GIS and GPS – The Backbone of Vermont's Statewide E911 Implementation

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Abstract

*In 1988 the Vermont General Assembly created a statewide geographic information system; five years later it authorized statewide implementation of Enhanced 911 services. By 1998 E-911 was a reality in Vermont's rural communities. E-911 had been brought about by combining a high-quality, statewide digital road base with local political savvy and volunteer energy, and a technical plan based around GIS and GPS. This paper will provide an overview of the key policy, technology, and implementation decisions which led the Vermont E-911 Board to use the state's spatial data infrastructure in building an enhanced 911 system, partnering with 256 local governments. The author will conclude with comments on the relevance of the Vermont experience to other jurisdictions. Bruce Westcott (**bspatial@together.net**) was the Executive Director (1990–98) of the Vermont Center for Geographic Information, Inc. (VCGI) (**http://geo-vt.uvm.edu**). He currently provides consultation to a variety of public and private organizations on issues related to spatial data policy and NSDI development.*

Introduction

Public-sector technology managers sometimes hope for the emergence of a "killer application" or for the gradual realization on the part of elected officials and constituents that technology is an indispensable part of basic business processes. Vermont's implementation of statewide "Enhanced 911 (E911)" services[1] may be a case of such hopes fulfilled, and innovative uses of geographic information system (GIS) and Global Positioning System (GPS) technologies lie at the root of the program's success. It is now difficult to see how success could have been achieved any other way, at such a relatively low cost, over such a large area, in such a tight time frame. This paper will provide an overview of the use of GIS and GPS in implementing statewide E911 services in Vermont. The first section will provide background information, including citations to statute. The second section will review key E911 implementation steps that relate to use of GIS and GPS. The third section will offer conclusions about the relevance of the Vermont experience to other jurisdictions.

Background

The State of Vermont occupies 9,609 square miles and is home to 584,771 people (1995); Vermonters and their 310,518 cows live in 256 cities and towns. Many of these local government units have just a few hundred or a few thousand people, and all pride themselves on citizen-volunteer government. Vermont's largest city, Burlington (1995 population: 38,392), lies at the center of Chittenden County, which is home to a large plurality of the state's population, cultural, technical, and economic resources. (These and other basic facts about Vermont's geography, people, economy and climate can be accessed at **http://mole.uvm.edu/Vermont/**.) Outside of Chittenden County, Vermont has a relatively small number of suburban developments, large employers, office or residential towers, shopping malls, freeways, or full-time emergency service personnel.

Other information relevant to Vermont's E911 implementation concerns Vermont's transportation network, which had to be thoroughly traveled by Vermont E911 contractor(s) in order to collect street name, building location, and other varieties of data. Vermont has 19,825 miles of vehicle-accessible roads, of which just under 706 miles (3.56 percent) are Interstate highways, and of which 2,363 miles (11.92 percent) are State or U.S. highways. Maintenance of the remaining roads, mostly unpaved, are the responsibility of local governments. (Details about Vermont's roads and other E911 databases can be obtained from the website of the Vermont Center for Geographic Information, Inc.: **http://geo-vt.uvm.edu**.) Road names are bestowed by local government in Vermont, and there are 23,223 unique road names currently identified by the state E911 program.[2] Until the advent of E911, many residents lived on back roads lacking "official" names, and their houses were referenced with rural route and box numbers rather than sequential numbering along named roads.

Vermont's GIS Program

In 1988 the Vermont General Assembly addressed growth management concerns with the passage of legistation intended to address land-use and growth-related issues at the municipal and regional levels. In order to support this work, the Legislature declared that "The State of Vermont shall support a comprehensive strategy for the development and use of a geographic information system, including (1) data and mapping standards, (2) potential applications and their priorities, (3) priorities for collecting and digitizing information, (4) geographic location standards for all data collection, ..." and eight

[1]Enhanced 9-1-1 Service (E911) is a system that can automatically route emergency calls to a pre-selected answering point based upon the geographic location from which the call originates. It offers such features as Automatic Number Identification (ANI) and Automatic Location Identification (ALI). Definitions for this and other terms have been excerpted from a more complete "Glossary" contained in the Vermont E911 Addressing Handbook.

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[2]Road names such as "Main Street" or "Elm Avenue" are common in many Vermont towns. Therefore, uniqueness is based on town jurisdiction, ZIP code, and road suffix.

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other factors.[3] It declared that "Data that has [sic] been ... generated with state support should be compatible with, useful to, and shared within the geographic information system," and placed such data within the scope of Vermont's liberal statutes covering access to public records.

Leadership of Vermont's GIS effort was initially established within an Executive office with an ambitious budget. In 1992 the General Assembly approved the formation of the Vermont Center for Geographic Information, Inc. (VCGI) —a non-profit corporation created as a partnership with the University of Vermont— in part to minimize direct state appropriations, diversify revenue sources, and build partnerships.

Vermont completed digitizing a statewide road centerline vector database at 1:5,000 scale in 1993. In several areas of the state these data were enhanced with the addition of locally generated road names, and served as the basis for creating spatial databases of building centroids and/or footprints. By 1994 GIS technology had become an accepted tool for data collection, display, and analysis in support of many planning and operational needs of local governments located in all of Vermont's 14 counties.

