A T T A C H M E N T S

Final Report

Boston Preparedness Pilot Project

GeoSpatial Data Development in Support of Critical Infrastructure Protection

September, 2003

APPLIED GEOGRAPHICS, INC.
Empowering People with Spatial Solutions

A T T A C H M E N T

A

Table of Acronyms

ACRONYM	ENTITY	ELABORATION
AGI	Applied Geographics, Inc.	Authors of the Boston Preparedness Pilot Geospatial Data Development Report
AM/FM	Automated Mapping / Facilities Management	
BPD	Boston Police Department	
BPP	Boston Preparedness Pilot	
CATS	Consequences Assessment Tool Set	Disaster analysis software developed by SAIC
CI	Critical Infrastructure	
CIP	Critical Infrastructure Protection	
CIS	Customer Information Systems	
CMR	Code of Massachusetts Regulations	
CSDGM	Content Standard for Digital Geospatial Metadata	Provides a common set of terminology and definitions for documenting digitial geospatial data
DCAM	Division of Capital Asset Management	Massachusetts agency responsible for tracking and management of all buildings and property owned by the Commonwealth.
DEP	Department of Environmental Protection	US Federal
DHS	Department of Homeland Security	US Federal
DoD	Department of Defense	US Federal
DoI	Department of Interior	US Federal
DoJ	Department of Justice	US Federal
DoT	Department of Transportation	US Federal
DPW	Department of Public Works	Typically a municipal-level center of public infrastructure maintenance resources and information.
E911	Enhanced 911	
EMS	Emergency Medical Services	
EPA	Enviornmental Protection Agency	US Federal
ESRI	Environmental Systems Research Institute	Private vendor of GIS software
ETL	Extract, Transform and Load	Primary steps involved in reconciling natively incompatible data sets.
FBI	Federal Bureau of Investigation	US Federal
FEMA	Federal Emergency Management Agency	US Federal
FGDC	Federal Geographic Data Committee	A 19-member interagency committee composed of representatives from the Executive Office of the President, Cabinet-level and independent agencies. Is developing the NSDI in cooperation with a large array of public and private participants.
FR	First Responders	
GDT	Geographic Data Technology	Private vendor of road network and other geospatial data
GSA	General Services Administration	
GeoDB	Geographic Database	Typically an ESRI database of geospatial information
GIS	Geographic Information System	
GITA	Geospatial Information and Technology Association	Non-profit educational association providing information exchange on geospatial information technologies worldwide. Addresses AM/FM, SCADA, CIS and others
GML	Geography Markup Language	XML encoding fo rthe transport and storage of geographic information, including the spatial and non-spatial properties of geographic features.
HIFLD	Homeland Infrastructure Foundation Level Database	
HS/CI	Homeland Security / Critical Infrastructure	
HSIP	Homeland Security Infrastructure Program	Authors of the Tiger Team Report, v1.0
HTML	Hypertext Markup Language	The language used to create Web pages with hyperlinks and markup for text formatting.
LiDAR	Light Detection and Ranging	A LASER device which emits pulses, the reflections of which are gathered by a scope aligned with the laser. The return signals are used to determine distance and position of reflecting material
MAPC	Metropolitan Area Planning Council	Regional planning agency for the greater Boston area
MassGIS	Massachusetts Office of Geographic Information	The primary public clearinghouse in Massachusetts for spatial data.
MEDS	Minimum Essential Data Sets	
MEMA	Massachusetts Emergency Management Agency	Agency that coordinates federal, state, local and private resources throughout Massachusetts during times of disasters and emergencies.
MWRA	Massachusetts Water Resources Authority	Greater Boston water supply and sewer collector system authority
NBI	National Bridge Inventory	US DOT index and inventory of bridges
NIMA	National Imagery and Mapping Agency	US Federal
NOAA	National Oceanic and Atmospheric Administration	US Federal
NSDI	National Spatial Data Infrastructure	Consequence of Executive Order 12906 calling for the establishment of technologies, policies, and people necessary to promote sharing of geospatial data throughout all levels of government, the private and non-profit sectors and the academic community.
OGC	Open GIS Consortium	An international industry consortium of more than 250 companies, government agencies and universities participating in a consensus process to develop publicly available geoprocessing specifications
RDBMS	Relational Database Management System	
SAIC	Science Applications International Corporation	Developers of CATS
SCADA	Supervisory Control and Data Acquisition	
SDSFIE	Spatial Data Standard for Facilities, Infrastructure and Environment	
SGML	Standard Generalized Markup Language	Generic language for writing markup languages. SGML makes possible different presentations of the same information by defining the general structure and elements of a document. HTML is based on SGML
USGS	United States Geological Survey	US Federal
WQTS	Water Quality Testing System	Massachusetts DEP database for water quality management
XML	Extensible Markup Language	Flexible text format derived from SGML (ISO 8879) by the World Wide Web Consortium. Originally designed to meet the challenges of large-scale electronic publishing, XML is also playing an increasingly important role in the exchange of a wide variety of data on the Web and elsewhere.

ATTACHMENT

B

Report to MassGIS titled:
"133 Urban Areas Boston Preparedness Pilot: Emergency Management GIS Schema Framework"

133 Urban Areas
Boston Preparedness Pilot

Emergency Management GIS Schema Framework

D R A F T #3

Prepared for:

MassGIS
Executive Office of Environmental Affairs

Prepared by:

APPLIED GEOGRAPHICS, INC.
Empowering People with Spatial Solutions

September 9, 2002

Revised:

October 21, 2002

1 Introduction

This document describes the GIS data layer schema framework for the Boston Preparedness (BP) Pilot/133 Urban Areas Emergency Management GIS. This framework should be considered an initial step in what will be an ongoing process. A broad consensus on priority layers and their attributes has not yet been achieved. Over time a more precise and comprehensive schema will emerge as further information is gathered from stakeholders and decisions are made throughout the schema development process. Ultimately, the schema will continue to evolve as data collection efforts ramp up and the data loading processes commence.

1.1 History and Methodology

The layers included in the schema originated from several disparate sources and have gone through several iterations/revisions. The BP Working Group narrowed an original list generated by the Massachusetts Emergency Management Agency (MEMA) of over 100 layers down to approximately 44. This list of 44 layers is found in table 1. While this is a solid list, there will doubtless be continuing discussion on which layers have the highest priority, and this will continue to be refined as data collection efforts get underway. AGI believes there is a need for more meetings and expert interviews to more precisely determine the attributes, domains, and rules for the data, as determined by use cases. In addition, this process should be moderated by a better understanding of the resources available to support data collection. It is strongly recommended that the Working Group first focus on data that have a high likelihood of being collected (i.e. funding or person-power is available to collect those data).

There also needs to be an overview and evaluation of existing emergency management schemas. For example, the Consequences Assessment Tool Set (CATS) has a robust data schema that covers many of the 44 priority data sets. It would be perfectly feasible to use many of the existing CATS schemas, while extending them to accommodate the contacts and document management data of interest to the BP Working Group.

The Homeland Security Infrastructure Program (HSIP) Tiger Team Report and its associated GIS layer schema became available during the latter stages of the BP schema design. Upon evaluation, it appears that this schema is a better fit than CATS for many of the 44 priority data sets. The valuable notion of Minimum Essential Data Sets (MEDS) and the three level National, Urban, and Comprehensive views described in the HSIP report will undoubtedly have an influence on subsequent work done for the BP. An evaluation of the HSIP report and a comparison of its schema with the BP's is being developed under separate cover. For the purposes of this report, the HSIP schema is widely referenced within the schema presented below.

Last, the structure of existing data sets needs to be considered in devising practical data loading and updating mechanisms. In particular, the members of the working group need to be fully informed as to the availability and condition of existing data sources, which requires that a systematic inventory be undertaken. As such, the schema described here, and in particular, the approach for handling base features and views, is provided as a framework upon which to build.

In an effort such as this, it is difficult to determine the appropriate level of granularity for the mass of data to be housed in the system. Some emergency management schemas have hundreds of columns for a single feature. Others have very simplistic schemas. The approach here, particularly without more attribute requests from the BP working group, has been to provide a practical minimum and make maximum references to existing schemas (e.g. HSIP and CATS). Also, the importance of contacts and document management data to supplement the GIS system, as described below, represents an important and necessary alternative to data overload. After all, what good is having hundreds of columns of attribute data if most of them never get populated?

1.2 Focus on Building Footprints

Given limited resources and the lack of consensus of schema composition across all 44 priority data layers, AGI has focused its efforts on constructing a robust schema for the what is universally acknowledged as one of the most key and complex data sets: building footprints. Buildings are generally the fundamental unit of response in most emergency situation, and it is clear that first responders require access to these spatial data as well as robust, descriptive attributes. Buildings are in fact a generic "base feature" and no fewer than 9 of the 44 priority layers (e.g. hospitals, schools, federal facilities) are actually buildings (or more accurately a sub-set of all buildings) with common attributes. Also, a group of buildings – for example, Northeastern University – may be act as a "campus complex" thus requiring that many individual features share attributes that pertain to their "parent" campus.

AGI has spent considerable effort modeling these complexities for buildings, and this will be presented in section 4.3, below. The other data layers were also modeled and are presented in section 4.4. However, it should be understood that those layers were not modeled with the same rigor as buildings. As described above, the schema for those layers more closely resembles a framework that will organize further discussions and support the consensus building process. Over time, details similar to what is found for buildings will be added to that framework.

2 Related Issues

2.1 Metadata

The value of metadata for the emergency management GIS system can't be over emphasized. A full web based data inventorying, compilation, and tracking system, part of which manages FGDC-CSDGM metadata for the wide variety of sources and data types used to populate a single GIS layer, needs to be considered. For example, a single data layer such as statewide Police Stations may be the result of numerous individual parties (.e.g Boston Police, Cambridge Police, Waltham Police, State Police, etc.) that contribute their own "data set". One eventual goal is that each GIS feature can be traced back to the data set from which it originated. As such, all the GIS features should have a DATASET column that will be used as a foreign key into a data set metadata table. The companion document titled "Data Set Compilation Schema" covers this issue in detail.

2.2 Contacts and Documents Management

While this document focuses primarily on GIS features, the management of both contact information and document management information will be crucial to the usefulness of any eventual emergency management GIS system. As such, basic contact and document data definition is provided below.

