summary of those standards:

- The Coordinating Council recommended the adoption of the proposed data format and structure standards of the Digital Cartographic Data Standards Task Force (DCDSTF) outlined in the January 1988 issue of The American Cartographer. PlanGraphics recommends inclusion of applicable portions of the Task Force standard in the Vermont data standard.

- A lineage report should be provided by the database creators for each land database. The lineage report should include:

  a) Description of all source materials including scale, map projection, media, date of automation, etc.
  b) Description of data collection methods
  c) Dates of source materials
  d) Actual sources used for each automated data element
  e) Control points used in coordinate control for base
  f) Coordinate system used for base; e.g., State Plane
  g) Software used for digitizing.

- A deductive estimate of the positional accuracy of the database should be provided by the database creators in the units of the coordinate system, e.g., feet if State Plane coordinates.

- An estimate of the attribute accuracy should be provided. The estimate should be based on the percentage of total attributes that have been misclassified.

- Software packages should be used that support reports on the logical consistency and completeness of a specific database. Logical consistency and completeness are addressed in the discussion of state level technical specifications later in this section.

- Positional and attribute accuracy estimates should be made at the occurrence level for databases with multiple sources. For instance, separate estimates should be made for each source when a wetlands map automated from 1:24000 sources is updated with boundaries obtained from field surveys.

- Standards should be developed for situs address fields.

- All current USGS specifications for digitizing 1:24000 maps should be used as the minimum requirements for any base map automation at the state and regional levels.

- GIS data should be displayed at no more than 75 percent of its real scale. Real scale is calculated by multiplying the actual error of a map by the theoretical distortion assumed in a display that conforms to small scale national map accuracy standards. The real scale of any composite maps should be the smallest real scale of any map used in generating the composite.

The real scale concept addresses the issue of map accuracy as it is affected by map scale. This issue is further addressed in the state level database portion of the discussion and recommendations on the Vermont data standards later in this section.

Utah

The Automated Geographic Reference (AGR) section of the Governor's Planning and Budget Office has a mandate to encourage and facilitate effective GIS implementation in Utah, and to develop and direct this process in state government. Types of databases acquired by AGR currently include natural resources, property, hazardous materials, demographics, and utilities. Spatial data range from site-specific data of engineering detail to generalized data for regional applications. In order to insure data compatibility, AGR has implemented a database design called the Target System. The aspects of the Target System that relate to data standards are as follows:

- All data is categorized by scale and subject matter for storage in partitioned areas of the database. Local, regional, and state level data each have their own area of storage. Each area of the database is managed separately.

- Data of indiscriminate quality is accepted and stored.

- The Arc/Info data structure is used.

- AGR provides a quality assessment and a lineage report for each database added to the system.

- The responsibility for evaluating the suitability of digital data for a particular application resides with the agency using the data.

- A set of quality standards is established for each storage area within the statewide database. These standards serve as thresholds for evaluating data quality. The principle determinants of data quality include:

  a) Accuracy of source information
  b) Resolution
  c) Integrity
  d) Attribute accuracy
  e) Completeness
  f) Currentness.

- Responsibility for managing the statewide database is split into two parts: Support Management and Quality Verification Management. The Support Management component assists other agencies in formatting new data for the database, and conducts training. The Quality Verification Management component researches, verifies, and maintains the integrity of new and existing data.

North Carolina

Legislation enacted in 1977 established the NC Land Records Management Program to assist local governments in land records improvement projects. As such, the Program is primarily involved in local level database creation. Standards and procedures established by the Program are incorporated in their Technical Specifications for Base, Cadastral, and Digital Mapping, and include:

- Use of an orthophoto or planimetric base
- Establishment of a statewide modular map sheet format based on the State Plane Coordinate System
- Technical specifications and project procedures for building parcel maps
- Daily maintenance of parcel maps
- Use of a parcel identifier based on the State Plane Coordinates of the parcel's visual center
- Specifications for digital accuracy, including digitizing precision, attribute accuracy, and edge-matching accuracy
- Establishment of the USGS Digital Line Graph Level 3 data format as a standard to be used when reformatting data for integration with existing databases.

Each of the approaches to standards summarized above has elements worth considering in establishing a Vermont GIS data standard. Particular aspects of each are incorporated in the discussion and recommendations later in this section.

DATA STANDARDS IN VERMONT

The following is a brief discussion of the various descriptors which the Vermont data standards should use to specify the characteristics of the local and state level databases.

- *Content* - Refers to the specific graphic features and nongraphic data elements selected for conversion to digital form. For example, the parcel layer in the Vermont GIS will contain parcel boundaries, tax numbers, rights-of-way, easement boundaries, etc.

- *Format* - Indicates the form in which the various data elements will be stored by the system, e.g., parcels stored as polygons; also the field formats for graphic data, e.g., assessed value in the tax parcel attribute record will be single precision integer format.

- *Coding and classification schemes* - Designates the particular codes assigned to each data element and groups the data elements into classes for organizational purposes. For instance, the Vermont GIS could use the land use coding schemes used for the CAPTAP database.

- *Map accuracy* - As mentioned above, graphic features must be assigned to the correct location. Map accuracy is a measure of how accurately a graphic feature has been placed in relation to either its true location (absolute accuracy) or to other graphic features (relative accuracy). For example, since the orthophotos have an accuracy of $\pm$ 10 feet the location of a building on the base will be within $\pm$ 10 feet of its true location relative to the control network.

- *Applicability and reliability of sources* - Determinations must be made regarding the relative usefulness of particular sources for converting various graphic and nongraphic data elements to digital form. The best, most authoritative source should be sought for each class of data elements. For instance, a subdivision plat based on a survey would probably be a more accurate, applicable, and reliable source of parcel boundary information than would a metes-and-bounds description of the parcel taken from deed records.

Standards that describe the characteristics of the GIS data drive the development of specific procedures (both technical and administrative) for database conversion and on-going maintenance. The need for standards in the development of the Vermont GIS is straightforward. Standards ensure consistency and provide a logical framework for building, maintaining, and using the GIS data.

Establishing State- and Local-Level Databases

As pointed out in the Phase I Report, GIS development in Vermont will require map databases at different levels of accuracy to address different application needs.

At the state level, positional accuracy of map features is much less important as compared to local level requirements. The concept of a state-level and a local-level GIS database are introduced in this report. These two logically separate, but related databases, will contain data that is normally used for state or local mapping, or analysis operations, respectively. The rationale for creating and maintaining these two databases is (a) the dichotomy of large-area versus site-specific GIS applications that have been identified, and (b) the scale and accuracy of common source materials available for update of the database. The state-level GIS database will be used primarily for analysis covering large areas. The state-level database will contain small scale, relatively low-accuracy map features and associated nongraphic attributes that are useful for statewide or regional planning, inventories, resource assessments, and large-area infrastructure management.

At the local level, maps at larger scales with a higher degree of accuracy are required. Parcel maps compiled on orthophoto base maps will form the basis for the local-level GIS. Other map layers, such as zoning, utility lines, and administrative boundaries, will be registered to the parcel maps and may be used for detailed impact assessments, detailed inventories, real property management, and detailed facilities management.

The accuracy limitations of added layers of information relative to both state-level and local-level base maps should be understood. The best accuracy that can be achieved is no greater than the inherent accuracy of the base maps. In fact, somewhat less accuracy than that of the base is likely due to several factors, including quality of source materials and method of registering layers to the base. The quality of source materials is very important to the accuracy of additional data layers. Inaccurate, incomplete sources result in a low degree of accuracy for the added layer of information.

The method of registering other layers to the base maps also affects accuracy. Section 5 includes a discussion of the method for registering the parcel layer of the base in a manner which will insure the highest degree of accuracy for the parcel layer.

The desired accuracy and content of the two distinct databases influence the methods to be used for map compilation and automation. To facilitate efficient sharing and use of GIS data at all levels, standards for mapping and automation must be established. The following discussion includes specific issues and recommendations relevant to creating state- and local-level data standards.

State Level Database

- As discussed further in Section 4, the USGS Digital Line Graph (DLG) from 1:100,000 scale maps should be used as the base map. The DLG includes transportation route centerlines, hydrography, and some boundary information. The map sheet layout established by the DLG will serve as a statewide geographic grid upon which to base the map boundaries of additional layers of information. The DLG meets National Map Accuracy Standards.

- It is important to understand that, although source materials are defined at a specific scale, the graphic data, as they are stored in the system, are scale-independent. Only when a map is displayed or plotted is a particular scale assigned. Most automated mapping systems have flexible routines for selecting any reasonable scale in map creation. However, while a map can be easily enlarged with such a system, its accuracy and resolution are still no greater than that of the original source at its original scale. This is an important issue, since system users will often request maps plotted at a scale larger than the one at which its accuracy can be quantified. Through proper management and notification to the user, problems that could develop as a result of this issue can be overcome. One option is for maps to contain marginal notation concerning scale and accuracy of source documents.

- The contents of the state-level database, and the sources from which various data elements are derived, must be determined and stated in the standards. Database design includes a determination of the elements necessary to perform desired applications. The conceptual database design included in this report provides a basis for a detailed database design.

- The DLG is built to the specifications of the USGS Digital Cartographic Data Standards. They will be translated to ARC/INFO thereby conforming to the standards for coding schemes and data element formats inherent to ARC/INFO. It will be necessary to translate any additional data to ARC/INFO format to conform with the Vermont GIS database. Standard coding schemes already in use, such as those used for coding land use information, should be used to construct additional layers.

Local-Level Database

- The 1:5000 and 1:1250 scale orthophoto maps that already exist in Vermont are the logical choice as a local level base map. The technical specifications for aerial photography, control, analytical triangulation, and orthophoto production will, therefore, be incorporated into the Vermont data standard. At an accuracy of $\pm$ 10 feet, and a relatively large scale, the orthophotos will satisfy the local level need for a relatively low degree of data generalization. The relatively high accuracy also contributes to the ability to evaluate parcel maps for multiple, geographically contiguous jurisdictions for state level applications. The map sheet layout established for the orthophotos, and based on the State Plane Coordinate System, will serve as a geographic grid to define map sheet boundaries for the parcel maps and for other layers registered to the orthos.

- The Property Mapping Guidelines established by the Vermont Mapping Program should be incorporated into the Vermont data standards. The Guidelines will serve to guide the local process of parcel map compilation. Parcels that have already been compiled using the orthophotos as a base will be acceptable for incorporation into the Vermont local-level GIS database. Parcels that have been compiled on some other base will require registration to the orthophoto base before they will meet state data standards.

- The content of the local-level database, and the sources used to derive the various data elements, should be determined within a detailed database design. As mentioned earlier, the conceptual database design prepared by PlanGraphics and presented in this report provides a basis for this detailed design.

- Standard coding schemes and data element formats compatible with those developed for the state-level database should be used to insure compatibility of data developed by various local jurisdictions.

Documenting the Database

In order to allow potential users of the Vermont GIS database to evaluate the usefulness of the database for particular applications, the database must be documented. This documentation should also be designed as a reference tool to answer questions that users may be confronted with when involved in application projects. Only with a clear understanding of the nature of the available data and the variety of available analysis techniques, can users achieve worthwhile results in an efficient manner.

A good method of database documentation is the creation of a data dictionary. A data dictionary documents the database's graphic and nongraphic data elements, defining such things as data type, source material, and format for individual data elements.

A data dictionary to document the Vermont GIS database should be developed for both the state-level and local-level databases.

The data dictionary systematically describes the accepted standards and provides users with all pertinent information about the database that is needed to perform applications and update the system. The data dictionary can be thought of as a "database about the GIS database" and should be maintained in automated form on the system so it can be changed as the database evolves. Hard copies may be generated periodically to be used as reference manuals on the system. There is no one accepted format for a data dictionary, but it should contain detailed information about the characteristics of the Vermont GIS databases and individual map features and data elements in the system.

The following information should be included in the data dictionary:

- General background about the preparation of the database
- Primary computer hardware and software being used
- Base map standards and accuracy
- Geographic coverage of various GIS layers or features

- Map feature format (e.g., point, line, polygon)
- Field formats for nongraphic data files
- Descriptions of alpha or numeric codes used for elements of the nongraphic data
- Dates at which particular layers or features were added or updated.

The Next Step

A definition of standards provides a basis for the development of specifications and procedures for detailed database design and conversion. This is the next task confronting the GIS Committee. The selection of a GIS software standard at the state level provides a basis to develop the detailed design and data conversion specifications. These specifications must address the needs of both the local level database, as well as the state-level database.

PlanGraphics is able to assist the GIS Committee in preparing the detailed data conversion specifications for building the databases. This will require a more detailed examination of existing map and data sources, and a definition of procedures for the conversion effort. For a number of system layers, contracted data conversion may be appropriate while in-house efforts may be suitable for other database components. Section 5 describes recommended conversion procedures for the GIS database layers.

SECTION 4
CONCEPTS IN DATABASE DEVELOPMENT AND CONCEPTUAL DATABASE DESIGN

INTRODUCTION

The purpose of this section is to present the Vermont GIS conceptual database design, distinguish between local and state level databases, and to outline procedures for updating the GIS database. We begin this section with an overview of GIS database concepts. These concepts are at the heart of GIS technology--technology that is providing exciting new tools for local and state governments. Reading about these concepts is a step towards mastering these new tools.

GIS DATABASE CONCEPTS

Many organizations in Vermont, whether a town or city government, state agency, utility, or a private company use geographic information. This information is used in a variety of activities including Act 250 reviews, highway right-of-way determination, wellhead protection, property assessment, Act 200 planning, public works, school bus routing, wildlife management, emergency service responses, transmission line routing, mine permit application and approval, and numerous others. Geographic information is commonly thought of as maps (graphic data elements), but also includes paper files and computer databases containing text and numbers (nongraphic data elements).

The strength of a geographic information system (GIS) is in its ability to link graphic and related nongraphic information. This link is accomplished through a common identifier or "geocode". For example, the link between a tax parcel and assessment information is accomplished using a parcel identification number; the parcel number is found on the tax map and also in the lister's grand list. The parcel number link allows the user to locate the tabular file record of an individual parcel after inspection of the parcel map. Inquiry from the opposite direction, and location of a parcel on the tax map following review of its tabular record, is also possible.

Other kinds of links are possible between graphic and nongraphic data. The most common ones are through a property house number and street name address and through an 'x' and 'y' coordinate pair determined using a geographic coordinate grid such as the Vermont State Plane Coordinate System. Links between networks (e.g., streets, highway systems, or rivers and streams) and nongraphic information about points on the network are created using locators such as site address, highway mile marker, and river mile index points.

Automating graphic and nongraphic information and the geocode yields numerous benefits. First, an automated graphic generation and manipulation capability improves map making efficiency and makes map production easier and more flexible. Second, an automated graphic and tabular database linkage provides ready access to both map and attribute data, synchronization between graphic features and associated tabular records, and greatly enhanced query capabilities.

The extensive capabilities afforded by this type of automation allow users to perform queries, generate customized maps, or complex geographic analyses which are impractical or impossible in a manual environment. Examples of questions or tasks that could be posed include "display parcels in the Town of Manchester where the value of land and improvements is greater than $60,000"; and "display all stretches of state highway in AOT District 'X' repaved since 1984". These queries are only possible because of the link between graphic and nongraphic information.

Database Layering

Digital databases differ importantly from the paper maps and files used by many organizations in Vermont. Data storage in a GIS can be conceptualized as a series of map layers each of which is geographically registered to an accepted base map layer. Each layer consists of a related set of map features and associated nongraphic information or "attributes". While the specific file structures and data storage approaches differ among GIS software packages, the layer concept can be used in organizing geographic data. This database layering concept is depicted in Figure 4-1.

GIS Database Components

Data in a GIS can be conceptualized as falling into the following four categories:

- Graphic elements
- Attributes
- Annotation
- Indices.

The graphic elements are individual map features that may be represented using:

1) Points, such as fire hydrant symbols or water well locations
2) Lines, such as road or highway centerlines or rivers and streams
3) Areas or polygons, such as a property parcel or administrative district.

Graphic elements define the images of physical features and are stored in the database using X and Y coordinates, usually in the state plane coordinate system. A point is represented by a single coordinate pair, while lines and areas are represented by a string of X and Y coordinate pairs. Map features are further identified by type to allow selection and display of similar features and use of symbology to portray the different classes of features. Each graphic data element also includes an identifier to relate it to nongraphic attributes which describe the element.

Attribute data describe characteristics of the graphic elements. Attributes are stored in the database in a way that allows them to be linked with their related map features. This linkage supports information retrieval through interactive inquiries of map feature location or associated attribute value content. Figure 4-2 depicts the relationships between graphic and attribute data.

Map annotation is text related to map features and plotted along with the features. It includes items such as street names, dimensions, and area identifiers. Depending on the capabilities of the system selected, annotation may be strictly graphic, residing on a separate map layer, or it may be stored in attribute data files and accessed for a particular map display.

FIGURE 4-1
MAP DATABASE LAYERING CONCEPT

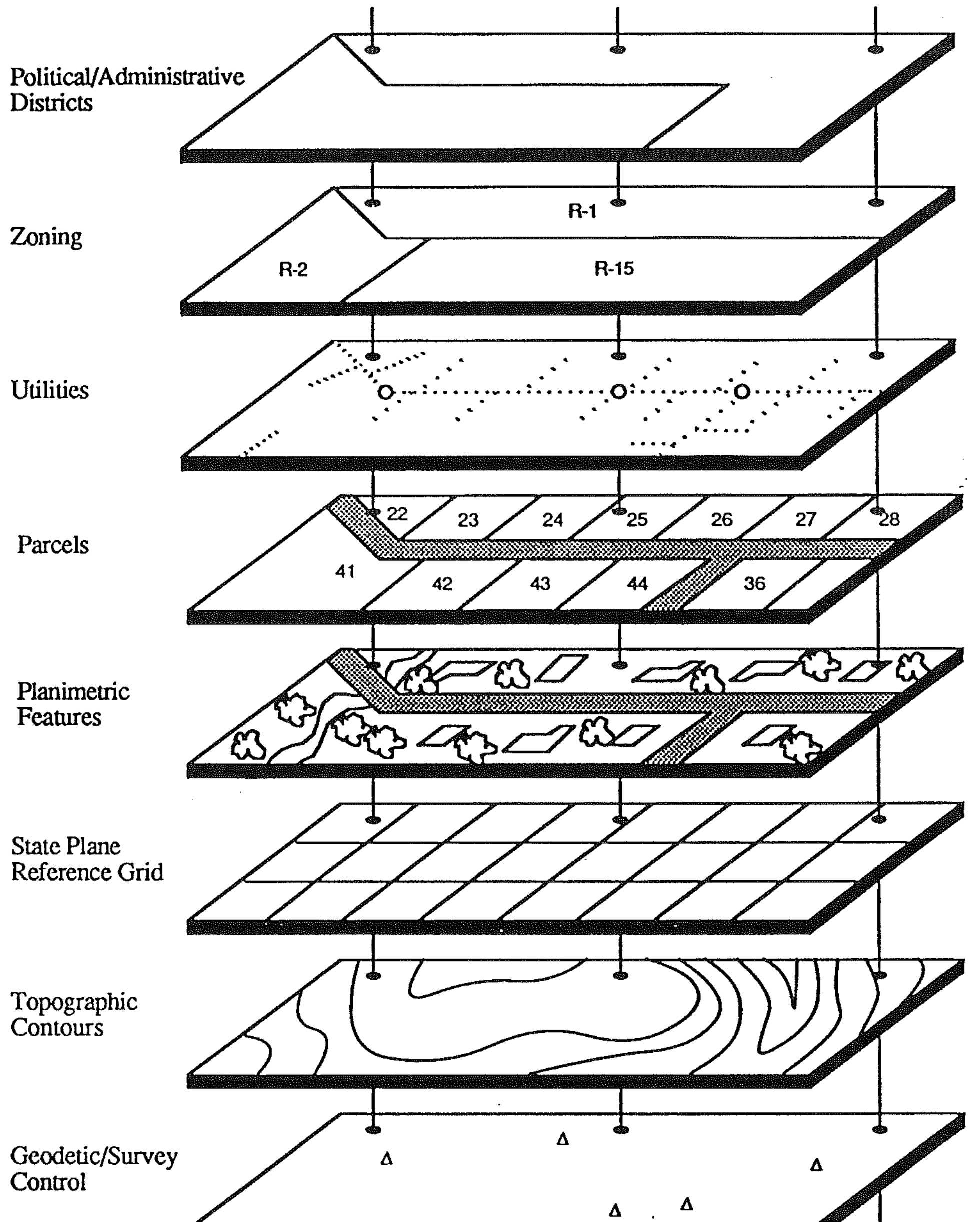
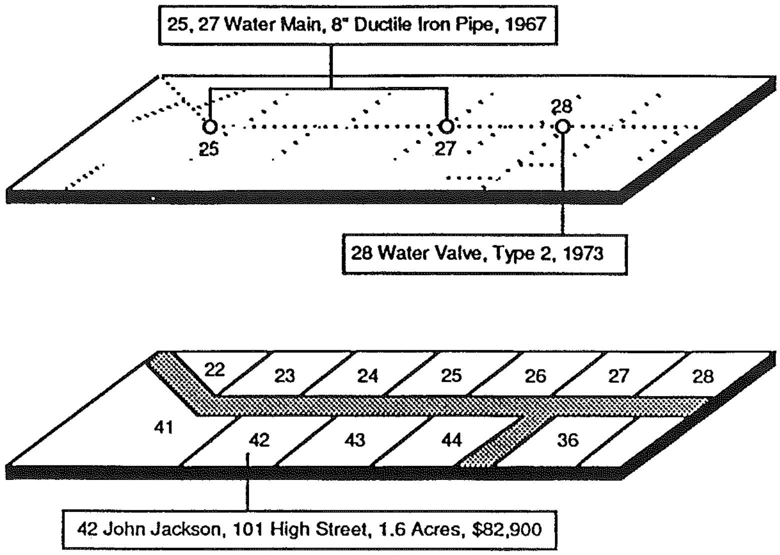


FIGURE 4-2
ATTRIBUTE DATA - MAP FEATURE LINKAGE



Reference indices are of two types: 1) arbitrary machine-assigned values used by the system to relate and process data, and 2) operator-defined codes used to relate data. Reference indices are special types of nongraphic attributes stored in a GIS. An index can be thought of as a pointer used to reference data associated with a map feature. As described earlier, geographic identifiers (parcel number, highway mile marker) are typically used in GISs for linking tabular records to a map feature.

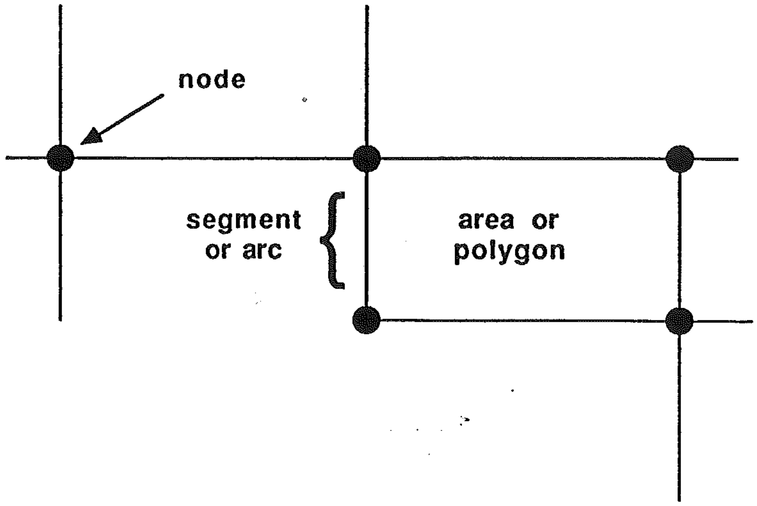
Other types of identifiers may be used to link or reference a range of automated or non-automated records to a map feature or location. For instance, a permit site may be identified as a point feature in the GIS and assigned a permit number as an index. This permit number provides a link to more detailed information about the permit. This information may be automated or may reside in a paper file. Indices are a special type of nongraphic attributes.