Vermont's E911 Program

Act 197 of the 1994 Vermont General Assembly began with these findings:

> "(a)(1) A statewide emergency communications network of enhanced 911 emergency calling service ... would further the safety, health, and welfare of the state's citizens and would save lives....
>
> (a)(3) Implementation of enhanced 911 emergency calling service ... should be implemented in Vermont through local initiative and operation....
>
> (b) It is the intention of the general assembly that ... the target date for completion of statewide enhanced 911 emergency calling service should be July 1, 1997.[4]"

Act 197 established a statewide Enhanced 9-1-1 Board and gave it authority to adopt rules (subject to legislative oversight) governing technical and operational matters. Each municipality was given the choice to participate in the Vermont E911 program, and those electing to participate were directed to "identify all building locations and other ... locations frequented by the public and [to] cooperate in the development and maintenance of the necessary data bases." Act 197 assured confidentiality relating to "individually identifiable information contained in the system data base.[5]"

Vermont's E911 program benefitted from a well-organized and vocal constituency of local, largely volunteer emergency service providers, and from the sustained desire of legislators to have E911 services available no later than the statutory deadline of July 1997. E911 leadership had to draw on constituents and legislative supporters repeatedly to educate lawmakers and the public, and to advocate for Board positions with respect to concerns about technology, and the confidentiality rights due to citizens. At one point confidentiality advocates embraced the concept of using geo-coordinate addressing[6] to identify the locations of telephones and display them on digital maps.

Implementation Steps Relating to the Use of GIS and GPS

In July 1994 the E911 Board and its newly hired Executive Director were faced with a daunting task, with limited funds and a statutory deadline less than three years away. According to 1990 U.S. Census data, there were 204,330 homes and 19,839 businesses in Vermont, leading to an estimated 239,959 telephone customers (1993). These customers were served by 143 telephone company exchanges, linkng Vermont customers through 30 host switches. In 1994 there were 37 24×7 emergency service dispatching centers serving Vermonters, and the majority of the state was served by B911 service.[7] Assuring E911 service in this environment would require concentrated effort.

As E911 leaders viewed the coming months, they envisioned a tightly linked sequence of deadlines relating to four task groups: Administration, Studies & Research, Standards & Rulemaking, and Community Outreach. Many of the tasks included in the Studies and Standards groups were focused on the need to provide reports and draft standards and rules for review, discussion, and (for some) approval during the legislative session of January through April 1995. This section will review key E911 implementation steps taken in 1994-97 that relate to use of GIS and GPS. Table 1 provides a summary of the steps that are discussed in this section.

Step 1—Startup Studies

Act 197 authorized E911 to spend up to $650,000 "for purposes of planning, engineering, development [sic] of a data base, and modeling alternative addressing strategies." Just six months after its effective date, the legislation called for a substantial report covering seven major cost and design issues, including "an analysis of alternative data base proposals.[8]" GIS was on the minds of some legislative leaders who very much wanted to know if Vermont's GIS investment could be useful to the E911 program. As a consequence, VCGI technical assistance and a

TABLE 1: KEY IMPLEMENTATION STEPS

Start	End	Implementation Task Description
Fall 1994		1.Obtain approval for expenditure of $650,000 startup planning funds
Summer 1994	Winter 1995	2.Draft and issue RFPs and RFIs for all aspects of startup studies; provide Legislature with "Report on Alternative System Design"
Summer 1994	Winter 1995	3.Complete Road Naming Contract(s)
Fall 1994	Spring 1995	4.Develop addressing standards; Draft "Addressing Handbook" and other materials
Spring 1995	Summer 1995	5.Survey readiness of participating towns; build database
Summer 1995		6.Develop specifications for GIS Database Development contract
Winter 1996	Winter 1997	7.GIS Database Development and Quality Control

[3]Originally enacted as Chapter 20 of Title 3, Vermont Statutes Annotated, the statute has been renumbered and revised in the 1990s. The current citation is 10 V.S.A., Chapter 8.

[4]Act 197 of 1994, Section 1; Vermont General Assembly.

[5]These provisions can be found in Title 30 ("Public Service") of Vermont Statutes Annotated: Chapters 87 ("Universal Telecommunications Service") and 88 ("Enhanced 911 Emergency Response System".) (30 V.S.A., Chapters 87 & 88).

[6]Geo-coordinate addressing assigns a unique location to every dwelling using the Vermont State Plane, or latitude/longitude coordinate systems, and doesn't use a numeric address.

[7]Basic 9-1-1 Service (B911) is a system providing dedicated trunk lines which allow direct routing of emergency calls to a pre-selected answering point. In most cases, call routing is based on telephone exchange area, not municipal boundaries.

[8]Act 197 of 1994, Section 3(a) and 3(b).

contract for studying spatial database alternatives were included in E911 planning activities.

Step 2—Preparation of the "Report on Alternative System Design"

E911 determined that it would address a number of related questions about the use of GIS and GPS technologies in the context of a single analysis. E911 had identified several potential advantages to utilizing GIS/GPS technologies in fulfilling its responsibilities; they included facilitating locatable addressing,[9] generating emergency response maps, making digital mapping available at PSAPs,[10] supporting Computer Aided Dispatch, and sharing multi-purpose spatial databases.

