

Town of Amherst
GIS Implementation Plan

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Executive Summary

The Town of Amherst is poised to implement a highly effective GIS enterprise given its current infrastructure and cooperation among departments. Upgrades made to the computer network in preparation for the year 2000 has created an excellent opportunity to implement a GIS. The system requirements currently exist within the town for a GIS to function effectively in a multi-department, multi-application environment. Although there are near term limitations such as access to remote locations, these are not permanent barriers to multi-department use.

OGIA recommends that the town use its wide area network (WAN) file server architecture for the storage and delivery of GIS data. In the near term this will require dedication of two separate GIS file servers. One server for the Town Hall and Bangs Cultural Center and the other for the Department of Public Works local area network. Until the telecommunications infrastructure is in place to effectively link remote offices to the WAN, the town will need to rely on strict maintenance protocols to ensure the currency of the GIS datasets between the two systems. In the report, OGIA also recommends steps the town may take to manage the public distribution of GIS data and protocols for receiving development plans in digital formats.

OGIA estimates that the WAN, as currently configured, will adequately support a peak load of 12 users. This is the expected peak load in the near term.

Expansions to the system in the future to incorporate and additional six “peak load” users may necessitate some minor adjustments to insure that network transmissions remain fast and efficient. This system design should allow all departments to benefit from functions identified in the user needs assessment portion of the implementation plan. The functions most noted by users included:

- ❖ The ability to view the permit/license history of a property by boundary, building footprint, or street address;

- ❖ The ability to identify properties based on permit or license attributes;
and
- ❖ The ability to inventory and display natural resources and town utilities.

Amherst's GIS enterprise originated in a decentralized nature through the GIS Steering Committee. Cooperating collectively, departments combined financial and personnel resources to successfully initiate a GIS enterprise (with external partners). It is foreseeable that full implementation and management will continue in this fashion for some time. It is recommended that the town consider the roles and responsibilities that key departments will need to play in order to realize the benefits of the GIS enterprise. These key departments are:

- ❖ Assessor;
- ❖ Conservation Commission;
- ❖ Department of Public Works;
- ❖ Information Services; and
- ❖ Planning.

The implication of this decentralized structure is a reliance on Information Services for database administration associated with GIS attribute datasets. This cooperative arrangement will require negotiation among all departments in relation to budget submissions so that no one department bears the sole financial burden for maintaining the GIS. Further, pre-planning for personnel and equipment allocations by Information Systems for its support of the GIS will require special consideration. Also, Planning and DPW will need to assume the roles of "GIS experts" and allocate resources to assist those offices unfamiliar with GIS.

OGIA is confident that the strong culture of cooperation among departments will foster a smooth transition into these new roles and responsibilities. The Town of Amherst has planned diligently for a highly successful GIS enterprise and will certainly reap the rewards for many years to come.

Section I: User Needs Assessment

This section summarizes work completed under Phase I of the GIS implantation plan process for the Town of Amherst conducted by the UMASS Office of Geographic Information and Analysis (OGIA). It is intended as an overview of the information compiled from a *user needs assessment* conducted by OGIA during the Spring of 1999. The purpose of the assessment was to gather information from town personnel regarding current mapping and database functions, hardware and software used, and data sharing among departments. This information was analyzed by OGIA and used as the basis for GIS implementation plan recommendations discussed in Section III of this report. OGIA would like to thank the Town of Amherst staff for their cooperation during the development of this plan.

This section includes a discussion of the following items:

- User needs assessment interview process;
- Spatial data managed by department;
- Wide Area Network structure and hardware/software components; and
- Data sharing issues among department;

Interview Methodology

Departments expected to use or be to affected by the GIS were selected for an interview by OGIA under the guidance of Niels la Cour, Planner, and the GIS Steering Committee. Interviewees were asked a series of questions relating to data collection, data sharing, and potential uses for the GIS within their department (see Appendix A: *Town of Amherst User Needs Questionnaire*). Interviews were conducted from April through May 1999. Twenty-two (22) interviews were completed in person and three (3) were performed by telephone at the convenience of town personnel.

Interview Summaries

OGIA compiled user needs assessment summaries for each department interviewed (see Appendix B: *User Needs Assessment Summaries by Department*). The summaries are formatted to provide the following information at a glance:

- a review of the spatial information managed;
- the difficulties with sharing data; and
- potential for GIS applications for each department.

In this report, spatial data refers to any information managed by the town that is either location dependent or may reference a geographic location. In the summaries, the *Immediate Spatial Data Needs* section refers to those GIS datasets (coverages) that would be of immediate use by the department. In the *Potential GIS Applications* section, OGIA made some assumptions about the types of coverages that would require development or acquisition by the town. Information provided under this section and in the *Potential Personnel Needs* section should not be taken as definitive requests for GIS applications and hardware by staff. All potential needs were taken into consideration by OGIA in evaluating various system design options presented in Section II of this report.

Summaries were not prepared for departments for which no preponderance of information related to spatial data use was indicated in the interviews.

Spatial Data Currently Managed by the Town

Hardcopy Maps

The primary planimetric maps used in the town are of parcel boundaries, public water distribution, zoning, roads, and sewer distribution networks. Maps of these features are maintained by Assessor and Department of Public Works (DPW), respectively. With the exception of some GIS maps produced by the Planning Department, map production is outsourced. Accurate parcel maps are critical to the Assessor's office, Inspection Services, DPW, Planning, Conservation Commission, and Public Health. Although updates are made to tax map tiles by the Assessor, a composite updating and distribution of all tax maps has not occurred since 1995.

Changes occurring to the existing infrastructure of roads, road drainage fixtures, public water lines, and sewer lines are recorded on individual Record Plans (asbuilt maps) submitted by contractors to the town. In most cases, these Record Plans are the only source of data depicting new roads and other infrastructure. Only a composite index of public water distribution and sewer distribution maps are maintained by DPW. Record Plans are submitted to DPW upon completion of the subdivision and construction process to reflect structural changes as they exist in the real world. The department admits that not all Record Plans are submitted in a timely manner and draft plans are often all that are submitted by contractors.

Hardcopy and Digital Databases

A summary of the hardcopy records and digital databases managed by various departments is provide in the appendix of this report (see Appendix C: *Matrix 1: Hardcopy Maps* and *Matrix 2: Databases*). Each department has its own methods for managing both types of databases. Software used for digital files includes Paradox, Excel, Access, and proprietary systems such as VISION Appraisal. In many cases, filing and indexing is done by street address. For the purposes of

understanding data sharing among departments, the proprietary systems are discussed in detail below.

Overview of Town's Primary Electronic Databases

VISION Appraisal

This database application is used by the Assessor to record all parcels and their valuations. There are 13 terminals connecting to a file server allowing users to perform a selected set of queries (this includes one public terminal) of the database. Account access is limited to all others save the Assessor using password protection. Operations and queries include:

- The Assessor performs a primary query by parcel identification number (PIN) - map and lot number. Queries are also possible by address or by name of property owner (the typical query operation made the public).
- Other departments and the public (due to the interface structure of the public terminal) mainly use the secondary queries of address or property owner.
- The database records do not contain a conveyance of the property. Under Commonwealth law the legal description of a property is in metes and bounds as recorded on the deed or plat. PINs, as unique identifiers, have no legal bearing due to their mutability at the town level.