Data Element Relationships

The format in which graphics, annotation, attributes, and indices are stored varies among systems. An important issue for the GIS users in Vermont to consider is that the system should have the capability to record and analyze physical relationships among elements. For example, the relationships of nodes at street intersections to the individual street segments could be defined in the database. Similarly, the relationships of these street elements to the blocks which they bound may also be established and recorded.

A database that contains a record of connectivity and adjacency relationships is referred to as being topologically structured. Topologically structured GIS databases define the spatial connectivity of map features. The connectivity provides an efficient foundation for complex geographic analysis such as network tracing and polygon analysis. Figure 4 -3 shows the relationships between features in a topological structure.

FIGURE 4-3
TOPOLOGICAL STRUCTURE



Base Maps

While there are many interpretations of the term "base map", the most common one is a map depicting natural and man-made features on the earth's surface; an example is the USGS topographic maps. In a GIS, map features are measured, stored, and referenced in east-west and north-south coordinates. These measurements are determined on the basis of a map projection. Many projections exist, and they can be divided into two types: projections that recognize and depict the curvature of the earth, and plane coordinate projections that depict a flat surface. A GIS base map incorporates a plane coordinate projection. The plane systems are simpler and can be used without significant distortion if the area involved is not enough for the earth's curvature to introduce a significant error. As a result, the State Plane Coordinate System is the most widely used by local governments for mapping and GISs.

The State Plane Coordinate System was originally established for each state by the Coast and Geodetic Survey, now known as the National Geodetic Survey (NGS). It is referenced by monumented geodetic control points, as described earlier. In preparing base maps, the relationship between the control points and the reference grid is established to provide a common reference for all information subsequently mapped on the base map.

The base map is the most positionally accurate map in the GIS, and is used as the positional base for the parcel and other maps. The base map serves as "control" to achieve common positional accuracy for the other GIS data layers.

Geodetic Control

To control the accuracy of map information in the GIS database, a common reference framework is needed with specific positions determined in accordance with common standards and with known accuracy. In mapping and surveying, this framework is a geodetic control network. Points on the ground are surveyed to determine their precise position, the distances and relationships between them (horizontal control), and their elevations (vertical control). The geodetic control monuments are marked so they are visible on the aerial photography flown to produce the orthophotos which will serve as the base maps for the new parcel maps. A photogrammetric procedure is used to reestablish the relationship between these control points and to create orthophotos showing the true position of the features photographed.

A geodetic control network consists of a series of accurately surveyed control points which are permanently monumented in the field. The National Geodetic Survey is responsible for establishing and maintaining a highly accurate nationwide network of horizontal and vertical control monuments. Geodetic control standards have been developed by the Federal Geodetic Control Committee. Compliance with these standards will provide a geodetic control network suitable for photogrammetry, land surveying, and engineering.

For local and state government mapping and surveying purposes, the NGS national network is used as the basis for establishing a network of monuments more closely spaced, appropriate for local purposes. Horizontal survey accuracy for engineering and local area network densification purposes should be not less than 1:50,000 (1 part in 50,000) or second order, Class I. The monument locations and other pertinent data are documented and stored in a manner that makes them accessible for local government functions and to private and public surveyors.

The State of Vermont should consider implementing a long-term program of survey control densification. This program should include provisions for maintaining information about where individual points are located as well as requirements for notification if a monumented point is disturbed or eliminated. Ultimately, as control points become more and more common, parcel subdivision could be required to tie to a monumented survey control point, thus providing more and more accurate legal records of parcels. These more accurate parcel records would foster continued increases in the accuracy of existing parcel maps.

OVERVIEW OF THE GIS DATABASE DEVELOPMENT PROCESS

The database is the most important part of any GIS. It should be considered an organizational asset whose value increases with time and as a coherent program of maintenance procedures is initiated. GIS databases for Vermont must be prepared in a systematic process which will take several years to complete.

Information "data layers" entered to the GIS database will be the graphic and nongraphic data required to support the applications; application development priorities determine what data layers will be implemented first. The process of developing the data layers in the database will proceed as described below.

The Phase I Report identified what data layers were required by the various applications. A conceptual database design is the next step. That design is presented later in this section. The design lists specific graphic features and nongraphic attributes for each proposed database layer. Primary sources for these features and attributes have also been identified. The conceptual database design and the primary sources in turn form the basis for (a) determining data conversion methods, and (b) calculating budgetary cost estimates for creating the GIS database.

The next step is developing standards and specifications that will be followed in mapping information and then entering it to a GIS database. Why these standards and specifications are necessary and the elements that make up database standards were presented in Section 3. Mapping standards and specifications are used now in Vermont. Two examples are tax mapping by towns and the state's orthophoto mapping program. Following application selection, budgeting, and standards development, the actual data conversion matching application development needs can begin.

VERMONT'S GIS DATABASE

Vermont's GIS database will consist of many different components derived from a variety of sources maintained by different organizations. Towns and cities will generally be the source of parcel-related information while state and federal agencies will be primary sources for maps and other geographic information covering larger areas of the state.

To fulfill the mandates of Act 200 as well as other GIS-related goals of state, regional, and local organizations, PlanGraphics recommends that the Vermont GIS database have two parts: (1) state (data covering large areas), and (2) local (parcel related data at the town and city level). This breakdown is based on the applications defined in the Phase I Report. These applications focus on either larger area mapping and analysis or smaller area mapping and analysis requiring more site-specific information. This distinction between state level and local level databases is also consistent with the level of detail needed to support applications and the scale and resolution of source maps and data generally available.

Determining the appropriate information for each database depends on the scale of source materials. Information on large scale maps will be part of the "local level" database. Examples of large scale maps include tax maps, zoning maps, maps of underground utilities, and flood zone maps. Information from small scale maps will be in the "state level" database. Examples of these maps include transportation centerlines, surface water features, soil associations, and watershed boundaries.

The two parts of the database will be "one" in the sense that they will all conform to a universally accepted statewide data standard (see Section 3) which will enable towns and cities to use information from state and other agencies and vice versa. Institutional arrangements for providing access to both local and state level GIS data are discussed in Section 2.

Although PlanGraphics has recommended the creation of two logically separate GIS databases, the system design and technical specifications will allow the combination of data from each of these databases. Certain applications, such as special land use planning or impact studies, for instance, may require an overlay of census statistics or geological layers from the state level database with property parcels from the local level GIS database covering a particular municipality.

The GIS software will provide the necessary capabilities to extract portions of either the state or local level database and combine them in such an analysis. While no major technical limitations exist in this type of operation, it is important for the user to understand the nature of the data layers being combined from the state and local databases. Because the positional accuracy of map features in the state level database will be approximately an order of magnitude below that of the local level data layers, the positional accuracy of resulting maps generated through a combination of state and local data will be no better than the lower accuracy state level layers.

There is no absolute solution to resolving the differences in accuracies of data layers used in Vermont GIS analysis. In some cases, it may be appropriate to conduct additional data collection or field work, in site-specific cases, to improve the accuracy of lower-accuracy layers. In most cases, however, the best way to deal with this dilemma is to design applications with a detailed familiarity of the characteristics and accuracy of the database, and to use resulting products appropriately. The data dictionary that was discussed in Section 3 provides a complete reference to the database to support efficient application design.

Local-Level Base Map

The "local-level" database will consist of information mapped using the existing orthophoto maps as a base map. These orthophotos are at a scale of 1:1250 (1" = 104') and 1:5000 (1" = 417'), with a horizontal accuracies of ± 10 feet, respectively, ± 3.5 feet and ± 13.9 feet.

The only potential drawback to using the orthophotos as a base is their age; one third of the existing orthos date from 1974 - 1975; three quarters of them date from 1978 - 1979 or before. Some areas of the state have experienced substantial growth since the orthophotos were created and the orthos for those areas are extremely out-of-date. This lack of currency will hamper applications dependent on observing base features, particularly parcel information. In the most extreme cases, existing orthophotos are so out-of-date that they are not adequate as a base map for parcel mapping. The state should consider placing all orthophotos on a 10-year update cycle to ensure reasonable currency of base information, and funding the update of the currently insufficient orthophotos immediately. This tool is critical for the first steps to GIS implementation.

State-Level Base Map

PlanGraphics recommends that the state-level base map in Vermont be the USGS Digital Line Graph (DLG) from 1:100,000-scale maps. The source materials for this DLG were existing 1:24,000, 1:25,000, and 1:62,500 scale USGS quad sheets. These source materials were generalized before they were used as sources for creating the 1:100,000 scale map sheet separates. After generalization, these sheet separates were scanned, beginning the process of creating the DLG from 1:100,000 scale maps. Therefore, the DLG that resulted from these larger scale source materials meets national map accuracy standards for 1:100,000 scale maps. The DLG is available from the U.S. Geological Survey and is part of the Survey's national mapping program. Complete DLG coverage of transportation route centerlines, perennial streams, rivers, and lakes and ponds is available for Vermont.

The reasons for this recommendation are as follows:

a) The University of Vermont has ordered statewide DLG coverage; delivery is expected by the second quarter of 1989 and this data will be available for the state level GIS database.
b) The DLGs are an inexpensive way of acquiring a basemap that will facilitate immediate implementation of state level applications.
c) The DLG's meet the requirements of many state and regional agencies for a small scale basemap.
d) The scale maps DLGs from 1:100,000 are the only existing source of digital base information with complete coverage for the State of Vermont.

Ideally, the state would use the DLGs prepared from the 1:24,000 scale maps. The source material includes advance manuscripts for 7.5 minute maps, published 1:62,500 scale 15 minute quadrangle maps, and primarily for Vermont, 1:24,000 scale 7.5 minute quadrangles. These source materials allow for an improved resolution field (small data collection down to features with 0.61 meter ground length). However, geographic coverage of these DLGs in Vermont is very limited (less than 20 percent of the land area). Prospects for additional DLG coverage at this scale are dim, as the USGS is currently focussing its resources on completing nationwide coverage from the 1:100,000 scale source maps. The DLGs from 1:24,000 scale maps could be used for applications in areas for which there is coverage (see Figure 4-4).

The base maps described above will be the base for preparing all other layers in the GIS database. Specific graphic and nongraphic components of that database are described below.

CONCEPTUAL DATABASE DESIGN

The first task in developing Vermont's conceptual database design was to identify the types of information needed to support GIS applications. Next, this information was grouped into 26 themes, or layers, with each layer containing similar information. Each application will require information from one or more layers, so the first layers to be developed will be those needed for the high priority applications.

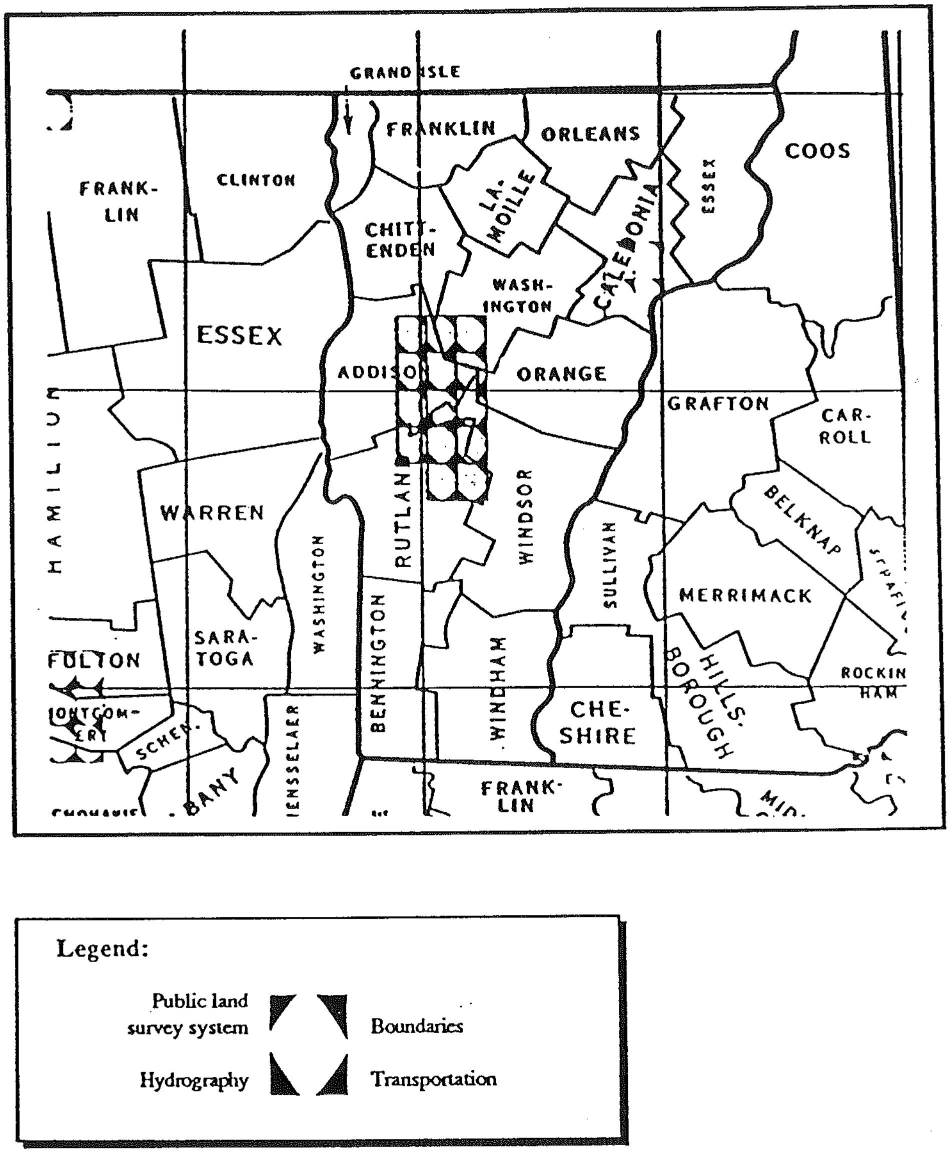
In the third step, each layer was designated as a state level, local level, or both, depending primarily on the scale of data capture. A brief description of each data layer is provided later in this section.

The conceptual database design described below is presented in the form of two tables, one each for map layers in the local-level and state-level databases (See Tables 4-1 and 4-2). Generally, this organizational separation reflects the differences in scale, accuracy, and geographic coverage of the data sources on which applications will depend. However, since mapping scale and accuracy is really a continuum from large scale and high accuracy to small scale and low accuracy, the designation of local or state level will not preclude use of the database by users of either group. As discussed previously in this section, layers from the local-level and state-level databases may be combined and overlaid where specific applications warrant.

The tables presenting the conceptual design also contain primary graphic and nongraphic data elements for each GIS database layer. In addition, potential data sources for the graphic and nongraphic data elements are idenfitied for each data layer. Where they are known, the organizational location of the source materials is also identified. The elements identified in each layer of the tables are not meant to be all inclusive; only during application development can all graphic and nongraphic elements be conclusively identified.

As more applications are implemented and the system matures, more data layers will be created. Some of these layers should be prepared under contract with a commercial data conversion firm. Others would be best prepared by the primary users. All of these overlays must use a base map to provide geographic framework so that information from different data layers can be reliably integrated. Before these other overlays are created, mapping standards will have to be developed. The purpose and type of content required for these standards was presented in Section 3.

FIGURE 4-4
1:24,000 SCALE DIGITAL LINE GRAPH COVERAGE FOR VERMONT



Primary graphic and nongraphic elements for each database layer were identified from survey forms provided in Phase I by project participants, from map samples, and from additional PlanGraphics research of federal, state, and local government databases. The conceptual design does not differentiate different types of graphic features. However, it is important to understand that all graphic features are either point features, line features, or area features.

The following sources were used in identifying potential data sources for the graphic and nongraphic data elements:

- Survey forms filled out by project participants
- The Vermont GIS data catalog
- Notes from interviews with project participants
- State agency documentation of existing databases
- Documentation of federal mapping programs and data sources.

The local-level conceptual database design contains some layers with the same names as ones in the state-level database and vice versa. These layers differ in that they will contain information orginally compiled at two different scales. For example, the transportation centerlines for the local level databases will be digitized from orthophotos (and where appropriate as part of developing a parcel map). Transportation centerlines in the state-level database will be from the DLGs.

The University of Vermont - School of Natural Resources has digital versions of some of the layers in both the state and local level databases. The geographic coverage of this data is limited to certain towns and regions of the state. The UVM database will be able to provide statewide coverage for one or two of the data layers. The existing digital data at UVM is listed in Appendix A and will be available for the appropriate state- or local-level database.

State-Level Conceptual Database Design

Table 4-1 lists the data layers that will be in the state-level GIS database. Each of the layers is discussed below. All layers in the state-level database will be compiled using digital line graphs as the base map. Two of the layers, transportation route centerlines and surface waters, will be derived primarily from information in the DLG files. Specific issues related to data conversion for topographic contours, existing databases with information tied to coordinate locations, and the Census Bureau's TIGER file are discussed in Section 5.

<u>Digital Line Graph (DLG) Base Map:</u> As discussed in-depth earlier in this section, PlanGraphics is recommending that the State use the DLG as the base map for the state-level GIS data layers. The DLG will provide a state plane grid, transportation route centerlines, surface water features, and jurisdictional boundaries. The jurisidictional boundary information will need to be supplemented from other sources, probably the U.S. Census Bureau's TIGER file and the UVM GIS database. The sheet layout of the DLG will be the basis for the statewide sheet layout.

TABLE 4-1
CONCEPTUAL DATABASE DESIGN FOR STATE-LEVEL DATA LAYERS

Layer	Primary Graphic Elements	Primary Sources	Primary Nongraphic Elements	Primary Sources
Digital Line Graph Base Map	Survey control grid; Transportation route centerline; Pipe and transmission lines; Surface waters	National Mapping Program (USGS)	Control grid numbers; Transmission line owner; Highway/road/number/name; Winter status; Road condition [1]	National Mapping Program (USGS); County Highway Maps (AOT); City/Town/Village Maps (AOT); Vermont Base Map (AOT); AOT Maintenance Division Records
Topographic Contours	20' contour lines; Index elevations	See text discussion Section 5	Elevations	Entered during compilation

[1] This layer of road and highway centerlines provides a base for the management of many more types of transportation records associated with highway segments and point features along the highway network including traffic volume; accident statistics; maintenance history; bridge, culvert and overpass data; and other highway information.

Agency Abbreviation Key:

AOT	Agency of Transportation	UVM	University of Vermont	ANR	Agency for Natural Resources
USGS	United States Geologic Survey	OSG	Office of State Geologist (ANR)	SCS	Soil Conservation Service
GWMS	Groundwater Management Section (ANR)	RD	Recreation Division (Department of Forests, Parks, Recreation (ANR)	DEC	Department of Environmental Conservation (ANR)
NHP	Vermont Natural Heritage Program (ANR)	DF&W	Vermont Department of Fish and Wildlife (ANR)	DHP	Division for Historic Preservation (Agency of Development and Community Affairs)
HMD/SWMD	Hazardous Materials Division and Solid Waste Management Division (ANR)				

TABLE 4-1 (continued)
CONCEPTUAL DATABASE DESIGN
FOR STATE-LEVEL DATA LAYERS

Layer	Primary Graphic Elements	Primary Sources	Primary Nongraphic Elements	Primary Sources
Political/ Administrative Boundaries	County/City/Town/State National boundaries; Park, forest, preserve; Military district; Agricultural district; Regional/local planning district; School districts; Transportation districts; Other state agency districts; State legislative districts	County/Town Road Maps (AOT); State Lands Maps (ANR); Selected Service and Administrative Boundaries (AOT); County and Town Outline Map (AOT)	Jurisdiction; Names; District number (if applicable)	County/Town Road Maps (AOT), State Lands Maps (ANR); Selected Service and Administrative Boundaries (AOT); County and Town Outline Map (AOT)
Census Areas	Census tracts; Minor civil divisions; Burlington SMSA	U.S. Bureau of Census	Census tract numbers	U.S. Bureau of Census
Land Cover	Land cover boundaries	LANDSAT, SPOT	Land cover classification	Coded at time of graphics compilation
Watersheds	Watershed and subwatershed boundaries	Drainage Basin Map (DEC)	Watershed or subwatershed name	Drainage Basin Map (DEC); UVM GIS Database

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AOT Agency of Transportation
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GWMS Groundwater Management Section (ANR)
NHP Vermont Natural Heritage Program (ANR)
HMD/SWMD Hazardous Materials Division and Solid Waste Management Division (ANR)
UVM University of Vermont
OSG Office of State Geologist (ANR)
RD Recreation Division (Department of Forests, Parks, Recreation (ANR)
DF&W Vermont Department of Fish and Wildlife (ANR)
ANR Agency for Natural Resources
SCS Soil Conservation Service
DEC Department of Environmental Conservation (ANR)
DHP Division for Historic Preservation (Agency of Development and Community Affairs)

TABLE 4-1 (continued)
CONCEPTUAL DATABASE DESIGN
FOR STATE-LEVEL DATA LAYERS

Layer	Primary Graphic Elements	Primary Sources	Primary Nongraphic Elements	Primary Sources
Geology	Surficial geology boundaries and names	Surficial Geologic Maps (OSG); Metallic and Non-Metallic Resource Map of Vermont (OSG)	Geologic classification	Surficial Geologic Maps (OSG); Metallic and Non-Metallic Resource Map of Vermont (OSG)
Soil Associations	Soil association boundaries	General Soils Map (SCS)	Soil association name	General Soils Map (SCS)

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OSG	Office of State Geologist (ANR)
RD	Recreation Division (Department of Forests, Parks, Recreation (ANR)
DF&W	Vermont Department of Fish and Wildlife (ANR)
ANR	Agency for Natural Resources
SCS	Soil Conservation Service
DEC	Department of Environmental Conservation (ANR)
DHP	Division for Historic Preservation (Agency of Development and Community Affairs)

TABLE 4-1 (continued)
CONCEPTUAL DATABASE DESIGN
FOR STATE-LEVEL DATA LAYERS

Layer	Primary Graphic Elements	Primary Sources	Primary Nongraphic Elements	Primary Sources
Surface Water	Rivers/Streams (major); Lakes; Ponds; Reservoirs; Marshes; Swamps; Wetland boundaries; Waterfalls; Gorges; STORET stations	Classifications of Surface Waters Wetland by County and Town Site (DEC); White Water Rapids Map (DEC); USGS Digital line graphs	Water body name/type; Milemarker numbers; Water body owner (if applicable)	Vermont Rivers Study STORET wetlands site listings (DEC); Lakes and Ponds Inventory (DEC); National Wetlands Inventory Maps (DEC); White Water Rapids Maps (DEC)
Groundwater Features	Groundwater aquifer boundaries; Wellhead protection areas; Public water supply wells	Wellhead/Aquifer Protection Area Maps (GWMS and UVM database); Ground-Water Investigations Maps (GWMS); Well Completion Report Locations Maps (GWMS)	Aquifer name; Area size; History (if applicable); Well identifiers; Well operator; Address	GWMS records; Class I-IV areas databases (GWMS)

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HMD/ SWMD	Hazardous Materials Division and Solid Waste Management Division (ANR)				

TABLE 4-1 (continued)
CONCEPTUAL DATABASE DESIGN
FOR STATE-LEVEL DATA LAYERS

Layer	Primary Graphic Elements	Primary Sources	Primary Nongraphic Elements	Primary Sources
Recreational Facilities	Recreational facility/trail locations	Vermont Recreation Plan (RD); Trail Maps (RD); State and Federal Public Lands Maps (RD)	Facility name; Owner; Use, Capacity (as applicable)	Vermont Recreation Plan (RD); Trails Inventory (RD); Community Recreational Facilities Database (RD)
Historical/ Archaeological Sites	Historic areas; Sites; Archaeology sites	Historic Site Maps (DHP); Village Historic District Maps (DHP)	Site identifier; Name; Responsible agency; Significance (as applicable)	Historic Sites Database (DHP); Archaeological Sites Inventory Database (DHP); Environmental Review Database (DHP)

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TABLE 4-1 (continued)
CONCEPTUAL DATABASE DESIGN
FOR STATE-LEVEL DATA LAYERS

Layer	Primary Graphic Elements	Primary Sources	Primary Nongraphic Elements	Primary Sources
Sensitive Natural Areas/Elements	Sensitive/natural area boundary; Points	Natural Areas Inventory (NHP); Unique Habitat Maps (DP&W); Important Plant Communities (ANR); Resources Maps (DF&W)	Area name; Size; Use; Significant characteristics	Natural Areas Inventory (NHP); Managed Areas Database (NHP); Natural Areas Inventory; Element Occurrence Database (NHP)
Special Infrastructure Facilities	Dams; Bridges; Name/Number; Others as appropriate	To be determined	Coordinate location; Name/Number	To be determined

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HMD/ SWMD	Hazardous Materials Division and Solid Waste Management Division (ANR)				

TABLE 4-1 (continued)
CONCEPTUAL DATABASE DESIGN
FOR STATE-LEVEL DATA LAYERS

Layer	Primary Graphic Elements	Primary Sources	Primary Nongraphic Elements	Primary Sources
Solid/Hazardous Waste Disposal Sites	Landfill sites; Hazardous waste storage disposal locations	Solid Waste Management Facility Information Database (HMD/SWMD); Underground Storage Tank Database (HMD/SWMD); Hazardous Waste Site Program Database (HMD/SWMD); Orthophotos	Landfill owner; Date installed; Capacity; Status; Owner; History; Hazardous waste type by common and chemical name; Volume; Status; Storage information; Plan number; Plan type	Solid Waste Management Facility Information Database (HMD/SWMD); Hazardous Waste Site Program Database (HMD/SWMD); Orthophotos
Utility Transmission Lines	Gas transmission lines; Electric transmission lines; Towers; Substations	Orthophotos; USGS quad sheets; Utility maps	Type of line; Emergency contact name/number[2]	Permit files; Vermont Public Service Commission records

[2] Utility transmission layers provide a base for the assignment of much additional information by power companies for managing their transmission networks.