2.2.1 Contacts Management

Contact management information provides one of the most important pieces of information required by emergency responders. The current prototype database being developed for both the GIS feature layers and the data compilation and tracking tool is using a view of the current MassGIS contacts management database.

The following create table statement matches the contacts view being used. It is provided as an implementation guideline and describes a solid base of minimum contact information that should be made available for all buildings, campus complexes, and emergency management personnel. The flexibility inherent in using RDBMS views to define an data access interface can be fully exploited for this and other table definitions in this schema. This approach allows for schema compliance and interoperability regardless of specific physical implementation details.

```
create table CONTACTS (
ID INTEGER NOT NULL,
FIRST VARCHAR(25),
LAST VARCHAR(25),
ORG VARCHAR(80),
TEL VARCHAR(25),
CELL_TEL VARCHAR(25),
BEEPER VARCHAR(25),
FAX VARCHAR(25),
EMAIL VARCHAR(40),
WEB VARCHAR(50),
TITLE VARCHAR(50),
SOURCE VARCHAR(50),
LASTUPDATE VARCHAR(50),
ADDRESS1 VARCHAR(80),
ADDRESS2 VARCHAR(80),
CITY VARCHAR(80),
STATE VARCHAR(2),
ZIP VARCHAR(20),
ORGCAT VARCHAR(3));
```

It should also be understood that contact management has two distinct components. First, there is a generic requirement to simply view contacts in association with the features (e.g. buildings) they are associated with. The table described above (which may, in some cases, be a database view) provides this mechanism. Second, there are specific requirements for a fully functional contacts management system. Such a system provides functionalities for efficient data entry/editing, enforcing database coding standards (e.g. organization names normalization) and managing relationships between people and organizations (e.g. one person having an affiliation with multiple organizations). It is not intended that the table above be able to provide this second type of functionality as part of the BP schema. Rather, if such contact management systems exists – as is the case for MassGIS – it is intended such a system be able to be used in association with the BP schema, likely as a derivative view housing the fields described above.

It is fully intended that during the course of populating the BP Pilot database a thorough exploration of the interaction between the MassGIS contact management environment and the schema proposed above will be completed. Such an exploration is necessary to confirm the implementation details of the schema, and to ensure that the resultant contact to feature association provides the functionality that MassGIS expects. Ultimately, such a test will provide valuable lessons to other jurisdictions that are interested in implementing this schema.

2.2.2 Document Management

Much of the most valuable information required to support emergency response scenarios is available in the form of photographs (not necessarily aerial or ortho), floor plans, complex site plans, and standard text documents. Document sets, such as the Boston Police Operation Safe City initiative, while not being strictly GIS in nature, should be fully accessible through a GIS interface. As such, an important function of the GIS is to provide a geographic view into an emergency management document system. It may not be feasible to house all of these documents in the master database itself. Rather, links to these documents, whether through a web based URL, or through contact information, needs to be made available in the system. In addition, the documents should be complemented with full metadata.

While individual feature records, building footprints for example, may reference a single primary site document as part of the base building record information, the document table described here supports multiple documents per feature.

There will be an N to 1 relationship between a given set of documents and a specific geographic feature. Also, documents will be associates with multiple GIS feature and table entities. To provide for this cardinality, a record in the document table uses the GdbFeatureTypeId as a foreign key into the ESRI GeoDatabase GDB_ObjectClasses table to indicate the parent feature type and the GdbFeatureId as a foreign key into the specific feature tables.

```
create table DOCUMENT (
ID INTEGER,
ORIGIN VARCHAR(50),
PUBDATE VARCHAR(50),
TITLE VARCHAR(50),
ONLINK VARCHAR(50),
```

```
FORMAT VARCHAR(50),
ABSTRACT VARCHAR(50),
GDBFEATURETYPEID INTEGER,
GDBFEATUREID INTEGER
);
```

This simple and skeletal document schema will no doubt be further developed and influenced by existing document management systems. The diagram below illustrates the document to feature relationships.

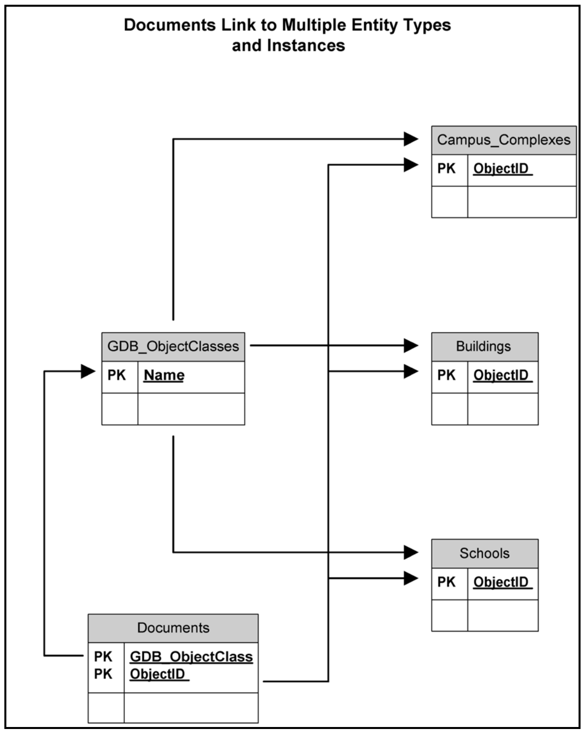

Figure 1: Documents of all types, including site plans, photographs, and evacuation plans, can link to multiple entity types and instances. The GeoDatabase GDB_ObjectClasses table provides a metadata list of all entities in the database, for both GIS features and supplemental attribute tables. The Documents table uses a compound primary key, consisting of the GeoDB entity type and the ObjectID instance key to uniquely identify a record. Many documents can be associated with a single record from any feature or attribute table

3 Schema Components

3.1 GIS Features

The GIS feature schema is structured as a set of specific elements consisting of:

1. GIS Features: Sets and Layers
2. Base Features and Views
3. Attributes
4. Domains
5. Sources

For base features, a rough grouping based on the Spatial Data Standard for Facilities, Infrastructure and Environment (SDSFIE) has been used. The standard SDSFIE organization was not, however, designed for the needs of an emergency management GIS data schema. For example, many of the most important features being modeled here are buildings. The SDSFIE entity class category for all of these uses a simple 'buildings_general'. Hence, the SDSFIE entity hierarchy was used as a guide and it is understood that Feature Classes still need to be developed to help organize several of the base layers. In addition, several of the layers suggested by the Working Group (e.g. terrorist targets) did not fall into existing SDSFIE entity classes. To address this, AGI has suggested a new entity set called "emergency_management" to house these layers.

The base layers used to initiate this schema are drawn from the original 44 layers developed by the Boston Prepardness (BP) Working Group. Table 1 illustrates these layers organized by SDSFIE entity sets.

Table 1: 44 Priority Data Layers Organized by SDSFIE Entity Sets

	SDSFIE Entity_Set	MEMA Layer Name
1	**buildings**	Hospitals
2		Public Health Facilities
3		Special Needs Facilities
4		Doctor/Medical Offices/Facilities
5		State Properties & Facilities
6		Federal Facilities
7		Municipal Facilities (e.g. schools)
8		911 Dispatch Centers
9		Emergency Operations Centers
10	**communications**	Communication Tower/Transmitter Locations
11	**environmental_hazards**	Hazardous Materials Storage Sites (Title 3)
12		Hazardous Waste Sites
13	**hydrography**	Bathymetric Data
14		Water Supplies/Watersheds
15		Nautical Data (Needs to be more specific)
16	**transportation**	Major Roads (Interstate, U.S., State)
17		Minor Roads (Local)
18		Bridges
19		Tunnels
20		Traffic Control/Access Control Points
21		Evacuation Routes
22		Access/Egress Routes (Hierarchy)
23		Rail Systems (Subway, Commuter, Freight)
24		Anchorages (Hazardous & Special)
25		Boat Ramps
26		Water Ports/Docks
27		Ferry/Boat Terminals
28		Ferry Routes
29		Airports

30	**utilities**	Electrical Systems - Facilities/Feeds
31		Power Plants
32		Gas Systems - Facilities/Feeds
33		Water Systems/Pipelines
34		Public Well Locations
35		Oil Pipeline
36		Gas Pipeline
37		Oil Storage Facilities
38		Liquid Natural Gas Facilities/Infrastructure
39	**military_operations**	Military Installations
40	**Emergency_management****	Access/Egress Building Locations
41		Large Crowd Gathering Locations
42		Staging Areas for MCI Use
43		Terrorism Targets
44		Staging Areas/Distribution Sites

** Emergency_management entity is not present in SDSFIE and is suggested by AGI.

3.2 Base Features and Views

A base feature class, like building footprints, will be joined with a variety of more specific thematic tables, e.g., hospitals and schools. The hospital and school tables will include foreign key references to the building table primary key. This is in keeping with the fact that base GIS features will tend to be available as a blanket layer, while more specific thematic attribute information for different types of features will tend to be available in separate tables. This organization will facilitate data loading and updating.

In addition, many proposed attributes and uses of the data require views spanning several thematic tables. This is particularly true for buildings and campuses or building complexes. For example, both hospitals and schools may act as emergency operations centers. Union views, built from these more specific tables will be created and again joined back to the base building layer. This will allow viewing the data in original form as hospitals and schools while also allowing the same base geometry to be viewed as emergency operation centers. Figure 2 below (in section 4.3.2) illustrates the mechanism for handling these union views.

3.3 Attributes

In addition to a spatial geometric field, features are made up of alphanumeric attributes or database columns. Each of these attribute columns should eventually have at least the following metadata elements described:

1. Name
2. Description
3. Short Name (for database column name)
4. Data Type
5. Cardinality
6. Null Allowed
7. Domain

3.4 Domains

Attributes may be free text or restricted to use a value from a specific numeric range or specific list of values. For example, a town name must be a member of a list Massachusetts towns for the study area.

3.5 Sources

Sources describe organizations and/or data sets that have been identified by the working group as likely candidates for data to be used for specific layers. Each source organization and data set requires a description and contact information. These data sources will be inventoried, gathered, and evaluated for prospective use. In some cases only a "type of organization" has been listed, for example "electric utilities". In these cases, a specific candidate set of electric utilities needs to be provided. For electric utilities, the candidates might include NStar, National Grid, et al. Sources are mentioned at any level in the feature hierarchy and a single source can be referred to by multiple features.