Updates to VISION are made as follows:

- Property values are entered annually in October for the following year; and
- Property data (address, ownership, PIN) is updated annually on the first of July in time for the preliminary tax bills.

VISION is downloaded into MUNIS for the calculation of tax bills. Data identical to both VISION and MUNIS includes:

- property value;
- PIN;

- street address;
- ownership; and
- parcel description.

Portions of the database are exported to the commercial Bankers and Tradesmen on-line database in return for modem access to its registry. The data is used by appraisers and realtors to create a registry of sales and reality guides.

The VISION application was upgraded to version 4.0, a Windows-based program, in December 1999. The version contains an ArcView extension that allows VISION to read ESRI shapefiles. The access is “read only.” Users can view a parcel shapefile and perform queries in an ArcView-like environment, but editing of Shapefile data is not possible from VISION (see Appendix D: “GIS Requirements and Considerations” documentation by Vision Appraisal Technology).

MUNIS

A relational database used to perform financial, payroll, and revenue/billing functions by the town. The application is comprised of five subsystems (subdatabases):

1. Payroll
2. Purchasing
3. Budget
4. Tax Assessor Process and Reports
5. Tax Collector Process and Reports

It is believed that the Assessor and Collector subsystems may differ in that the latter subsystem functions to reconcile revenue received for the two tax billing periods issued by the former. The two may share one or more common fields or relates.

MUNIS conducts seamless transactions among all subsystems. The posting routine allows relational sharing once data has been added/edited in one subsystem. MUNIS has import/export capabilities using ASCII file format. All subdatabases are individually exportable. MUNIS is available on the town's WAN.

Data entry schedule is as follows:

- *Tax Assessor information* twice annually (July and January)
- *payroll*..... biweekly
- *invoices* weekly

PERMIT*PLAN

This database program is used extensively to track the permit process for land development from initial application through approval. Tracking is performed by permit number or by address of the property in question. The application is available on the town wide area network (WAN) and is used by Planning (including Zoning Board), Inspection Services, and the Conservation Commission. The application was upgraded to Windows-based version for Year 2000 compliance. The new version is supported by an Oracle 8.04 database and is accessible to departments on the Wide Area Network including Public Health and Public Works. The GIS capabilities of PERMIT*PLAN are similar to VISION. The application contains an Avenue script within its System Utility Libraries to access ESRI shape files, however, the link is one-way. *PLAN can also import VISION parcel datasets (see Appendix E: for PERMIT*PLAN system utility documentation by Tidemark Corporation).

Computer Network Structure

Integral to the management of digital data is the town's computer network. This section is presented as an introduction to future discussions regarding the capability of the network to manage and distribute spatially-enabled datasets.

Servers and their function

Dickinson Compact Prolient 1600: 128MB RAM; 4G HD; Pentium I 166 MHz processor. Novell Netware 4.11. File and print sharing functions. Town-wide and file sharing.

Blake Compact Prolient 3000: 128MB RAM; 12G HD; Pentium II 300 MHz processor. Novell Netware 4.11. Primary function is for Information Services (Info Services) to archive PC software and related files.

Frost Compact Prolient 500: 160MB RAM; 4G HD. Novell Server. DPW's local area network, performs print and file sharing. Access to WAN via Shiva net modem.

Kipling DEC Digital Prioris XL (Dual Pentium 90's): 128MB RAM, 2 - 1G HD, NT Server. Runs Info Services' Help Desk application and tracks all help requests.

Beckett Dell 2300: 256MB RAM; 9G HD, Pentium III. Oracle 8.04. Runs VISION Appraisal.

“Copy” DEC Pentium 60. SCO Unix server. Copy of VISION. No terminal emulation or network connectivity.

Spenser IBM AIX server. 294MG RAM; 13G HD. Runs MUNIS (town financial software).

Byron Dell 6300. 1G RAM; 3 - 9.1G HD, Raid Array, Zyon 500. Oracle 7.x. Runs PERMIT*PLAN. This system is slated to receive the GIS datasets and will also be upgraded from Oracle 7.x to Oracle 8.01 (date of upgrade pending finalization per Information Services). In the future it may also include a copy of the VISION database.

Switches, Hubs, and Ports

Due to the size of the WAN it is necessary to segment the network into sections or groups of segments to optimize performance. The reason is that the longer the physical length of the network wiring, the greater the overhead and loss of performance. Switches act to segment the network and thereby increase overall performance by allowing each segment to operate in a smaller more efficient environment. The point of interface between a switch, the network, and a piece of hardware is called the port which resides on a hub.

The town WAN includes a combination of 10MB/second and 100MB/second switches. Hardware is allocated either a 10 or 100 switch is based on the capability of the network card installed and the need for a 100MB transmission speed. Older network cards are limited to 10MB/second switches. There are also a limited number of ports for 100MB/sec switches. Information Services estimates there are 24 ports for 100MB/sec switches and more than 36 ports for 10MB/sec switches. Hubs and switches are replaced on an as needed basis with an upgrade to 100MB/sec switches. Information Services expects that the GIS may require the purchase of new 100MB/sec switches for its most active users if reallocation is not easily made given the current stock of ports.

Network Structure and Use

An understanding of the Town's wide area network requires some explanation of how servers are linked and communication among departments is possible (see *Figure 1*). The networking software used is Novel Netware version 4.11. The

benefit of this version is that individual PC's may log into a single Novel Tree (the network) and have access to files available from multiple servers. For now the Novell Tree consists of:

- Dickinson, Blake, Beckett, Byron, Spenser and Frost.
- PCs on the Tree have a transparent log-in.
- Tree users include all departments in the Town Hall and Bangs Center and DPW.
- Access to PERMIT*PLAN requires a separate log-in procedure.
- The Town Hall contains 10x100 cables cable of transmission speeds of 350MB/second.

Sharing environments are set by Information Services and each department is provided its own share area and access to a town-wide share area on Dickinson. Users of the Tree have internal email capabilities (external Internet connection is still pending). Access to the WAN requires a user account and password. The rights (access capabilities) of an account are assigned to it by Information Services using Novell Directory Services security structure.

Connection to the Novel Tree from outside of the Town Hall is enabled by modem access at 10MB/second using Media One cable company's infrastructure. The town purchases one channel access from Media One. A Shiva net (cable) modem hard/software is used for eight-line continuous access to the Bangs Cultural Center. The modem software is not serial data output, but network data transferred through the network port using Internet Protocol (IP) for the Oracle platforms and IPX protocol for the Novell servers.

Connection from DPW is made via a telephone modem on the Frost server that supports the DPW local area network (LAN). Access from Frost to the WAN is limited due to the bandwidth of telephone modem access at 56.6 kilobytes per second. Large file transfers between the two are not allowed by Information Services as the transfer of a 2 to 3 megabyte file would take up to an hour and, in

turn, slow all other interactions between Frost and the WAN. However DPW users *do have log-in capabilities to MUNIS, VISION, and PERMIT*PLAN.*

Departments not connected to the WAN include the Library, Fire, and Police (see *Figure 2*). However, the Library maintains its own Internet connection and has dial-up modem access to the MUNIS system. These departments along with DPW are expected to have cable modem access when Media One completes its upgrade to a town-wide, all fiber optic system by 2001 (see *Figure 3*).