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Topographic Contours: Project participants expressed interest on survey forms in statewide topographic contours with a 20' contour interval. However, none of the high priority applications require this data layer. Topographic information with this contour interval may be useful for some moderate priority applications such as waste site planning, groundwater modelling support, and environmental impact analysis support. The various options open to the State for this layer are discussed in detail in Section 5. Because of the expense and limited need, PlanGraphics is not recommending development of a digital statewide topographic data layer. However, the existing limited coverage of digital elevation models (DEM) compiled at 1:24,000 scale should be used where it is available. For applications in areas without this DEM coverage, topographic contours can be developed on a case-by-case basis.

Political/Administrative Boundaries: At the state level, this data layer will include the following boundaries:

- County and town boundaries
- Boundaries of public areas (parks, forests, etc.)
- State agency jurisdictions and regional office boundaries
- Legislative districts
- School districts
- Regional commission boundaries
- Other special districts.

In addition, relevant attribute information (i.e., emergency incident records, park visitation data, etc.) may be associated with this data layer.

Census Areas: Census tracts and minor civil divisions will be in the census geography layer. In most cases these boundaries will coincide with the town boundaries. The 1990 TIGER file tapes containing census area boundaries will be delivered to the State in the first or second quarter of 1989.

Land Cover: Uses for a state-level map of land cover are limited to small scale regional or state level generalized mapping such as that performed in the initial stages of waste disposal site planning or wildlife habitat evaluation. The existing 1978 LANDSAT image of the state is a currently available source for statewide land cover information. Although the image is "raw", meaning it has not been already classified into land cover types for Vermont, and significant changes in land cover have occurred in some parts of Vermont since 1978, this image can still provide useful information for these applications. However, because of the expense involved, PlanGraphics recommends that the requirements for this information in the applications be evaluated in more detail. If the applications warrant it and if there is no other alternative, the financial resources can be committed to the image classification process required for developing a land cover map (state or regional coverage) from the LANDSAT image.

Watersheds: Watersheds and subwatershed boundaries will be a state level data layer. This layer will contain names and boundaries of watersheds and, were available, subwatersheds.

Geology: This state-level data layer will contain surficial geology features. Other geologic features may be added to this layer as appropriate for specific applications. Two applications that might warrant expanding the surface geology information to include subsurface geology are hazardous or solid waste disposal siting and mining resource mapping.

Surface Water: The starting point for this state-level layer will be the USGS digital line graphs (see discussion of DLGs in the base map subsection above). The DLG coverage includes rivers and perennial streams, and lakes, reservoirs, and ponds. Additional surface water features will be added as necessary for applications such as environmental impact analysis support. Additional features might include waterfalls and gorges. The attribute information associated with these features will be the name of the water body, mile marker locations on rivers, and water body owner or responsible jurisdiction (if applicable).

Groundwater Features: Graphic data in this layer will include aquifer boundaries, wellhead protection areas, and public water supply well locations. Attribute information will be the aquifer name, well identifers, and other nongraphic information about groundwater maintained by ANRs Groundwater Management section. Public well locations have been mapped statewide through a recently completed pilot project by UVM.

Recreational Facilities: This layer will contain the locations of recreational sites and attribute information about the site, such as the facility name, owner, use, and associated information about services, usage, and maintenance.

Historical/Archeological Sites: The locations of historic and archeological sites will be contained in this layer. Along with the location of each site, the responsible agency, site identifier number, and significance (as appropriate) will be included.

Sensitive Natural Areas and Elements: This state-level data layer will contain the boundaries and/or locations of sensitive and natural areas along with the area name, size, responsible agency, and the protection status of the areas (protected and owned by the state, protected and privately owned, candidate for protection). The status of the plant and animal surveys for each area could also be noted (i.e., complete, in progress, or pending).

Solid/Hazardous Waste Disposal Sites: The solid and hazardous waste site layer will contain the locations of all sites containing solid or hazardous waste. Attribute information will include landfill owner/operator, date constructed, capacity, status, history, hazardous waste type by common and chemical name, volume, status, storage information, and reference to emergency plan, as appropriate.

Utility Transmission Lines: This layer will contain the locations of gas and electric transmission lines, substations, and structures such as transmission towers along with the owner name and emergency contact name, address, and telephone number. The location of some of these lines is part of the DLG base map. Maps and other information from utility companies should be consulted in preparing this data layer.

Local-Level Conceptual Database Design

Table 4-2 lists the GIS database map layers that will be in the local-level GIS databases. These layers will be developed or compiled using orthophotos as the base map or as a source for mapping specific features. Additional discussion about each of these layers follows.

TABLE 4-2
CONCEPTUAL DATABASE DESIGN FOR LOCAL-LEVEL DATA LAYERS

Layer	Primary Graphic Elements	Primary Sources	Primary Nongraphic Elements	Primary Sources
Survey Control	Control grid; monumented points	Grid generated from survey coordinates; Monuments located using coordinate values	Monument identifiers; Date surveyed; Source agency	Orthophoto records; AOT; ANR; City/ Town survey records; Private surveyors
Transportation Centerlines	Street centerlines; Railroad centerlines	County Highway Maps (AOT); City Street Maps; City/ Town/Village Maps (AOT); Orthophotos	Street name; Number; Address; Address ranges[1]	County Highway Maps (AOT); State Map of Town Highways (AOT); City Street Maps; Highway Performance Monitoring System (AOT); AOT Maintenance Division files; City/Town maintenance records

[1] Street centerlines provide a base for the mapping and analysis of many types of street-related data. This includes street segment data (road type, condition, maintenance history) or address-related information such as police and fire incidents, or building permits.

Agency Abbreviation Key:

AOT Agency of Transportation
SCS Soil Conservation Service (United States Department of Agriculture)
FPMS Floodplain Management Section (ANR)
UVM University of Vermont
ANR Agency for Natural Resources

TABLE 4-2
CONCEPTUAL DATABASE DESIGN FOR LOCAL-LEVEL DATA LAYERS

Layer	Primary Graphic Elements	Primary Sources	Primary Nongraphic Elements	Primary Sources
Property Parcels	Survey; Parcel; Easement lines; Right-of-Way lines; Subdivision boundaries	City/Town Tax Maps; Subdivision Maps; Lot Maps; Court LandPlats; Deeds	Listings book and page number; Owner; Address; Date acquired; Deeded acreage; Dimensions; Assessed value; Purchase price; Easement descriptions; Subdivision map number; Permit type; Number; Date issued; Issuing agency	City/Town Tax Maps; Lot Maps; Deeds; Court and Land Plats; Subdivision Maps; Permit files; Lister's Property Tax Maps; Grand Lists
Political Administrative Boundaries	County/City/Town/ Fire protection district; Agriculture district; Enforcement districts; Voting precinct boundaries (as applicable)	County/City/Town Road Maps (AOT); State Lands Maps (ANR); Public Safety Maps; Vermont Department of Agriculture; City Election District Records and Maps	Jurisdiction names; Community/ Neighborhood names; District District number (if applicable)	County/Town Road Maps (AOT)
Special Planimetric	Basic infrastructure and other natural and madmade features as needed for specific areas	Orthophotos	As needed for specific areas	Entered at time of digitizing graphics

Agency Abbreviation Key:

AOT	Agency of Transportation	FPMS	Floodplain Management Section (ANR)	ANR	Agency for Natural Resources
SCS	Soil Conservation Service (United States Department of Agriculture)	UVM	University of Vermont		

TABLE 4-2 (continued)
CONCEPTUAL DATABASE DESIGN
FOR LOCAL-LEVEL DATA LAYERS

Layer	Primary Graphic Elements	Primary Sources	Primary Nongraphic Elements	Primary Sources
Land Use/Cover	Land use boundaries; Land use and cover type annotation	City/Town orthophotos; Zoning Maps; Existing Town Land Use Maps; Local government resolutions	Land use type	City/Town orthophotos; Zoning Maps; Existing Town Land Use Maps; UVM GIS Database (limited coverage)
Zoning	Zoning area boundaries; Zoning type annotation	City/Town Zoning Maps	Zoning designation	City/Town Zoning Maps
Flood Zones	Flood zone boundaries (FEMA); Floodways	Flood Insurance Rate Maps (ANR-FPMS)	Flood zone designation; Floodway names	ANR-FPMS army corp of Engineers; FEMA
Topographic Contours	2' contour lines; Spot elevations	Compiled photo-grammetrically as needed	Spot elevations; Index contour elevations	Entered during compilation process

Agency Abbreviation Key:

AOT	Agency of Transportation	FPMS	Floodplain Management Section (ANR)	ANR	Agency for Natural Resources
SCS	Soil Conservation Service (United States Department of Agriculture)	UVM	University of Vermont		

TABLE 4-2 (continued)
CONCEPTUAL DATABASE DESIGN
FOR LOCAL-LEVEL DATA LAYERS

Layer	Primary Graphic Elements	Primary Sources	Primary Nongraphic Elements	Primary Sources
Soils	Soil boundaries; Soil type annotation	USDA/SCS; County soil survey (where available); Prime Agriculture Soils Maps	Soil type; Soil characteristics	USDA/SCS Soil Survey (for each county); Prime Agriculture Soils Maps; SCS Soils-5 Database
Sanitary Sewer Facilities	Mains; Valves; Manholes	City/Town sewer maps	Manhole number; Pipe material type; Date installed; Size; Pipe segment identifier; Valve number; Flow direction	City/Town sewer maps; As-built drawings; Other sewer records
Septic System	Tank or field location (if available)	Unknown	Owner name; Address; Date installed; Permit number	Unknown
Stormwater Facilities	Stormwater lines; Manholes; Catchbasins; Manhole and catchbasin numbers; Line segment identifier; Ditches	City/Town stormwater facility maps and records	Manhole and catchbasin identifier; Pipe capacity and size; Invert elevations; Maintenance history; Date installed	City/Town stormwater facility records

Agency Abbreviation Key:

AOT	Agency of Transportation	FPMS	Floodplain Management Section (ANR)	ANR	Agency for Natural Resources
SCS	Soil Conservation Service (United States Department of Agriculture)	UVM	University of Vermont		

TABLE 4-2 (continued)
CONCEPTUAL DATABASE DESIGN
FOR LOCAL-LEVEL DATA LAYERS

Layer	Primary Graphic Elements	Primary Sources	Primary Nongraphic Elements	Primary Sources
Special Infrastructure Facilities	Dams; Bridges; Culverts; Other public works and transportation facilities as appropriate; Dams and bridge names or identifiers	To be determined	Bridge and dam names or identifiers	To be determined
Water Facilities	Water lines and line identifiers; Valves; Fire hydrants; Pressure zone boundaries	City/Town maps and records	Line segment numbers; Manhole; Manhole and valve numbers; Equipment installation dates; Fire hydrant identifiers; Line size and materials types; Maintenance data	City/Town records
Gas Distribution Lines	Gas mains, service and transmission lines	Gas Utility Maps	Operator name; Address; Phone	Utility companies
Electric Distribution Lines	Underground lines, overhead lines, control features, poles	Electric Utility Maps	Operator name; Address; Phone	Utility companies
Telephone Lines	Underground lines, aboveground lines, poles	Telephone company maps	Operator name; Address; Phone	Utility companies

Agency Abbreviation Key:

AOT Agency of Transportation
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FPMS Floodplain Management Section (ANR)
UVM University of Vermont
ANR Agency for Natural Resources

Not all the data layers in the local-level conceptual design will have complete geographic coverage either across the state or in individual towns. For example, underground utility features (water, sanitary sewer) will only be available for those areas where these utility services exist (and for areas where they have been digitized). Similarly geographic coverage will be limited by the coverage of existing maps. Also, the Soil Conservation Service is not projected to complete a detailed soil survey for some of Vermont's counties until 1999. Data conversion issues concerning property parcels are addressed in Section 5. Characteristics of each data layer in the local-level database are discussed below.

Special Planimetric Features: Planimetric features are natural and cultural features visible on the earth's surface. Examples include streams, rivers, railroads, streets and highways, and electric transmission lines. Planimetric features are typically used as a background for other geographic information such as property boundaries.

Specific projects, particularly at the local level, may require a digital representation of planimetric features. For example, a particularly complex Act 250 review might warrant digitizing planimetric features as part of preparing a display for the Environmental District's review. These features will be digitized from the orthophoto base map and stored in this database layer.

Topographic Contours: Creating digitial topographic contours is expensive. The full range of options available are discussed in detail in Section 5. Because of the expense, PlanGraphics recommends that local-level topographic contours be obtained only for specific projects or areas as the need arises.

Property Parcels: The ownership parcel is the primary land unit for most land-related records in Vermont's cities, towns, and villages. A parcel map will be essential for many local government GIS applications. This layer will include parcel boundaries and related information, easements, and right-of-way lines. Nongraphic, or "attribute" information linked to parcels by a parcel number should include, at a minimum, information currently maintained in the grand lists.

Currently there are approximately 289,000 parcels in Vermont. Of those 289,000, about 135,000 are mapped (and 90 percent of those mapped use orthophotos as the base map) and about 40,000 are already computerized. The remaining parcels are not mapped at all.

Transportation Centerlines: Towns and cities will need a small scale map depicting their area on one map sheet. The orthos are too large a scale to permit a single sheet display of a town. This type of small scale map may be the most useful way of displaying a variety of information including "point" data, boundary locations, and the context for a specific planning issue.

A single line representation of transportation routes (streets, town roads, state and federal highways, and railroads) should be digitized for each town. Digitizing street centerlines could be accomplished as a preliminary step in parcel mapping because GIS software could use the same line to create an approximate street right-of-way. This right-of-way would be created by specifying a distance from the centerline, say 30 feet, for the right-of-way line on each side. This would only provide an approximate right-of-way, but given the accuracy limits of the orthophotos (± 10 feet), it would be useful one for parcel mapping.

Appropriate nongraphic information, such as route numbers, and street names, will also be part of this layer. A transportation centerline layer is also a logical layer with which to associate traffic volume and accident statistics as well as street maintenance.

Political/Administrative Boundaries: At the local level, this data layer will include the following:

- Town boundaries
- Emergency service districts
- School districts
- Election districts (e.g. city council districts)
- Voting precinct boundaries
- Other special districts.

Where possible, all these boundaries should be associated with parcel boundaries. Also, relevant attribute information (i.e., emergency incident records, park visitation data, etc.) will be part of this data layer.

Land Use/Cover: Towns and cities identified land use/cover information as important for local-level applications. This layer will be most easily and accurately developed by someone using parcel maps, orthophotos, the grand list, and personal knowledge to create a parcel level land cover/use map. However, it is ESSENTIAL that any such effort be completed using a standardized set of land use/cover codes so that the information can be aggregated in a meaningfull way at regional and state levels. The standardized codes should be part of the local level mapping standard (see Section 3).

While the effort to map land use/cover in this manner will be significant, it is an essential part of the Act 200 process and so should receive priority in the database development process. Of course a parcel map will have to be available first.

Zoning: The zoning layer will include zoning area boundaries and classifications. This layer will be developed for those towns and cities which have a zoning ordinance. Zoning boundaries should be tied to parcel boundaries. This serves a dual purpose of making them easier to map and, more importantly, provides a way of legally describing the boundary.

Flood Zones: The flood zones data layer will contain flood zone boundaries for those towns that have a flood zone map. This data layer will be developed from the FEMA flood maps. These maps vary in accuracy and scale from the parcel base map. However, they are accepted as the legal record of flood zones.

Soils: The Soil Conservation Service has completed detailed soils maps at the county level for eight Vermont Counties (field work for the Rutland soils map is complete, but the survey will not be published until 1990). The remaining five counties are scheduled for completion by 1999. As with FEMA maps, this data layer source differs in scale and accuracy from the base maps. Absent correction, a user must recognize the limitations of spatial analysis using this layer. The existing county soil surveys have been or are contracted to be digitized by the UVM - School for Natural Resources. Digitized soil surveys are available for the following counties: Franklin, Grand Isle, Chittendon, and LaMoyle. The following county soil surveys are contracted for digitizing: Addison, Orange, Windham, and Rutland.

Sanitary Sewer Facilities, Septic Systems, Stormwater Facilities, Water Facilities: Information will be entered to these layers as needed to support applications in towns and cities with this kind of public works infrastructure. This layer will include the various facility types (e.g., mains, valves, manholes, septic system locations, and pressure zones) and the type, size, capacity, manufacturer, and installation date of specific facility components. In addition, maintenance history and other relevant nongraphic information may be associated with this data layer.

Special Infrastructure Facilities: This layer is primarily intended to contain the locations of specialized transportation infrastructure such as bridges. However, it might also contain the locations of dams, culverts, and other public works and transportation facilities. In addition, attributes such as name, number, identifier, maintenance history, and date installed might be included. Information will be entered to this layer as needed for specific projects. A likely reason for placing information in this layer will be as part of an Act 250 review.

Utility Distribution Lines: Using maps provided by electric, gas, and telephone utilities, some local jurisdictions in Vermont may want to record and digitize the approximate locations of utility lines and other features. As with other parts of the local-level database, this information would first have to be compiled on the orthophoto base maps and then digitized.

DATABASE UPDATE PROCEDURES

A GIS database is a dynamic entity. This reflects the nature of geographic information, much of which is constantly changing; for example, as property is bought and sold and new subdivisions are created. When property changes hands, a grand list needs to be updated. Similarly, when a parcel is subdivided, new lines have to be added to a parcel map and new parcel numbers have to be added to the grand list. Natural features are not static either; additional plant and animal species may be designated as rare or endangered species and wetlands appear and disappear. Thus any GIS database must be established with resources available for keeping it current to the extent required by applications.

Currently, many source documents and databases that may contribute to the GIS database are routinely generated and maintained by state and local agencies. As the Vermont GIS database development proceeds, it will be necessary to examine in more detail procedures through which existing data maintenance programs can be incorporated into the GIS update process. Act 200 specifies the importance of GIS database maintenance and clearly designates the importance of municipalities along with state agencies in the GIS development effort. The Regional Planning Commissions are given a special role as liaisons and support agencies for the municipalities in maintaining and providing GIS data and assistance. Update procedures must be initiated for both the local- and state-level GIS databases described in this report. This subsection will discuss important issues and make recommendations on how update procedures can be formulated.

State-Level Database Update

State-level data layers will be created from sources available through many different agencies. Implementing the GIS will in specific cases be a matter of integrating existing data sets. Examples include the Natural Heritage Program's Element Occurrence Database, the Class I and II surface water files (paper), or the computer files on wetlands in each county and town maintained by the Agency of Natural Resources. Part of implementing the GIS will also involve integrating existing procedures for maintaining the data sources. Some agencies will maintain their portion of the database directly. Agencies without direct access to the GIS database will provide information for the database updates by indicating changes on a paper copy. Whether or not direct access is required by a particular agency will depend in part on the sensitivity of the data, the likely frequency of the updates, and the likelihood that they will have staff sufficiently proficient with the GIS software. Suggested maintenance responsibilities for the various state-level GIS data layers are provided in Table 4-3.

Updates to the GIS database must be conducted in conformance with data quality standards. These standards will not only involve the accuracy of source documents, but also the need for documenting the source of the update.

Since many GIS data users will rely entirely on paper maps produced from the GIS, a procedure for informing those users about changes to the database should be developed. This might take the form of a monthly or quarterly announcement distributed throughout the GIS community. This procedure will allow data users to request a more up to date version of the map or other product if their use of it justifies the expense. Data layers most likely to change frequently are historical/archeological sites, sensitive natural areas, and water wells and related wellhead protection areas.

Local-Level Database Update

The majority of towns or cities will probably not have their own GIS capability, but will arrange to have their Regional Planning Commission or some other assigned service center develop and maintain digital geographic data for the town. This arrangement will primarily involve automated updating and production of parcel maps, although other information will also be involved from time to time. This information might only include a parcel map, or it might include a variety of other data layers. The service center will supply paper maps, records, and other special analysis services to the town. The town or city will record changes as they occur. These changes will be forwarded periodically to the service center on a regular schedule (as negotiated with the user) and the town would, in turn, receive regularly scheduled updates of its maps, records, and analysis. Again, updates will have to meet data quality standards and will have to be documented. Regular announcements of database updates should also be distributed, as previously discussed.

Some towns and cities in Vermont have already developed microcomputer GIS capabilities. Other towns will acquire this capability. These towns should maintain and update the geographic data which they produce and become a service center to their community. For data which changes frequently, these updates should occur on a regular schedule so that the timeliness of the information is always known and predictable. It is also essential that these updates meet data quality standards (see Section 3) set by participants in Vermont's GIS program. Finally, records should be maintained identifying the source document for the update. Tracking update sources is part of establishing the "data lineage", as discussed in Section 3.

Some towns and cities with their own GIS capability will want to routinely produce and distribute copies of entire map sets. A likely candidate is the parcel map and related nongraphic information. The production and distribution schedule might be annual. However, some users of these hard copy GIS products might need to have more current information. Therefore, GIS service bureau should consider distributing monthly or quarterly announcement concerning database changes. Those users requiring immediate updates could then request them.

TABLE 4-3
SUGGESTED DATABASE UPDATE RESPONSIBILITIES FOR STATE-LEVEL DATA LAYERS

Digital Line Graph Base Map	GIS Organizational Home
Topographic Contours	N.A.
Transportation Centerlines	AOT-Mapping Section
Political/Administrative Boundaries	GIS Organizational Home[1]
Census Areas/Socieconomic Data	U.S. Census Bureau/AD&CA
Land Cover	GIS Organizational Home
Watersheds	ANR-Water Quality Division
Geology	Office of the State Geologist
Soil Associations	N.A.
Surface Water	GIS Organizational Home[2]
Groundwater Features	ANR-Groundwater Section
Recreational Facilities	ANR-Recreation Division
Historical/Archeological Sites	HC&CD-Historic Preservation
Sensitive Natural Areas	ANR-Natural Heritage Program
Special Infrastructrue Facilities	AOT-Mapping Section
Solid/Hazardous Waste Disposal Sites	ANR-Hazardous Materials Management Division
Utility Transmission Lines	GIS Organizational Home

[1]Update based on information supplied by relevant state agency.
[2]Changes will be rare, primarily consisting of adding detail to existing features. Since this involves changing the basemap, these changes should be made by the GIS Organizational Home staff. However, changes should be be made in cooperation with ANR's Water Quality Division staff.