In the fall of 1994, E911 authorized VCGI to draft a "Request for Proposals for a Cost/Benefit Study of Alternative Addressing Strategies and Other Potential Uses of Geographic Information Systems (GIS) in Vermont's Enhanced 9-1-1 System." The four goals of this solicitation were[11] (1) to provide E911 with the basis for making a policy decision on how or whether to assist municipalities to implement locatable, street-style addressing; (2) to provide E911 with sufficient information to determine budgeting and staffing needs for providing such assistance; (3) to enable E911 to plan the implementation process from locatable addressing to the uses of GIS in the greater E911 system—incorporating use of GIS/GPS at the outset, or later on; and (4) to provide E911 with analysis of costs and benefits of various E911 system alternatives.

The RFP[12] asked proposers to assess five technical alternatives for establishing locatable addressing: (1) manual addressing with a fifth wheel or other measuring device (no use of GIS/GPS); (2) use of existing Vermont digital spatial data (primarily roads), plus paper 1:5,000-scale orthophotos and GPS; (3) vehicle-mounted GPS field data collection; (4) use of existing Vermont digital spatial data (primarily roads), plus door-to-door GIS/GPS data collection and correction; and (5) manual addressing, using new digital orthophotographs (as they become available) to update GIS data layers.

A series of 1664 orthophotographs of all of Vermont had been created between 1974 and 1990. They were warranted to meet National Map Accuracy Standards at 1:5,000 scale (±3 meters ground accuracy). A comparable series of digital orthophotographs was initiated in 1993; the first products were expected for delivery in early 1995. (Details about this resource are available at **http://www.state.vt.us/tax/map2.htm**.)

The February 1995 final report provided E911 with objective information about the approaches identified and the technologies under review. It identified a large number of cost variables and supplied a spreadsheet-model for assessing the costs of each approach. The report did not equivocate in suggesting that approach #1 (fifth wheel) would be an outmoded choice with very limited future value, and that approach #3 would be the fastest and most accurate choice. However, the contractor cautioned that "Choosing the appropriate blend of techniques and technologies to accomplish rural addressing for 9-1-1 is more of an art than a science. Furthermore, the methods chosen for address assignment are sometimes based more on political considerations and other uses of the data, than simply on the costs of the addressing method.[13]"

Step 3—Complete Road Naming Contract(s)

The report provided in Step 2 also emphasized that attempting to define locatable addresses in the absence of a comprehensive and authoritative road names database would be quite difficult. Fortunately, in early 1994 the Emergency Medical Services Division (EMS) of the Vermont Department of Health had contacted VCGI and local authorities, explained the availability of limited funding to provide community assistance to emergency medical services personnel, and solicited proposals for action. Interest had focused on the need for many towns to catalog recognized road names, to assign new road names where needed, and to produce maps useable for community comment and markup.

VCGI's role[14] had been to provide technical support to EMS (which had no GIS capabilities), to develop standards and procedures for municipal road naming, to finalize detailed database specifications, to perform quality assurance procedures on interim deliverables from the regional planning commissions (RPCs), and to assure data integration (including analysis of the final data to determine the extent of effort needed to complete a statewide road naming project). The role of RPCs had been to perform updates to regional extracts of the statewide road centerline database, and to initiate the contact with interested citizens and organizations in each town, soliciting the needed volunteer labor and generating awareness and excitement about the likely implementation of E911.

Road naming was a crucial implementation step for E911: it taught valuable lessons about how to solicit and sustain community involvement, develop data statewide in a cooperative and decentralized manner, and define data collection and mapping standards that could be implemented successfully and uniformly. At the local level, this step also paved the way for future steps and provided local officials with three deliverables: a tabular road name database, a GIS road centerline database attributed with road names, and a replicable hardcopy map that citizens and volunteers could use to find errors and better understand the challenges of E911 implementation.

Step 4—Addressing Standards, "Handbook" and other materials

E911 determined that it would need to make contact with both formal municipal decision-makers (town Boards of Selectmen, and City Councils) and the professionals and volunteers in each town who would be responsible for the actual implementation work. E911 knew that it would have to provide (1) information sufficient to allow each town to determine whether or not it would participate, (2) a uniform "Memorandum of Understanding" by which it could confirm town participation and which would state the implementation responsibilities of towns, (3) guidelines and standards which would both assist local officials and assure compatibility with a single statewide program, and (4) incentives and assistance to local government.

In late 1994, E911 moved forward on two tracks: recruitment and planning efforts for towns, and analysis and drafting of technical standards for review and approval by the E911 Board, anticipated in March 1995. E911 worked on the technical track with VCGI, the U.S. Postal Service, the Vermont Agency of Transportation, telecommunications experts, and the National Emergency Number Association (NENA) to identify, modify, and/or develop relevant standards. A succinct "Addressing Standards" publication was drafted in early 1995;

[9]Such an addressing system uses a road name and house number (e.g., 103 Birch Street) unique to each community. By adopting street addressing, every structure in a community is assigned an address that is unique to that location and easily recognizable.

[10]A Public Safety Answering Point (PSAP) is a facility assigned the responsibility of receiving 9-1-1 calls and, as appropriate, directly dispatching emergency response services or transferring or relaying 9-1-1 calls to other public or private safety agencies.

[11]VCGI 1994b, "RFP for ... Alternative Addressing Strategies," page 1.

[12]*Ibid.*, p.9.

[13]Vermont E911 Board 1995a, "Addressing Alternatives Analysis," p.1.