Personal Computer (PC) Capabilities

In late 1999, the Information Services Department upgraded all personal computers to Pentium III systems with a minimum of 64MB RAM and 6.4G HD using a Windows NT operating system and Ethernet connections. These specifications will facilitate use of the desk-top GIS software by staff.

Data Sharing Among Departments

Summary by Department

During the needs assessment, staff were asked to discuss information transfer and data sharing in their office and with other departments. Overall, staff expressed that there was a considerable amount of cooperation among departments, especially with regards to the land development and building construction permit processes. Summaries of the most critical data sharing needs and inconsistencies are provided below. Instances where spatial information managed by one office was cited as a need by another office is noted.

Assessor

- Access to PERMIT*PLAN application. Receives hardcopy printout of building permits and must manually enter this into VISION Appraisal database. Need for interface.
- Inconsistent parcel number and street address matching.

Clerk

- Inconsistencies of street address matching among the Clerk, Assessor, and Inspection Services for the same property.
- Integration of Underground Storage Tank Registration database with PERMIT*PLAN for access by all departments including Fire.

Conservation Commission

- Con Coms hardcopy files may not contain accurate map and lot numbers and/or addresses. Consequently, Con Com has found inaccuracies in the assessment database regarding this information due to unique identifier mismatching.
- Property assessments may omit APR and easement data all together.

Fire

- Networking of Fire stations to one another and the town WAN.
- The ability to review all permits associated with a property managed in digital form by other departments.

Information Services

- Long-term goal is a centralized relational database structure for all applications and users to improve overall information management and efficiency of storage.

Inspections Services

- Housing office of Inspection Services does not have adequate access to PERMIT*PLAN and uses an entirely separate permit tracking software application.
- Inconsistent parcel numbers and street address matching.

Library

- Town personnel lack awareness of the content of its special collections. Archives could prove useful to planners and engineers.

Police

- Town Clerk issues Business Certificates that are the public record of ownership, occupancy, and location. This database could be of use to Police in maintaining current occupancy data on commercial buildings.
- Access to town WAN. [Note: Information systems management for the Police Department is now a responsibility of Information Services.]

Planning

- Until recently Planning, Con Com and Building Inspection are networked to the Plath server which was not part of the WAN. The capability for Planning to access VISION and share PERMIT*PLAN data with other departments is just

emerging. However, for departments not connected to the WAN there is still a barrier to sharing permit data for the purposes of spatial analysis.

Public Health

- Records of noncompliance and permits managed by the Public Health Inspection Services office would be more useful in digital format for access and analysis by Department and the Board of Public Health.

Public Works

- Access speed to town WAN.

Town Manager

- Need for convenient access to street regulations including speed limits and parking during Select Board and other committee meetings.

Veterans Services

- Town Clerk manages cemetery deeds and death records. These databases could be useful to Veterans Services in tracking the gravesites of veterans.

Discussion of Data Sharing Issues

Several data sharing issues surfaced repeatedly during the needs assessment of 1999 that may prove critical to the implementation of the GIS. First among them is expansion of the WAN to include Fire and Police and improving modem access at DPW. Second, staff expressed the need to improve upon the permit review process so that all departments involved may have access to the various digital databases of permits with the goal being consistency of review. This goal is illustrated in the request for a GIS application that would allow users to view the entire licensing and permit history of a single property by selecting a parcel, building footprint, or by querying an address in the GIS. Third, there is a need to

improve the matching of street addresses to the corresponding parcel identification numbers.

Property Address Matching

As gleaned from the needs assessment, property address mismatching occurs in two ways. First, addresses may be assigned before a PIN is established by the Assessor. A dummy parcel number may prove useful in the near term, but seems to only propagate future problems. For once a permanent PIN is established, other departments have already instituted use of the dummy PIN with its associated street address in their records.

Thus queries made by staff and the public of the Assessor's database may not provide an address matching that which is listed on the building permit or other records. Further, parcel numbers have changed over time and may possibly change entirely under the GIS implementation. Thus, a correct street address to parcel match may be two to three generations removed from the point at which a data trail was originally established.

The second mismatch occurs when street addresses are derived from sources other than Inspection Services. For example, the Town Clerk publishes the Town Street Guide using address assignments from Inspection Services and responses to the town census. Staff enter into the Commonwealth Voter Registration (CVR) database the mailing address from each town census response. The Clerk uses the CVR database to track voters, as required by law, and to maintain Amherst's census registry.

Street addresses in the CVR database are used the following year for the Guide update and to generate a new census mailing. Census questionnaires returned by the U.S. Postal Service (USPS) marked "undeliverable" are investigated by the Clerk. In doing so, the Clerk has noted inconsistencies with the addresses listed in the Assessor's database and Inspections Service's records. A resolution may

be difficult to achieve especially if the source of error is unknown. In some cases Inspection Services has found that residents intentionally or unknowingly use the wrong address. The Clerk's policy is to remove those addresses from the database that were undeliverable by the USPS.

The question of address accuracy raises a question about spatial data sharing. Are departments aware of the breadth of spatial information collected and the data's currency? For example, the Police Department will find during a call for service that occupancy and street address do not match their records originally obtained from Inspections Services. Frequent residency turnover in a college town is to be expected and it is not unusual that occupancy information is quickly outdated. However, the Clerk's Business Certificate database and Voter Registration data are current to the previous year and should present the most recent source for information on commercial and residential occupancy at a specific location. Whether or not the Police Department is aware of this data or its availability points out that there are many avenues of data collection for the same information converging within town government.

Parcel Identification Number Recommendation

Because the street address is widely used as a unique identifier and since departments are in the process of automating hardcopy records, OGIA recommends that the GIS Committee consider adopting a standard address format for computer databases. In the future this step will greatly speed a user's ability to attach attribute data to coverages and thus add immediate value to the GIS. Linking a GIS coverage to a database requires a common field or relate. The relate must have the same width, format, and definition, either number or string. OGIA recommends the standardized address format developed by Urban and Regional Systems Association and the Association of Assessors (1992) (see *Figure 4*).

To minimize redundancy and maximize the use of the spatial data, either in electronic or hardcopy form, street addresses should be recorded and spelled only one way. Regardless of whether an address is used as the primary identifier, it is recommended that GIS Committee adopt some type of standardization for use by all departments.

There is an expectation that the GIS will provide a resolution to data sharing issues. Only thoughtful planning about how information is collected and the most efficient and logical way to manage that information will resolve redundancies and errors. In the long run, the GIS can increase the efficiency of data management for all users. The GIS implementation is the process whereby inconsistencies in spatial data management are resolved in preparation for better use through the GIS.