SECTION 5
DATA CONVERSION TECHNIQUES
AND
DATABASE DEVELOPMENT COSTS AND PRIORITIES

INTRODUCTION

This section concludes the portions of the Phase II Report that relate to developing the GIS database. Section 3 presented basic GIS database concepts and described the role of database standards in creating and maintaining a GIS database. Section 4 presented the conceptual design for local and state level portions of the database.

This section introduces the various data conversion techniques used in GIS database development. Specific techniques are also identified for each of the proposed GIS database layers. Subsequently, specific local and state level issues relevant to developing GIS databases in Vermont are addressed. Next, budgetary cost estimates for development priorities for the different data layers are presented and discussed. This section concludes with a discussion of contracted versus in-house data conversion.

DATA CONVERSION TECHNIQUES

Below are brief descriptions of data conversion techniques that will be used in developing Vermont's GIS database. Typically, one or more of these techniques are used during the course of converting data into a digital database. We have also provided a description of the data preparation processes usually encountered in conversion projects.

Data Preparation Processes

The source documents used in the creation of a GIS database may be in the form of maps, card files, automated databases, or aerial photography. There is usually some preparation of source documents required before they are usable for conversion. Source preparation may range from organizing and assembling maps, to a detailed review and revision of their content. Each GIS data layer source material needs to be evaluated to determine the amount of preparation, or "scrubbing", and whether the process should be undertaken by state or local staff, or by a contractor.

An example of a more complex scrubbing process involves information which has to be gathered from more than one source. Sources may include separate maps, field inventory, or tabular data relating to map features. Depending on the circumstances, it may be more efficient to redraft information from these sources on a hard copy of the base map before digitizing. Document scrubbing is a time consuming process; however, it allows resolution of inconsistencies, provides a source which can more rapidly be digitized, and ultimately, results in better quality information in the GIS database.

Besides redrafting, document preparation tasks may include photographic enlargement, reduction and removal of extraneous marks and notes, or clarifying handwritten notes. Depending on their condition, source materials may be used as inputs into the geographic information system without redrafting. For example, tax maps developed using orthophotos as a base map can be digitized without redrafting following a review bringing them up-to-date and general "scrubbing" to meet uniform quality standards. Some of the existing topographic maps may require remapping rather than correction, depending on the gap between existing maps and general standards.

Tables 5-1(a) and 5-1(b) suggest how the different layers in local- and state-level databases might be developed using one or more of the techniques described below.

Photogrammetric Compilation

The primary data used in this process are aerial photography and a combination of horizontal and vertical survey control. Generally, the process involves using specialized equipment (a stereoplotter) to project overlapping aerial photos so that a viewer can see a three dimensional picture of the terrain, known as a photogrammetric model. In the photogrammetric model, the location of survey control points placed on the ground before the photography was flown can be identified. Therefore, the mathematical relationship between the survey control points, and thereby all other features visible on the photos, can be reestablished. Using the three-dimensional view and and the accurate locational relationships between features, the photogrammetrist is able to compile a map by digitizing the locations of roads, buildings, and other features on the stereoplotter. The information digitized from the photographs can then be checked and edited, annotation can be added, and the result plotted as a planimetric base map.

Photogrammetric techniques are also used in preparing orthophoto base maps, which are planimetrically correct pictures of the earth. Rather than digitizing selected map features, the photogrammetrist identifies, in a predefined grid, the precise horizontal and vertical location of points visible in the photogrammetric model. These points are digitized and the values are used to drive an orthophoto printer which renders an orthophoto base map without distortions found on standard aerial photographs.

Trace Digitizing

Digitizing graphic features occurs at digitizing workstations using a digitizing tablet and cursor. Both the tablet and cursor are connected to a computer that controls their functions. Most digitizing tablets come in standard sizes that relate to engineering drawing sizes (A through E, and larger). Digitizing involves tracing features on a source map, taped to the digitizing tablet, with a precise cross-hair in the digitizing cursor and instructing the computer to accept the location and type of feature. Instructions are often coded in button-type switches located on the digitizing cursor. The person performing the digitizing may separate features into map layers, or attach an attribute to identify the feature.

Digitizing is used in a variety of data conversion tasks including:

- Trace digitizing map graphics from source documents
- Editing trace digitized graphics
- Editing graphics entered using COGO (see discussion below)
- Editing vectorized graphic output from scanners.

Since digitizing is both labor and machine intensive, it is among the most expensive of all data conversion processes. It is also the most common data conversion method.

TABLE 5-1(a)
SUGGESTED DATA CONVERSION APPROACH
FOR STATE-LEVEL DATA LAYERS

Data Layer	Primary Graphic Elements	Primary Nongraphic Elements	Data Conversion Approach
Digital Line Graph Base Map	Survey control grid; Transportation route centerline; Pipe and transmission lines; Surface waters	Control grid numbers; Transmission line owner; Highway/road/number/name; Winter status; Maintenance history	Load digital data supplied by USGS on magnetic tape; Convert to state plane coordinate; Run ARC-DLG command from ARC/INFO software; Add and update highway identifiers to conform with nongraphic records; Keypunch nongraphic records
Topographic Contours	20' contour lines; Index elevations	Spot elevations	Digitize as needed from USGS quad sheets
Political/ Administrative Boundaries	County/City/Town/State National boundaries; Park, forest, preserve; Military district; Agricultural district; Regional/local planning district; School districts; Transportation districts; Other state agency districts; State legislative districts	Jurisdiction; Names; District number (if applicable)	Merge existing UVM data with data from DLGs and TIGER file; Compile other boundaries on DLG base map and digitize; Keypunch annotation and attributes
Census Areas	Census tracts; Minor civil divisions; Burlington SMSA	Census tract numbers	Load from Census Bureau magnetic tape

TABLE 5-1(a) (continued)
SUGGESTED DATA CONVERSION APPROACH
FOR STATE-LEVEL DATA LAYERS

Data Layer	Primary Graphic Elements	Primary Nongraphic Elements	Data Conversion Approach
Land Cover	Land cover boundaries	Land cover type	If needed, can be developed by classifying and vectorizing existing LANDSAT image using image processing software at UVM; More up-to-date LANDSAT or spot images could also be purchased
Watersheds	Watershed and subwatershed boundaries	Watershed or subwatershed name	Use existing data from UVM; Digitize additional boundaries from USGS quad sheets or DEC Drainage Basin Map with keyboard entry of annotation
Geology	Surface geology boundaries and names	Geologic classification	Digitize from existing maps; Keyboard entry of annotation
Soil Associations	Soil association boundaries	Soil association name	Digitize from existing maps; Keyboard entry of annotation
Surface Water	Rivers/streams (major); Lakes; Ponds; Reservoirs; Marshes; Swamps; Wetland boundaries; Waterfalls; Gorges; STORET stations	Water body name/type; Milemarker numbers; Water body owner (if applicable)	Develop layer from DLG base map

TABLE 5-1(a) (continued)
SUGGESTED DATA CONVERSION APPROACH
FOR STATE-LEVEL DATA LAYERS

Data Layer	Primary Graphic Elements	Primary Nongraphic Elements	Data Conversion Approach
Groundwater Features	Groundwater aquifer boundaries; Wellhead protection areas; Public water supply wells	Aquifer name; Area size; History (if applicable); Well identifiers; Well operator; Address	Use existing data from UVM; Augment by digitizing from existing maps and with keyboard entry of annotation
Recreational Facilities	Recreational facility/trail locations	Facility name; Owner; Use, Capacity (as applicable)	Digitize from existing maps; Keyboard entry of annotation
Historical/ Archaeological Sites	Historic areas; Sites; Archaeology sites	Site identifier; Name; Responsible agency; Significance (as applicable)	Upload and reformat existing databases; Use known coordinate locations to map features; Digitize additional information from existing maps; Keyboard entry of attribute information
Sensitive Natural Areas	Sensitive/natural area boundary; Points	Area name; Size; Use; Significant characteristics	Upload and reformat existing databases; Use known coordinate locations to map features; Digitize additional information from existing maps; Keyboard entry of attribute information

TABLE 5-1(a) (continued)
SUGGESTED DATA CONVERSION APPROACH
FOR STATE-LEVEL DATA LAYERS

Data Layer	Primary Graphic Elements	Primary Nongraphic Elements	Data Conversion Approach
Special Infrastructure Facilities	Dams; Bridges; Name/Number; Others as appropriate	Coordinate location; Name/Number	Digitize features from orthophotos; Keyboard entry of annotation and attributes
Solid/Hazardous Waste Disposal Sites	Landfill sites; Hazardous waste storage disposal locations	Landfill owner; Date installed; Capacity; Status; Owner; History; Hazardous waste type by common and chemical name; Volume; Status storage information; Plan number; Plan type	Upload CERCLA data and map CERCLA sites from latitude/longitude coordinates; As addresses of other sites are field verified, map site locations
Utility Transmission Lines	Gas transmission lines; Electric transmission lines; Towers substations	Emergency contact name/number	Develop layer from DLG base map; Digitize corrections and updates from utility maps; Keyboard entry of annotation

TABLE 5-1(b)
SUGGESTED DATA CONVERSION APPROACHES
FOR CREATING LOCAL-LEVEL DATA LAYERS

Data Layer	Primary Graphic Elements	Primary Nongraphic Elements	Data Conversion Approach
Survey Control	Control grid; Monumented points	Monument identifiers; Date surveyed; Source agency	Keypunch survey coordinator
Transportation Centerlines	Street centerlines; Railroad centerlines	Street name; Number; Address; Address ranges	Digitize from orthophotos with keyboard entry of annotation and attributes
Property Parcels	Survey; Parcel; Easement lines; Right-of-Way lines; Subdivision boundaries	Listings book and page number; Owner; address; Date acquired; Deeded acreage; Dimensions; Assessed value; Purchase price; Easement descriptions; Subdivision map number; Permit type; Number; Date issued; Issuing agency	Digitize or COGO existing maps (if prepared on ortho base) with keyboard entry of annotation and attributes; Unmapped parcels should be mapped from legal records - see text for detailed discussion
Political/ Administrative Boundaries	County/City/Town Fire protection district; Agriculture district; Enforcement districts; Voting precinct boundaries (as applicable)	Jurisdiction names; Community/ Neighborhood names; District; District number (if applicable)	Map boundaries on parcel/ orthophoto base and digitize; Or "tag" existing lines as also being boundary lines based on legal record of boundary; Keyboard entry of annotation
Special Planimetric	As needed for specific areas	As needed for specific areas	Digitize from orthophotos with keyboard entry of annotation and attributes

TABLE 5-1(b) (continued)
SUGGESTED DATA CONVERSION APPROACHES
FOR CREATING LOCAL-LEVEL DATA LAYERS

Data Layer	Primary Graphic Elements	Primary Nongraphic Elements	Data Conversion Approach
Land Use/Cover	Land use boundaries; Land use and cover type	Land use type	Overlay tax maps on orthophoto base and, based on information in the grand list, and on knowledge of local land use/ cover, assign attribute code to parcels; Then produce map based on codes
Zoning	Zoning area boundaries; Zoning categories	Zoning designation	Prepare map using parcels/ orthos as a base; Digitize; Keyboard entry of zoning area classifications; Where zoning boundaries follow parcel boundaries, zoning map can be developed by assigning zoning category to parcels
Topographic Contours	2' contour lines: Spot elevations	Spot elevations; Index contour elevations	Developed only for areas with a specific need; Contract for digital photogrammetric services using stereoplotters and stereoaerial photographs

TABLE 5-1(b) (continued)
SUGGESTED DATA CONVERSION APPROACHES
FOR CREATING LOCAL-LEVEL DATA LAYERS

Data Layer	Primary Graphic Elements	Primary Nongraphic Elements	Data Conversion Approach
Soils	Soil boundaries; Soil type annotation	Soil type; Soil characteristics	Download digital data from UVM GIS database using a standard interchange format if GIS software different, adjust to fit orthophoto/parcel base
Sanitary Sewer Facilities	Mains; Valves; Manholes	Manhole number; Pipe material type; Date installed; Size; Pipe segment identifier; Valve number; Flow direction	Use parcel/ortho base to prepare map from existing records; Digitize; Keyboard entry of annotation and attributes
Septic Systems	Tank or field location (if available)	Owner name; Address; Date installed; Permit number	Identify location on orthophoto base, and digitize; Keyboard entry of annotation
Stormwater Facilities	Stormwater lines; Manholes; Catchbasins; Manhole and catchbasin numbers; Line segment identifier; Ditches	Manhole and catchbasin identifier; Pipe capacity and size; Invert elevations; Maintenance history; Date installed	Use parcel/ortho base to prepare map from existing records; Digitize; Keyboard entry of annotation and attributes
Special Infrastructure Facilities	Dams; Bridges; Culverts; Other public works and transportation facilities as appropriate; Dams and bridge names or identifiers	Bridge and dam names or identifiers	Digitize from orthophotos with keyboard entry of annotation and attributes

TABLE 5-1(b) (continued)
SUGGESTED DATA CONVERSION APPROACHES
FOR CREATING LOCAL-LEVEL DATA LAYERS

Data Layer	Primary Graphic Elements	Primary Nongraphic Elements	Data Conversion Approach
Water Facilities	Water lines and line identifiers; Valves; Fire hydrants; Pressure zone boundaries	Line segment numbers; Manhole; Manhole and valve numbers; Equipment installation dates; Fire hydrant identifiers; Line size and materials types; Maintenance data	Use parcel/ortho base to prepare map from existing records; Digitize; Keyboard entry of annotation and attributes
Gas Distribution Lines	Gas mains; Service and transmission lines	Main/Line sizes; Operator name; Address; Phone	Use parcel/ortho base to prepare map from utility records; Digitize; Keyboard entry of annotation and attributes
Electric Distribution Lines	Underground lines, aboveground lines; control features; poles	Operator name; Address; Phone	Use parcel/ortho base to prepare map from utility records; Digitize; Keyboard entry of annotation and attributes
Telephone Lines	Underground lines, aboveground lines	Operator name; Address; Phone	Use parcel/ortho base to prepare map from utility records; Digitize; Keyboard entry of annotation and attributes

Coordinate Geometry (COGO)

COGO is a technique for entering information to a GIS database by keypunching distances and bearings surveyed from a known starting point. When distances and bearings define the position of boundary lines based on a coordinate grid, such as the State Plane Coordinate System, GIS software can use this survey information to create a graphic representation of the lines. Where coordinate values are not known, COGO can still be used as a method of accurately rendering a graphic image of survey data. This technique is most commonly used for entering real property boundaries.

Scanning

Optical scanning systems automatically capture map features, text, and symbols as a matter of individual cells, or pixels, called a "raster" format. Most scanning systems provide software to convert the grid cell information to a form which can be recognized by computer software as individual graphic point, line, and area features called "vector" map. However, scanning software has not advanced to the state that it can reliably identify scanned map features. The result is a need for human recognition to tag vectorized data with the feature type and any labels required for identity.

Raster data may be manipulated in its size, color, or shading for display purposes; however, the user cannot identify individual features by pointing with a cursor and querying the system. Vector data is capable of changes in its character for display purposes as well as having separate identities that may be pointed to and queried.

Scanning is useful and cost-effective in GIS data conversion for two types of source documents. One application of scanning is to convert data that will remain in raster format, such as detailed engineering drawings that are only required to be displayed or plotted. Optical scanning systems may be interfaced with a GIS that contains an index to drawings in a vector format. Scanning has also been successfully used to convert maps consisting primarily of sharply delineated line sets with little or no text features. The line information is later transformed from raster to vector format for use on a GIS. The Franklin County, Vermont, soil survey was computerized in this manner and entered to UVM's ARC/INFO database.

Scanners are currently limited to the kinds of drawings and maps described above because of the difficulties associated with programming software to correctly interpret text and symbols on maps. This problem is made more difficult if features on the source document are not sharply defined and if they are close together. In addition, and perhaps most importantly, there is the problem of writing software to establish the relationship between text strings and specific map features (for example a tax parcel and the parcel number). Since the essence of geographic information system data is in the text attributes and their relationship to the graphics, the inability of scanners to properly establish this relationship limits their usefulness to the cases described above.

Converting Existing Digital Data

An important part of developing a GIS database is incorporating digital data from existing sources. These data may be graphic or nongraphic.

Existing Graphic Data

The University of Vermont's (UVM) School of Natural Resources has a substantial quantity of graphic data available on its ARC/INFO geographic information software system. This information is readily available to other ARC/INFO installations via magnetic tape.

Translating and transferring graphic data from UVM's ARC/INFO database, or from any other GIS software to another, involves using a data exchange format. Data exchange formats have been developed for transferring data between many of the more popular GIS software packages. Sometimes these formats are available from the GIS vendor. They may also be available from commercial data conversion firms which develop these formats to deliver GIS data in a form useable by a client's GIS software. It is important to understand that the interchange format software package will require some modification to handle the specific data being transferred. In addition, graphic data is more readily transportable between systems than nongraphic attribute data. Experiments with transferring tax parcel maps from the UVM ARC/INFO database to another graphic software package are already being conducted in the Town of Underhill.

Existing Nongraphic Data

Nongraphic data in the UVM - School of Natural Resources ARC/INFO GIS database can also easily be transferred on magnetic tape to other computers running ARC/INFO software. Other nongraphic attributes in existing computer database may be integrated with the GIS database by transferring selected information from the source database format to a "flat file" format. The flat file is then moved onto a magnetic tape and from there to the other computer. The flat file may also be passed to the new computer via modem. This flat file places the desired information in a form which can in turn be translated into a format acceptable to GIS software. A more in-depth description of this transfer method was provided on pages 6-16 and 6-17 and in Figure 6-7 of the Phase I Report. Information on personal computers can be transferred to other computers by converting it to ASCII format and transmitting it via modem or disk.

GIS database development also may provide the opportunity to combine two or more existing files containing the same or very similar information. Accomplishing this merger usually involves transferring data from one computer to the GIS computer via magnetic tape, or modem, as described above. Subsequently, the two data sets are compared allowing conflicts to be resolved and redundancies to be eliminated.

Tabular Data Entry

Much of the nongraphic information associated with graphic features in the Vermont GIS database (local and state) exists in paper files. Information from these sources will be required for GIS applications and will have to be converted to digital form through keypunch entry. Examples of nongraphic GIS data include the following:

- The lister's grand lists
- Sewer and water facility card files
- ANR - Water Quality Division's Potential Pollution Sources files.

This kind of data entry is commonplace and relatively easy to accomplish. Furthermore, the GIS software can facilitate this process by providing the capability for creating data entry screens. Data entry screens are particularly useful because they can be set up to prompt entry of specific information. They can also be supported by software which provides quality control on information being entered. This control involves checking entries against lists of acceptable entries or ranges of acceptable values. Use of automated quality control needs to be evaluated thoroughly for the types of data appropriate for this type of editing. It may be necessary to manually check some data elements, comparing the source document and an edit printout to ensure data quality. Quality control is an often overlooked issue in creating nongraphic attribute data files.

Image Classification

Satellite imagery can also be a source for small-scale statewide geographic information. In particular, satellite imagery has often been used to produce land cover maps. This is possible because each type of land cover reflects light of different wavelengths; this is what the satellite "senses" and is why our eyes see different colors. However, this reflectance is not uniform, because, for example, moisture conditions change from place to place. These changes in moisture will, in turn, show up as slightly different colors even for the same type of land cover. Classifying a satellite image involves deciding what kinds of colors correspond to what kinds of land cover. The resulting information is the basis for classification of a satellite image and creation of a land cover map. This process requires special software, and large amounts of computer processing time and computer storage.

There are two primary commercial sources for satellite imagery, LANDSAT and SPOT Image Corporation. The UVM - School of Natural Resources has experience in processing LANDSAT imagery and has available a 1978 LANDSAT image of Vermont. This image could be classified and used to create a small-scale statewide land cover map. While land cover in some parts of the state has significantly changed since 1978, many areas have not changed. Depending on the area and the application, a land cover map from the 1978 image could be useful.

DATA CONVERSION CASES, METHODS, AND ISSUES FOR VERMONT

Specific Data Conversion Cases

In the discussions below specific points related to developing certain parts of the GIS database, or related to specific potential source materials, are addressed. Some of these points have been raised by project participants and others are presented by PlanGraphics to clarify the process.

<u>Parcel Maps</u>

Tax parcel maps will be part of the local level GIS database and should use the orthophotos as a base map. Most of the existing parcel maps were compiled from deeds and other legal property records onto orthophoto base maps in order to achieve a level of spatial accuracy. Parcel maps created in this manner are suitable for digitizing and entering to a GIS database, assuming that they are up-to-date and all parcels are mapped. Towns that have not had a parcel map prepared in this manner should consider mapping parcels using orthophotos as a base map using the process outlined below.

Mapping parcel boundaries on orthophotos using deeds and other legal records, such as subdivision maps, involves a subjective mapping process. The process is subjective because it involves using a combination of often contradictory legal records and observable features and parcel boundaries on the orthophoto image. A person preparing the parcel map in this manner is striving for a "best fit" between the legal record of parcel boundaries (deeds, subdivision maps, etc.), and features observable on the orthophotos. These features include road boundaries, rivers/streams, fences, and edges of agricultural fields. These features may or may not be the actual location of parcel boundaries. However, any error occurring in this process will be localized to the area surrounding the parcel and its adjacent parcels, rather than resulting in a need to shift parcel boundaries over an entire parcel map sheet. The result of this "fitting process" is a mylar overlay to the orthophoto base map suitable for digitizing.

In compiling a parcel map as described above, certain source documents should be considered more reliable than others. Thus sources can be thought of as falling into a "hierarchy" as follows:

> Level 1: This level includes subdivisions, parcels, rights-of-way, and other entities which are portrayed with relative accuracy on existing parcel maps, but may not show the true geographic location (absolute accuracy) of the parcels. These parcel boundaries have not been adjusted from the recorded configuration to fit existing mapping conditions. During compilation, Level 1 parcels will be reoriented geographically to fit features shown on the orthophoto base map, but no change would be made to the shape and character of parcel boundaries, or to external or internal subdivision boundaries.

> Level 2: This level includes all the remaining boundaries. These are parcel boundaries whose graphic depiction on existing parcel maps do not represent their legal descriptions. Dimensions of parcels in this priority will be adjusted to physical features on the orthophoto, identifiable as a logical boundary location. Typical features used to infer legal boundaries in this priority include fences, streams, and roads. While these features are not necessarily definitive, they are indicators of parcel boundaries. In addition to the physical features, parcel boundaries compiled from Level 1 source information are used as reference points.

As more accurate parcel boundary information becomes available (for example, if AOT completes a right-of-way survey or a subdivision is recorded with State Plane Coordinate values referenced), then the new boundaries would be added in their accurate location and adjacent boundaries would be adjusted to fit.

TIGER File

The TIGER file is the U.S. Census Bureaus nationwide "base map" for the 1990 census enumerations. It is a set of computer files containing the positions of roads, rivers, railroads, and political and census area boundaries. The roads, rivers, railroads and political boundaries in the TIGER file were developed using Digital Line Graphs (DLGs) prepared from the USGS 1:100,000 scale map series. The Census Bureau added census area boundaries and updated the DLGs with the approximate locations of transportation routes added since the DLGs were compiled. The currency of the TIGER file data needs to be reviewed to assess the extent of updating required to ensure its usefulness.

The portion of Vermont's TIGER file containing jurisdictional boundaries, surface waters, pipelines, and transportation route lines is available and expected to be delivered in March of 1989. The TIGER file, and the demographic data that will result from the 1990 census, will be the logical source for Vermont's census information. It will also provide boundaries of Vermont's "minor civil divisions" to augment existing UVM - School for Natural Resources data on county and town boundaries. The file will be delivered on magnetic tape from the U.S. Census Bureau and can be easily transferred to the Vermont

GIS. Most GIS software vendors, including ESRI (ARC/INFO), are developing or have developed software to support integration of TIGER files with other data used by their software.