4 The GIS Schema

4.1 Features Sets

As described above, the SDSFIE feature sets were used as the initial, basic organizational scheme for grouping the priority 44 data layers. The 7 major SDSFIE Geographic Feature Sets, and one additional feature set suggested by AGI, are:

1. Buildings
2. Communications
3. Environmental Hazards
4. Hydrography
5. Transportation
6. Utilities
7. Miltary Operations
8. Emergency (not modeled under SDSFIE)

Although in most cases the initial 44 data layers were retained, during data modeling there was some need to expand these layers into sub-types. For example, a "school" is a sub-type of "municipal facility". The basic layers/views for the Feature Sets identified to date are listed below. While this listing is similar to Table 1 above, new sub-types not included in Table 1 are identified in *italics*.

1. Buildings

- *Building complex boundaries (i.e. campuses)*
- Hospitals
- Public Health Facilities
- Special Needs Facilities
- Medical Offices
- Nursing Homes
- State Facilities

- Federal Facilities
- Municipal Facilities
- 911 Dispatch Centers
- Emergency Operations Centers
- *Police Stations*
- *Fire Stations*
- *Schools*
- *Universities*

2. Communications

- Communication Tower/Transmitter Locations

3. Environmental Hazards

- Hazardous Materials Storage Sites (Title 3)
- Hazardous Waste Sites

4. Hydrography

- Bathymetric Data
- Water Supplies/Watersheds (some overlap here with water utility information)
- Nautical Charts (linked documents)

5. Transportation

- Major Roads (Interstate, U.S., State)
- Minor Roads (Local)
- Bridges
- Tunnels
- Traffic Control/Access Control Points
- Evacuation Routes
- Access/Egress Routes (Hierarchy)
- *Regional Rail Line*
- *Intercity Rail Line*
- *Railroad Station*
- *Subway Line*
- *Subway Station*
- Anchorages (Hazardous & Special)
- Boat Ramps
- Water Ports/Docks
- Ferry/Boat Terminals
- *Ferry Routes*
- Airports
- *Heliports*

6. Utilities

- *Electrical Transmission Lines*

- *Electric Substation*
- Power Plants
- Water Pipelines
- *Reservoir*
- Public Wells
- *Dams*
- Gas Pipeline
- *Gas Storage Tank*
- Oil Pipeline
- Oil Storage Tank

7. Military

- Installations

8. Emergency Management (not included in SDSFIE)

- Access/Egress Building Locations
- Large Crowd Gathering Locations
- Staging Areas
- Terrorism Targets
- Special Needs Facilities
- Emergency Operations Centers
- 911 Dispatch Services

4.1.1 Layers Not Currently Included in the Boston Pilot

Although AGI has attempted to adhere to the prioritized list of 44 layers, our research and exposure to the homeland security literature and other schema (e.g. CATS) has suggested that there are numerous other priority data layers. Some, but not all of these layers were included in the original MEMA list of 100 priority layers. AGI recommends that a formal review of existing emergency management schemas should be undertaken, both to ensure completeness and to take advantage of work already done in this area. Additional layers considered high priority include, but are not limited to:

- Financial Institutions
- Sewage Treatment Facilities
- Large Commercial Centers
- Monuments
- Tourist Attractions
- Postal Facilities
- Wholesale Grocery Supplies
- Softdrink Plants (i.e. alternative source of potable liquids)
- Industrial Plants
- Chemical Plants
- Air Navigational Aids
- Weather Stations

- Telephone Exchange Centers
- Internet Data Centers

In addition, while not specifically mentioned in the layers list, a set of base reference geographic layers needs to be available in the system including:

- Land/water boundary
- Census tracts/population data
- Political boundaries including state, county, and town
- Digital orthophotography
- Elevation/hypsography

4.2 Layer Definitions

Each feature layer in the schema needs to have the following data items defined. The following layer-by-layer write-ups adhere to this overall structure:

- **Description:** A brief description of the feature
- **Geometry**: Point, Polyline, or Polygon
- **Priority:** Importance, as determined by the working group
- **Reference Schema:** In many cases, there were very few attributes gathered from the BP Working Group. For these cases, references to existing schema have been provided. The two most notable "referenced schema" were CATS and Homeland Security Infrastructure Program Tiger Team Report (HSIP). Both of these documents maintain robust schema for many of the features on the Massachusetts list. It should be noted that for HSIP only the 130 Urban "layers" were referenced as opposed to the "comprehensive" listing that included over 250 layers. Full listings of these schemas are provided in the appendices.
- **Attributes:** Where attributes have been provided by the working group, a simple SQL CREATE TABLE statement has been created.
- **Views:** If a given table is expected to be combined with another table through a join or union join, a view name is provided.
- **Sources:** Lists generally available sources for the information in this table.
- **Notes:** Miscellaneous comments, explanations, and information.

A note on schema completeness:
In reviewing the schema below, one will note that for some layers many of the above listed elements are blank. Such blanks to **not** reflect omissions, rather they may be more accurately categorized as "to be determined" (TBD). This reflects the fact that based on the research completed to date no suitable answer has been uncovered. It is fully anticipated that through reviews of this document, and through further efforts of both the BP Working Group the blanks will be "filled in". Ultimately, it is anticipated that the schema document will evolve incrementally as lessons are learned through initial

implementation efforts, and as further input is obtained from the BP Working Group and first responder communities.

4.3 Buildings and Campus Complex Schema

As described above, buildings and campus complexes are core layers for emergency response. This study modeled these entities at a level of detail in excess of all other layers. As such, these write-ups are presented at the outset and apart from the rest of the individual layer schema, which are found in section 4.4. In addition to the core building and campus complex layers, this section contains the schema descriptions for layers that are *derived* from these base layers such as schools, hospitals and police stations.

4.3.1 Campus Complex

Complexes and campuses will be modeled as separate polygons, similar to buildings. Buildings may have a foreign key into the Campus_Complex table indicating a child → parent relationship. There is considerable overlap between Complex and Building attributes. A primary value in storing explicit complex polygon records will be in linking them to raster site plan documents, frequently available for hospitals, universities, and other multi-structure facilities. These types of site plans efficiently provide a great deal of emergency management information. Once campus complex geometry was developed, individual buildings could have their parent complex ID number assigned very efficiently using GIS-based spatial joins/overlays.

Description: A group of buildings with overarching, similar characteristic such as the owner. Examples of building complexes include university or hospital campuses, or buildings owned by State Government.

Geometry: Polygon

Priority: 1

Reference Schema: HSIP: Building, Institutional Site

Attributes:

```
create table CAMPUS_COMPLEX (
ID INTEGER,
LAT FLOAT,
LON FLOAT,
X FLOAT,
Y FLOAT,
NAME VARCHAR(64),
TYPE VARCHAR(32),
GOVT VARCHAR(16),
PRIME_USE VARCHAR(32),
ADDR1 VARCHAR(48),
ADDR2 VARCHAR(48),
STREET VARCHAR(48),
TOWN VARCHAR(48),
ZIP VARCHAR(16),
```

```
DAMAGE_ASSESSMENT VARCHAR(128),
DESCRIPTION VARCHAR(128),
DAY_POP INTEGER,
NIGHT_POP INTEGER,
CAPACITY_POP INTEGER
AREA INTEGER,
BACKUP_POWER VARCHAR(64),
EMERGENCY_CONTACT1 INTEGER,    // foreign key into Contact table
EMERGENCY_CONTACT2 INTEGER,  // foreign key into Contact table
OWNER_CONTACT VARCHAR(128),
PLACE_NAME VARCHAR(64),
PARCEL_ID VARCHAR(32),
LAND_USE_CODE VARCHAR(16),
SITE_PLAN_REF VARCHAR(64),
HOURS_OPERATION VARCHAR(32),
ALTERNATE_LOCATION VARCHAR(128),
PHOTO LONG RAW,
NOTES VARCHAR(255),
DATASET INTEGER
);
```

Views: None at present

Sources: 133 Urban Areas Boston Preparedness Working Group and local first responders.

Notes: Buildings making up complexes or campuses will still be modeled individually wherever appropriate.

4.3.2 Buildings

Description: Built structures. As appropriate, the set of all buildings in a region, could be filtered such that only buildings having attributes with a specific matched or exceeded threshold, would be included. An example of a specific threshold that might be used to create a data set of "significant buildings", might be "Number of Floors" greater than or equal to five.

Geometry: Polygon

Priority: 1

Reference Schema: HSIP: Building

Attributes:

```
create table BUILDING (
ID INTEGER,
CAMPUS_COMPLEX_ID INTEGER,  // foreign key into Campus_Complex table
LAT FLOAT,
LON FLOAT,
```

```
X FLOAT,
Y FLOAT,
NAME VARCHAR(64),
TYPE VARCHAR(32),
GOVT VARCHAR(16),
PRIME_USE VARCHAR(32),
ADDR1 VARCHAR(48),
ADDR2 VARCHAR(48),
STREET VARCHAR(48),
TOWN VARCHAR(48),
ZIP VARCHAR(16),
DAMAGE_ASSESSMENT VARCHAR(128),
DESCRIPTION VARCHAR(128),
DAY_POP INTEGER,
NIGHT_POP INTEGER,
CAPACITY_POP INTEGER
AREA INTEGER,
FLOORS INTEGER,
HEIGHT INTEGER,
BACKUP_POWER VARCHAR(64),
EMERGENCY_CONTACT1 INTEGER,    // foreign key into Contact table
EMERGENCY_CONTACT2 INTEGER,  // foreign key into Contact table
OWNER_CONTACT VARCHAR(128),
PLACE_NAME VARCHAR(64),
PARCEL_ID VARCHAR(32),
LAND_USE_CODE VARCHAR(16),
SITE_PLAN_REF VARCHAR(64),
HOURS_OPERATION VARCHAR(32),
ALTERNATE_LOCATION VARCHAR(128),
PHOTO LONG RAW,
NOTES VARCHAR(255),
DATASET INTEGER
);
```

Views: See below.

Sources:
MassGIS LIDAR–based building data

City of Boston base map

Individual GIS base maps from local communities. For instance, Cambridge, Brookline, Waltham, Newton, Quincy, Bedford, Natick and many other cities/towns have their own building footprints derived from accurate (i.e. 1”:40’ or 1”:100’) aerial flyovers.