GIS Enterprise Partners

The Town of Amherst's data development contract with Merrick is a multi-partner agreement involving Amherst College and the University of Massachusetts (UMASS). As such, the partnership will constitute data sharing among the three institutions and this will in turn expand opportunities for project applications, the scope of data maintenance, and data distribution issues. The latter topic is explored in greater detail as part of the town's potential data maintenance protocols.

Potential GIS Applications Requested by Departments

During the needs assessment, OGIA asked each interviewee to identify the different GIS applications or products that would be useful to that particular department. These potential GIS applications are provided in Appendix B: *User Needs Assessment Summaries by Department.*

In general these request constitute the following applications, products, or functions:

1. The ability to view the permit/license history of a property, building footprint, or street address;
2. The ability to identify properties based on permit or license attributes;
3. Identification and analysis of natural resources;
4. The ability to inventory and track utilities and infrastructure (i.e., sewer lines, manhole covers, street lights);
5. Modeling and analysis of natural and manmade systems such as erosion rates on slopes and changes in water pressure due to the addition of new structures;
6. Enhance emergency response operations;
7. Identify potential threats to drinking water sources for surface and subsurface activities;
8. Enhance landuse, demographic, and economic development analysis;
9. Streamline collection, management, and updating of spatial data by all departments involved in issuing or approving permits and licenses; and
10. Provide convenient public access to spatial data managed by the town.

Section II: Analysis of GIS System Design Options

In this section OGIA evaluates the various options for GIS data storage and delivery. Given the rapid changes in technology, it is necessary to consider each GIS system design option within the context of the town's current hardware structure. In cases where particular advances are required in Internet capabilities or network access, OGIA attempted to forecast how scheduled changes in network components and capabilities by the town may affect these options. The following data storage and delivery options are explored in this section:

- Client/server systems
- Internet
- SDE

Based upon the needs assessment, there is a strong indication that customization of a software applications would enable staff to perform routine and beneficial functions using the GIS. Customization within a system can occur in many ways. Third party software applications may be used as "extensions" to enhance existing software applications. For example, Southern Digital Services (SDS) pARCEl mAPPer software will allow the Assessor to edit the line work of the parcel coverage without having to master advanced GIS software. There are also customizable templates for web-based applications that would allow users to select datasets for querying and printing of thematic maps.

In this section, OGIA looks broadly at the system design strategies, all of which can be modified to incorporate customization of software and extensions. Recommendations based on these findings are discussed in Section III of this report.

Traditional Client/Server Architecture of An Area Network

The most direct method of sharing GIS data is through file sharing services and relational database management systems (RDBMS) residing on an area network. GIS applications may run locally on PCs or workstations and the file servers are mounted as local disk drives to provide transparent access to spatial data and to attribute data. Communication between the PCs and the file servers is dictated by permissions assigned by the system administrator through the file sharing security network and through the RDBMS.

Since communication across network will produce overhead no matter what server platform is used (UNIX or Windows NT) the speed of transactions is dependent upon the type of network equipment: cable, switches, and hubs and the RAM and hardware disk capacities of the file servers. Improper sizing of the GIS to the network can result in delayed processing times for servers tasked by even a minimum number of users and/or by processing a single large megabyte datasets (such as graphic files).

System Requirements

The addition of a GIS to an area network may work in the following manner. Standard GIS client applications (ARCINFO and ArcView) send queries to a file server and receive the sum total of a spatial data or an attribute file for processing at the desktop. Data required by the client is loaded in its entirety and the efficiency of this transaction has many variables. Bandwidth and network transmission speeds will define the performance of GIS client applications that are dependent upon remote file servers. For example, ESRI estimates that a 1 megabyte (MB) file transferred from a data server to a GIS client application will take 360 seconds at 56 kilobytes per second (KBPS) as opposed to .2 seconds at 100 MBPS.¹ Further, a typical GIS application requires up to 1 MB of data to generate a new

¹ Peters, Dave. 1999. *System Design Strategies*. Environmental Systems Research Institute, Inc. Redlands, California: 3-5.

display of geographic features. [This alludes to the fact that there should be 100-200 MB of free "swap space" on a PC's hard drive to perform routine GIS operations.]

ESRI recommends a bandwidth of 16 megabits per second (MBPS) for local area networks (LAN) supporting 8 to 16 client applications and 6.16 MBPS modem to support 3 to 6 clients over a wide area network (WAN).² *In the typical client server processing environment cited by ESRI, a single-CPU Pentium III Xeon 500 system can support 15 concurrent GIS clients.* In this example ESRI does not distinguish among GIS clients as both ARC/INFO or ArcView client applications are considered equal for sizing purposes.³ However, as a general rule for determining network demand concurrent GIS clients are defined as follows:

- 1 ARC/INFO = 2 ArcView clients
- 1 Batch process = 3 ARC/INFO clients

To put this into this information into the context of the town's situation, a GIS system using the current WAN infrastructure could support 6 to 16 clients. OGIA bases this estimate on the following system components identified in the needs assessment:

- the Byron server (1G RAM, Raid Array 3, 9.1G hard drives) for GIS data storage;
- the 10 by 100 fiber optic cable infrastructure and available 100MB switches; and
- the 10MBPS cable modem transmission speed as the minimum bandwidth to remote sites (Town Hall transmission speed is 350MBPS).

Recommended sizing requirements are discussed in greater detail in Section III.

² Peters, Dave. 1999. *System Design Strategies*. Environmental Systems Research Institute, Inc. Redlands, California: 3-7.

³ Environmental Systems Research Institute, Inc. System Architecture Design Notes: 7-6, 7-24, 7-25.

Disk Mounting (Connecting to Multiple Servers)

Disk mounting options will vary between UNIX and NT platforms. For example, on NT ARCINFO will require open database connectivity (ODBC) drivers for each type of RDBMS used on the remote spatial data or attribute servers (MS SQL, Access, Oracle, Sybase). UNIX systems use Novell File Sharing (NFS) products that are readily executable by ARCINFO for this purpose. In environments where multiple users may have need to update/edit spatial data, transaction permissions may be managed by two ARCINFO extensions: ArcStorm Data Server and ARCINFO LIBRARIAN. [Note: VISION and *PLAN both use different versions of SQL and Oracle. If versions are compatible, it may present an opportunity for connection between these RDBMS and a GIS database.]

ArcStorm provides control over what types of spatial features are available for use and editing by what user. It also records transaction histories providing a measure of documentation on use. LIBRARIAN is a module that provides for the currency of tiled coverages in a multiple user environment. When a particular tile is edited by one user, other users are prevented from also editing this tile, but not from accessing it for display and analysis purposes. LIBRARIAN is a tool for multiple users to maintain and manage a large GIS database.

Remote Client/Server Access

DPW's remote location and use of a centralized GIS database is an example of remote client/server access. Remote access is facilitated in a Windows NT environment using Windows Terminal Server software developed by Citrix Corporation. Citrix's software has low bandwidth requirements whereby centrally housed data and applications are transmitted over the network to remote users with little overhead (for more information see www.citrix.com/products/).

Internet (Intranet) Delivery Options

The potential also exists for an Internet (Intranet for internal operations) delivery system for data and applications. Customizable mapping and analysis tools could be made readily available to users within the town government and provide similar access to the public. Internet delivery requires additional technology beyond file servers including a dedicated web server and in some instances a dedicated map server.