An essential part of developing the state's census information in the GIS will involve integrating socio-economic information collected for census areas at all levels of Vermont government. This important task involves developing the computer program(s) required to transfer existing digital data to a format compatible to the GIS database software. This task has immediate implementation priority because of its importance to GIS applications for the State Department of Health as well as a variety of other human service activities. Cost estimates for this database development effort are included in the database development cost estimates in Table 5-2(b)

Existing Databases Containing Site-Specific Information

Many state agencies and some local and regional organizations maintain computer databases containing information about specific locations. Often the information recorded about these locations includes the latitude and longitude or a coordinate position in some other coordinate grid. Examples of these kinds of databases include the Natural Heritage Program's Element Occurrence Database.

A latitude and longitude coordinate is a locational identifier, or "geocode", which can be used by GIS software to identify a specific geographic location. It will be possible to integrate files with geocoded information into the GIS database. This integration is typically accomplished by transferring information from the source file format to a "flat file" format which can in turn be translated into a format acceptable to the GIS software. If the GIS database uses a different coordinate system than the new data, a coordinate transformation will be needed. Most basic GIS software includes a coordinate transformation routine. More detail on these integration methods was provided above in the discussion of data conversion methods. GIS software vendors are accustomed to facilitating these kinds of transfers. How meaningfully these kinds of databases can be used in the GIS will depend on the accuracy of the coordinate identifiers in the source database and the intended use of the data.

Topographic Contours

On survey forms and in interviews, project participants indicated interest in topographic contour information. For local level applications, a small contour interval of one, two, or five feet was desired. Examples of applications supported by this kind of detailed topographic information are as follows:

- Large scale timber stand management
- Hazardous and solid waste disposal site design
- Plat/site plan review
- Underground utility construction designs
- Preliminary engineering design.

Respondents with state or regional concerns desired a twenty foot contour interval. Examples of applications supported by this level of detailed topographic information include:

- Small scale timber stand management
- Hazardous and solid waste disposal site identification
- Sensitive natural area mapping

- Groundwater modelling support
- Environmental impact analysis support
- Wellhead protection area mapping
- Support for public lands acquisition.

Little or no large scale (1, 2, and 5 foot) contour interval map coverage exists. Twenty foot contour intervals are mapped on USGS 1:24,000 scale quad sheets. The only digital topographic information available with statewide coverage is the USGS's digital elevation model from 1:250,000 scale maps with contour intervals of 200 feet. Small portions of the state have digital elevation models prepared by USGS from 1:24,000 scale maps.

Various alternatives exist for developing digital topographic contour information. Topographic contours could be trace digitized from existing USGS maps. PlanGraphics does not recommend this option as it would be extremely expensive and impractical given the need to develop priority applications quickly.

Another option is scanning the mylar sheet "separate" of the topographic contours available from the production of USGS quad sheets. However, the resulting product could only enable users to perform the computerized equivalent of opening a flat file drawer to look at an elevation or count the number of contour lines when determining a slope; no software-based analysis or manipulation could be accomplished. If the scanned contour data were vectorized and contour intervals were identified, the contours could be used to determine the elevation points required for developing a digital elevation model. A digital elevation model is quite useful in supporting elevation related analyses. However, PlanGraphics does not recommend this approach either. The resulting elevation data would be interpolated from contours on a regular grid and are less accurate than the original source. Additionally, the process would be extremely expensive and impractical to accomplish.

Topographic contours could also be produced using the photogrammetric compilation process. Contours may be compiled either directly, by tracing a continuous elevation on the ground, or by compiling a dense mass of elevation points and feature breaklines (a digital elevation model or DEM) to be used with contour interpolation software for producing contour lines. The elevation product, either direct contours or DEM, would provide the most accurate rendition of elevations short of surveying. However, both these options are expensive with typical costs ranging from $2,000 to $3,000 per square mile or more (for 2' contours compiled at 1" = 100'; this cost includes photography) depending on terrain characteristics. These costs could be significantly reduced by the compilation of a DEM as a by-product of the state orthophoto update process, and such DEMs are currently available for Chittenden County.

Orthophoto production involves producing a DEM. However, the typical elevation points selected for this kind of DEM are spaced along a predetermined grid with little regard for the characteristics of the terrain involved. In addition, the elevation at these points may be determined less precisely. For this kind of DEM to be useful in creating a representation of topographic contours, the number of points would have to be increased substantially and additional elevation points would have to be added for sharp changes in terrain (break lines). Although not field tested, Vermont's orthophoto contractor is producing a special DEM that could be used to reduce costs for developing 20 foot contours. Even with proven field testing of this process, the contours produced from this DEM would be accurate only for the equivalent of defining large watershed boundaries.

The basic problem with an orthophoto DEM is that it is originally produced for a different purpose. A DEM for producing topographic contours involves <u>interpreting the terrain</u> by placing elevation points that reflect both the obvious and subtle elevational characteristics of the terrain. This kind of interpretation is not the focus of an orthophoto DEM. Advancements in software and technique of point selection may prove this general rule wrong for the particular process being applied by Vermont's orthophoto contractor. However, even with these advancements, the DEM product will probably not be suitable for site specific engineeing design level analyses and planning.

For the present, the most viable option will be continued use of paper USGS quad sheets. Digital topographic information can be acquired for the GIS database as specific projects or needs justify the expense. For local engineering projects, on-site surveying will probably be the most cost-effective approach.

State-Level Political/Administrative Boundaries

Most administrative boundaries (e.g., AOT and ANR districts) can be derived by "tagging" the appropriate town boundaries as being a distinct boundary. Administrative boundaries not associated with a town boundary will have to be mapped using the DLG base map and, probably, the town boundary layer. Once the boundary is mapped, it can then be digitized.

Database Development Cost Estimates and Schedule

Table 5-2(a) contains budgetary cost estimates for developing local-level database layers. Table 5-2(b) contains similar information for state-level data layers. These cost estimates are intended to guide budget development. Actual costs may differ for the following reasons:

1) In some cases the estimates are based on viewing individual samples from data sets, samples that may or may not be representative.

2) Some estimates are based on knowledge of source documents typically available for the particular data layer, but not actually available for review. Actual costs in these cases may vary if the source documents are atypical.

3) Cost estimates for layers targeted for conversion by commercial services (parcels, utility facilities, and topographic contours) may differ from eventual bids. These differences will reflect different levels of experience, different methods for developing cost estimates, differences in operational costs from vendor to vendor, different kinds of conversion techniques, and the market.

In reviewing these cost estimates, readers should also keep the following in mind:

1) Local level database cost estimates for all layers except property parcels presume the availability of a parcel map and the orthophoto base map.

2) State level database cost estimates for geology, soils, recreational facilities, historical/archaeological sites, sensitive natural areas, public water wells, solid/hazardous waste sites, and utility transmission lines presume the availability of the DLG base map.

TABLE 5-2(a)
ESTIMATED COSTS FOR LOCAL LEVEL DATABASE LAYERS[1]

Data Layer	Cost Range		
Priority 1			
Orthophoto Base Map	Already purchased by Vermont[2]		
Property Parcels - mapped (135k parcels)	$ 337,000	- $	472,000[3]
Property Parcels - unmapped (114k parcels)	2,280,000	-	2,850,000[4]
Land Use/Cover - for mapped parcels	3,000	-	8,000/municipality
Zoning[5]	1,000	-	3,000/municipality
Flood Zones[6]	3,000	-	5,000/municipality
Transportation Centerlines[7]	1,000	-	3,000/municipality
Priority 2			
Soils	$ 75,000	- $	100,000/County
Sanitary Sewer Facilities	200	-	300/sq. mi.
Water Facilities	200	-	300/sq. mi.
Septic System	8		
Priority 3			
Special Planimetric Features	8		
Topographic Contours (2' interval)	$ 2,000	- $	3,000/sq. mi.[9]
Political/Administrative Boundaries	500	-	1,000/town
Stormwater Facilities	200	-	300/sq. mi.
Special Infrastructure Facilities	8		

[1]Preparation of all layers presumes an orthophoto base map.

[2]This is true unless existing orthophotos are unsuitable as base for parcel mapping because of age and significant subsequent development.

[3]This cost is for digitizing existing maps; price based on contract costs for similar work for PlanGraphics clients.

[4]This cost is for creating new parcel maps from legal records and is based on per parcel costs being bid by parcel mapping firms in Vermont.

[5]Developing this layer presumes the existence of a zoning map based on an existing parcel map; costs presume contract with UVM, a state or regional "service bureau", or a commercial vendor.

[6]This cost presumes work is contracted through a state or regional "service bureau", or a commercial vendor.

[7]This layer will be digitized from orthophotos.

[8]Cost will depend on type and number of features and will be highly variable from town to town.

[9]This cost is for stereocompilation from aerial photographs and includes cost for photography and survey control.

TABLE 5-2(b)
ESTIMATED COSTS FOR STATE LEVEL DATABASE LAYERS

Data Layer	Cost Range
Priority 1	
Digital Line Graph Base Map	Already purchased by the University of Vermont[1]
Transportation Centerlines	[2]
Surface Water	[2]
Political/Administrative Boundaries	[3]
Census Areas and Socio-economic data	$ 25,000 - $ 50,000[4]
Land Cover	See text
Wetlands	$ 124,000 - $ 186,000[5]
Priority 2	
Soil Associations	Derived from digital detailed soil surveys
Groundwater Features	[6]
Historical/Archaeological Sites[7]	35,000 - $ 45,000
Sensitive Natural Areas[8]	$ 18,000 - $ 23,000
Priority 3	
Topographic Contours (20' interval)	$ 1,500 - $ 2,500/sq. mi.
Watersheds[9]	4,500 - 11,000
Geology	5,000 - 8,000
Recreational Facilities[10]	1,500 - 2,000
Special Infrastructure Facilities	[11]
Solid/Hazardous Waste Sites	[12]
Utility Transmission Lines	[2]

[1]The DLG data will be available in ARC/INFO format from UVM. Time for checking, updating, edgematching.

[2]Included in DLG base map.

[3]Town and county boundaries are available from UVM; also see discussion in text.

[4]The state will receive magnetic tape of the TIGER files later this year; the cost listed is for integrating socio-economic data into the GIS database.

[5]This cost presumes this digitizing task will be commercially contracted.

[6]Digital version of wellhead protection areas available in UVM-SNR ARC/INFO databases; includes wellhead locations.

[7]Source data is complex (approximately 30,000 entries) and requires in-house conversion; cost is for 18 months of one full-time staff person and part-time intern.

[8]Source data is complex (approximately 2,000 entries) and requires in-house conversion; cost is for 1/2 time staff person and part-time intern over 18 months.

[9]Large watersheds available from UVM GIS database (for Franklin, Grand Isle, and Chittenden Counties); cost is for digitizing water sheds of major river basins and of lakes.

[10]Cost is for 25% time intern over 6 months to digitize and categorize recreation facility locations.

[11]Cost depends on number and type of facilities.

[12]Not predictable on basis of available information.

3) The following data layers will have limited geographic coverage because of their limited extent or because they will only be required for specialized site-specific applications:

   - Zoning
   - Floodways
   - Sanitary sewer facilities
   - Water facilities
   - Stormwater facilities
   - Topographic contours (large scale)
   - Special infrastructure facilities.

   Because their coverage is limited and by definition unpredictable, cost estimates for these data layers are given as per unit quantity.

4) For data layers already available from federal or state sources DLG base map, TIGER files, limited coverage of digital elevation models and a DLG prepared from 1:24,000 scale maps, there will be little or no cost for data conversion. However, these sources will have to be integrated into the GIS database which will involve GIS staff time. The UVM - School of Natural Resources GIS staff have experience with DLG and Census Bureau GBF/DIME files (GBF/DIME is the predecessor to TIGER); their experience will facilitate developing those portions of the database.

5) In some cases town or state agency staff are best suited to developing a specific part of the database because of their knowledge of the kind of information involved. Examples include:

   (a) Developing town land use/cover maps. Local knowledge of this information, combined with a tax map and the orthophoto base map, in many cases will be the best approach to developing this data layer.

   (b) The Natural Heritage Program's information about the location of sensitive natural areas. In this case the quality of the existing records, although variable, is well documented. However, the specificity of some boundary information is subject to interpretation by trained staff. Except for a simple "incident" map of sensitive area locations, this data layer should be developed by Natural Heritage staff.

Data Conversion Service Alternatives

The layers discussed in this subsection are only those for which digital data is not available. The role of the University of Vermont's School of Natural Resources and the Regional Commissions is discussed under "contracted conversion services."

In-House Conversion

Map and data sets that should be considered for in-house conversion generally have the following characteristics:

- Small sets (i.e., few sheets or a small paper files)
- Straight forward content and conversion specifications
- Lower conversion priority
- High confidentiality or security needs
- Information subject to interpretation, reformatting, other preparation that requires specialized knowledge of that particular data.

Data layers which, within the limitations of the above list, may or should be considered for in-house data conversion are listed in Table 5-3.

Before converting boundary information by trace digitizing, it is worth investigating how they are legally defined. Some legal boundaries are defined in terms of street centerlines and right-of-way boundaries and could be developed by adding codes to that information.

TABLE 5-3
CANDIDATE DATA LAYERS FOR IN-HOUSE DATA CONVERSION

Local Level	State Level
Transportation Centerlines	Political/Administrative Boundaries
Land Use/Cover	Soil Associations
Zoning	Groundwater Features
Special Infrastructure Facilities	Historical/Archaeological Sites
Political/Administrative Boundaries	Sensitive Natural Areas
	Recreational Facilities
	Special Infrastructure Facilities
	Solid/Hazardous Waste Disposal Sites

Contracted Data Conversion Services

Many reputable companies exist that specialize in mapping and data conversion. These companies usually operate multiple shifts with experienced staff using software particularly suited for data conversion as opposed to analysis functions. These factors result in efficiencies, timeliness, and consistency which cannot be matched by inexperienced or single shift operations.

Generally speaking, it is better to spend funds allocated for in-house purposes on application development and staff training. The following local level data layers should be considered for contracted data conversion:

- Property parcels
- Underground utilities
- Flood boundary maps
- Detailed soils maps (for those counties that are not yet mapped)
- Topographic contours
- Transportation centerlines.

The following state level data layers should be considered for contracted data conversion:

- Land cover
- Wetlands
- Topographic contours
- Geology

The UVM - School of Natural Resources has substantial experience in data conversion through contracts with the state and with some towns, and should receive continued consideration for conversion services when competitive with private sector commercial sources.

Depending on staffing, funding, and equipment limitations, Regional Commissions should consider providing data conversion services to towns in their area. There are advantages to having the Regional Commissions provide data conversion services:

1) Because they would have the opportunity to serve more than one town, Regional Commission staff would be able to develop expertise in database development, thus achieving efficiencies from experience that individual towns may not be able to achieve.

2) Because fewer organizations would be involved in digitizing, greater consistency and adherence to standards could be achieved in database development.

3) They would have ready access to any data that they convert.

Providing the resources for Regional Commissions to offer data conversion services is also consistent with their role as described in Act 200 and with PlanGraphics' recommendations for organizational structure.

Database Development Priorities

Database development will be an evolutionary process, reflecting application priorities, financial and personnel resources for data conversion, priorities of project participants, and availability of source information. In fact, GIS database development is a continuous and dynamic process: additional applications are identified which in turn require additional data, existing information has to be maintained, and over time resources become available for working to improve the positional accuracy or quality of existing data.

Data layers required for recommended Immediate Implementation applications at the state and local level are listed below. These layers are required to support the Immediate Implementation applications identified in the Phase I Report, but must be adjusted to reflect final priorities assigned by the Oversight Committee and other policymakers in final application development decisions.

Local Level - Immediate Implementation

Property Parcels
Transportation Centerlines
Land Use/Cover
Zoning
Flood Zones

State Level - Immediate Implementation

Digital Line Graph Base Map (includes transportation centerlines and surface water features)
Political/Administrative Boundaries
Census Areas (and data)
Land Cover
Wetlands

The remaining data layers are all required in order to perform the Near Term applications. However, PlanGraphics has identified some layers that are more important than others because they support more applications than the others. The following layers are suggested for Near Term Implementation because they support at least 25 percent of the Near Term applications identified in the Phase I Report:

Local Level - Near Term Implementation

Soils
Sanitary Sewer Facilities
Water Facilities
Septic Systems

State Level - Near Term Implementation

Soil Associations
Groundwater Features
Historical/Archaeological Sites
Sensitive Natural Areas

The remaining data layers (topographic contours, geology, recreational facilities, stormwater facilities, special infrastructure facilities, and hazardous/solid waste sites) should be developed as resources are available, or as implementation priorities change. The grouping of data layers provided above is only suggested. Low cost for converting a specific layer, changes in application priorities, identification of new applications, or significant importance of one or two applications may alter these groupings. The Policy Committee as well as individual towns and cities will base their database implementation priorities on the importance of particular applications.

SECTION 6
CONCEPTUAL GEOGRAPHIC INFORMATION SYSTEM CONFIGURATION

INTRODUCTION

This section presents the conceptual configuration of the Vermont GIS as envisioned by PlanGraphics. This configuration is conceptual in that it discusses pertinent issues of system design at a diagrammatic level. This is not a detailed design in that it does not present detailed specifications for each hardware, software, and database component of the system, and does not specify procurement schedules or exact costs. Instead, the conceptual design discusses each major component of the system in the context of how it solves design requirements and how it interrelates with other components. Locations and configurations of major processing nodes are illustrated and discussed; communications issues are identified and discussed; software functionality is discussed in terms of what is required to support the highest priority applications; and database requirements are discussed in fairly specific terms.

The conceptual system design is important because it raises and discusses many design issues that are preliminary to a more detailed design. It can serve as a basis for development of detailed specifications suitable for inclusion in a procurement document. The conceptual design provides an overview of targeted system configuration and initial cost estimates which are valuable to early planning for the system.

The purpose and objective of this section is three-fold. First, an indication of the factors which must be considered in developing a GIS design are discussed. This is provided as background supporting the conceptual design. Next, the requirements for hardware and software components are presented in support of implementing the highest priority applications. The third portion of this section presents the conceptual system configuration, in two stages of development, designed to address the functional and operational requirements of participating organizations.

The two "stages" of hardware configuration are not intended to directly track organizational development "phases". Section 1 dealt with organizational issues and institutional development that will be solved over the next four years (interim phase), and then the permanent institutional structure (final phase). Hardware configurations are presented in line with the staged development of GIS applications: Stage I (immediate acquisitions which are an integral part of establishing the organizational home over the next year), and Stage II (near-term expansion of the system over the next four years). Long-term hardware configurations that match the final phase of institutional formation and the long-term application development recommendations would be too speculative to be worthwhile. The experience with pilot projects, application development, improved hardware technology, and success of the service centers will all impact the improvement and expansion of the hardware configuration beyond 1994.

HARDWARE AND SOFTWARE DEVICE NEEDS

The hardware and software device needs of participants in the Vermont GIS may be categorized and defined in response to several factors. Included in these factors are the geographic distribution of users, the level of access to the system required by those users, the development and phased implementation of system applications, and the phased development of the GIS database. All of these factors must be evaluated to determine the specific hardware and software requirements of individual organizations, and to integrate those requirements into an overall conceptual system configuration for Vermont's GIS.

Geographic Distribution of Users

A wide geographic distribution of participants is inherent in a GIS conceptual design such as Vermont's. The requirements of Act 200 mandate the involvement of organizations representing all levels of government and private firms from all areas of the state. Although the phased implementation and development of the Vermont GIS will limit this involvement during initial GIS implementation, there still remains a geographically diverse set of participants which must be integrated into an operationally functional and cost-effective system configuration, including:

- State agencies and district offices
- Regional Planning Commissions
- Municipalities (cities, towns, villages)
- Private companies
- Public organizations.

In addition to the geographic distribution of GIS participants from each of these groups, several other factors must be considered in determining an appropriate configuration for the statewide system. These factors include distribution of responsibilities, development of local, regional, and state level databases, and data sharing with existing systems.

Hardware and Software Needs in Response to Stage I Applications

Two fundamental aspects of preparing a successful GIS conceptual system configuration are, first that distinctions be made as to what organizations will participate in the initial GIS configuration, and secondly, that adequate provisions are made in the conceptual design for including each of those participants. In Vermont's case, the distinction of GIS participants for Stage I has been established. This decision is in direct response to the suggested development timing of "immediate implementation" applications as described in the Phase I Report (Table 4-5) and reiterated below.

Immediate implementation applications:

- Land Cover Mapping
- Wetland Mapping
- Flood Zone Mapping
- Land Use Map Production
- Demographic Analysis
- Special Road System Map Production (Transportation Centerlines)
- Identifying Parcels in the Current Use Program
- Property Map Update/Production.

Those organizations directly involved with the production or use of these eight applications were identified in the Phase I Report and include the following groups.

Major participants/Users of immediate implementation applications:

- Agency of Natural Resources
  - Multiple Divisions (Land Cover Mapping)
  - Division of Water Quality (Wetland Mapping)
  - Floodplain Management (Flood Zone Mapping)

- Agency of Administration
  - Division of Property Valuation and Review (parcel map production and identifying parcels in current use program)

- Agency of Transportation
  - Planning Division (special road system map production)

- Agency of Development and Community Affairs
  - Department of Housing and Community Affairs (demographic analysis)

- Agency of Human Services
  - Department of Health (demographic analysis)

The Phase I Report also associated these applications with necessary GIS software capabilities (Table 5-1). The information contained in this table has been used in defining both hardware and software requirements necessary to satisfy the associated applications. Software capabilities may be divided into three categories; those which require special software programs, those which require special hardware components (i.e. data entry, display, and output devices), and those which should be provided as a basic core function of most commercially available GIS hardware/software. This information has been used to establish the required and appropriate system hardware and software components for each participating organization. Reference to the Phase I Report is recommended for further explanation and definition of software capabilities.

Phased System Acquisition in Response to Phased Application Development

The Vermont GIS Oversight Committee has identified the following general groupings to be used in the scheduling of application development:

- Immediate implementation (1989-1990)
- Near-term implementation (1990-1994)
- Long-term implementation (after 1994).

Due to the inherent uncertainties involved in specifying a system configuration beyond 1994, two conceptual system configurations, Stage I and Stage II, are presented which correspond to the immediate and near-term implementation periods above, and to the interim phase of organization described in Section 2.

It is important to note that the equipment specified in each stage configuration is intended to be acquired over the duration of the implementation time period indicated, rather than in a single, comprehensive procurement. This phased acquisition within each stage will allow for a more efficient and cost-effective procurement of system components.

CONCEPTUAL SYSTEM CONFIGURATION

The organizational model presented in the Phase I Report discussed the roles and computing requirements of users at the state, regional, and municipal levels. This hierarchical organizational concept should be reflected and supported by the system configuration. Therefore, system configuration will be discussed in this context, as well as the context of staged procurement.

Overview of Stage I Configuration

Figure 6-1 provides an overview of the conceptual Stage I configuration. The figure indicates both the theory behind the functional operations of the initial configuration, as well as, the major areas of activity and involvement. The Stage I configuration design addresses the requirements of those state, regional, and local users which are immediately involved in the implementation of high priority applications described above.

Overview of Stage II Configuration

Figure 6-2 provides an overview of the conceptual Stage II configuration. The Stage II configuration has been designed to facilitate the continued development of high priority applications, as well as the new development of additional applications. This continuing application development process will, obviously, require new users to come on-line as the system matures. It is not appropriate to definitively identify who these new participants may be so long as the exact ordering of Stage II application implementation has not been established. However, the addition of Stage II participants (and the expansion of Stage I participants) should adhere to the overall system design as indicated, and should also follow the organizational model regarding the information flow between the state, regional, and local levels.

Stage I Conceptual System Configuration

The following discussion describes the Stage I system configuration in terms of hardware devices, software requirements, data communications, and system expansion into Stage II. Within these subject areas, the system description will address the interactions required within and between each organizational level and the subsequent hardware and communications equipment necessary to support those interactions. Detailed explanations and definitions of the hardware components mentioned were discussed in Section 6 of the Phase I Report and are not further defined in this section.