NStar/MWRA: Boston Edison, prior to being purchased by NStar created a region-wide (in excess of “inside Rt. 128”) building data layer dating from 1994. These data have been licensed to, and supplemented by MWRA

Notes:

Building Views:
The building entity described above will be used as a base GIS feature class. Thus, there will be an ESRI GeoDatabase polygon building feature class. The more specialized building information, associated with the building types listed above (e.g. school) will be joined to this base building class, through presentation software such as ESRI's™ ArcGIS™ ArcMap, to allow a wide variety of thematic building views. This arrangement accommodates the fact that building points or footprint polygons will tend to be available as sets covering an entire area, while the more thematic information for a specific type of building will tend to be available through purely attribute tables. Figure 2 below illustrates how schools, police stations and prisons can be segregated from buildings, and managed as their own layer through specific attribute tables.

Union Views:
In some cases, it will be desirable to view an SQL union view, or cross table, join of specific building types against the base feature class. This would allow different types of buildings sharing a subset of attributes, i.e., emergency operations information for schools and hospitals, to be seen as one layer. Figure 2 below illustrates how emergency operations centers can be created via a union view of schools, police and prisons.

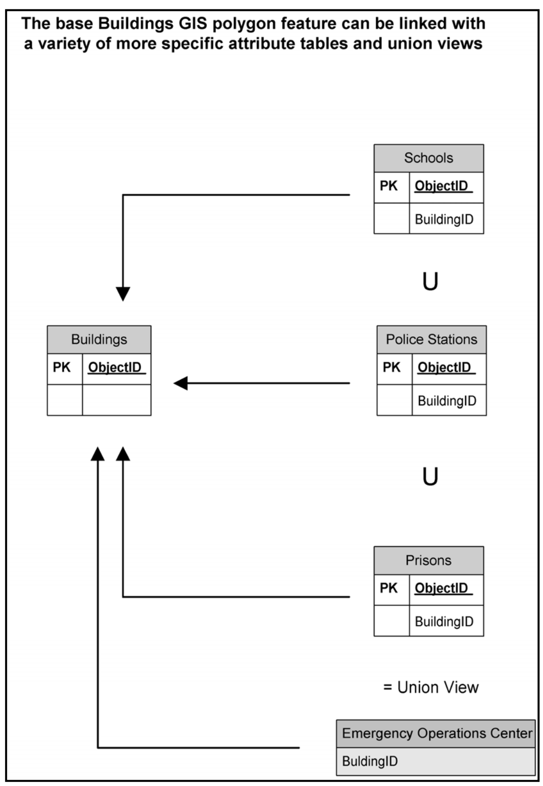

Figure 2: The base Buildings GIS Polygon Feature primary key is used as a foreign key by more specialized building type records from supplemental attribute tables. Cross table SQL union views, built using a common subset of attributes from a set of tables, can appear as a

single entity which is also linked to base building features. These join relationships can be stored persistently, both as SDE views, or in the presentation layer, as part of an ArcMap or ArcIMS .mxd file

In general, the view and union view approach as described above, may be adopted as a general mechanism for defining a flexible schema framework to handle the wide variety of views and roles different features may play within the system.

A list of categories and specific thematic building and complex types follows.

HEALTH RELATED VIEWS:

4.3.2.1 Hospitals

Description: Location of public and private hospitals.

Geometry: Polygon

Priority: 1

Reference Schema: CATS: Hospitals, VA Hospitals, VA Hospital Staff, HSIP: Primary Care Facilities, Health Services

Attributes:

Views: Hospitals has a foreign key, BUILDING_ID, to the BUILDING table. Hospital may also participate in Emergency Operations Center.

Sources:
Metro Boston EMS Health Council Survey;
MA-DPH Bureau of Health Quality Mgmt.;
US Veteran Admin. National Disaster Medical System;
Boston Med Flight (for landing areas) (see Heliports)

Notes:

4.3.2.2 Public Health Facilities

Description: Location of non-hospital public health facilities (e.g. clinics, HMO offices, state Public Health offices, etc.)

Geometry: Polygon

Priority: 1

Reference Schema: CATS: Medical Personnel, HSIP: Health Services

Attributes:

Views: Public health facilities has a foreign key, BUILDING_ID, to the BUILDING table

Sources: MAPC Survey, MA Department of Public Health, Massachusetts Health Data Consortium

Notes:

4.3.2.3 Medical Offices

Description: Location of non-hospital, non-clinic medical offices, including doctors offices.

Geometry: Polygon

Priority: 1

Reference Schema: CATS: Medical Personnel, HSIP: Health Services

Attributes:

Views: Medical offices has a foreign key, BUILDING_ID, to the BUILDING table

Sources: MAPC Survey, Massachusetts Health Data Consortium

Notes:

4.3.2.4 Nursing Homes

Description: Location of nursing homes and other elder care facilities.

Geometry: Polygon

Priority: 1

Reference Schema:

Attributes:

Views: Nursing homes has a foreign key, BUILDING_ID, to the BUILDING table

Sources:
Local Emergency Planning Committees (LEPC), Massachusetts Health Data Consortium, Massachusetts Department of Public Health (Division of Health Care Quality), Massachusetts Executive Office of Elder Affairs, Massachusetts Divisionof Medical Assistance, Statehouse bookstore (*List of Long Term Care Facilities*)

Notes:

4.3.2.5 Day Care Centers

Description: Location of day care centers.

Geometry: Polygon

Priority: 1

Reference Schema:

Attributes:

Views: Day care center facilities has a foreign key, BUILDING_ID, to the BUILDING ta

Sources:
LEPC, Massachusetts Office of Child Care Services (licensing agency)

Notes: Large facilities with major employers may have "on-site" day care centers. The schema will need to handle this condition.

GOVERNMENT RELATED VIEWS:

Please Note:
A for Federal, State, and Municipal Government buildings are all found in the base BUILDING table and are designated as such through the BUILDING.GOVT field.

4.3.2.6 Federal Government Facilities

Description: Location of federally owned facilities and those facilities that house federal offices (i.e. not owned by govt. but leased to govt.).

Geometry: Polygon

Priority: 1

Reference Schema: CATS: Government Databases, FEME Regional Centers, RRS Mobility Sites, FEME Personnel, HSIP: Government, Government Installations

Attributes:

Views: Federal government facilities has a foreign key, BUILDING_ID, to the BUILDING table

Sources: GSA

Notes: A variable allowing differentiation between "federally owned" and "federally occupied" should be present.

4.3.2.7 State Government Facilities

Description: Location of state owned facilities and those facilities that house state offices (i.e. not owned by state but leased to state).

Geometry: Polygon

Priority: 1

Schema Reference: CATS: State Emergency Operation Centers, HSIP: Government, Government Installations

Attributes:

Views: State government facilities has a foreign key, BUILDING_ID, to the BUILDING table

Sources: Division of Capital Asset Management (DCAM)

Notes: A variable allowing differentiation between "state owned" and "state occupied" should be present.

4.3.2.8 Municipal

Description: Municipally owned and managed property and facilities. In particular, city/town offices (i.e. City Hall) and departmental offices, DPW yards and parks.

Geometry: Polygon

Priority: 1

Schema Reference: CATS: Local Emergency Operation Centers, HSIP: Government

Attributes:

Views: Municipal government facilities has a foreign key, BUILDING_ID, to the BUILDING table

Sources: Individual municipality GIS programs

Notes: Several classes of "municipal facilities" are captured below in Police and Fire Stations and Schools.

4.3.2.9 Fire Stations

Description: Location of fire stations

Geometry: Polygon

Priority: 1

Reference Schema: HSIP: Fire Stations/EMS Stations

Attributes:

Views: Fire station facilities has a foreign key, BUILDING_ID, to the BUILDING table

Sources: Individual municipal fire departments, MEMA, METROFIRE (33 Greater Boston communities & Massport), Massachusetts Department of Fire Services

Notes: Municipal fire stations should be able to be referenced to the municipal facilities layer.

4.3.2.10 Police Stations

Description: Location of police stations and facilities (e.g. police boat docks)

Geometry: Polygon

Priority: 1

Reference Schema: HSIP: Law Enforcement

Attributes:

Views: Police station facilities has a foreign key, BUILDING_ID, to the BUILDING table

Sources:
Individual municipal police forces, Massachusetts State Police, MEMA,
Notes:

4.3.2.11 Schools

Description: Location of public and private schools.

Geometry: Polygon

Priority: 1

Reference Schema: HSIP: Schools

Attributes:

Views: School facilities has a foreign key, BUILDING_ID, to the BUILDING table

Sources:
Individual municipal school departments/authorities, LEPC, Massachusetts Department of Education (http://profiles.doe.mass.edu/search.asp?)

Notes: Schools will often need to be modeled as campus complexes as well.

4.3.2.12 Colleges and Universities

Description: Location of public and private higher education institutions, including, colleges, universities, and junior/community colleges.

Geometry: Polygon

Priority: 1

Reference Schema: HSIP: Colleges and Universities

Attributes:

Views: University facilities has a foreign key, BUILDING_ID, to the BUILDING table

Sources:
Individual institution of higher education, University of Massachusetts, MA DCAM property inventory

Notes: Universities will often need to be modeled as campus complexes as well.

4.4 Other Layer Schema

As described above, the layers schemas presented below are at a "framework" level and do not contain the same level of detail as the building/building complex schema presented above.