[14]VCGI 1994a, "Road Name Database Contract—Specifications," page 3.

it included sections covering adopting and standardizing a system for addressing, administering the municipal addressing system, road naming, standard road name suffixes, GIS mapping and updating of maps, and (NENA) tabular databases-linking addresses to the E911 system.[15] E911's standards concerning GIS simply referred readers to the relevant standards established by VCGI under authority of 10 V.S.A. § 123. (Relevant VCGI standards cover base maps, mapping, data updates, etc. See **http://geo-vt.uvm.edu** for further information.) The availability of existing Vermont GIS standards—including those developed as part of the road centerline data development project (1990–1993) and the road naming work already performed (Step 3)—and NENA tabular database specifications served to minimize the amount of technical analysis necessary to arrive at addressing standards that were relatively comprehensive and non-controversial.

Some municipalities embarked upon street addressing and database development before the standards were available; others retained idiosyncratic "grandfathered" addressing practices which did not conform to the standards. As with many projects which require integration of community-based data, this (politically necessary) ability to integrate non-standardized data was maintained at relatively great cost in data conversion effort, community goodwill, and system effectiveness.

Step 5—Surveying the Readiness of Participating Towns

VCGI cooperated with E911 to build a tabular "Municipal" database which would (1) provide E911 with a standard data structure in which to store, update, query, and map information about each of Vermont's towns; (2) provide E911's contractor with this and other information details needed to analyze the scope of tasks to be performed; and (3) help E911 to solicit and organize additional information from each town about technical aspects of its current and planned addressing needs. This tabular database was initialized in the summer of 1995 by several means: (1) automated generation of a tabular database file from attributes stored in VCGI's "Town Boundary" polygon attribute table (and related files), (2) key entry of contact information supplied in the "Municipal Plan" documents submitted by towns (Step 4), (3) key entry of information solicited by RPCs in the course of their road naming and other work for towns, and (4) telephone interviews conducted by E911 staff.

By the fall of 1995, a "master" municipal database was assembled; it contained the unique ID number and "official" name of each municipality, a code indicating its planning region (one of 14 in Vermont), and municipal E911 contact information (name, address, title, phone, fax). It contained binary (Y/N) or coded answers to other questions, such as (1) What is the distance increment for house numbering?[16] (2) What is the current status of road naming and addressing efforts?[17] (3) Does the town wish to request GIS addressing assistance from a contractor? The database also allowed for extensive comments about local conditions pertinent to the addressing plan; these proved invaluable at later stages of implementation.

The municipal database was extended to allow the linking of town-based information needed over subsequent years. One version was supplied to prospective database development contractors; it was extended to include road mileage statistics and several census variables for their review. Another version of the database was extracted and used by VCGI as a master tracking database for town-based paper and data deliverables provided by the GIS database contractor. It proved to be a critical communication medium between E911, VCGI, RPCs, towns, and contractors.

Step 6—Develop Contract Specifications for GIS Database Development

E911 anticipated that database development would last from November 1995 until January 1997, and that testing and maintenance activities would lead to a July 1997 implementation. VCGI worked with E911 over the summer of 1995 to prepare a "Request for Proposals for Development of GIS Databases for Support of Vermont's Enhanced 9-1-1 System."

In the RFP, E911 stated that it had determined the need for a GIS-based implementation in part because ongoing FCC rulemaking related to wireless communications would likely lead to coordinate-based solutions, and because digital mapping was increasingly (nationwide) being linked to dispatch functions. E911 did not provide specifications for any particular techniques—including use of GIS or GPS—to be included or excluded; rather, E911 said: "Respondents are encouraged to propose proprietary, innovative, and/or alternative technical approaches, if they will provide technical, schedule, or cost advantages to the project... ." Also, E911 stated its belief that "it made practical sense to piggy-back municipalities' addressing onto our GIS development... . Yankee frugality indicated that E911 should seek economies of time, effort and money.[18]"

In describing the scope of work, E911 provided prospective bidders several information resources, including an inventory of all relevant digital and analog data sources available from VCGI and elsewhere, and metadata for the existing statewide road centerline spatial data. Bidders were provided with the municipal database developed in Step 5; among other critical factors, the database showed that 46 percent of Vermont's 256 political subdivisions were requesting technical assistance from the contractor, and had not done any locatable addressing. Another 13 percent were requesting assistance, but had commenced addressing. Just 4 percent had completed locatable addressing and were also requesting contractor assistance. Thirty-eight percent of towns did not request assistance at that time; however, many of these towns later joined the program and needed assistance.[19]

The RFP specified the contractor's responsibilities;[20] E911 expected that bidders would propose to (1) drive GPS-equipped vehicles along all roads; (2) provide assistance to towns in capturing building access points, fire hydrants, pay telephones, public gathering places, and (optional) road centerlines and other point features; (3) post-process the data; (4) match old and new addresses using U.S. Post Office field edit sheets; and (5) perform local verification, working with RPCs and town contact personnel.

The RFP specified the following seven deliverables: (1) final hardcopy maps for municipalities and for E911; extensive map features were detailed, (2) a standardized GIS database for E911, (3) official road name and locatable address listings, (4) a

[15]Vermont E911 Board, 1995b. "Addressing Handbook."

[16]*Ibid.*, "Addressing Handbook," p.6. The E911 Board recommended an increment of 0.001 mile, so that 790 Main Street would be located at about 0.79 miles from the start of Main Street.