The initial system configuration at the state level should involve the following agencies:

- Agency of Administration
- Agency of Transportation
- Agency of Natural Resources
- The University of Vermont
- Agency of Development and Community Affairs
- Agency of Human Services.

PlanGraphics has recommended an office within the Agency of Administration be established to serve as the organizational home for the Vermont GIS.

FIGURE 6-1
STAGE I CONFIGURATION OVERVIEW

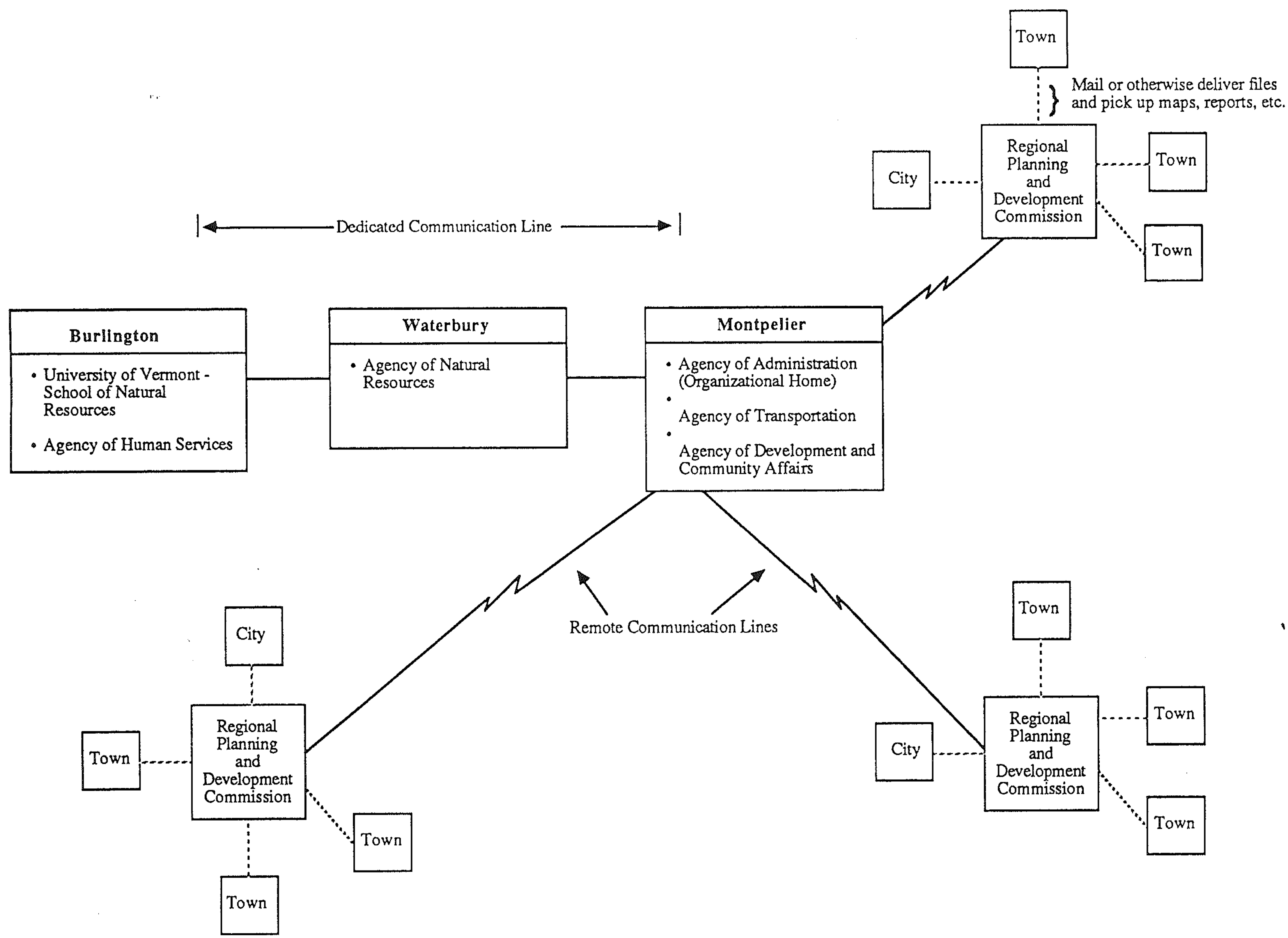
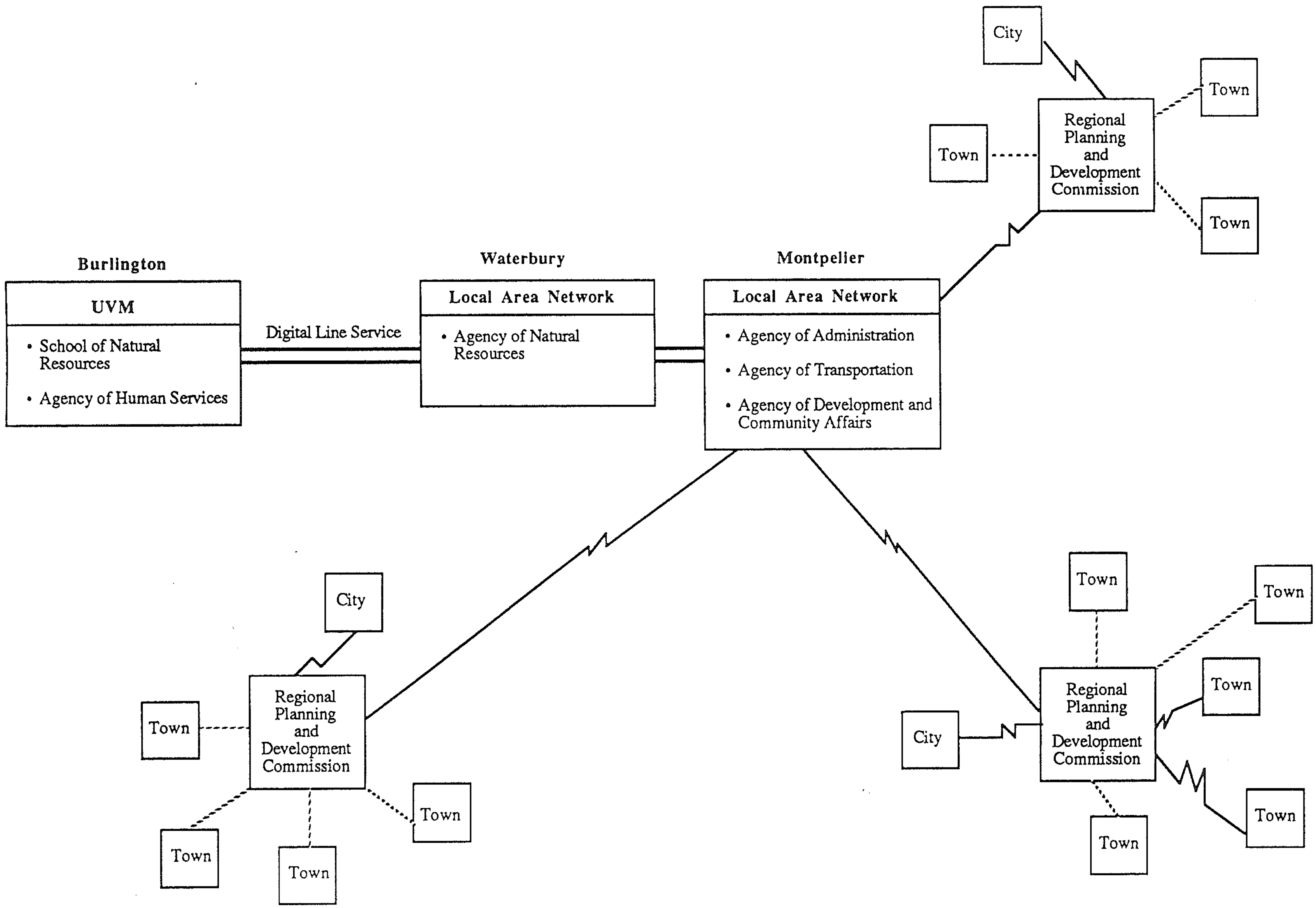


FIGURE 6-2
STAGE II CONFIGURATION OVERVIEW



Various hardware devices should be acquired for the GIS organizational home to provide both a "centralized" processing and data repository facility, as well as a site for conducting geographic analysis. Processing activity within the Stage I system configuration will occur, in part, at the organizational home, and partly within other organizations.

In this respect, the overall system may be described as being partially centralized and partially distributed in its processing activities.

It is important to differentiate between distributed processing and a distributed database. The GIS database will be accessed from a network node through the host processing unit in the organizational home. Portions of the database can be downloaded to various offices for updating and analysis, then transferred back to the central GIS database. These procedures for data distribution minimize redundancy of data and database maintenance requirements, while enabling remote sites to use portions of the GIS database locally.

Hardware Devices

This subsection discusses the types of GIS hardware which, in combination, make up the Phase I conceptual design.

Host Processing Unit: The focus of the recommended hardware within the organizational home is a mid-range minicomputer capable of initially operating at 3-5 mips (million instructions/second), and containing approximately 16 to 24 megabytes of main memory. This processing unit must support local peripheral devices with near instantaneous response time for interactive graphics and database operations. In addition, demands will be placed on this processing unit to support a variety of processing requests from remote locations. It is important for this unit to have a clear upgrade path (upgradability at the site), including the ability to add main memory, data storage capacity, or communication enhancements. The ability to upgrade the processing unit will enable Vermont to add new GIS users without having to replace the processing unit.

Mass Storage: Magnetic storage devices will be configured with the GIS processing unit for direct access to data and software programs. Accurate estimates on the volume of storage required vary with the various GIS software formats available. To estimate mass storage volume needed, the amount of graphic data and attribute data to be stored on the system must be taken into account, as well as the storage required by the operation system and application programs. As a general rule, no more that 55 to 65 percent of total disk space available should be occupied with GIS data or programs. This gives adequate work space for special projects, temporary work files, and report files.

In the Stage I conceptual design, 750 megabytes of disk drive storage have been included. This should be adequate to support the initial database development and software storage requirements of the Vermont GIS.

Tape Drive:: The tape drive will be connected to the host processing unit and will facilitate the initial loading of a majority of the software acquired through a system procurement. In addition, periodic, scheduled backups of the GIS database are recommended and may also be accomplished using this equipment. A third function of the system tape drive is transferring information between the GIS organizational home site and other locations throughout Vermont.

The tape drive should be an industry standard reel-to-reel magnetic drive capable of reading or writing at 1,600 or 6,250 bits per inch in start/stop or streaming mode.

Alphanumeric Terminal: The alphanumeric terminal specified for the GIS organizational home site will be used to generate reports, support routine system operations, and will also serve as the system console. Activities typically executed from the system console include system backups, booting the system, monitoring system performance through special diagnostic utilities, and other operator functions.

Graphics Stations: There are three general types of graphics stations included in the Stage I GIS configuration:

1) Graphics terminal-based digitizing stations
2) Edit/Query stations
3) Intelligent workstations.

The first class of station is made up of a graphics terminal connected to a large-format digitizing tablet. It has either limited or extensive local graphics processing capacity, but is dependent on host processor programs and disk storage. These are primarily used for graphic data input and map production activities such as map digitizing, editing, manipulation, and preparation of graphic output files.

Edit/Query stations are simply graphics terminals, and are used to perform graphic query and display activities and to produce reports. Since they do not have large digitizing tablets, they are not used for extensive data entry. However, many edit/query stations have a mouse or some other pointing device, so they can be used to perform limited data entry and graphic editing that does not require direct digitizing from a hard copy product.

Several State agencies require a digitizing station to support data entry activities, and/or an edit/query station as indicated in Figures 6-3 through 6-5.

The digitizing stations should be equipped with high-resolution color monitors (minimum 1024 x 768 resolution) capable of displaying at least 16 colors simultaneously, keyboards, and a mouse or other "pointing devices". The digitizing stations will also have a digitizing tablet with at least a 36" x 48" active surface area for graphic data entry. The query stations will have a lower resolution color monitor (minimum of 512 x 512) capable of displaying at least 16 colors, as well as a keyboard and a mouse or other pointing device.

Intelligent Workstations: Intelligent Workstations traditionally have been used for Computer Aided Drafting, Manufacturing, and Engineering (CAD/CAM/CAE). Recent trends indicate that graphic stations based on various super microcomputers or minicomputers are becoming the platform choice for computer mapping and GIS vendors. Providing similar functions as the graphics terminal-based digitizing stations, these processor-based stations are faster and more versatile. Because they include their own operating system software, these intelligent graphic stations have the potential for substantial distributed processing, as well as the ability to operate as fully functional, independent graphic stations. Increasingly, GIS vendors are taking advantage of high-performance features, such as multiple graphic windowing capabilities and simultaneous processing in different operating systems, by developing versions of their software which will operate on these hardware platforms.

Two intelligent graphic stations are included in the Stage I hardware configuration. One graphic station located in the Agency of Natural Resources (ANR) is configured as a graphic data entry (digitizing) station, while the other graphic station, located in the Agency of Transportation (AOT), will function as a query workstation. The query station in AOT will also serve the function of translating files from the GIS to AOTs Intergraph System,

FIGURE 6-3
AGENCY OF ADMINISTRATION STAGE I CONFIGURATION
Pavilion Office Building, Montpelier

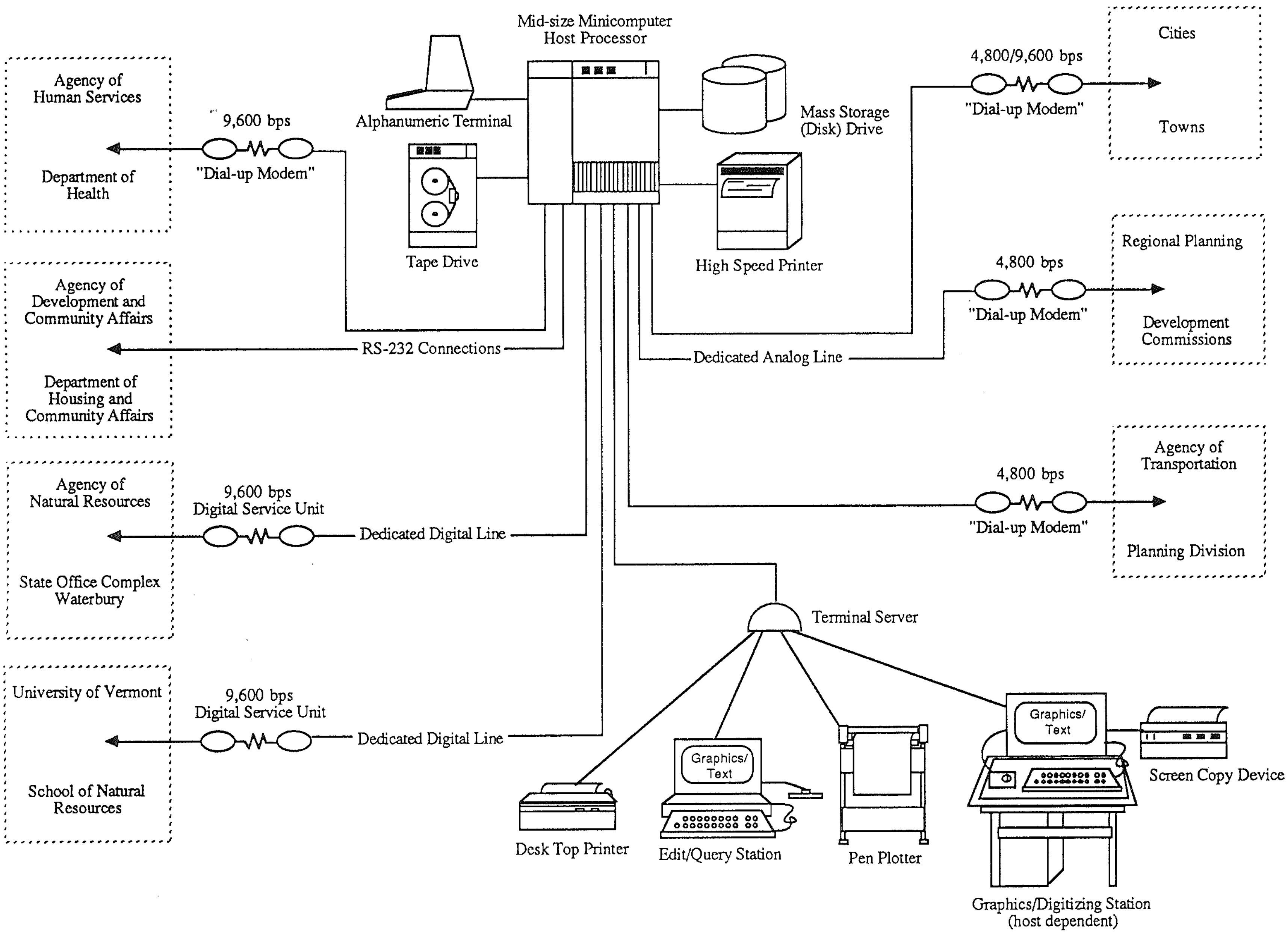


FIGURE 6-4a
AGENCY OF NATURAL RESOURCES STAGE I CONFIGURATION
State Office Complex, Waterbury

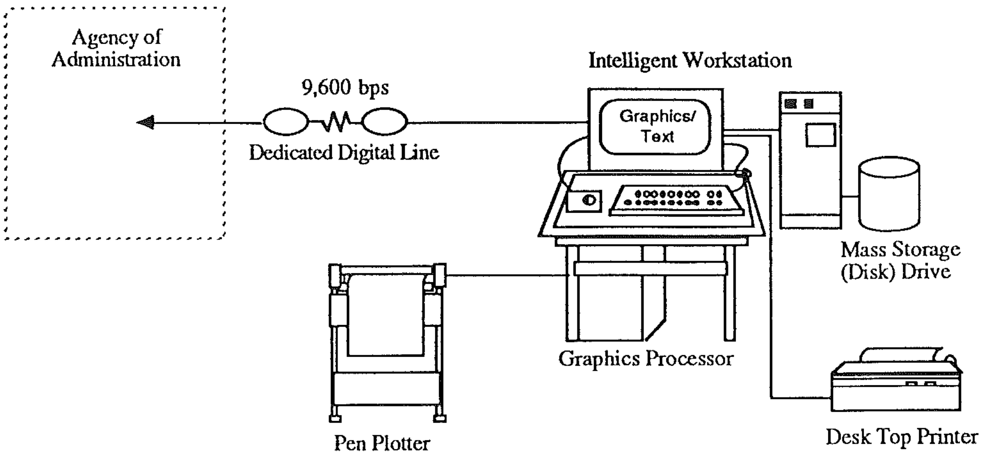


FIGURE 6-4b
AGENCY OF HUMAN SERVICES STAGE I CONFIGURATION
Department of Health
Burlington Offices

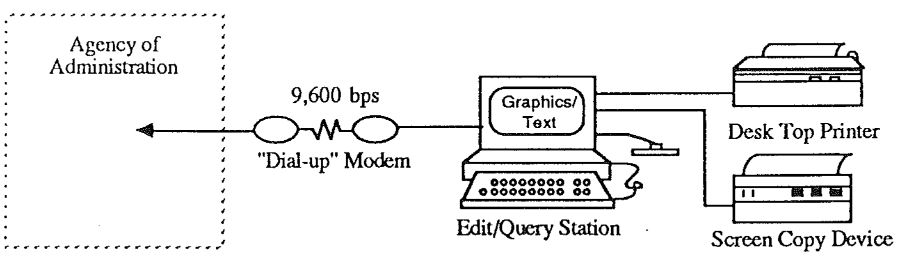


FIGURE 6-4c
AGENCY OF DEVELOPMENT/COMMUNITY AFFAIRS STAGE I CONFIGURATION
Department of Housing and Community Affairs, Pavilion Office Building
Montpelier

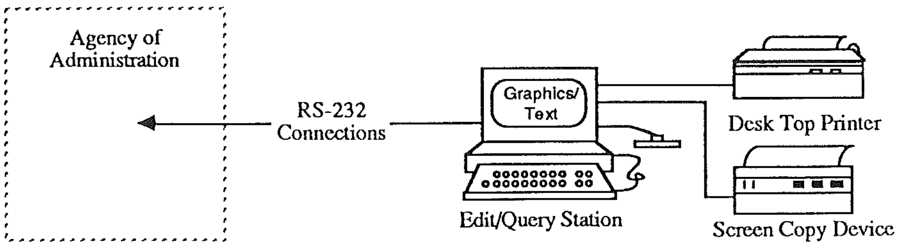


FIGURE 6-4d
AGENCY OF TRANSPORTATION/PLANNING DEPARTMENT
STAGE I CONFIGURATION
State Administration Building, Montpelier

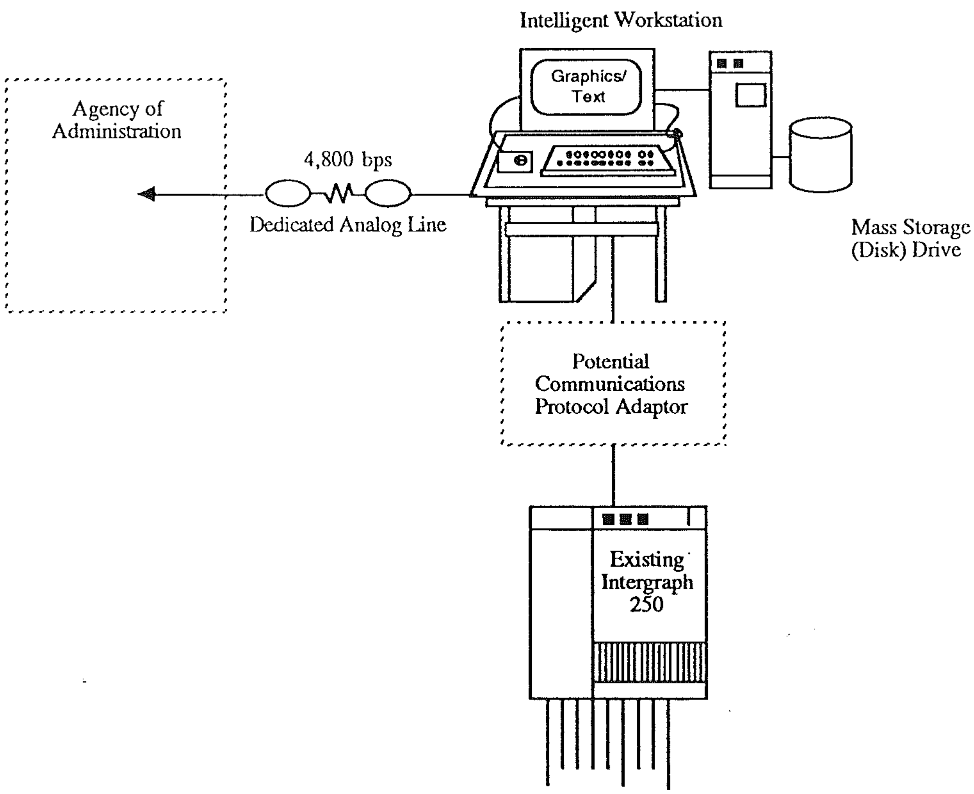
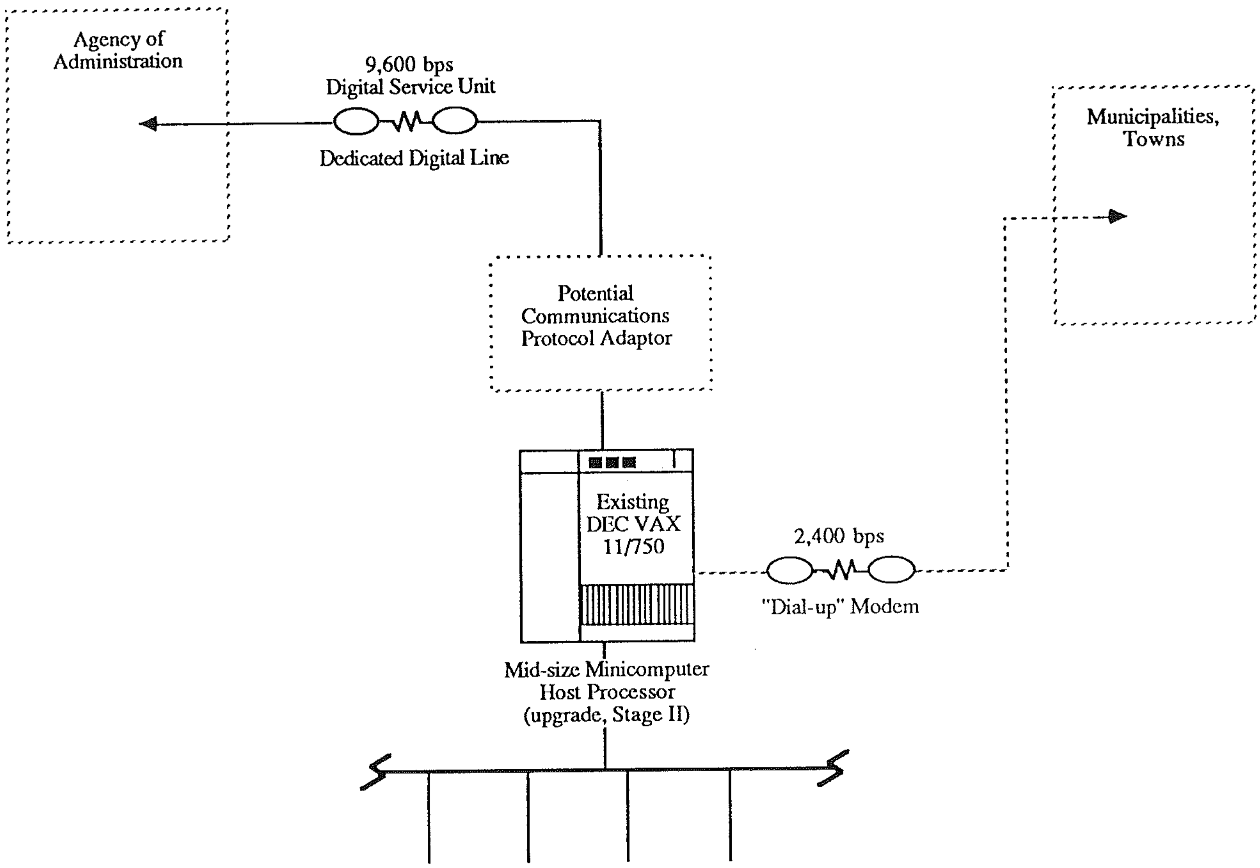


FIGURE 6-5
UNIVERSITY OF VERMONT STAGE I CONFIGURATION
School of Natural Resources, Burlington



and visa versa. Each station contains four to six megabytes of local memory each, 40 to 100 megabytes of disk storage, a high resolution color monitor (1024 x 768 minimum resolution), a keyboard, and a pointing device such as a mouse.