4.4.1 Communications

4.4.1.1 Communication Tower/Transmitters

Description: Communication Tower/Transmitters

Geometry: Point

Priority: 1

Reference Schemas: CATS: Radio TV Communications, EBS AM-FM-TV EMP, PBS AM-FM, TV All, Communications Nodes, HSIP: Tower

Attributes:

- Lat/Lon
- Height
- Backup Power
- Owner
- Customers
- Channels

Views:

Sources: DEM, State Police, FCC, SARA Tier II DB, Wireless Carriers: Verizon, AT&T, Cingular, Sprint,

Notes:

4.4.2 Environmental Hazards

4.4.2.1 Hazardous Materials Storage Sites

Description: TBD

Geometry: Polygon

Priority: 1

Reference Schema: HSIP: Hazardous Materials Facilities

Attributes:

```
Create table HAZMAT_SITE (
ID INTEGER,
NAME VARCHAR(50),
TYPE VARCHAR(50),
ADDR1 VARCHAR(50),
ADDR2 VARCHAR(50),
STREET VARCHAR(50),
TOWN VARCHAR(50),
ZIP VARCHAR(50),
CHEMICALS VARCHAR(128),
QUANTITY DOUBLE
```

```
);
```

Views:

Sources:
US-EPA SARA Tier II Chemical DB
State DPH for University research "permits"
Notes:

4.4.2.2 Hazardous Waste Sites

Description: TBD

Geometry: Polygon

Priority: 1

Reference Schema: HSIP: Superfund Sites

Attributes:
```
Create table HAZWASTE_SITE (
ID INTEGER,
NAME VARCHAR(50),
TYPE VARCHAR(50),
ADDR1 VARCHAR(50),
ADDR2 VARCHAR(50),
STREET VARCHAR(50),
TOWN VARCHAR(50),
ZIP VARCHAR(50),
CHEMICALS VARCHAR(128),
QUANTITY DOUBLE
);
```

Views:

Sources: DEP 21E DB, MassGIS

Notes:

4.4.3 Hydrography

4.4.3.1 Bathymetric

Description: Ocean, river and lake depth values

Geometry: Polygon

Priority: 2

Reference Schema: HSIP: Elevation/Bathymetry

Attributes:

Views:

Sources: NOAA

Notes:

Source

4.4.3.2 Water Supplies/Watersheds

Description: Public water supplies (surface water and wells)

Geometry: Polygon

Priority: 1

Reference Schema: HSIP: Public Water Supply Intakes

Attributes:

Views:

Sources: DEP, MassGIS

Notes:

4.4.3.3 Nautical

Description: TBD

Geometry: Polygon

Priority: 2

Reference Schema:

Attributes:

Views:

Sources: NOAA

Notes:

4.4.4 Transportation

4.4.4.1 Major Roads

Description: Limited access highways and major arterials

Geometry: Polyline

Priority: 1

Reference Schema: HSIP: Roads

Attributes:

Views:

Sources: MHD, commercial vendors (GDT, Navtech)

Notes:

4.4.4.2 Minor Roads

Description: Minor arterials and local roads

Geometry: Polyline

Priority: 2

Reference Schema: HSIP: Roads

Attributes:

Views:

Sources: MHD, commercial providers

Notes:

4.4.4.3 Bridges

Description: Motor vehicle, rail and viaduct bridges

Geometry: Polyline

Priority: 1

Reference Schema: HSIP: Bridges

Attributes:

```
Create table bridges (
ID INTEGER.
HEIGHT DOUBLE,
LENGTH DOUBLE,
CLEARANCE DOUBLE,
WIDTH DOUBLE,
MAX_LOAD INTEGER
);
```

Views:

Sources: MHD, US-DOT

Notes:

4.4.4.4 Tunnels

Description: Motor vehicle, rail and viaduct tunnels

Geometry: Polyline

Priority: 1

Reference Schema: HSIP: Tunnels

Attributes:

```
Create table TUNNELS (
ID INTEGER.
LENGTH DOUBLE,
CLEARANCE DOUBLE,
WIDTH DOUBLE,
MAX_LOAD INTEGER
);
```

Views:

Sources: MHD

Notes:

4.4.4.5 Traffic Control/Access Points

Description: Stop lights, intersections, bridges and other traffic pinch points.

Geometry:

Priority: 1

Reference Schema: HSIP: Interchange

Attributes:

Views:

Sources:

Notes:

4.4.4.6 Railroad

Description: Freight and commuter rail lines

Geometry: Polyline

Priority: 1

Reference Schema: HSIP: Railroads, Railroad Facilities, Railroad Yards

Attributes:

Views:

Sources: MHD

Notes:

4.4.4.7 Subway Line

Description: Light rail in urban areas

Geometry: Polyline

Priority: 1

Reference Schema: HSIP: Railroads

Attributes:

```
CREATE TABLE SUBWAY_LINE (
ID INTEGER,
OWNER VARCHAR(64),
NAME VARCHAR(64)
);
```

Views:

Sources: MBTA

Notes:

4.4.4.8 Subway Station

Description: Location of stations on subway lines.

Geometry: Polyline

Priority: 1

Reference Schema: HSIP: Railroad Facilities

Attributes:

```
CREATE TABLE SUBWAY_STATION (
ID INTEGER,
OWNER VARCHAR(64),
NAME VARCHAR(64)
);
```

Views:

Sources: MBTA

Notes:

4.4.4.9 Railroad Station

Description: Location of railway stations and depots.

Geometry: Polyline

Priority: 1

Reference Schema: HSIP: Railroad Facilities

Attributes:

```
CREATE TABLE RAILROAD_STATION (
ID INTEGER,
BUILDING_ID INTEGER
);
```

Views:

Sources: MHD, MBTA

Notes:

4.4.4.10 Communter Rail/Regional Line

Description: Location of commuter rail routes

Geometry: Polyline

Priority: 1

Reference Schema: HSIP Railroads

Attributes:

```
CREATE TABLE RAIL_REGIONAL (
ID INTEGER,
OWNER VARCHAR(64),
TYPE VARCHAR(64),
NAME VARCHAR(64)
);
```

Views:

Sources: MHD

Notes:

4.4.4.11 Intercity Rail Line

Description: Existing freight and passenger rail lines currently operational in service between cities

Geometry: Polyline

Priority: 1

Reference Schema: CATS: Railroad Databases, Railroad Bridges, Railroad Computers, Railroad Controls, Railroad Interfaces, Railroad Interlockings, Railroad Miscellaneous Sites, Railroad Repair Sites, Railroad Tunnels, Railroad Yards, HSIP: Railroads

Attributes:

Views:

Sources: MHD

Notes: Regional and Intercity rail lines will be coincident in some segments, as are highways.

4.4.4.12 Ports and Harbors

Description: Marine ports and harbors

Geometry: Polyline

Priority:

Reference Schema: CATS: Inland Waterways and Terminals, Ports East and West Coast, HSIP: Commercial Ports, Port Facilities

Attributes: 1

Views:

Sources: Massport; Coast Guard; NOAA, Massachusetts CZM

Notes:

4.4.4.13 Anchorages

Description: Established moorings and anchorages

Geometry: Polyline

Priority:

Reference Schema:

Attributes: 2

Views:

Sources: Coast Guard; NOAA

Notes:

4.4.4.14 Boat Ramps/Piers Docks

Description: Boat land/water access points

Geometry: Polyline

Priority: 2

Reference Schema:

Attributes:

Views:

Sources: Massachusetts Coastal Zone Management public access points.

Notes:

4.4.4.15 Ferry Terminals

Description: Passenger and auto ferry docking and loading areas

Geometry:

Priority: 1

Reference Schema: HSIP: Ferries

Attributes:

Views:

Sources:

Notes:

4.4.4.16 Navigation

Description: Navigable channels and hazards offshore

Geometry:

Priority: 1

Reference Schema: HSIP: Navigable Waterway Network

Attributes:

Views:

Sources: NOAA

Notes:

4.4.4.17 Airports

Description: Established Massachusetts airfields of all sizes

Geometry: Polyline

Priority: 1

Reference Schema: CATS: Airports, Airports <= 5000 Ft., Air Flight Service Stations, Military Airports, Air Navigational Aids, HSIP: Airports and Airfields, Airport Facilities, Runways and Taxiways

Attributes:

Views:

Sources: FAA; MAC, commercial vendors (ESRI, GDT, NavTech)

Notes: A single polygon feature may be created to generalize the airport. Individual airport buildings will still be included in the BUILDING table with an appropriate identifying TYPE, e.g., AIRPORT TERMINAL

4.4.4.18 Heliports

Description: Established helicopter landing locations.

Geometry: Polygon

Priority: 1

Reference Schema: CATS: Helicopter Pads, HSIP: Airports and Airfields

Attributes:

Views:

Sources:

Notes: (See Hospitals)

4.4.5 Utilities

4.4.5.1 Electric Power Plant

Description: Electricity generation plants contributing to the Massachusetts grid.

Geometry: Polygon

Priority: 1

Reference Schema: CATS: Power Plants, Electric and Nuclear, HSIP: Power Plants

Attributes:

Views:

Sources:
Mass. Energy Facillity Siting Council;
ISO-New England;
Commercial sources

Notes: A single polygon feature may be created to generalize the power plant complex. Individual plant buildings may still be included in the BUILDING table with an appropriate identifying TYPE.

4.4.5.2 Transmission Line

Description: Power transmission lines.

Geometry:

Priority: 1

Reference Schema: HSIP: Power Lines, Transmission Line

Attributes:
```
Create table elec_transmission_line (
ID INTEGER,
OWNER VARCHAR(64),
NOTES VARCHAR(128)
);
```

Views:

Sources:

Notes: At some point there may be an appropriate threshold determining the capacity of “lines of interest” to first responders, i.e. “not the last mile”.

4.4.5.3 Distribution Substation

Description: Sub-stations, >115 volt lines, not "the last mile".

Geometry: Polygon

Priority: 1

Reference Schema: HSIP: Substations

Attributes

```
Create table elec_SUBSTATION (
ID INTEGER,
OWNER VARCHAR(64),
VOLTAGE VARCHAR(32),
NOTES VARCHAR(128)
);
```

Notes:

4.4.5.4 Natural Gas Plants

Description: Natural Gas Plants

Geometry:

Priority: 1

Reference Schema: CATS: Natural Gas Plants, HSIP: Natural Gas Storage Facilities, Tank

Attributes:

Views:

Sources:

Notes:

4.4.5.5 Natural Gas Storage Tank

Description: Natural gas “large” storage tanks with a capacity in excess of <threshold>

Geometry: Polygon

Priority: 1

Reference Schema: CATS: Natural Gas Storage, HSIP: Natural Gas Storage Facilities, Tank

Attributes:

Views:

Sources:

Notes:

4.4.5.6 Major Natural Gas Transmission

Description: Natural gas transmission pipelines

Geometry: Polyline

Priority: 1

Reference Schema: HSIP: Pipelines

Attributes:

```
Create table gas_PIPELINE (
ID INTEGER,
OWNER VARCHAR(64),
CAPACITY VARCHAR(32),
NOTES VARCHAR(128)
);
```

Views:

Sources:

Notes: Major transmission pipelines; not "the last mile".

4.4.5.7 Potable Water Reservoirs

Description: Reservoirs used as public drinking water supplies.