Use of Internet technologies requires an additional layer of expertise and resource management; the cost of which cannot be fully quantified by OGIA due to the dramatic evolution underway in the Internet industry. Considerations for an overall Internet strategy for the town may be required to fully pursue this GIS system option.

The use of Internet technology provides the following opportunities for GIS users:

- The ability to search for and download GIS datasets (raster and vector) using a PC's Internet browser;
- The ability to conduct multi-step queries of datasets interactively over the Internet so that the user may print the results as a thematic map or tabular data; and
- The ability to preview raster images, graphics and vector data prior to downloading.

To provide an effective service for GIS data delivery on the Internet it's necessary that users have the ability to select specific datasets and perform queries. The common approach here is to categorize GIS datasets by function or use. A functional grouping of the town's spatial datasets could be maintained as an HTML page with hyperlinks to the individual datasets. A similar approach is used by MassGIS on its website (see <http://www.state.ma.us/mgis/ftpintro.htm>).

In order to serve spatial datasets on the net, it is necessary to link the web server and the associated server containing the GIS database. This link is enabled using special software that receives and returns the results of queries to the GIS database from users via the web server.

Some popular web servers have this functionality including the Microsoft Internet Information Server (MS IIS). This software provides for elementary database operations: query, editing record etc. Several solutions for advanced database publishing capabilities can be suggested. OGIA uses Cold Fusion (<http://www.coldfusion.com>) software in its applications and recommends it in addition to the Microsoft Internet Information Server.

Viewing and Obtaining Spatial Datasets Using Internet Protocols

This function assumes that users can download GIS datasets to work with them locally. This capability is provided with almost all Internet servers through HTTP and FTP protocols (hypertext transfer protocol, file transfer protocol). For example MS IIS includes web and ftp servers. To download data through HTTP protocol users can use any Internet browser and in the case of FTP protocol users can use any FTP client program. This option will be effective if there is metadata search capability as discussed above.

Based on analysis of GIS delivery servers of several organizations (ESRI, MassGIS) OGIA noted the tendency to supply a data viewer with datasets, as well as special format conversion utilities. For example, ESRI offers their ArcExplorer viewer and import utility (www.esri.com/arcexplorer) at no cost. ArcExplorer supports ESRI shape files, ARC/INFO coverages and SDE layers. The import utility converts .E00 interchange files into ARC/INFO coverages readable by ArcExplorer. In another example, MASSGIS (www.massgis.com or www.state.ma.us/mgis) provides its DataViewer as a download option from its website and on CD ROMs as an accompaniment to spatial datasets. In fact, the

DataViewer is a runtime version of ArcView v.3.0, with special limitations in functionality. This viewer provides tools to create finished maps and to save it in most popular formats.

The drawback of these products is that they are single-platform oriented and they do not function on Macintosh and Unix operating systems. In conclusion, the most efficient and least costly method for distributing complete GIS data sets for public and internal use is to store a copy of the spatial datasets a single Internet server coupled with (free) downloadable viewers and metadata documentation.

Internet Mapping

Originally, Internet technology provided limited opportunity for interactive applications between the user (via a browser) and the data or images. To bring GIS interactive capability to the web it is necessary to use software extensions. The internet/intranet GIS datasets delivery model includes three components:

- web server
- map server
- user application.

An advantage of the three component approach is that users don't need to obtain special client software for their browsers. The uniformity provided by the browser is also a positive feature of this approach. ESRI offers three products for Internet Map publishing. The differences between them are distinguished by how individual software elements are distributed among model elements. They are:

- ArcView Internet Map Server
- Arc Internet Map Server
- MapObjects Internet Map Server.

The abilities and advantages of each Internet map publishing application is discussed as follows.

ArcView Internet Map Server (IMS)

ArcView IMS is an extension for ArcView GIS and provides Web publishing capability. This product includes a special Java (an Internet programming language) applet, MapCafe. MapeCafe is used as the client application. The user's browser loads this applet and it is used to request content from the ArcView IMS application. The process works this way:

1. The web server receives a request from the browser such as *<display Voting District Map>*;
2. The web server passes the request to the map server hosting ArcView IMS for processing; and
3. After the GIS application performs that request the results are sent back to web server. The web server then transmits the result back to the browser. Such a result might be such a graphic file depicting the Voting District Map at a set scale using specific labels selected by the user in the original request.

The advantages of this interactive approach from browser to web sever to map server is the opportunity to serve the contents of ArcView projects including the graphic map content and data tables. The drawback is the cost and investment in ArcView IMS extension and a version of ArcView GIS must be dedicated for use with the extension.

Arc Internet Map Server (IMS)

Arc IMS implements the same functionality as ArcView IMS does but Arc IMS does not require ArcView GIS. Arc IMS is a stand-alone service or daemon. Arc IMS Manager makes map publishing easy based on a set of ready-to-use templates.

MapObjects Internet Map Server (IMS)

This application is a set of components that manage Web client requests, dispatch and broker requests to Web server GIS applications, and sent results(maps and data) to users. MapObjects IMS is part of the MapObjects Internet Solutions Kit that includes MapObjects IMS, MapObjects, and ArcExplorer.

MapObjects IMS provides two methods for authoring maps. The first and easiest method is to create maps within the map creation interface of ArcExplorer. A map is constructed as an ArcExplorer Project File (similar to the View-to-Layout operation of ArcView) and is loaded into the IMS Administrator interface as a map object. Once in the administrator, the object is available for deployment to web clients. The second method is to use the components of MapObjects and MapObjects IMS to build a custom mapping application that serves a map view to web clients based on a set of variables they select interactively on the browser (geographic features, scale, colors, etc.).

The latter method provides the user with the greatest amount of selection and utility whereas the first option is akin to providing pre-published maps over the web. MapObjects IMS offers extended functionality to customize your application, but requires mastery of object-oriented programming skills to utilize the templates (see www.esri.com for an introduction to MapObject's capabilities).

A Spatially Enabled Relational Database Warehouse

ESRI's Spatial Database Engine (SDE)

This is a true advance in geospatial data management. It takes advantage of the record storage functions of relational database management systems to combine attribute and geographic data as a single record within a RDBMS server. Traditional client/sever communication results in a great deal of network traffic and inefficiently places the burden of query processing on the GIS client application. SDE transfers the query processing from the client to the SDE server and significantly enhances the performance of the client and reduces network traffic.

SDE Data Warehouse

In this schema, the feature object is the SDE layer (also known as a GeoObject). The GeoObject is an amalgam of three compressed data types containing feature attribute elements, topology, and projection. The SDE server is an application interface server between the client GIS application and the RDBMS file server. The SDE server receives a transaction request for data from the client and returns the request from the DBMS server(s).