Plotting Devices and Printers: A GIS produces both graphic and alphanumeric output. As a result, plotting and printing devices must be included in a GIS configuration. Pen plotters or electrostatic plotters are used to generate large, "cartographically correct" graphic documents. Both pen plotters and electrostatic plotters can produce A to E sized plots on a variety media, in color or black and white. Electrostatic plotters can produce maps at a much faster rate than pen plotters, however, electrostatic plotters tend to be more expensive than pen plotters even though recent price reductions have narrowed this gap. Thus, an electrostatic plotter is appropriate for a GIS site if large numbers of maps are routinely produced. Otherwise, a pen plotter will provide sufficient plotting capacity.

In the Stage I configuration, the GIS organizational home, the Agency of Natural Resources, participating Regional Planning Commissions, and participating municipalities should receive a pen plotter. No electrostatic plotters are specified for Stage I.

A screen copy device will produce copies of images displayed on a graphics terminal and is useful for copying displays resulting from queries or analysis. In the Stage I configuration, a screen copy device is connected to the majority of edit/query stations. The screen copy device will be capable of producing seven colors at a minimum and will be used to produce exact copies of the display screen in at least an 8.5" x 11" size.

In the Stage I configuration, a screen copy device will be connected to each edit/query station.

An alphanumeric printing device is necessary to produce reports and various types of files. A dot matrix printer should have draft and near letter quality modes of operation and be equipped with tractor feeds to handle continuous feed paper. A printer is provided for each participating organization in the Stage I configuration.

GIS Software

The Stage I system should provide the GIS capability required to support Vermont's applications slated for immediate implementation. PlanGraphics recommends that graphics/mapping, database management, and analytical software be acquired for Vermont's Stage I GIS. The software components should include:

- Processing unit operating system
- Graphics processing
- Database management
- High level language compiler
- Applications programs
- System specific software.

Individual software components will be integrated with the devices of the proposed hardware configuration to provide an efficiently operating system.

Most of the software and some applications programs will be purchased as part of a pre-packaged set of software "tools". However, some customization of standard GIS functions will be required. These customization activities, such as special application development involving macro programming and screen customization will be required to tailor the GIS to the specific needs of Vermont users. This can be completed by in-house staff, the GIS vendor, or consultant programmers.

Communication Requirements

In the Stage I configuration, the GIS software components, as well as the GIS database, will reside on the host processing unit. Consequently, the GIS peripheral devices must communicate directly with the host processing unit. Since Vermont state, regional, and municipal/local offices are dispersed over a wide area, the configuration must support remote devices, as well as local devices. Local communication is readily accomplished through direct cabling to the host processing unit. Remote devices, however, must be linked to the host processing unit through an alternative mode of communication.

As indicated in Figure 6-3, a central communication component of the Stage I configuration is the linking of state agencies located in Montpelier, Waterbury, and Burlington. There are various possible remote communication options (i.e., microwave systems and very high-speed digital service) which could accomplish a linkage of this distance. However, these communication methods are comparatively expensive and their ability to move information at very fast transmission speeds is not warranted in the Stage I configuration.

The most frequently used remote communication medium for a linkage such as the Montpelier-Waterbury-Burlington connection involves the use of the local or long distance telephone system. Phone companies such as New England Bell offer dedicated leased lines in which a direct point-to-point connection between two computer devices is established. Digital leased lines of this nature offer adequate transmission speed, a high quality signal, good security, and are significantly less expensive in installation charges and monthly leases. Digital phone lines of this type are currently available between Montpelier, Waterbury, and Burlington.

Where lower speed communications are acceptable (i.e., batch file transfer between regional/local sites and the GIS organizational host site), standard, voice-grade telephone lines present a viable and inexpensive communication alternative. Inexpensive, dial-up modems, capable of transmitting data at speeds ranging normally from 300 bits/second to 4800 bits/second are required when using voice-grade telephone lines.

The use of voice grade and leased telephone lines provides the most reasonable remote communications approach for Vermont during initial system development. In the Stage I configuration, it is likely that six remote communication lines will be required to support initial system participants. The communications cost range listed in Tables 6-1(a) and 6-1(b) assumes that six remote communication lines, two local communication lines, and various associated peripheral equipment are included in the Stage I configuration.

System Expansion

As the Vermont GIS matures, it will be necessary to add graphic stations and other devices to support new system users. To expand the typical centralized processing GIS configuration, additional peripheral devices are connected to the host processing unit, either by direct cabling or over remote communications lines. Since all devices in a configuration of this type are host processing unit dependent, the ability of the host processing unit to provide adequate response time decreases as the number of attached devices increases. Under these circumstances, the host processing unit would eventually have to be upgraded or replaced by a larger processing unit.

The Stage I configuration, however, is designed to address Vermont's immediate functional requirements while, at the same time, minimizing the requirement for upgrading the processing unit in the organizational host site. Within the Stage II configuration, sites have been selected for installing distributed processing facilities which will relieve much of the processing burden on the organizational home's CPU as new users are brought on-line.

An important notation to be made here concerns the involvement of the local governments in the Stage I design. Participation by local governments in the Vermont GIS will be a mandatory factor in the successful implementation of Act 200 goals. However, the level of direct on-line participation remains dependent on financial resources beyond those currently allocated for GIS implementation. The Stage I configuration presented here will accommodate all local governments capable of acquiring their own compatible computer equipment. The conceptual configuration example for local governments is equivalent to that of Vermont Cities and Municipalities as indicated in Figure 6-6(b).

Stage I Configuration Cost Estimates

The total cost for the Vermont GIS Stage I configuration is estimated to range from $437,000. to $649,000. A more detailed breakdown of costs associated with the various Stage I system components is provided in Tables 6-1(a) and 6-1(b).

Also indicated in Tables 6-1(a) and 6-1(b) are the costs associated with implementing GIS technology at the regional and municipal/local levels. These costs have been calculated on a "per site" basis for the hardware, software, and communication components indicated in Figures 6-6(a) and 6-6(b). Total cost estimates for participants at these levels may not be determined at this time.

Stage II Conceptual System Configuration

The following discussion describes the Stage II system configuration in terms of hardware components, software requirements, data communications, and system expansion. Within these areas, the system description will concentrate on the differences between the Stage I and Stage II configurations.

The Stage II conceptual configuration is designed to build on the acquisitions made during Stage I. In every case, equipment specified for Stage I is applicable to the Stage II design. The main differences in the two configurations lie in additional hardware devices and communication facilities.

Hardware Components

Host Processing Unit: The host processing unit within the GIS organizational home will likely need to be upgraded at some point within Stage II. This upgrade may take several forms depending on the unit's utilization during Stage I. One method of upgrading the host processing unit is through the addition of main memory. It is unreasonable to consider doubling the unit's memory to respond to Stage II demands.

FIGURE 6-6a
REGIONAL PLANNING COMMISSIONS
Example Stage I Configuration

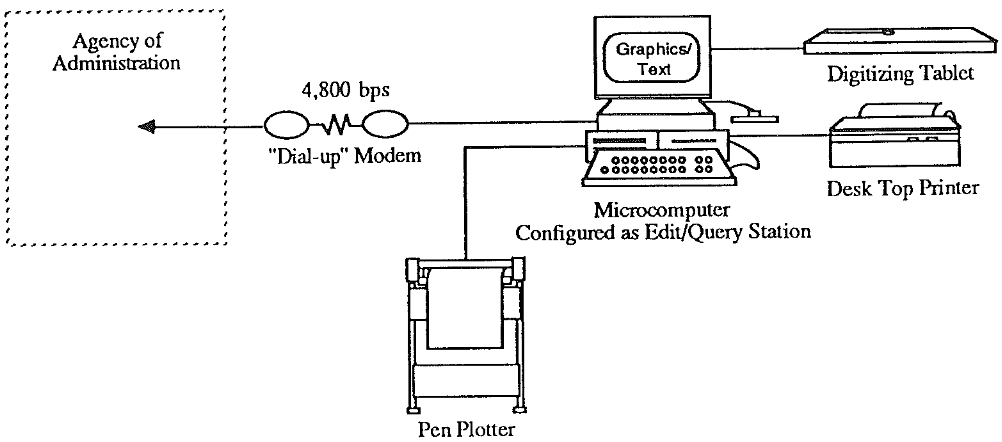


FIGURE 6-6b
VERMONT CITIES/TOWNS
Example Stage I Configuration

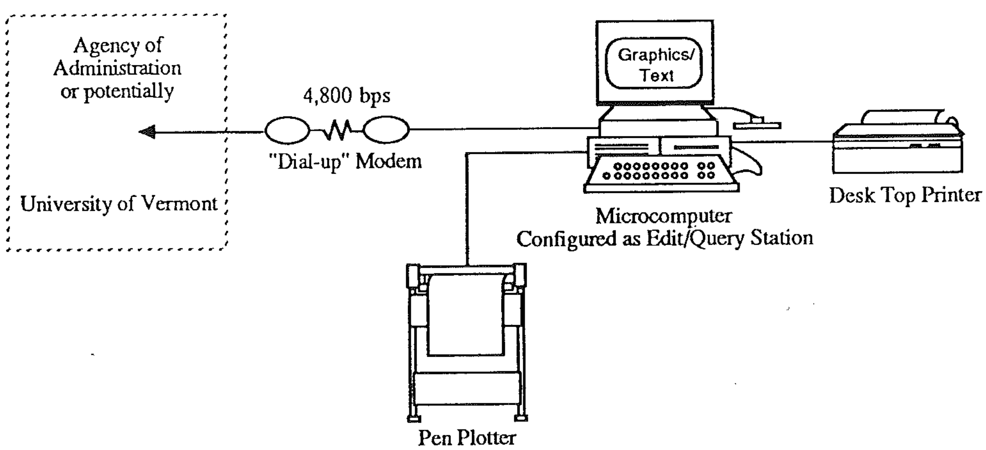


TABLE 6-1(a)
STAGE I CONFIGURATION COST ESTIMATES FOR STATE CONFIGURATION
(noted in thousands of dollars)

Component	Base Cost Low	Base Cost High	Units	Extended Cost Low	Extended Cost High
Hardware					
Processing Unit	170.0	240.0	1	170.0	240.0
Small Minicomputer	45.0	60.0	0	0.0	0.0
Mass Storage 250 mb	10.0	15.0	3	30.0	45.0
Tape Drive	15.0	25.0	1	15.0	25.0
Micro Edit/Query	6.0	15.0	0	0.0	0.0
Edit /Query Station	5.0	10.0	4	20.0	40.0
Intelligent Edit/Query	20.0	30.0	1	20.0	30.0
Dig WS Host Dependent	15.0	25.0	1	15.0	25.0
Intelligent WS Diskless	25.0	35.0	0	0.0	0.0
Intelligent WS Disk	35.0	50.0	1	35.0	50.0
Pen Plotter	9.0	12.0	2	18.0	24.0
Electrostatic Plotter	30.0	70.0	0	0.0	0.0
Screen Copy Device	3.0	6.0	3	9.0	18.0
Desk Top Printer	.5	1.0	4	2.0	4.0
High Speed Printer	6.0	12.0	1	6.0	12.0
Alphanumeric Terminal	.5	1.0	1	.5	1.0
Total Hardware				**340.5**	**514.0**
Software					
GIS Software License				80.0	110.0
Total Software				**80.0**	**110.0**
Communications					
Modem 4800	.5	1.0	6	3.0	6.0
Modem 9600	1.0	1.5	2	2.0	3.0
DSU Multi-Rate	.6	.8	4	2.4	3.2
Multiplexer	8.0	15.0	0	0.0	0.0
Terminal Server	3.0	5.0	1	3.0	5.0
Miscellaneous	6.0	8.0	1	6.0	8.0
Total Communications				**16.4**	**25.2**
GRAND TOTAL				**436.9**	**649.2**

TABLE 6-1(b)
STAGE I CONFIGURATION COST ESTIMATES FOR REGIONAL AND LOCAL CONFIGURATION
(noted in thousands of dollars)

Component	Base Cost Low	Base Cost High	Units	Extended Cost Low	Extended Cost High
<u>Hardware</u>					
Micro Edit/Query	6.0	15.0	1	6.0	15.0
Intelligent WS Disk	35.0	50.0	0	0.0	0.0
Pen Plotter	9.0	12.0	1	9.0	12.0
Desk Top Printer	.5	1.0	1	.5	1.0
Total Hardware				**15.5**	**28.0**
<u>Software</u>					
GIS Software License	2.5	5.0	1	5.0	10.0
Total Software				**5.0**	**10.0**
<u>Communications</u>					
Modem 4800	.5	1.0	2	1.0	2.0
Modem 9600	1.0	1.5	0	0.0	0.0
DSU Multi-Rate	.6	.8	0	0.0	0.0
Multiplexer	8.0	15.0	0	0.0	0.0
Terminal Server	3.0	5.0	0	0.0	0.0
Miscellaneous	.5	1.0	1	.5	1.0
Total Communications				**1.5**	**3.0**
GRAND TOTAL				**22.0**	**41.0**

A second method of upgrading the host processing unit is by actually increasing the processing power of the unit. Many minicomputers have the ability to significantly increase processing capability by adding internal boards. As discussed in the Stage I description, the processing unit for the GIS organizational home should facilitate this type of "internal" upgradability so that an entirely new unit is not required to support the Stage II configuration.

File Serving Processing Unit: Two processing units based on minicomputers are proposed as "file servers" within the Stage II configuration. These units should be located within the Agency of Natural Resources and the Agency of Transportation respectively, and will serve similar, but slightly different purposes.

The file server within AOT will provide two main functions. First, AOTs "window" into the Vermont GIS will be enhanced by using the file server's storage capacity to move greater volumes of information in fewer sessions between the Vermont GIS and AOTs Intergraph system. This enhancement is also advanced by the attachment of the dependent edit/query station specified in Stage I to the file server. The second potential use of the file server is in providing an efficient point of contact for communications between AOTs central offices and remote transportation district field offices.

The file server within ANR will provide two-fold functionality as well. First, the storage capacity of this processing unit will allow ANR to continue to develop graphic and attribute data which may be maintained within ANR with updates being "posted" to the GIS host processing unit within the organizational home. This ability to manipulate increasing amounts of information will be important to ANR as new agency applications are brought on-line. ANRs file server may also provide a small amount of processing and storage capabilities to the Agency of Human Services. As indicated in Figure 6-9, ANR and Human Services should share a local area network in Stage II. Should this be the case, it will be technically feasible for Human Services to make use of the file server within ANR.

Mass Storage: As the GIS database continues to grow, the requirement for additional disk capacity will increase correspondingly. Even with the establishment of remote data storage facilities in various organizations, the total available mass storage during Stage II may well need to double over that of Stage I.

Tape Drive: The tape drive requirements for Stage II should remain the same as those of Stage I. The main opportunity to utilize the tape drive for data transfer will be in the exchange of information between the University of Vermont and the GIS organizational home. During Stage II, existing tape drives will facilitate this data transfer. Depending on the GIS development status of other participating organizations, a tape drive unit may be warranted at additional sites.

Alphanumeric Terminal: Alphanumeric terminals will be supplied with the file serving processing units specified for Stage II.

Graphics Stations: The utilization of workstations will increase significantly during Stage II. Several of these devices will be host dependent with little local processing capability, and consequently will place increased demands on the organizational host site's processing unit. A total of two graphic stations of this nature have been specified for Stage II as an addition to equipment acquired in Stage I. Throughout the Stage II design efforts have been made to limit the overall dependence on the host processing unit by linking units such as these to a local processing source.

Intelligent Graphic Stations: Intelligent graphic stations play an important role in the Stage II configuration, not only by providing significantly greater data manipulation capabilities (above those of a dependent graphic station), but also by providing additional processing resources to the overall system. By distributing intelligent graphic stations at appropriate locations within the overall system architecture, the individual sites are provided improved capabilities to analyze and maintain data, and at the same time, the processing burden placed on the organizational home's CPU is significantly reduced. A total of three intelligent graphic stations have been specified for Stage II in addition to those of Stage I.

Plotting Devices and Printers: Stage II requirements for plotting and printing devices involves a general expansion of pen plotters, screen copy devices, and printers as indicated in Figures 6-7 through 6-10. In addition, an electrostatic plotter has been specified for the GIS organizational home during Stage II. The ability of an electrostatic plotter to produce high quality hardcopy output on a variety of plotting media, at a much faster rate than pen plotters, will warrant the additional investment over that of a pen plotting device.

GIS Software

The expansion of GIS software for Stage II will involve additional acquisition of all software components described within the Stage I configuration. These components include:

- Processing unit operating system
- Graphics processing software
- Database management software
- High level language compiler
- Applications programs
- System specific software.

The exact nature of this additional acquisition will vary greatly due to system development decisions and achievements during Stage I (i.e., new users at the regional and local levels), however, estimations have been made and are reflected in the cost information of Tables 6-2(a), 6-2(b), and 6-2(c).

Communication Requirements

Stage II communication facilities will be different than those of Stage I in two principal ways. First, most remote communication lines which were established in Stage I will be upgraded to allow faster transmission speeds. This will be accomplished through the use of faster modem devices by shifting from analog lines to digital lines in some locations. The second difference in the two communication scenarios is the establishment of two local area networks (LAN). A LAN is a special type of network design to support multiple devices within close proximity. LAN's support high speed data transmission allowing all network nodes access to all other nodes (within established security parameters). Stage II LAN's will be established at the state level with one located in Montpelier and one in Waterbury.

The Montpelier LAN will connect the Agency of Development and Community Affairs with the GIS organizational home. The LAN located in Waterbury will link the Agency of Natural Resources with the Agency of Human Services.