Geometry: Polygon

Priority: 1

Reference Schema:

Attributes:

```
Create table RESERVOIR (
ID INTEGER,
OWNER VARCHAR(64),
CAPACITY VARCHAR(32),
NOTES VARCHAR(128),
SERVICE_AREA VARCHAR (64)
);
```

Views:

Sources:

Notes: There will be some feature overlap here with hydrogaphy.

4.4.5.8 Public Water Supply Wells

Description: Location of wellheads used to supply public drinking water.

Geometry: Point

Priority: 1

Reference Schema: HSIP: Public Water Supply Intakes

Attributes:

```
Create table WELL (
ID INTEGER,
OWNER VARCHAR(64),
TYPE VARCHAR(32),
VULNERABILITY VARCHAR(128),
NOTES VARCHAR(128)
);
```

Views:

Sources:
DEP for public water supplies;
MWRA

Notes: Other public water supply infrastructures need to be accounted for, including but not limited to: water tanks, cisterns, filtration facilities, and pumping stations.

4.4.5.9 Major Water Transmission Pipelines

Description: Major pipelines used for the transmission of public drinking water.

Geometry: Polyline

Priority:

Reference Schema: HSIP: Water System Control Facilities, Water Tanks, Water Towers, Water Treatment Plants

Attributes:

```
Create table WATER_PIPELINE (
ID INTEGER,
OWNER VARCHAR(64),
NOTES VARCHAR(128)
);
```

Views:

Sources: MWRA

Notes: Largest pipes and aqueducts, not "the last mile".

4.4.5.10 Dams

Description:

Geometry: Polygon

Priority: 1

Reference Schema: CATS: Irrigation Dams, Water Supply Dams, Deep Water Locks and Dams, Inland Waterways Locks and Dams.

Attributes:

Views:

Sources: DEM, FEMA/Federal Energy Regulatory Commission

Notes: Large dams only

4.4.5.11 Oil Storage Tank

Description: Clusters of or individual large volume oil and fuel storage tanks.

Geometry: Polygon

Priority: 2

Reference Schema: CATS: Tank Farms, HSIP: Tank

Attributes:

Views:

Sources:
MEMA
MA Dept. of Energy
SARA Tier II DB

Notes: 1500 gallons was suggested as potential minimum sized tank of concern (same as threshold for regulatory reporting requirements)

4.4.5.12 Oil Transmission Pipelines

Description: Location of oil transmission pipelines.

Geometry: Polyline

Priority: 2

Reference Schema: HSIP: Pipeline

Attributes:

```
Create table OIL_PIPELINE (
ID INTEGER,
OWNER VARCHAR(64),
CAPACITY VARCHAR(32),
NOTES VARCHAR(128)
);
```

Views:

Sources:

Notes: Major transmission; not "the last mile".

4.4.6 Miltary Operations

4.4.6.1 Military Installation

Description: Location of facilities operated by the US Department of Defense.

Geometry: Polygon

Priority: 1

Reference Schema: CATS: Coast Guard, Military Airports, HSIP: Military Installation

Attributes:

Views:

Sources:

Notes: Appropriate criteria potentially defining "thresholds of interest" for size or mission may be considered.

4.4.7 Emergency

Please note: The "Emergency" entity set is not present in SDSFIE (unlike all others listed above) and is suggested by AGI.

4.4.7.1 911 Dispatch Centers

Description: Location facilities used as E911 dispatch centers.

Geometry

Priority: 1

Reference Schema:

Attributes:

Views: Could be be implemented a view against "police/fire stations"

Sources:

Notes:

4.4.7.2 Access/Egress Building Locations

Description: Location of access and egress points in buildings.

Geometry: Point

Priority: 1

Reference Schema:

Attributes:

```
Create table access_egress (
ID INTEGER,
X DOUBLE,
Y DOUBLE,
BUILDING_ID INTEGER,
NOTES VARCHAR(128)
);
```

Views:

Sources: Site visits, windshield surveys, captures from as-builts.

Notes: Access/egress locations should be considered a "child" data set to buildings. Assigning the correct BUILDING ID number to all ACCESS_EGRESS points will require substantial effort. Consideration of implementing "thresholds of interest" should be given.

4.4.7.3 Large Crowd Gathering Locations

Description: Location where regularly scheduled events drawing large numbers of people are planned.

Geometry: Polygon

Priority: 1

Reference Schema: HSIP: Tourist Attractions, Public Venues, Shopping Malls and Complexes, Shopping Center, Sports Site

Attributes:

```
Create table LARGE_CROWD (
ID INTEGER,
NAME VARCHAR(128),
START_DATE DATE,
END_DATE DATE,
NOTES VARCHAR(128)
);
```

Views:

Sources:

Notes: In many cases large crowd instances will be temporal, e.g. July 4th at the Hatch Shell/Esplanade or sports venues.

4.4.7.4 Staging Areas for MCI Use

Description: TBD

Geometry:

Priority: 1

Attributes:

Views:

Sources:

Notes:

4.4.7.5 Special Needs Facilities

Description: Facilities that house populations that require special assistance in a time of emergency.

Geometry: Polygon

Priority: 1

Reference Schema:

Attributes:

Views: Special Needs Facilities will be generated as a view against the base BUILDINGS table using a query for the following TYPES:

- Prisons
- Halfway houses
- Day care centers
- Nursing homes
- Schools
- Elder care

Sources:

Notes:

4.4.7.6 Emergency Operations Centers

Description: Locations that may be used for ad hoc emergency response.

Geometry: Polygon

Priority: 1

Reference Schema: HSIP: Emergency Management and Operation Centers

Attributes:

Views: Emergency Operations Centers will be generated as a union view against the specific thematic building attribute tables using the following columns:

- Usable_spaces,
- Bed_spaces,
- Pop_capacity,
- Generator,
- Fuel_14_day,
- Food_14_day,
- Water_14_day,
- Medical_supplies

Sources:

Notes:

4.4.7.7 Staging Areas/Distribution Sites

Description: Locations suitable for use as ad hoc organization and distribution nodes.

Geometry: Polygon

Priority: 1

Reference Schema:

Attributes:

```
Create table staging_area (
ID INTEGER,
FOOD_SERVICES VARCHAR(32),
CAPACITY INTEGER,
NOTES VARCHAR(128)
);
```

Views:

Sources: American Red Cross Shelter Survey

Notes:

4.4.7.8 Evacuation Routes

Description: Suggested routes away from a location where there has been an emergency incident.

Geometry: Polyline

Priority: 1

Reference Schema: HSIP: Evacuation Routes

Attributes:

Views: Evacuation routes will be generated as a view against the base Major and Minor Roads features.

Sources:

Notes:

4.4.7.9 Terrorism Targets

Description: Locations where there is a threat of terrorist activity, and where pre-planning is deemed necessary.

Geometry:

Priority: 1

Reference Schema:

Attributes:

Views:

Sources: DOJ Site Assessment DB

Notes:

Additional information…

Sources: Datasets and Organizations

Metro Boston EMS Health Council Survey
MA-DPH Bureau of Health Quality Management
US Veteran Administration National Disaster Medical System
Boston Med Flight
MAPC Survey
GSA
DCAM
Municipalities
DEM
State Police
Wireless Carriers: Verizon, AT&T, Cingular, Sprint,
SARA
Tier II DB
FCC
US-EPA SARA
Tier II Chemical DB
State DPH for University research "permits"
DEP 21E DB
NOAA
Electric Utilities
Gas Utilities
Water Utilities
Pipeline Utilities
Mass. Energy Facillity Siting Council
ISO-New England;
Commercial sources
MWRA
DEP for public water supplies
DEM for dams
MEMA
MA Dept. of Energy
SARA Tier II DB
American Red Cross Shelter Survey
DOJ Site Assessment DB

Domains: TBD

Acronyms: TBD

Appendices: CATS schema, HSIP Schema, and any others we reference

ATTACHMENT

C

Available Only on Project CD and through the project web-site:

http://www.appgeo.com/clients/NOAA_HomelandSecurity

XML Report of GeoDatabase Design

ATTACHMENT

D

Available Only on Project CD and through the project web-site:

http://www.appgeo.com/clients/NOAA_HomelandSecurity

FGDC CSDGM Metadata report of GeoDatabase contents

A T T A C H M E N T

E

Concept Paper titled:
"GeoSpatial Schema Development and Data Exchange for National Critical Infrastructure Protection"

DRAFT

Concept Paper

GeoSpatial Schema Development and Data Exchange for National Critical Infrastructure Protection

Applied Geographics, Inc.

April, 2003

1 Introduction

This concept paper outlines an approach for the development of a standard GeoSpatial database schema to promote Critical Infrastructure Protection (CIP) data exchange among a large number of distributed and dissimilar data sources. In this context, suggestions for 1) schema and data development efforts and 2) a plan of action for a parallel multi-site pilot project, are provided. Specific suggestions are also provided for the continued evolution of Homeland Security Infrastructure Program (HSIP) GeoSpatial Database requirements. The emphasis here is on interoperability and rapid exploitation of available data to meet national objectives.

The ideas presented here represent the continuation and refinement of research findings presented by Applied Geographics Inc. (AGI) to members of the HSIP Team at USGS, on March, 20, 2003. AGI has been involved in the development of a general solution to the problem of developing and maintaining a CIP Geographic Information System (GIS), known as the Boston Preparedness Pilot (BPP), during the 2002-2003 time period. Additionally, AGI opinions concerning CIP have been influenced by involvement in a variety of GIS and Facility Management projects with both state and local entities, and the U.S. Navy.

2 Executive Summary

2.1 XML Schema Development

The development and maintenance of a high quality national CIP GIS requires that data from State and local sources be identified, extracted, and transformed into a format that can be readily imported into a central repository, for use and distribution, in an ongoing and repeatable fashion. The wide variety of data necessary to populate this central repository is spread across a significantly different number of database systems and commercial GIS packages, some of which are highly customized for specific end user requirements. The data models or schemas being used in these systems are many and varied. In order for this collection of distributed data to succeed, given these conditions, three important requirements must be met. First, an unambiguous specification concerning the contents of the CIP GIS needs to be developed. Secondly, data owners and managers need to make changes to their data models and maintenance operations, in order to accommodate CIP contents requirements. Thirdly, a physical data exchange infrastructure, with explicit physical formats and import/export software tools, needs to be built.

Schema harmonization and reconciliation efforts, to ensure that CIP data contents requirements are met, will provide an important benefit to overall distributed data collection activities. This is particularly true for data schemas enjoying widespread use, such as the Spatial Data Standard for Facilities, Infrastructure, and Environment (SDSFIE). However, a great deal of the data required to populate a central CIP GIS will not be compliant with a standard schema. For these datasets, a different approach is required.