[17]A 1994 phone survey of towns had revealed the following: 65 percent of towns—no street addressing, rural routes only; 14 percent—street addressing completed; 9 percent—mix of street and rural routes; 8 percent—begun street addressing; 4 percent—no response.

[18]Vermont E911 Board, 1995e. "Request for Proposals for Development of GIS Databases for Support of Vermont's Enhanced 9-1-1 System," pages 1-2.

[19]*Ibid.*, page 12.

[20]*Ibid.*, pages 13–18. E911 said "Where this RFP refers to 'GPS' each bidder may choose to address pertinent issues from the perspective of the technology (s)he proposes to employ."

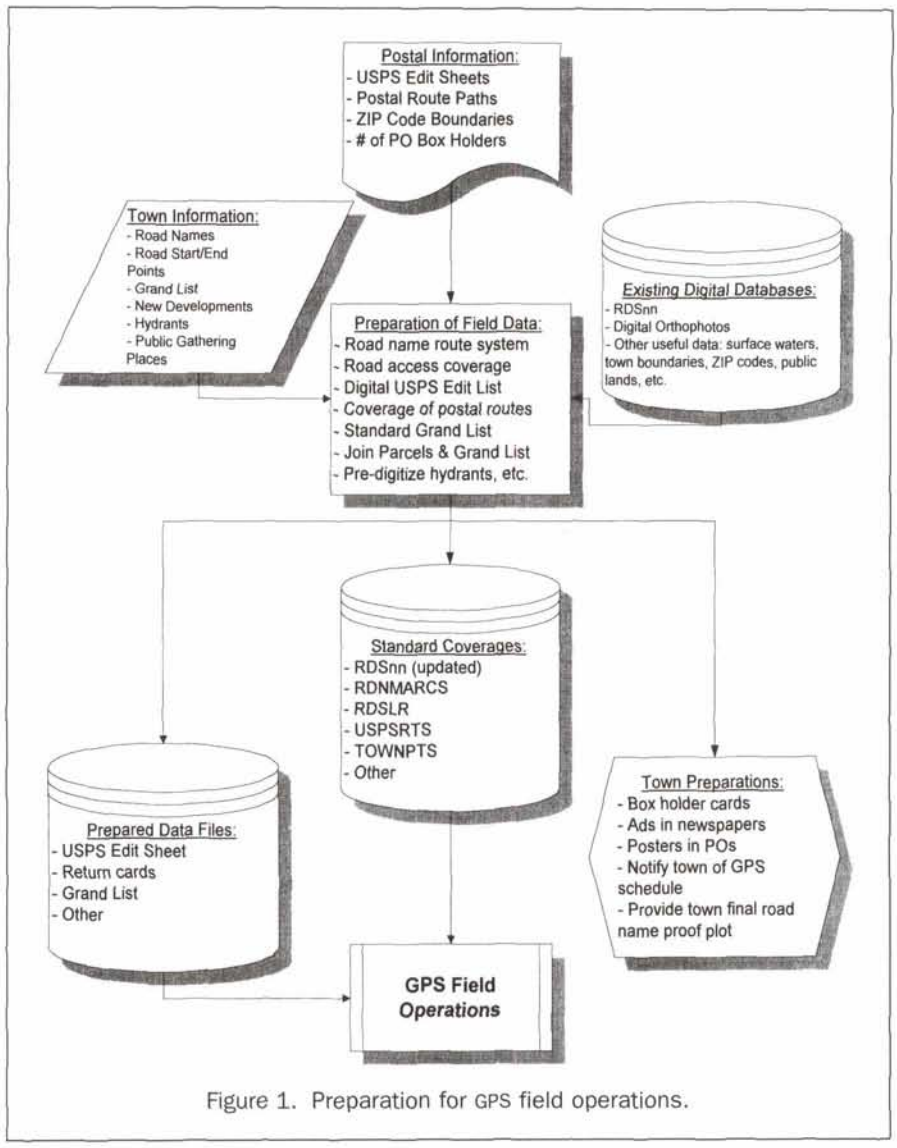

Figure 1. Preparation for GPS field operations.

database matching old mailing addresses to new locatable addresses, (5) a Master Street Address Guide (MSAG)[21] for all participating communities, (6) periodic status reports, and (7) digital data and products (all of the above, plus programs, graphics, etc.).

Nine proposals were received, and the three teams which received the highest preliminary ranking were interviewed. The prime contractor of the team ultimately chosen—microDATA GIS, Inc. of St. Johnsbury, Vermont—had invested heavily (since 1993) in performing locatable address work for a number of Vermont towns which commenced E911 work before the statewide program formally started.

Step 7—GIS Database Development and Quality Control

The microDATA proposal included a technical work plan of some 20 tasks, which involved subcontractors as well as elements of cooperation and approval by each of the towns. Tasks were grouped together in six "stages" of work:

(1) Road Naming and Town Coordination (RPCs were subcontracted to provide continuity with the EMS-supported efforts described in Step 3),
(2) Preparation for Field Operations—Many sources of information had to be collected in order to commence field operations (see Figure 1),
(3) Field Operations—GPS data collection was performed, with the assistance of a laser range finder (see Figure 2),
(4) Processing, Database Development and Draft Maps,
(5) Town and Postal Addressing Review—Packaging preliminary data into a proprietary DOS-based editing package allowed interactive town review, and
(6) Final Update and Delivery.

microDATA later summarized its work on this contract as follows: "Utilizing our highly specialized GIS/GPS/Dead Reckoning (DR) and Laser Range Finder technologies and our custom E911 addressing and data collecting systems..., microDATA GIS completed the 18 month-long statewide E911 addressing project for the State of Vermont [in early 1997]. Our innovative GIS techniques enabled us to accurately develop, among other

[21]The MSAG is a listing of all street names and their high/low number ranges as well as each community's Emergency Service Numbers (ESNs).