FIGURE 6-7
AGENCY OF ADMINISTRATION STAGE II CONFIGURATION
Agency of Development/Community Affairs
Pavilion Office Building, Montpelier

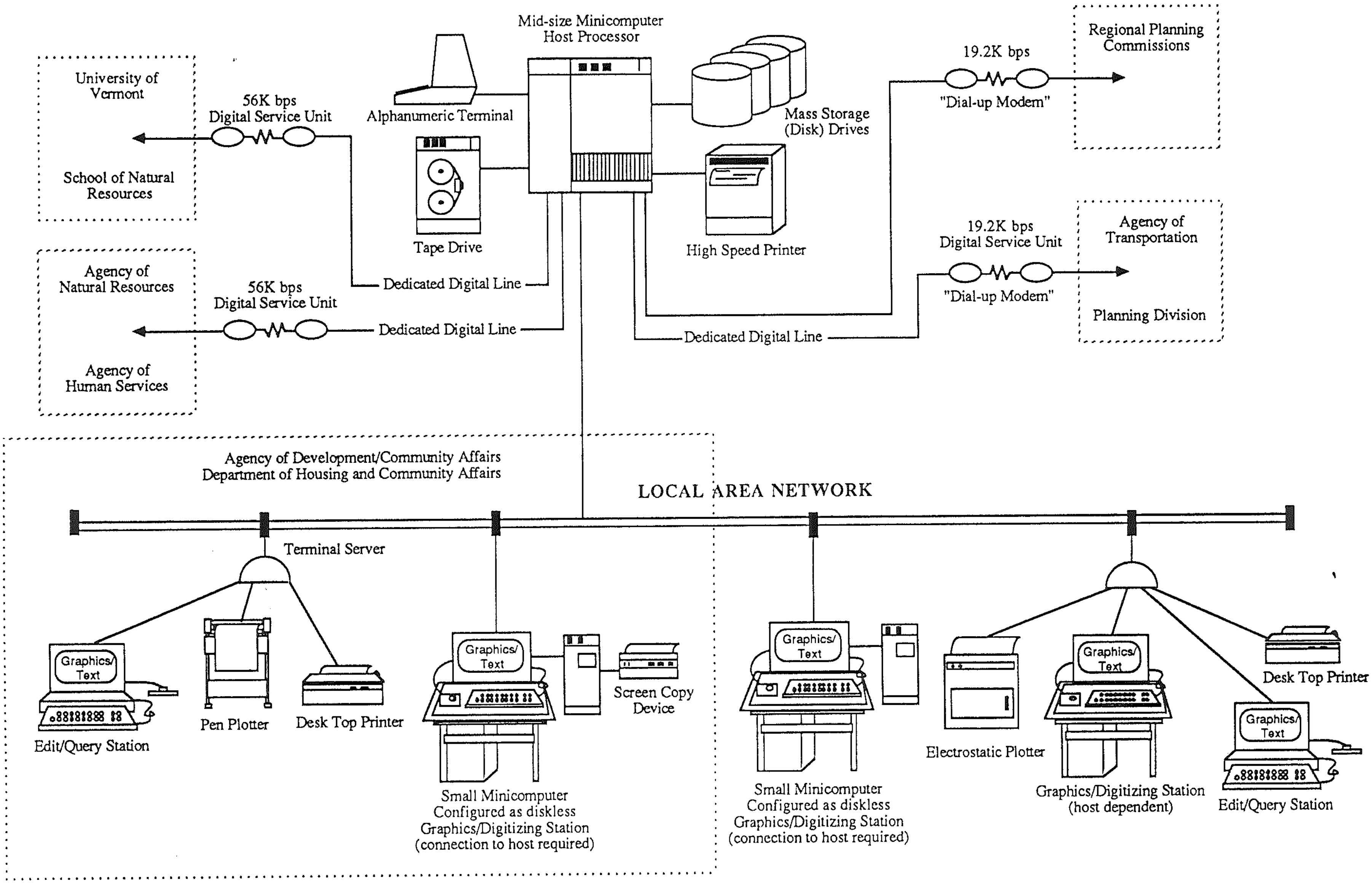


FIGURE 6-8
AGENCY OF TRANSPORTATION STAGE II CONFIGURATION
State Administration Building, Montpelier

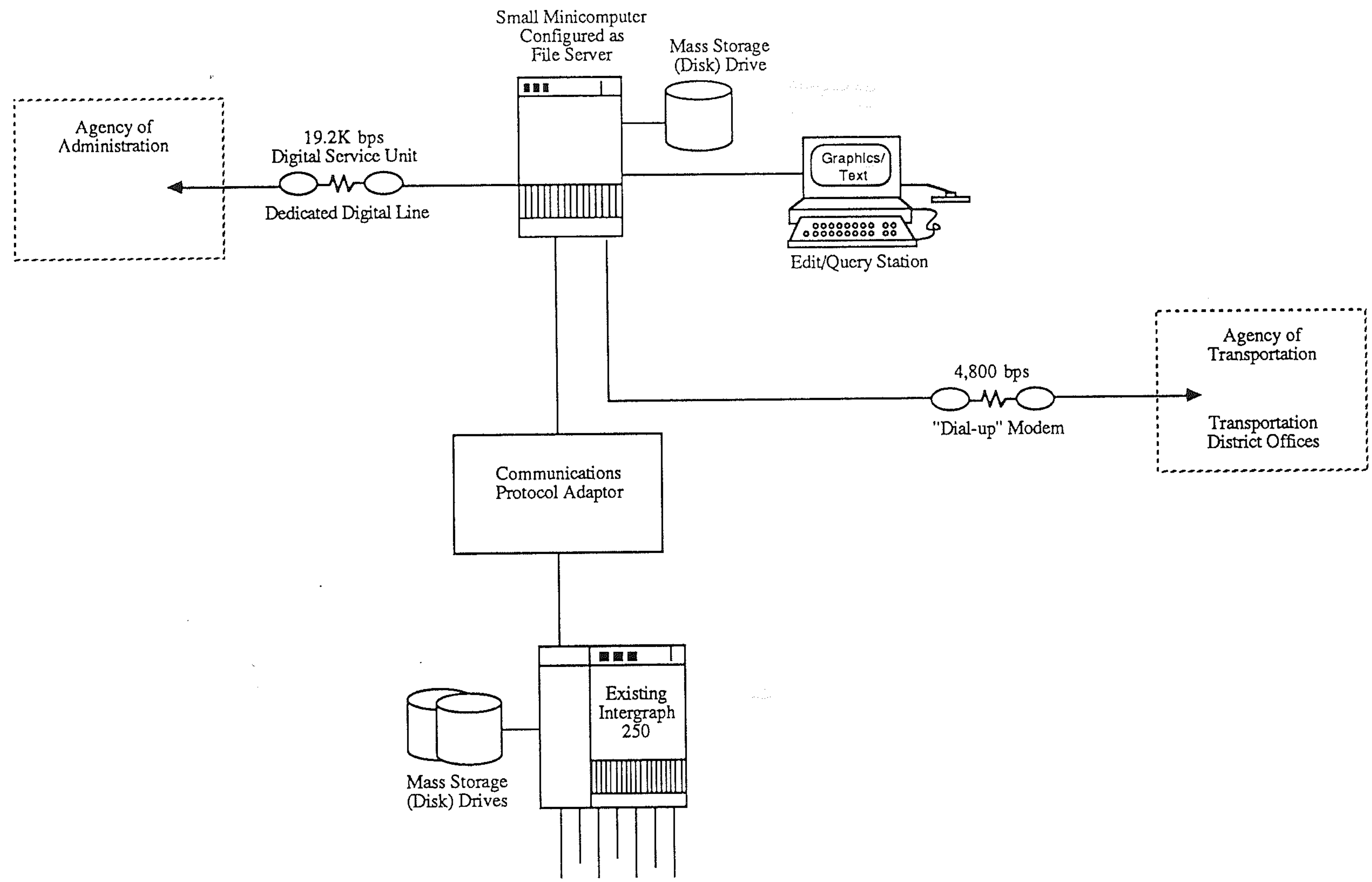


FIGURE 6-9
AGENCY OF NATURAL RESOURCES
STAGE II CONFIGURATION
State Office Complex, Waterbury

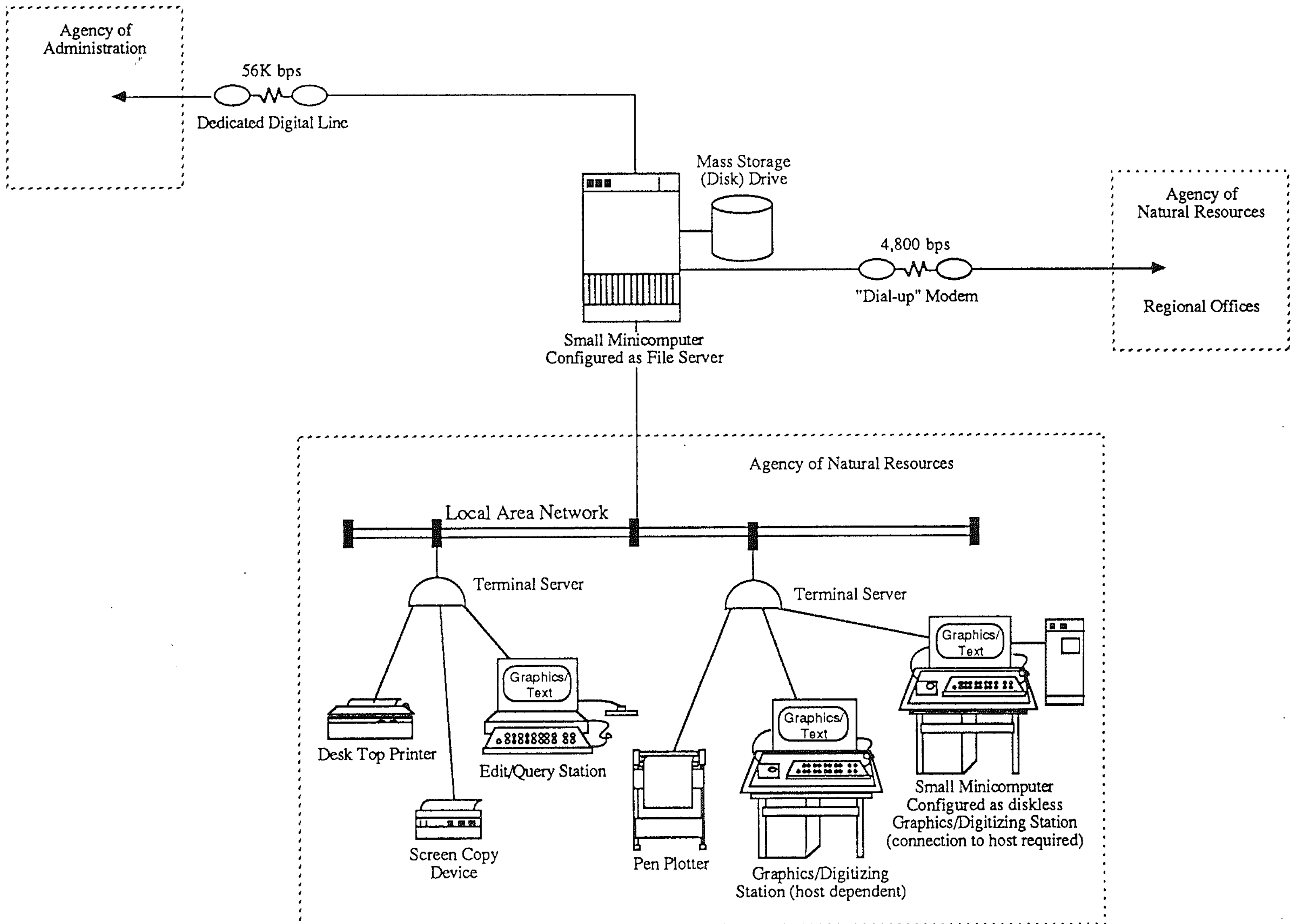
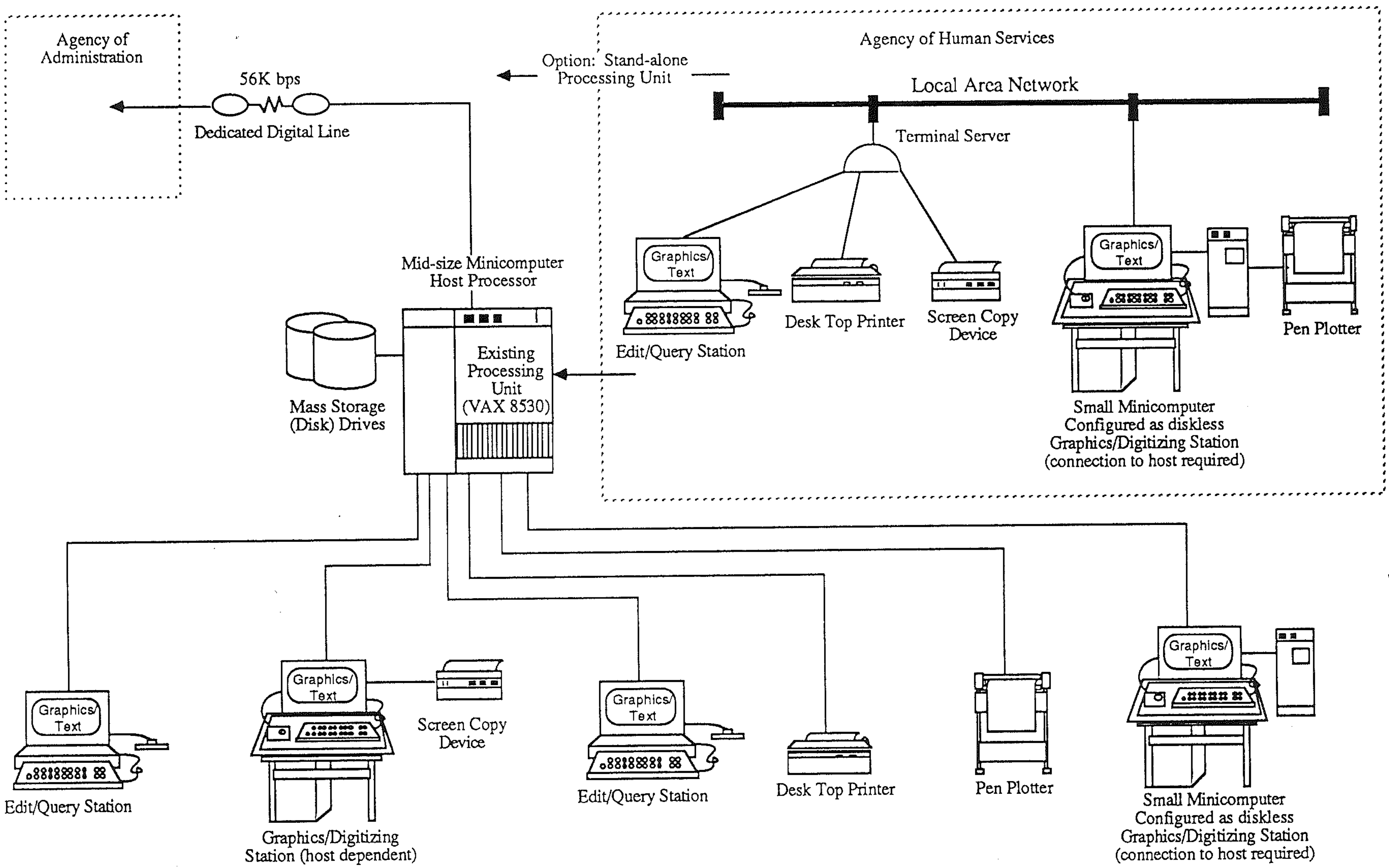


FIGURE 6-10
UNIVERSITY OF VERMONT SCHOOL OF NATURAL RESOURCES
AND AGENCY OF HUMAN SERVICES STAGE II CONFIGURATION
Burlington



The logic behind establishing these local area networks during Stage II is two-fold. First, the use of LAN technology will greatly improve the ability to transfer information throughout the GIS network. User access to data and devices will expand dramatically so that sharing of resources may be maximized where desired. The second justification of establishing LANs during Stage II is that these networks will lay a foundation on which future system expansion may be built.

System Expansion

Expansion of the Vermont GIS beyond Stage II may be accomplished in a variety of ways. Certainly one option is the continued expansion of the local area networks at the state level by incorporating additional users. These users may take the form of divisions and sections within participating state agencies, and new participants among the other classes of existing users: municipalities, regional commissions, private industry, and public organizations.

Additional equipment to support users such as these should be in keeping with that discussed in Stages I and II.

Stage II Configuration Cost Estimates

The total cost for the Vermont GIS Stage II configuration is estimated to range from $524,000. to $734,000. A more detailed breakdown of costs associated with the various Stage II system components is provided in Tables 6-2(a), 6-2(b), and 6-2(c).

Also indicated in Tables 6-2(a), 6-2(b), and 6-2(c) are the costs associated with implementing Stage II GIS technology at the regional and municipal/local levels. These costs have been calculated on a "per site" basis for the hardware, software, and communication components indicated in Figures 6-11(a) and 6-11(b). Total cost estimates for participants at these levels may not be determined at this time.

TABLE 6-2(a)
STAGE II CONFIGURATION COST ESTIMATES
FOR STATE LEVEL
(noted in thousands of dollars)

Component	Base Cost Low	Base Cost High	Units	Extended Cost Low	Extended Cost High
<u>Hardware</u>					
Processing Unit Upgrade	144.0	148.0	1	144.0	148.0
Small Minicomputer	45.0	60.0	2	90.0	120.0
Mass Storage 250 mb	10.0	15.0	2	20.0	30.0
Tape Drive	15.0	25.0	0	0.0	0.0
Micro Edit/Query	6.0	15.0	0	0.0	0.0
Edit/Query Station	5.0	10.0	3	15.0	30.0
Intelligent Edit/Query	20.0	30.0	0	0.0	0.0
Dig WS Host Dependent	15.0	25.0	1	15.0	25.0
Intelligent WS Diskless	25.0	35.0	3	75.0	105.0
Intelligent WS Disk	35.0	50.0	1	35.0	50.0
Pen Plotter	9.0	12.0	1	9.0	12.0
Electrostatic Plotter	30.0	70.0	1	30.0	70.0
Screen Copy Device	3.0	6.0	3	9.0	18.0
Desk Top Printer	.5	1.0	2	1.0	2.0
High Speed Printer	6.0	12.0	0	0.0	0.0
Alphanumeric Terminal	.5	1.0	0	0.0	0.0
Total Hardware				**443.0**	**610.0**
<u>Software</u>					
GIS Software License				60.0	90.0
Total Software				**60.0**	**90.0**
<u>Communications</u>					
Modem 4800	.5	1.0	4	2.0	4.0
Modem 9600	1.0	1.5	0	0.0	0.0
DSU Multi-Rate	.6	.8	2	1.2	1.6
Multiplexer	8.0	15.0	0	0.0	0.0
Terminal Server	3.0	5.0	4	12.0	20.0
Miscellaneous	6.0	8.0	1	6.0	8.0
Total Communications				**21.2**	**33.6**
GRAND TOTAL				**524.2**	**733.6**

TABLE 6-2(b)
STAGE II CONFIGURATION COST ESTIMATES
FOR REGIONAL LEVEL
(noted in thousands of dollars)

Component	Base Cost Low	Base Cost High	Units	Extended Cost Low	Extended Cost High
Hardware					
Micro Edit/Query	6.0	15.0	0		
Intelligent WS Disk	35.0	50.0	1	35.0	50.0
Pen Plotter	9.0	12.0	0		
Desk Top Printer	.5	1.0	0		
Total Hardware				**35.0**	**50.0**
Software					
GIS Software License	8.0	21.0	1	8.0	21.0
Total Software				**8.0**	**21.0**
Communications					
Modem 4800	.5	1.0	0	0.0	0.0
Modem 9600	1.0	1.5	2	2.0	3.0
DSU Multi-Rate	.6	.8	0	0.0	0.0
Multiplexer	8.0	15.0	2	16.0	30.0
Terminal Server	3.0	5.0	0	0.0	0.0
Miscellaneous	.5	1.0	1	.5	1.0
Total Communications				**18.5**	**34.0**
GRAND TOTAL				**61.5**	**105.0**

TABLE 6-2(c)
STAGE II CONFIGURATION COST ESTIMATES FOR LOCAL LEVEL
(noted in thousands of dollars)

Component	Base Cost Low	Base Cost High	Units	Extended Cost Low	Extended Cost High
Hardware					
Micro Digitizing	15.0	25.0	1	15.0	25.0
Intelligent WS Disk	35.0	50.0	0	0.0	0.0
Pen Plotter	9.0	12.0	0		
Screen Copy Device	3.0	6.0	1	3.0	6.0
Total Hardware				**18.0**	**31.0**
Software					
GIS Software License	2.0	5.0	1	5.0	10.0
Total Software				**5.0**	**10.0**
Communications					
Modem 4800	.5	1.0	2	1.0	2.0
Modem 9600	1.0	1.5	0	0.0	0.0
DSU Multi-Rate	.6	.8	0	0.0	0.0
Multiplexer	8.0	15.0	0	0.0	0.0
Terminal Server	3.0	5.0	0	0.0	0.0
Miscellaneous	.5	1.0	1	.5	1.0
Total Communications				**1.5**	**3.0**
GRAND TOTAL				**24.5**	**44.0**

FIGURE 6-11a
REGIONAL PLANNING COMMISSIONS
Example STAGE II Configuration

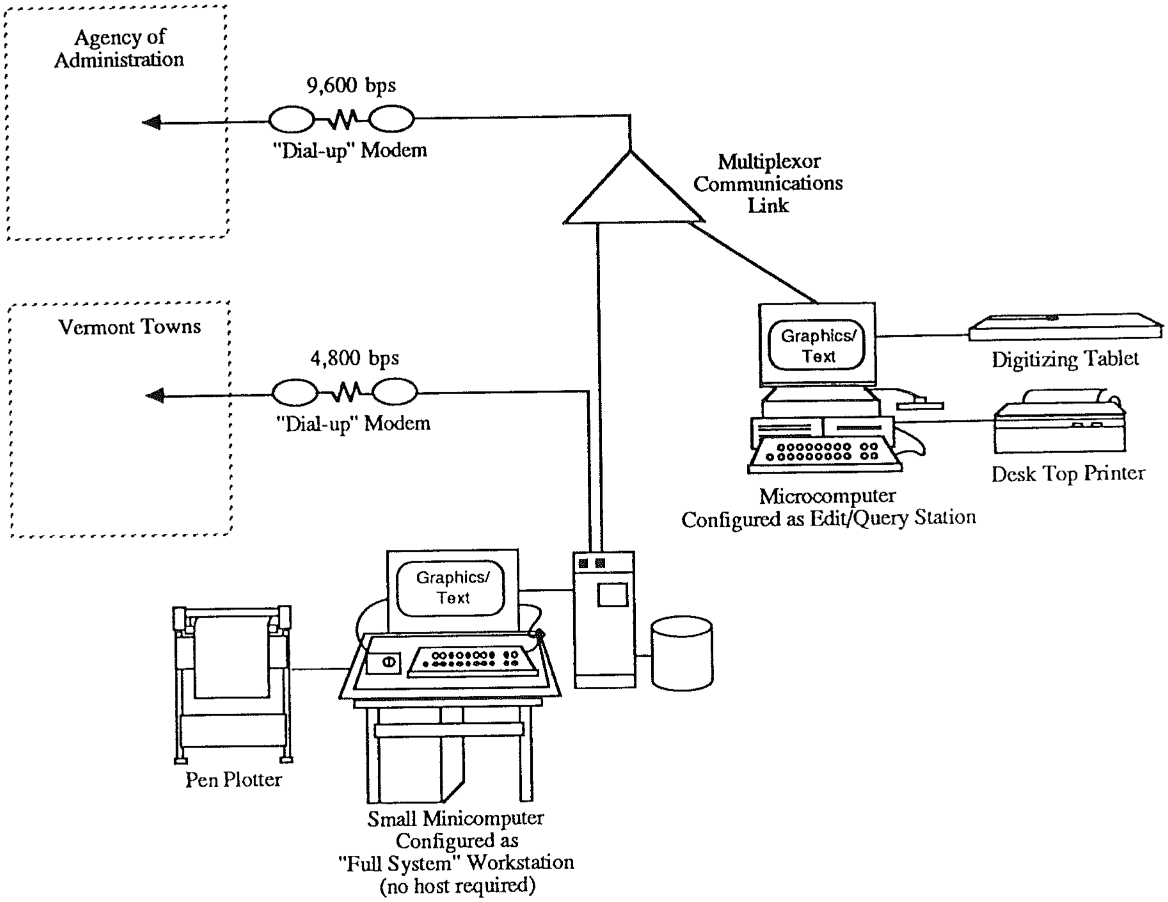
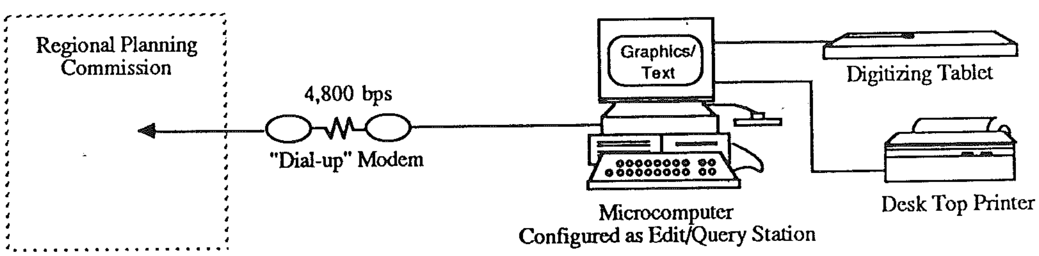


FIGURE 6-11b
VERMONT TOWNS
Example STAGE II Configuration



APPENDIX A
UVM - SNR GIS DATA SETS

APPENDIX A
UVM - SNR GIS DATA SETS

For Franklin, Grand Isle, and Chittenden Counties

Projection: State Plane
Input Source Scale: 1:20,000 scale state orthophoto reductions
Data Layers:

1. Soils (attributes from the SOI - 5)
2. Transportation Network (attributes from AOT)
3. Streams (coded by contamination class)
4. Town and County Boundaries
5. Major River Watersheds
6. Lakes and ponds are a part of the Soils Database
7. Land Use for Colchester, Williston, and Essex
8. General Zoning for Colchester, Williston, and Essex
9. Speciality mapping for Colchester, Williston, and Essex
10. LANDSAT TM Land Use for Franklin County.

For Lamoille County

Projection: UTM
Input Scale(s): 1:20,000 and 1:24,000
Data Layers:

1. Soils (1:24,000)
2. Town and Village Boundaries
3. Surface Waters (1:1000,000 DLG that was really taken from 1:24,000)
4. Transportation (same source as Surface Waters)
5. Major Public Land Holdings.

Separate Town Data Layers from Around the State

Projection: State Plane
Input Scale: 1:5,000 and larger
Data Layers:

STOWE
1. Land Use
2. Public Lands
3. Facilities
4. Transportation
5. Building Locations

PLAINFIELD (only about 1/2 of the town was studied)
1. Parcels
2. Soils

WOODSTOCK
1. Parcels
2. Soils

WESTON

1. Parcels
2. Zoning
3. General Land Use
4. Land Use and Cover currently in work

Statewide

All GIRAS data, Wellhead protection areas, Pollution Source Inventory, USGS DTTs, all DLG 1:100,000 Surface Waters and Transportation + Names are on order.