The definition of a minimum number of prioritized essential CIP GIS features, attributes, and value domains, together with an easy to read and write physical exchange format provides a solution to this problem. The use of eXtensible Markup Language (XML), and related technologies, would provide a viable long-term solution for both the high level logical data contents definition and the specification of a physical exchange format. In addition, focusing on specific CIP data layers and physical exchange will provide results in a relatively brief turn-around time. In comparison, comprehensive schema harmonization projects, involving hundreds of feature layers, and thousands of attributes and domains, for both CIP and base map entities, may be complex and time consuming operations.

2.2 Parallel Multi-Site Pilot Project

Isolated, single-site CIP GIS pilot projects are providing valuable information and methodology development to support eventual large-scale national level processes and systems. However, due to the highly distributed nature of the problem at hand, a parallel and integrated multi-site pilot project will provide a more realistic and valuable set of results. Collecting a subset of prioritized CIP data layers, using a single simplified XML based schema, as described above, in several priority urban areas would provide valuable experience in developing consistent and repeatable methodologies for all 133 Urban Areas. This would also allow exercising and developing the required interagency multi-site coordination that will be so important in building the national CIP GIS.

XML technology is already being used to support data exchange in related applications. As a participant in the US Navy's Task Force Web (TFW) initiative, AGI built an NMCI-compliant, DITSCAP-certified operational Website to integrate and serve GeoSpatial and tabular data for all Shore Installations under COMLANTFLT. Both XML and Web services are integral parts of the system's architecture and concept of operations, and we believe the lessons-learned are applicable to a multi-site pilot project in support of the national CIP GIS effort. In addition to a subset of prioritized urban areas, we believe it would be useful to consider including a DOD base, such as Portsmouth Naval Shipyard (PNS) in the recommended pilot project, to help explore security issues related to data access and release-ability. As a candidate site, PNS has a GML-capable map server, and its data are generally consistent with the SDSFIE, thereby representing a relevant case.

3 The Boston Preparedness Pilot

The Boston Pilot has been executed in 2 phases. Phase I addressed the development of an overall solution framework with a focus on database schema development and data compilation processes. Phase II involves data capture for a specific set of GIS feature layers. Phase I was funded by MassGIS, the State of Massachusetts' Executive Office of Environmental Affairs (EOEA) centralized GIS agency, with additional support from the United States Geological Survey (USGS) and the National Imagery and Mapping Agency (NIMA). Phase II is being funded by the National Oceanic and Atmospheric Administration (NOAA). The pilot area includes 102 cities and towns in and around greater Boston with approximately 3 million inhabitants.

The development of an overall framework to support the design and maintenance of a national CIP GIS needs to provide practical answers the following 5 key questions:

1) What data is needed?
2) How will the data be compiled and collected.
3) How will the data be presented and used?
4) How will the data be maintained?
5) How will the data be protected?

The complexity of developing a workable solution to these problems, due to the sheer number of participating organizations and datasets, is considerable. An overall approach to such a challenging mission is well served by applying standard database application development guidelines. To this end, the BPP has developed a set of recommendations for a variety of issues including:

1) Use case development and input from First Responders (FR)
2) Existing dataset inventorying
3) GeoSpatial database schema design
4) Distributed data compilation
5) Metadata requirements
6) Data access security
7) Data maintenance
8) Data presentation and use
9) Collection and collaboration software tools

In addition, recommendations for overall organization and coordination among multiple public and private entities are being developed.

4 Development of a Standard GeoSpatial Schema for CIP

The issues discussed in this paper are primarily concerned with schema development and data exchange mechanics.

The development of the national CIP GIS schema needs to take into account both existing geospatial data standards as well as new input from the FR user community. To that end, the development of the BPP schema has included review and consideration of the following:

- Initial layers lists developed by various sources and the FR community
- The Spatial Data Standard for Facilities, Infrastructure, and Environment (SDSFIE) from the CADD/GIS Center
- The Consequence Assessment Tool Set (CATS) from SAIC
- The Homeland Security Infrastructure Program (HSIP) Tiger Team Report from NIMA and USGS
- The Feature Attribute Coding Catalog (FACC) and the Digital Geographic Exchange Standard (DIGEST)
- GeoSpatial One-Stop and the National Spatial Data Infrastructure (NSDI) from the Office of Management and Budget (OMB)
- A wide variety of existing data sources

4.1 Boston Pilot Schema Observations

In addition, work on the BPP has resulted in a number of observations regarding schema development and data requirements. These are briefly summarized in the following list:

- The availability of accurate and timely Critical Infrastructure owner and operator contact management information, including telephone numbers, pagers, faxes, e-mail, web sites is crucial.
- The availability of documents not specifically related to GIS, including site plans, floor plans, evacuation plans, and photographs, is crucial.
- A single base geometry feature set, e.g., building footprints, needs to be linked with a variety of disparate, separately compiled tabular attribute information datasets.
- Many CIP features need to be assigned to multiple classification categories.
- Many CIP features need to be modeled in nested parent child relationships.

- A resulting single feature layer will often be compiled from numerous contributing data sets. This has specific consequences for both metadata development and maintenance as well as data access security for both data compilers and users.
- Schema development and data exchange operations need to account for existing data conditions.

4.2 Schema Reconciliation and Data Exchange Issues

There is clearly a requirement to develop a single standard database schema in order to populate a comprehensive CIP GIS. Recent activity to support this has been focused on schema reconciliation among various contributing frameworks including HSIP, SDSFIE, CATS, FACC, GeoSpatial One-Stop/NSDI, and the BPP. Specific operations are currently focused on extending SDSFIE to accommodate HSIP and the BPP. A brief review of standard database modeling concepts can provide some useful context in developing a system design strategy here.

There are two distinct types of models that need to be developed when building a database application, GeoSpatial or otherwise. One is logical, the other is physical. The logical model captures the higher level semantics of the problem space. It reflects how the data and its eventual uses are actually perceived by end users - it is user friendly. The physical model is actually implemented through software data files, programs, and hardware – it is computer friendly. The distinction between these two types of models is readily seen in the frequent use of Views in Relational Database Management Systems (RDBMS) that are used to provide a single simpler set of data while hiding a more complicated underlying network of interconnected data objects.

In addition, the components and relationships making up the model are defined and constrained by the underlying technology being used. Different data modeling possibilities exist depending on whether one is using traditional RDBMS, Object-RDBMS, Object Oriented Database (ODB), eXtensible Markup Language (XML), or some combination of these.

Finally, it is important to consider that at some point, data has to be created within these models or use of Extraction, Transformation, and Loading (ETL) technologies to collect the data from existing external sources. This last point is all-important: this system must be able to import data from a large number of disparate data sources, all widely varying in structure and quality.

In summary, designing a system to accommodate data exchange and sharing to the extent that it is required here needs specifically to allow:

- Flexible underlying data modeling capabilities to capture the end user logical semantics of the problem space
- A physical representation that can be easily written to and read from across a wide variety of software platforms
- A combined semantic and physical representation that can be easily validated to ensure the highest possible data quality

- Integration with existing metadata standards

4.3 XML Technology as a Solution to CIP Data Definition and Exchange Framework

To fully address the above list of requirements, AGI is recommending that XML be considered as the base underlying technology for both modeling and exchanging data to support the implementation of a national CIP GIS. The advantages of using XML for data exchange are many and firmly established in the Information Technology (IT) industry. XML technology provides a solid solution to each of the points mentioned above:

- XML provides a wide variety of flexible data constructs which allow ready mapping to RDBMS systems, linking to external documents, and hierarchical nesting relationships which are naturally found in many GIS problem domains. The use of XML for modeling and exchange ensures long term, vendor independent, flexibility. This is crucial in establishing data sharing scenarios that must remain in place while software systems and capabilities are continually evolving.
- Physically, XML is easily written and read across all computing environments and communication channels, through the use of:
    1. Standard Application Programming Interfaces (API) for creating and managing XML data stores. These include the Document Object Model (DOM), the Simple API for XML (SAX), and XML Stylesheet Language Transformation (XSLT)
    2. The eventual ubiquitous availability of HTTP/XML based Web Services.
- The contents of XML instance documents can be readily validated against an XML Schema data definition model with a wide variety of existing software tools. While import/export tools are readily available for common de facto GIS/CAD exchange formats, such as ESRI Shape Files, or AutoCAD DWG Files, standard off-the-shelf content validation is not available, as it is with XML.
- The Content Standard for Digital GeoSpatial Metadata (CSDGM) is itself implemented as an XML model. Use of XML for CIP GIS can take full advantage of this.

Furthermore, with working standards established by the Open GIS Consortium (OGC), a specific XML vocabulary has been developed to facilitate data exchange in the GIS community. The OGC's Geography Markup Language (GML) and associated guidelines for developing GML Application Schemas and Profiles provide a solid foundation for developing CIP GIS data sharing capabilities.

The full set of capabilities that GML offers, particularly with the latest release of the version 3.0 specification, can be used to model highly complex situations and is rightly perceived by many as considerably elaborate. AGI is specifically recommending that a very small and simple subset of GML modeling constructs be used in the development of a CIP GIS Application Schema.

Also, like RDBMS data, XML data can be structured as either highly fragmented and normalized datasets linked through key references, or in simpler more user-friendly arrangements, similar to 'flattened' RDBMS views. Normalized and segmented models are used primarily to provide data integrity for data editing operations. Because it is imagined that the data will be primarily used for read only purposes, once housed in a central repository and distributed to support FR operations, preference should be given to simpler, view oriented constructs in designing XML Schemas for CIP GIS.

In summary, the development of XML Schemas for CIP GIS data exchange eases the burden of potentially complex physical schema reconciliation and shifts the focus to interoperability.

This is not to suggest that current schema reconciliation efforts should not be pursued. On the contrary, the adoption and accommodation by SDSFIE of GeoSpatial schema components developed through HSIP and the BPP would provide a very clear benefit. It would help to ensure that the contents of SDSFIE compliant systems, of which there are many, contain required CIP information that can be readily imported into the national GIS.