The SDE client/server configuration allocates the burden for processing the data query on the DBMS, not the GIS application. The requested data is located and filtered so that only the specific components requested by the client are returned over the network. Thus a data transfer can be much smaller in size and effectively reduce network overhead and peak loading from each client/server transaction. ESRI estimates that an SDE warehouse can support 10-20 users on a LAN with a bandwidth of 10 MBPS or 6-12 users on a WAN using a 6.16 MBPS modem.⁴

ARCINFO version 7.x and 8.0 for desktop and workstation, ArcView, and AutoCad include SDE clients that support direct access to a single RDBMS server. If more

⁴ Ibid., 3-7.

than one RDBMS is used, each will require an SDE interface. The main advantages of SDE are superior storage efficiency and economy; the ability to convert and eliminate the use of multiple spatial data types into SDE layers; and more efficient use of the client's processing functions. ARCINFO LIBRARIAN compliments SDE in systems where there is more than one ARCINFO client in operation. No disk mounting is required under this architecture.

Currently, prototypes of SDE implantation are underway in some large public organizations. The Maine Department of Environmental Protection www.state.me.us/dep/gis has prepared a summary of its prototype development current to November 1999. Although it is too early to predict how Maine's implementation lessons may be of value to smaller institutions, SDE technology warrants future evaluation by the town (see Appendix F: *MDEP's Integrated Information Systems Development with Arc Info 8.0*).

Configuration Guidelines

The following configuration guidelines are adapted from ESRI⁵. ESRI developed the chart to demonstrate what the baseline for configuring a distributed area network would look like for a number of GIS system options. The number of recommend clients is based on ESRI's experience with actual system implementations and does not represent worst-case, peak load situations.

ESRI recommends that networks should be conigured to accommodate "GIS power users" whose data transfer needs meet the maximum bandwidth parameters of the system. For example, in the town's WAN this would constitute allocating 100MB switches to power users and fiber optic connections to remote users.

Chart 1: User Configuration Guidelines

Area Network Bandwidths	Concurrent Client Loads			
	File Servers	SDE Servers	Windows Terminals	Web Products
56KB/sec modem	not recommend	not recommend	1-2	1-2
1.54MB/sec T-1	not recommend	not recommend	25-50	25-50
10MB/sec	5-10	10-20	150-130	150-300
100MB/sec	50-100	100-200	1500-3000	1500-3000
1G/sec	500-1,000	1,000-2,000	1,000-30,000	1,000-30,000

⁵ Peters, Dave. 1999. *System Design Strategies*. Environmental Systems Research Institute, Inc. Redlands, California: 7.

Section III: Recommendations

In this section OGIA provides its recommendations for a near term GIS implementation plan. Special consideration is paid to administrative responsibilities as well as system requirements. In this section OGIA addresses the following:

- A near term system design;
- Administrative structure;
- Data maintenance and management protocols; and
- An implementation schedule.

GIS System Design

Client Server Network

The town is poised to implement a highly effective client/server system given its current infrastructure. OGIA recommends that the town use its WAN file server architecture for the storage and delivery of GIS data given the following considerations (*see Figure 5: GIS System Near Term*).

- Two separate GIS file servers are required because DPW is a primary GIS user with remote access to the WAN that does not permit file transmissions (a limitation 56.6KB/sec dial-up modem).
- The recommended GIS servers are –
 - Byron, for the Town Hall and the Bangs Cultural Center, and
 - Frost for all of DPW LAN.
- In the interests of data security and currency, both servers should mirror each as much as possible.

The Byron server with its three 9.1G partitions should provide ample space for all GIS datasets (vector and raster files) in the near term and once all departments are connected to the WAN. Network transmission speeds of 350MB/sec in the

Town Hall and the 10MB/sec using the Shiva cable modems are more than adequate to handle the peak load of clients within the near term.

OGIA estimates that the town WAN, as currently configured, will support a peak load of 12 users in the near term. Expansions to the system in the future may necessitate some reengineering such as the allocation of 100MB switches to the most active GIS clients. The following chart is provided to illustrate the number of concurrent GIS users identified in OGIA's estimate. The chart is also useful in understanding how use will change once fiber optic systems connect all remote offices (Fire, Police, DPW, Library) and adds GIS clients the system.⁶

⁶ Adapted from ESRI. System Architecture Design Notes: 5-7.

Chart 2: User Application Requirements

Location	ARCINFO		ArcView		ArcExplorer	
	Total	Peak	Total	Peak	Total	Peak
Town Hall / Bangs Center						
Assessor*			1	1	1	1
Clerk					2	1
Conservation Commission			3	2		
Inspection Services			2	1		
Leisure Services					1	1
Planning	1	1	3	2		
Public Health					1	1
Town Manager					2	1
Veterans Services					1	
<i>Subtotal 1</i>	<i>1</i>	<i>1</i>	<i>9</i>	<i>6</i>	<i>8</i>	<i>5</i>
Remote Offices						
Fire					1	1
Library					2	1
Police					1	1
Public Works**	2	2	2	1		
<i>Subtotal 2</i>	<i>2</i>	<i>2</i>	<i>2</i>	<i>1</i>	<i>4</i>	<i>3</i>
TOTALS	3	3	11	7	12	8

*(the ArcView extension in VISION or pARCEl mAPPER is considered one ArcView client)

** (AutoCad is considered one of the two ARCINFO clients)

Hardware

OGIA expects that the town will have few hardware expenditures to fully implement the GIS. Upgrades made by IS to the computer in preparation for the year 2000 to have indirectly met the system needs of a GIS. In summary this upgrades include:

- expanding the RAM and hard disk capacity of the servers,
- the addition of new and faster servers;
- upgrades of the major RDBMS to Windows-based platforms; and
- upgrade of all personal computers to Pentium III, 64MB RAM, 6.4G hard drive systems

Expected near term purchases may include

1. new 100MBPS switches for its most active GIS users; and
2. additional ports or new hub of ports to accommodate 100MBPS switches.
3. map plotter for the Assessor's office; and
4. large scale color printers for Inspection Services, Clerk, and Public Health for producing functional maps as part of their public duties may be considered by the GIS Steering Committee after full implementation has occurred.

Near Term Considerations for DPW

Since DPW does not conduct file transfers over the WAN, the department will have to maintain separate copies of spatial data on Frost. This will necessitate the need for a CD ROM writer to transfer data between the department and other users until fiber optic connections make file transfers across the WAN feasible.

GIS Client Software

Based on the needs assessment and discussions with the GIS Committee, OGIA recommends that the town develop a two-tier system for software distribution. The first tier would include GIS users who require high-end software application that perform the necessary functions of data development, manipulation, and mapping. The second tier describes users who need mapping and query functionality, but for whom learning a high-end desktop GIS software package would be cumbersome and potentially lead to avoidance of the GIS. There is also an issue of cost in that each running copy of GIS software requires a separate, annual license fee. Annual maintenance and support fees are additional costs to the town.

OGIA suggests the use of ArcExplorer 1.01, a free software package from Environmental Science Research Institute (ESRI), for Tier 2 departments. ArcExplorer will support their immediate needs and foster learning and integration of the GIS at the lowest cost. In the future, the GIS committee can look at upgrading individual departments to other applications.

Software will run locally on PCs using the Windows NT operating system.