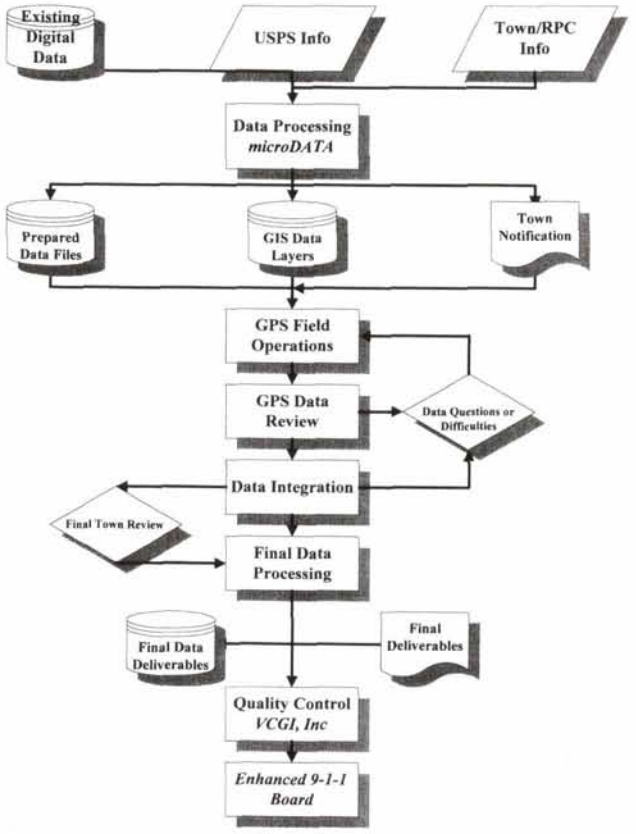

Figure 2. Enhanced 9-1-1 data development process.

items, the master street address guide (MSAG), emergency service zone (ESZ) and emergency service number (ESN) data layers,[22] and the automatic location identification (ALI) database for each township in Vermont.

"There are a total of 213 towns participating in the project and 14 counties. The population of the project area is 550,000 and the number of address sites is 300,000. The number of sites requiring GPS/DR data collection and complete re-addressing is 200,000. Additional "grand-fathered" sites requiring GPS coordinate capture is 60,000. Our six GPS crews have collected GPS field data for over two-thirds of the towns in the State of Vermont.[23] Table 2 provides a breakdown of the various types of Emergency Sites captured by the contractor using GPS.

E911 contracted with VCGI to perform formal quality control and acceptance testing on all final digital data products provided by the contractor. VCGI and microDATA iteratively developed a detailed specification for each data deliverable. An overview of data deliverables is presented in Table 3; detailed metadata on each database can be can be obtained from the "Spatial Data Clearinghouse" section of the VCGI website: **http://geo-vt.uvm.edu**.

VCGI and microDATA worked together to define the tests that would be independently applied to determine acceptance. Once these were defined, microDATA was able to incorporate some of the test code into its production software in order to anticipate possible acceptance problems. An overview of the portion of the VCGI quality control procedures that applied to the updated road centerline database is provided in Figure 3. Other procedures were in place for other data deliverables.

TABLE 2: GEO-CODED EMERGENCY SITES IN VERMONT, BY TYPE (1998)

Code	Description	#	%
C1	Commercial - Retail	10,363	4.5%
C*	Commercial - Other	3,516	1.5%
EH	Fire hydrant	9,183	4.0%
EP	Fire ponds & dry hydrants	401	0.2%
ET	Public telephone	767	0.3%
I1	Industrial	708	0.3%
P1	Public - Government	1,147	0.5%
P4	Public - Educational	1,080	0.5%
P8	Public - Gathering Place	855	0.4%
P*	Public - Other	1,516	0.7%
R1	Residential - single	147,451	64.2%
R2	Residential - multi	5,287	2.3%
R3	Residential - mobile	17,646	7.7%
R5	Residential - seasonal	18,530	8.1%
—	Other, or unknown	11,277	4.9%
	TOTAL	**229,727**	**100.0%**

Conclusions

Many factors influence the relative victories and defeats which together make up the "successful" implementation of a complex project; the previous sections of this paper are a description of aspects of the Vermont GIS and E911 technical and policy environment, and of key steps leading to E911 implementation in