This approach, through which existing data schemas are modified to accommodate CIP, should not be limited to only SDSFIE compliant data management operations. Much of the data required to populate a central CIP GIS, particularly from State, local, and utility sources will not be compliant with any standard schema. For these datasets, the Homeland Security mission will benefit greatly from:

- Compliance, at the logical level, in maintaining feature and attribute data deemed necessary for CIP, and
- The ability to export and map this data into a common XML format. This ultimately practical approach has been widely adapted in the commercial IT world through the development of XML based Enterprise Application Integration (EAI) technologies and Data Warehousing systems.

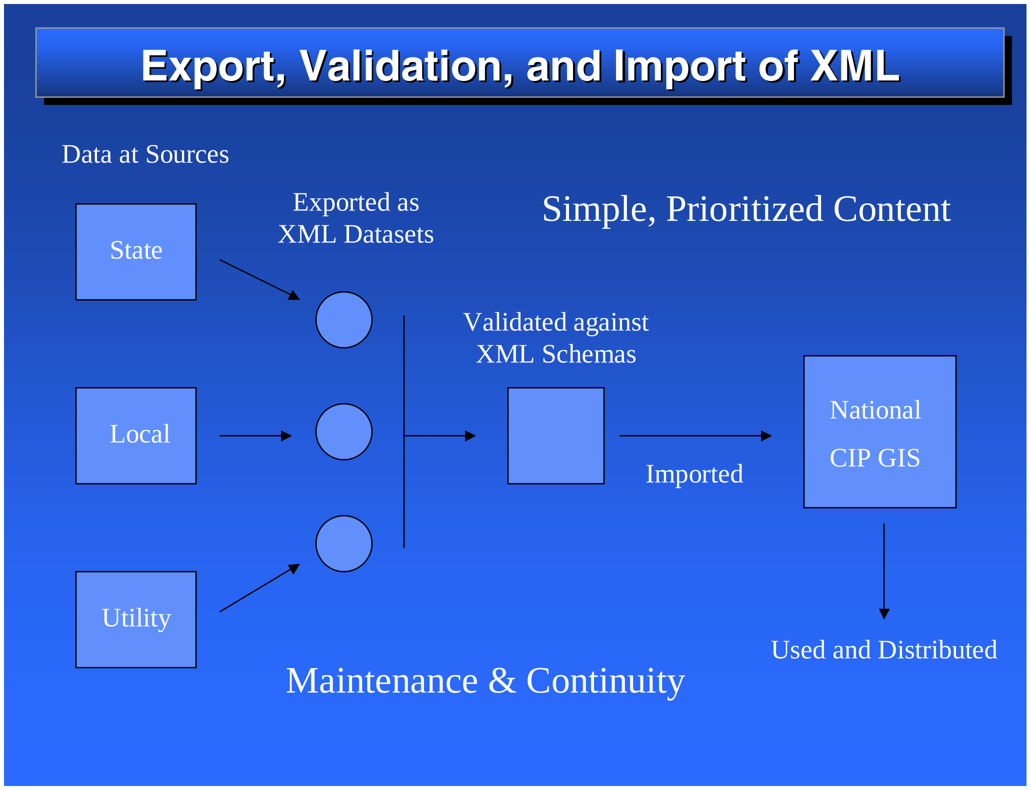

Figure 1: XML Based Data Exchange and Validation

4.4 Suggested Next Steps for HSIP

The completion of the HSIP requirements specification, which captures logical data definitions, clearly needs to precede the development of concrete XML Schemas for CIP GIS. To this end, the following next steps for HSIP evolution may be considered:

- 60% of the HSIP record definitions consist of:

1) A header with unique object ID, foreign key into metadata set, security level, and NAICS codes
2) An address location
3) A primary contact
4) A list of feature specific attributes

For clarity and brevity, a degree of normalization, whereby each of these fundamental components can be defined once, and referenced in individual feature definitions, may be used.

- HSIP currently has features prioritized by larger level category groupings. FR and other input can also be gathered to clearly establish data priorities.
- There are relatively few feature specific attributes. An organized and systematic approach may be taken, through surveys and/or meetings, to gather FR input to augment these attribute lists, while maintaining an approach to gather only the minimum and essential elements.
- Several levels of compliance to a CIP data content standard can be established to accommodate for different levels of data availability and quality. These compliance levels can serve as summary abbreviations of metadata. For example, a dataset of hospitals, consisting of only geometric points, with only basic contact information would be rated at a different level from a hospital dataset consisting of a facility complex polygon, individual building footprints, and full feature specific attributes. Different rules, specifying what fields and domains are required for a given level of compliance, could be defined to support this.
- For organizational flexibility, with the idea that the logical data definition constructs can be used to generate an RDBMS or XML data definition, the next version of HSIP feature definitions could be structured as a set of MS_Access tables.
- An explicit use of CSDGM metadata, to replace part of the existing HSIP record header (described above) to house both data quality and security access level description, can be incorporated.

5 Suggested Action Plan

Through HIFLD, HSIP, FGDC-HS, the BPP and other related efforts, a great deal of very useful information and methodology development has taken place. Many aspects of developing a viable long-term solution are being considered and put forward. To make the best use of this work, subsequent activities need to take into account a two key aspects of any eventual solution, 1) distributed but parallel efforts and 2) multi-level interagency coordination. To this end, multi-site, multi-agency pilot projects should be considered.

5.1 Multi-Site Pilot Project

The challenging experience and lessons learned gained from AGI's effort to compile over 30 different layers of GIS feature data for the 102 cities and towns making up the BPP leads to a conclusion that it would be highly beneficial for subsequent project activities to address collecting fewer feature layers, but in more places. Instead of working on 30 layers in one of the designated 133 urban areas, a project whose goal was to collect 5 priority CIP layers in 5 of the priority areas, using the same minimum essential GML Application Schema, could provide very valuable experience in building long term and consistent interoperability and data exchange practices.

These GML Application Schemas, based on work from the next phase of HSIP, could be developed very quickly. In addition, software import/export tools to read and write this XML can be developed quickly, and in some cases, exist today in Commercial Off-The-Shelf (COTS) GIS data exchange products. This effort would not be dependent on comprehensive schema reconciliation, for both base map and thematic features, which may require a considerably longer time period.

Such a pilot could additionally address:

- Data inventorying using minimum CSDGM to capture existing data characteristics
- Distributed data collection practices and coordination
- Distributed data collection software tools
- Integration with existing data maintenance workflows
- Import into a single central database
- The application of standard symbolization, which should reflect the underlying logical model.
- Ongoing update operations
- Data access security
- Overall coordination for parallel mission management

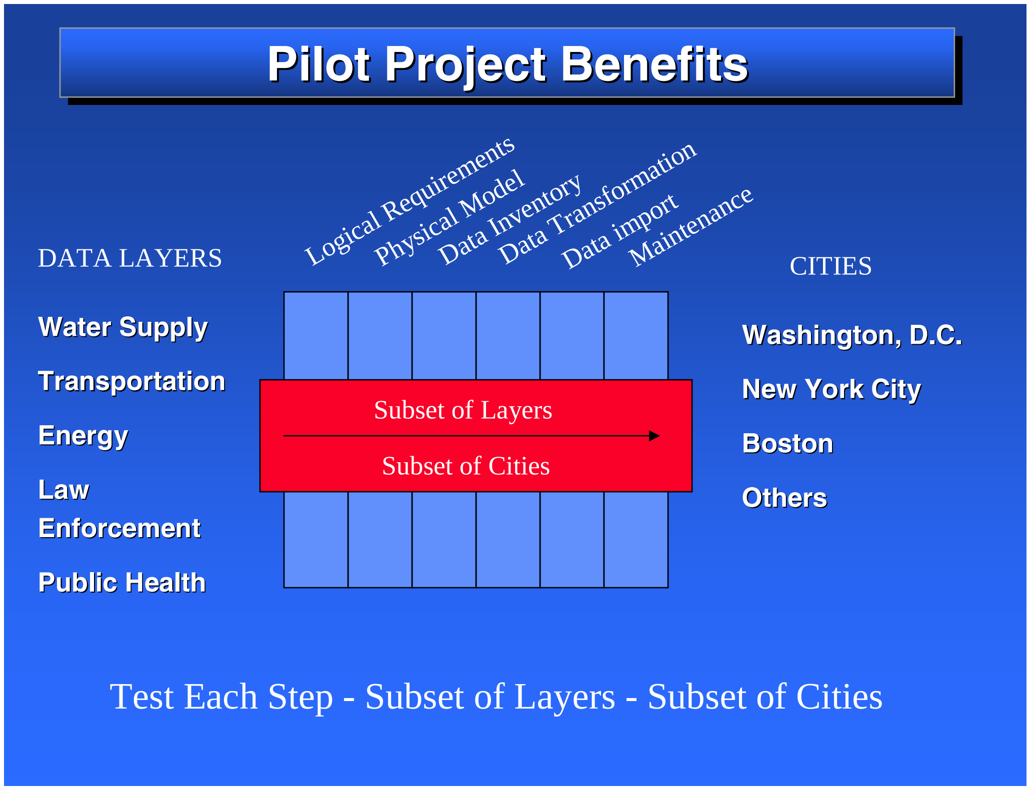

Figure 2: Pilot Project Benefits

6 Summary and Conclusions

Building and maintaining a nationwide CIP GIS for the United States is a major challenge. Given its unprecedented complexity, a successful approach requires focus, timeliness, and prioritization. The application of the Minimum Essential principal should be practiced in all aspects of these next steps. This refers not only to datasets, but to schemas, symbolization, software tools, metadata, and security as well.

In summary, an action plan consisting of the following tasks is recommended:

- Complete the logical requirements definition for HSIP.
- Begin the process of modifying SDSFIE, and other widely used GIS schemas, to accommodate the logical requirements specified in HSIP.
- Develop a minimum essential GML Application schema for 5 priority CIP layers, as identified in HSIP.
- Develop a set of guidelines for follow on 133 Urban Area projects, by collecting and consolidating results from the various CIP pilot projects that have been conducted to date.

- Conduct pilot projects in several of the high priority 133 Urban Areas using the guidelines and schema mentioned above.

In order to build a useful national CIP GIS, frequently updated high quality data from State and local sources is a necessity. Collecting data into a single system, from several minimum essential datasets in several of the priority urban areas, using a common easy to use XML Schema as outlined above, would go a long way in contributing to the establishment of repeatable and consistent methodologies to be used for building CIP datasets for all 133 Urban Areas and help to achieve the goal of One Nation, One Map.

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