Tier 1

- Software: ArcView 3.0
- No. of copies: 8-10
- Departments: Planning, Con Com, DPW, Inspection Services (including Public Health Inspections), and Assessor.
- In addition Planning and DPW will require one copy each of ARCINFO 8.0 and the Spatial Analysis Extension for ArcView

Tier 2

- Software: ArcExplorer 1.1
- No. of copies: 12
- Departments: Town Manager (including Board of Selectmen duties) Fire, Police, Clerk, Public Health, Leisure Services, Veterans Services and Library.

Tile Management Software

In the near term, the town does not necessarily need to use LIBRARIAN or ArcStorm to manage its tile data. As described in the section above, it is not expected that more than one or two individuals from either Planning or DPW will be responsible for editing datasets. Given this and the maintenance protocols suggested, there is no near term need to use the tile management and security functions of LIBRARIAN. Also, discussions with Information services would suggest that SDE technology is not a near term option for the town, however it may be given consideration after implementation and the benefits of the GIS are realized in multiple departments and the public.

As suggested by Merrick, use of Mr. Sid compression software will help to alleviate potential problems with the speed of access over the network and screen regeneration time associated with the file size of the 75MB orthophoto tiles.

Training

In regards to desktop GIS applications, approximately 35 staff will require training in a desktop GIS applications ArcExplorer or ArcView. OGIA recommends two half day sessions for each application. The training should encompass general GIS concepts, protocols, and the network architecture as well as functional use of the software

Long Term Recommendations

In the long term the town may consider operating both Frost and Byron as mirrored GIS servers (see *Figure 6: GIS System Long Term*). Each would contain the same geospatial datasets and allow users to transparently access the system using the server that had the most capable of handling the client's request. The scheme would also work well using ESRI's Arc Internet Map Server and SDE. Arc IMS has administrator utilities designed to allocate server processes dynamically based on current system demands. A mirrored system would also provided backup capabilities and support a migration from legacy data models to SDE.

As discussed in Section II, there are other system design options available to the town. The GIS Steering Committee should evaluate the advantages of SDE technology after the initial implementation of the GIS. The town's current network structure is well suited for the optimization of system resources inherent in the GeoObject schema.

OGIA recommends this as a long-term option due to the relative unknowns related to the implementation of SDE. At this time resource allocation for transition of legacy data into an SDE format is not well documented for enterprises the size of Amherst. All associated costs for hardware and software are also difficult to estimate. As more SDE pilot projects move beyond the evaluation stage and information becomes available, the town may contact OGIA for findings on SDE implementation issues.

Administrative Structure for the GIS

Amherst's GIS enterprise originated in a decentralized nature through the GIS Committee. Cooperating collectively, departments combined financial and personnel resources to successfully initiate a GIS enterprise (with external partners). It is foreseeable that full implementation and management will continue in this fashion for some time. It is recommended that the town consider the roles and responsibilities that key departments will need to play in order to realize the benefits of the GIS enterprise.

Potential Roles and Responsibilities for Departments

In OGIA's opinion, there are key departments that bare responsibility for spatial data creation and management. These key departments include:

- Planning
- DPW
- Assessor; and
- Conservation Commission

Because of the significant role each department plays with the use of GIS technology and the management of particular data streams it is necessary to consider Planning and DPW and primary enterprise managers. For example, infrastructure projects (roads, sewer, utilities) are primarily under the purview of DPW. As new projects are undertaken, especially by the enterprise partners – Amherst College and UMASS - management of spatial data related to these projects would naturally fall to DPW. Also, special consideration is given to the Assessor for his role in maintaining both the attribute data and the line work associated with the parcel coverage. As stated in the user needs assessments, the parcel coverage and its primary attributes are of importance to the majority of users in the enterprise.

The implication of this structure is a reliance on Information Services for database administration and application development of the GIS and associated attribute databases. This cooperative arrangement will require the following:

- ❖ Pre-planning of personnel resources and equipment purchases specific to GIS-related work by Information Systems.
- ❖ Distribution of GIS related tasks by department.
- ❖ Negotiation among all departments in the submission of budget requests so that no one department bears the sole financial burden for maintaining the GIS.
- ❖ Planning and DPW assume the roles of “GIS experts” and allocate resources to assist those offices unfamiliar with GIS.

The following delineation of potential roles is offered a starting point for discussion among the members of the town’s GIS Committee. It is not intended as an exclusive and limited assignment of responsibilities.

Assessor

Since the Assessor is responsible for the maintenance of the property assessment database, his role should be expanded to include the routine export of the parcel attribute data for use with the parcel geospatial dataset (parcel coverage). Physical changes to the line work of the parcel coverage should also be managed by the Assessor. Software is available to facilitate this process so that knowledge of advanced GIS software is required on the part of the Assessor.

Although the VISION software will act as interface to the GIS permitting queries and mapping, it does not permit editing of coverages. There are two options to assist the Assessor in editing the spatial data. One is to work with software experts of VISION Appraisal to craft a customized solution. The other option is to employ the pARCEl mAPPer suite of software developed by Southern Digital Services (SDS). SDS crafted this application to permit quick and easy editing of parcel line work in a CAD-like environment. OGIA recommends that the town

evaluate the utility of this (see Appendix G: a summary of SDS pARCEl mAPPer documentation).

Conservation Commission

Because of Con Com's focus on resource management and protection within the town, it is best suited to manage datasets related to this topic. This may include development and maintenance of trails, APR lands, historic/cultural sites, and watershed datasets.

DPW

Because of DPW's focus on infrastructure, the department should become the primary interface on all utilities spatial datasets (roads, sewer, water, etc.). As a result DPW would be responsible for maintenance and distribution of these datasets. For example when plans for the expansion of a sewer line are approved, DPW would undertake the integration of the data into the appropriate GIS coverages. This would also apply to management of plans submitted by contractors in a digital GIS format.

Information Services

IS may be called upon to provide on-going support in the installation and integration of the GIS database with other RDBMSs (VISION and PERMIT*PLAN). Understandably, compatibility issues may not permit full integration, but the department's expertise in RDBMS issues may help the town better understand the nature of the problem and plan for alternative solutions.

Planning

Because of its expertise in GIS, the department is in leadership position to provide oversight of hardware/software purchases, training, and implementation of maintenance protocols. In regards to the latter, Planning may need to assume

responsibility for the maintenance of spatial and attribute databases for non infrastructure datasets not managed by DPW.

Initially, Planning may have to support the Assessor in structuring the maintenance protocol parcel line work editing and the attachment to the coverage of the parcel attribute data exported from VISION and PERMIT*PLAN. Planning may also work as the interface between Information Services and other departments in the connectivity of attribute databases to spatial.

GIS Steering Committee

As ad hoc committee made up of departments who will make primary use of the GIS, it is poised to take on the role of a monthly forum in which policies for data exchange, maintenance, and upgrades decisions may be discussed and resolved.

Under the auspices of the GIS Committee, departments should agree upon a maintenance schedule whereby datasets are updated in a timely and consistent manner. Use of maintenance and other procedural protocols should promote a sense of reliability in the data among enterprise users.

Recommended Data Management Protocols

OGIA recommends the institution of protocols to unify GIS functions and to provide a set of operational guidelines for all users. Suggested protocols are as follows.