TABLE 3: OVERVIEW OF MICRODATA GIS' DATABASE DELIVERABLES

Primary Data Layers:	
E911\DW	Driveways
E911\ESITE	Enhanced 9-1-1 site locations-structures
E911\ESZ	Emergency Service Zones
E911\RDS	Road centerline data layer (Geo coded)
E911\SHEETS	Layer used for production of E-911 map atlases
E911\ESA	Emergency Service Agency location
E911\TBLINE & TBPOLY	Town Boundaries-lines and polygons
Secondary Data Layers:	
E911\RDESZnnn	Road Access Zones
E911\RDANNOnnn	Road name annotation
Background Data Layers:	
E911\SW & SWPOLY	Surface water-lines and polygons
RR	Railroads
E911\ELEC	Electric Transmission lines
E911\CITIES	City & town names
Tabular Databases:	
E911\RDNMS.DBF	Road name lookup table
E911\ESN.DBF	Emergency Service Numbers lookup table
E911\ESADATA.DBF	List of Emergency Service Providers

[22]An Emergency Service Number (ESN) is the number or code assigned to a geographic area that is served by the same police, fire, and emergency medical services. This code is linked to a specific address range so that the appropriate emergency response unit is dispatched for every 9-1-1 call. An Emergency Service Zone (ESZ) is the geographic area that is served by the same police, fire, and emergency medical services. Every phone is linked to a specific ESZ. Each Emergency Service Zone has a unique Emergency Service Number (ESN).

[23]microDATA GIS, Inc., 1999. "Proposal for Maintenance of the GIS Databases in Support of Vermont's Enhanced 9-1-1 Program," page IV.6.

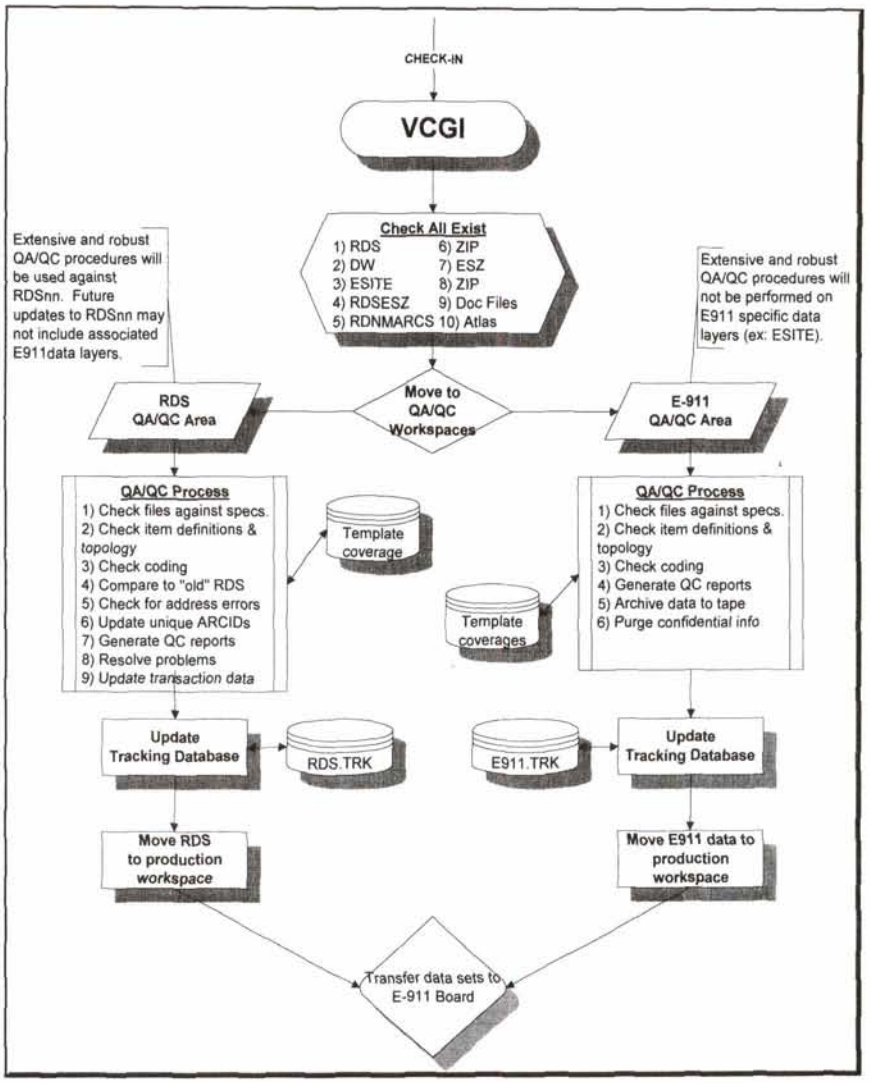

Figure 3. RDSnn/E-911 quality assurance process

Vermont. The reader might well ask what (if any) relevance these environmental and operational factors have in other jurisdictions. The author, therefore, must venture some answers:

E911 services—and no doubt many other programs which directly impact individuals, families, and communities—must be based firmly on some level of public acceptance and understanding. Citizens and residents, local activists and volunteers, services providers, and local government decision-makers must all become comfortable over an extended period of time with the possible problems, as well as the benefits, of such services. Further, a heavy reliance on technologies which seem nearly magical to many people, e.g., computerized analysis, spatial data mapping, GPS, and laser rangefinders, increases the potential for lack of understanding and acceptance. Three non-technical factors supported success in Vermont:

(1) GIS applications had been visible at the community level for several years in Vermont: tax parcel mapping, zoning and planning, and other applications had become common. Whether or not many citizens understood the technology in 1994, there was general agreement that it was a valuable component of local decision-making.