Coverage and Attribute Maintenance

It is assumed that spatial and attribute data will be maintained separately by the department traditionally responsible for managing that set of geographically related information/features. As such, GIS maintenance may compliment the existing information management routines for that department. Each department should be encouraged manage their components of the GIS in timely and uniform manner to ensure optimal reliability for other users in the enterprise. This discussion uses the parcel database as an example of protocol development.

Parcel Coverage Example

A annual update of the parcel coverage line work should coincide with the changes or additions made to the VISION Appraisal database in July by the Assessor. The VISION software can export a select set of property records in a format that is compatible with the coverage attribute table using the PIN as the relate.

Since attribute data tends to change more rapidly than parcel boundaries, other departments relying on the parcel coverage must be made aware of these routine changes. During “updates” users should disengage and re-establish the links between attribute databases and the spatial dataset. Planning and DPW may consider the use of customized Macro Routines to facilitate this operation. Macro routines, or case-specific programs, can be written, for example within ARC/INFO, to simplify map production. Routines written in ARC/INFO use ARC Macro Language (AML). Other programs, such as ArcView, utilize the scripting language of Avenue and Visual Basic. Macros perform repetitive functions and operations.

Macros require conditional logic that is necessary when program variables are subject to constant change. Conditional logic applies, for example, to the selection of the household numbering along a street.

It should be noted that it is necessary only to update the parcel tile that required editing of lines or polygons and not the whole parcel coverage. A tile is first copied, then edited, and finally substituted for the original tile. For the purposes of tracking changes, a copy of the entire parcel coverage may be made prior to editing for archiving.

Date of Last Transaction Field

An important part of the maintenance protocol is the inclusion of "Date Of Last Transaction" field in spatial datasets. Commonly used update fields are 'poly_date' or 'aat_date'. Such information should help users distinguish between current and outdated records and flag those attribute databases which may require updating prior to performing intensive analysis or mapping operations.

RDBMS (Network) Permissions

Amherst may wish to consider storing all attribute data related to geographic features into a single RDBMS. This recommendation is consistent with the goals of Information Services and its on-going maintenance of large relational databases. Physically, this could be a single server, like Byron, containing all attribute databases including VISION Appraisal and PERMIT*PLAN or a number of servers operating collectively as a "single" attribute source. In the future, a single attribute architecture would eliminate redundancy of storing of the same data in multiple servers and obviate the need for users to craft potentially complex joins between or among VISION, *PLAN and other attribute databases (from Clerk, Fire, Public Health, etc.) with the GIS spatial data.

Business Rules

The GIS Committee, working in conjunction with Information Services, could establish permissions and business rules that would determine what attributes are available as read/write to all users while rendering those attributes that should remain executable to only one user, undetectable. There are numerous advantages to this type of intelligent use of relational databases:

- Account permissions may function as security measures for sensitive attribute data; and
- Permission rules would dictate how all users are made aware of updated and when such editing could occur and in what order.
- For example, in VISION, the Assessor could require that a parcel id must be created first before a street address can be assigned in a database record.

The latter bullet alludes to a resolution to Amherst's street addressing conflicts. The potential exists because a unified relational database of geographically related attributes indexed by both parcel id and street address may be managed by an RDBMS to prevent orphan or duplicate records. In the situation where the Assessor is restricted by law from creating an official record of a parcel after June 30th, the department could still create a valid record for a new parcel in the RDBMS and use a separate attribute field to assign a temporary value to it. Two examples are provided to illustrate this:

Parcel_Id	Temp	Street Address
30-85-01	T	13 Smith Lane

Parcel_Id	Street Address
30-85-01-T	13 Smith Lane

There is every indication that a database administrator with programming skills would be necessary to implement and maintain such a system. At this time, OGIA cannot estimate the number of personnel hours required to implement this system.

***Neither VISION nor *PLAN can join to a GIS. Each can perform one-way, read only operations of the data. Users must export the data from each in order to link it to the appropriate spatial dataset. There is no plan by the developers of either software to add a READ/WRITE functionality to future versions.*

Public Data Distribution

In Massachusetts General Law (M.G.L.) Chapter 4, Section 7(26), the Public Records Law, broadly defines public records to include all documentary materials, regardless of their physical form, that are made or received by any office of any Massachusetts government. The statutory definition of public records does not distinguish between traditional paper records and records in digital format.⁷ Under the law, digital parcel datasets are considered public records and local governments are obliged to furnish copies, at the cost of reproduction, upon request. With this said, the procedures for responding to a digital data request are similar to those currently facing governments, with one exception. The heart of the matter lies with the fundamental ability of a GIS to link a specific location with an infinite number of attribute databases.

Departments using the GIS should recognize that information associated with a specific location may be privacy-sensitive. They should also acknowledge in their preparation and use of digital data the expectation of citizens that public records will not contain information unrelated to the purpose of the data collection. To comply with privacy exemption of the Public Records Law, Amherst should consider the adoption of a privacy protection policy regarding the use and dissemination of GIS data. Such a policy would provide the basis for consistent and fair responses to requests for not only parcel data, but also all databases created by the town for the GIS. Amherst may consider the following guidelines:

- construct and manage parcel datasets to include only that information which is traditionally relevant to public data managed by the town;
- collect, manage, and disclose GIS data in an format that maintains anonymity whenever possible; and
- educate all staff involved in the development, use, or delivery of GIS programs including parcel data about the privacy issues of GIS technology and share these guidelines with the public.

It should be noted that under Commonwealth law, local governments are not required to create digital records in response to a request for information.

Acceptance of Development Plans in GIS Format

OGIA's review of available information indicates that communities who have implemented this protocol did so after having established a set of guidelines governing the cadastral standards of hardcopy data submitted by surveyors. In order to insure compliance by surveyors or contractors the Town should publish guidelines pertaining to digital map submission and at a minimum provide contractors:

- a digital file of grid control points for the town including road center line data and;
- data pertaining to the location of physical control monuments.

The town may elect to require from contractors the following deliverables including but not limited to:

- traverse data – a digital (ASCII) file containing bearings and distances of boundaries, streets, centerlines, lot lines, and easements; and
- graphics data – a digital file representing graphically the required elements of the cadastral map in DXF or E00 format.

⁷ Commonwealth of Massachusetts Division of Local Services. 1999.

Implementation Schedule

The following implementation schedule is proposed to coincide with delivery schedule under the town's Photogrammetry and GIS Basemapping contract with Merrick. It is intended to make use of pilot project produced in June 1999 (planimetric data) and February 2000 (parcel coverage).

Activity	Date
<p>Approve Implementation Plan</p> <p>Test export operation for VISION and PERMIT*PLAN and "link" procedures with parcel pilot coverage.</p> <p>Order software from ESRI</p> <p>Install software - Tier 1</p> <p>Install software - Tier 2</p> <p>Staff Training – Tier 1</p> <p>Staff Training – Tier 2</p> <p>Merrick Project Close-out</p> <p>Export VISION parcel attributes for joining to parcel coverage attribute table.</p> <p>Public Presentation to Board of Selectman highlighting an immediate use of the GIS.</p> <p>Public Presentation at Town Meeting. PR event to showcase capabilities and current projects underway.</p>	