(2) Vermont's community of emergency service providers was a potent force in state-level lobbying activities, and at the level of providing friends and neighbors with information and enthusiasm. Providers worked well with the technicians who created and oversaw the GIS- and GPS-based implementation, and were not deterred in their support by fear of the technology.

(3) Local initiative and oversight of the data collection process were critical—there simply was no "fallback" plan for towns whose officials and volunteers were unable to provide the hours necessary to complete key tasks. Road naming, draft map review and correction, and researching misfits between old and new addresses happens in late-night meetings, on weekends, in lonely ill-lit rooms. Tasks which so intimately touch rural communities simply cannot be done by paid contractors who lack the local knowledge and dedication of community-based workers.

Several other factors relating to GIS and GPS technology contributed to the success of this project:

(4) Vermont started this project with several key data assets: a highly-accurate and complete road centerline file, and locally generated road names which were a great improvement over the only other digital source available at that time, TIGER Line Files from the U.S. Bureau of the Census. These digital roads and road names were used regularly by microDATA, VCGI, the

RPCs, and local officials before the E911 project commenced, so the comfort level of all parties was high.

(5) Vermont has few public-sector technology resources; therefore, many policy-makers have an expectation that those which exist should be shared. VCGI had been the steward of most of the GIS investments made at the state level over a number of years, and operated with the expectation that it would "partner" with other agencies in order to use those resources to support the partners' program objectives. E911 and VCGI developed a natural partnership; the E911 implementation benefitted from the availability of no-cost, high-quality GIS databases—to E911, towns, RPCs, and contractors—and the GIS infrastructure and expertise within VCGI and RPCs. The project also benefitted from the more formal role which VCGI was able to perform for E911. VCGI was able to act as a third-party technical resource which could provide data integration, consultation, and quality control services to E911, separately from the services provided to E911 by its contractors. Similarly, RPCs were able to function as subcontractors with existing community relationships relating both to GIS technology, and to broader community planning processes.

(6) Though the proposal review committee found several contractor teams to be well-qualified to handle the GIS database development assignment, the E911 implementation benefitted from the selection of a team whose prime contractor had actually performed "pilot" locatable addressing assignments for several Vermont towns. The contractor's prior experience helped all concerned to have confidence that the proposed uses of GIS and GPS would yield tangible and useful results.

(7) Finally, the E911 project revealed growing and explicit agreement that use of GIS technology supports the development and use of data for multiple purposes, by multiple parties. The value added to Vermont's road centerline database and the utility of the E911/ESITE (emergency site) database for many planning and commercial applications was not measurable as part of a before-the-fact assessment of costs and benefits. But these benefits, particularly those which result from use of GIS and GPS technology, have begun to reveal themselves as additional applications produce social and economic returns on Vermont's investment in a shared spatial data infrastructure.

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[24]Most sources are available at the URLs listed in the text or below, or are available as a matter of public record from the Vermont E911 Board and/or VCGI.

References[24]

Bailey, Evelyn, 1994. "FY 1995 Expenditure Plan" (a memorandum to the Vermont Secretary of Administration), Montpelier, Vermont.

MicroDATA GIS, Inc., 1995. Proposal for Development of GIS Databases for Support of Vermont's Enhanced 9-1-1 System, St. Johnsbury, Vermont.

———, 1999. Proposal for Maintenance of the GIS Databases in Support of Vermont's Enhanced 9-1-1 Program, St. Johnsbury, Vermont.

Vermont Center for Geographic Information, Inc. (VCGI), 1994a. "Road Name Database Contract—Specifications", Burlington, Vermont.

———, 1994b. "Request for Proposals for a Cost/Benefit Study of Alternative Addressing Strategies and Other Potential Uses of Geographic Information Systems (GIS) in Vermont's Enhanced 9-1-1 System," Burlington, Vermont.

———, 1999. "Request for Proposals for Maintenance of the GIS Databases in Support of Vermont's Enhanced 9-1-1 Program," Burlington, Vermont.

Vermont E911 Board, 1994a. "Estimated Start-up and Maintenance Costs of Enhanced 9-1-1 in Vermont" (a memorandum to legislators), Montpelier, Vermont.

———, 1994b. "Addressing Standards," Montpelier, Vermont.

———, 1995a. "Addressing Alternatives Analysis," Montpelier, Vermont.

———, 1995b. "Addressing Handbook," Montpelier, Vermont.

———, 1995c. "Report on Alternative System Design," Montpelier, Vermont.

———, 1995d. "Municipal Planning Guide for Enhanced 9-1-1 Services," Montpelier, Vermont.

———, 1995e. "Request for Proposals for Development of GIS Databases for Support of Vermont's Enhanced 9-1-1 System," Montpelier, Vermont.

Vermont Statutes Annotated, Equity Publishing Corporation, Orford, New Hampshire. (1999).

URLS

http://www.nena.org—The homepage of the National Emergency Number Association (NENA), Columbus, Ohio.

http://www.microdatagis.com—The homepage of MicroDATA, Inc., the primary GIS/GPS contractor to the Vermont E911 Board, St. Johnsbury, Vermont.

http://www.leg.state.vt.us/—The homepage of the Vermont General Assembly maintained by the Office of the Legislative Council, Montpelier, Vermont.

http://www.state.vt.us/e911/—The homepage of the Vermont E911 Board.

http://www.state.vt.us/health/ems/—The homepage of the Emergency Medical Services Division of the Vermont Department of Health.