

Designing a Utility Geodatabase to Support Maintenance Management

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Abstract

The City of Akron Public Utilities Bureau (APUB) has recently implemented an integrated GIS and Computerized Maintenance Management System (CMMS) for management of its water and sewer utility assets. APUB designed an ArcGIS 9.1 geodatabase to house its spatial asset data and integrate with Datastream 7i CMMS. By designing the geodatabase to support integration from the ground up, the geodatabase is designed to seamlessly integrate with the CMMS, and provide maximum benefits from the integration.

Project Background

Introduction

The City of Akron Public Utilities Bureau, along with most other municipalities, was facing a smaller work force, shrinking budgets, enlarging service area and growing customer needs. To focus the knowledge and effort of its resources APUB, using EMA Inc. as its consultant, purchased and began a design/implementation process for Datastream 7i in 2005. During the initial design stages it was decided that the CMMS implementation would not be a success without the integration of APUB's water/wastewater GIS system.

This, however, was easier said than done. APUB has been in a data conversion stage since the mid 1990's and was nearing the completion of the conversion but had not yet focused it's attention to the water/wastewater geodatabase structure and design. With a clear understanding of the requirements that would be placed on the GIS to support a specific enterprise CMMS, the geodatabase design was started.

Tools

Infor's Datastream 7i ver. 7.10

ArcGIS Desktop 9.1

ArcSDE 9.1 (Multiple database structure)

ArcIMS 9.0 (Image service and ArcMap Image services)

AutoCAD 2006

Microsoft visio studio 2003

Systems & Software Inc. EnQuesta (CIS system)

Wachs Valve operation software

CUES Granite XP

Requirements

1. Integration with a non-GIS centric CMMS system. (Datastream 7i)
 - The CMMS was chosen prior to the GIS being involved. The decision to integrate the CMMS with the GIS was made after the CMMS had already been chosen, but prior to the finalization of a water/wastewater geodatabase. When the decision was made to integrate the GIS with the CMMS, special considerations had to be made when designing the geodatabase.
2. Must be flexible enough to allow for integration with multiple other enterprise applications such as CIS (EnQuesta), CSR (Motorola), Wachs Vitals (valve operation software) and field collection software such as CUES and ArcPad.
 - As the program progressed forward, multiple other integrations were looked at and incorporated into the geodatabase. The CIS would need to integrate with the GIS to pull service location and curb box information. CUES Granite XP is a comprehensive sewer inspection/TV software that would need to be integrated in the future. The City's current CSR software would also need to be able to integrate with the GIS for service request information. Valve operation is an integral part of the operation of a utility system and would require a seamless data transfer between the Wachs valve operation software and the GIS.
3. The asset data must be maintained at a high level of accuracy between the CMMS and GIS since personnel will be using both systems to complete their assigned duties daily.
 - Engineering and field personnel are using APUB's GIS to facilitate operation and maintenance procedures on a daily basis using ArcIMS to view the assets as well as the CMMS for work requests and work orders. With this level of data usage, data in the two systems must be synchronized regularly to provide users with current data. It was ultimately decided that a weekly update schedule would be sufficient to maintain data integrity and currency.
4. To ease the final conversion and to leverage future data maintenance needs, the geodatabase needed to conform to existing standards to accept data directly from AutoCAD with minimal data manipulation.
 - The City of Akron uses AutoCAD for its construction design, utility as-built and GIS conversion process. Careful consideration was given to this process to ensure that the current procedures could be maintained with nominal adjustment.

Solutions

In order for the City to meet their objectives for this integrated system, careful consideration was made to ensure the end product fulfilled the initial requirements for both the GIS and the GIS/CMMS integrated environment.

Initial Geodatabase Design

First and foremost, the geodatabase must fulfill the needs of the GIS as a stand alone system. To accomplish this, we executed a “typical” geodatabase design process whereby feature classes, attributes, domains, network capabilities and other requirements were identified. These requirements were then modeled into the initial geodatabase design in a Microsoft Visio UML document.

Modifying the Geodatabase to Support Integration with the CMMS

After the initial geodatabase design was created and validated by APUB Subject Matter Experts, the design was modified and enhanced to support integration with the CMMS. The following sections describe the modifications that were made to support the integration.

Separation of Purpose

During the initial design process for the integrated geodatabase it was apparent that a definition of the purpose for each system must be clearly defined. Although the CMMS does have the capabilities to perform as an asset management system, it cannot perform this task at the same level of data precision and accuracy as the GIS. The GIS can also perform work history and cost analysis but is inefficient and less productive accomplishing these tasks. Using these points as our template, the decision was made to use the GIS to manage and maintain all underground utility assets. The GIS is then responsible for supplying and updating these assets to the CMMS. The CMMS is then responsible for building the maintenance and cost history for these assets. This decision allows both systems to develop independently while ensuring the integrity of the asset system throughout the enterprise systems.

Unique Identifiers

In order to support integration with external systems, there is generally a primary and foreign key relationship built. These relationships are built upon unique identifiers that serve to link a feature in the GIS to a record in an external system.

- **GIS/CMMS ID**

In this case, Datastream 7i requires the use of a field named GISOBJID. The GISOBJID is a numeric field that is maintained by Datastream 7i via its off the shelf interface tools. In our case, we create asset records in GIS, and then use

the Datastream interface tools to create the assets in Datastream. This asset creation process assigns the unique GISOBJID values to each record in the GIS that had not previously been integrated with the CMMS.

- **CMMS ID**

Each asset that is created in Datastream receives an equipment ID. This ID is used by Datastream to maintain a unique identity for each asset in the system. GIS and non-GIS assets are all treated alike by Datastream and pull this ID from the same sequence.

- **GIS ID**

There was a need for the GIS to maintain a more comprehensive identifier to tie the assets to existing field utility conditions. The GIS ID is generated within the GIS by combining attributes within the geodatabase and a number sequence for each asset. Since this ID relies on attributes of the features it is possible for this ID to change as the system changes. This ID is used as the link between the GIS, CMMS and the field operations within the utility to uniquely identify the assets directly from the field.

Managing the CMMS Asset Hierarchy

Though much of the data between the GIS and CMMS are analogous, the data structures are quite different between the two systems. The CMMS data is based on an Asset Hierarchy whereby the assets are stored in a single table. The various feature types are differentiated by their placement in the Asset Hierarchy as defined by parent/child relationships in the CMMS.

To ensure each GIS feature is placed properly in the CMMS hierarchy, each feature must be mapped using the Datastream Field Mapping tool. Each GIS feature class must have a series of fields mapped to the CMMS prior to creation of the assets in the CMMS. These CMMS hierarchy fields generally include.

- **Organization**

Organization is the highest-level attribute in the hierarchy. Organizationally, APUB is a bureau under Akron Public Service (APS). As a result, all water and sewer assets are assigned a value of "APS" for Organization.

- **Department**

Department differentiates an asset from those found in other departments within the same organization. In the case of water and sewer assets, they all belong to APUB. Therefore, they are all assigned a Department of "APUB".

- **Class**

Class defines the type of feature being mapped. It is analogous to the feature class in the GIS. Examples of classes in the CMMS are Hydrant, Water Pipe, Manhole, Sewer Pipe, etc.

- **Parent Asset**

Parent defines which asset is the parent of each individual asset. In most cases, each feature class may have a single parent. For example, Sanitary Manholes in the GIS may all have a common parent called SAN-MH or something similar.

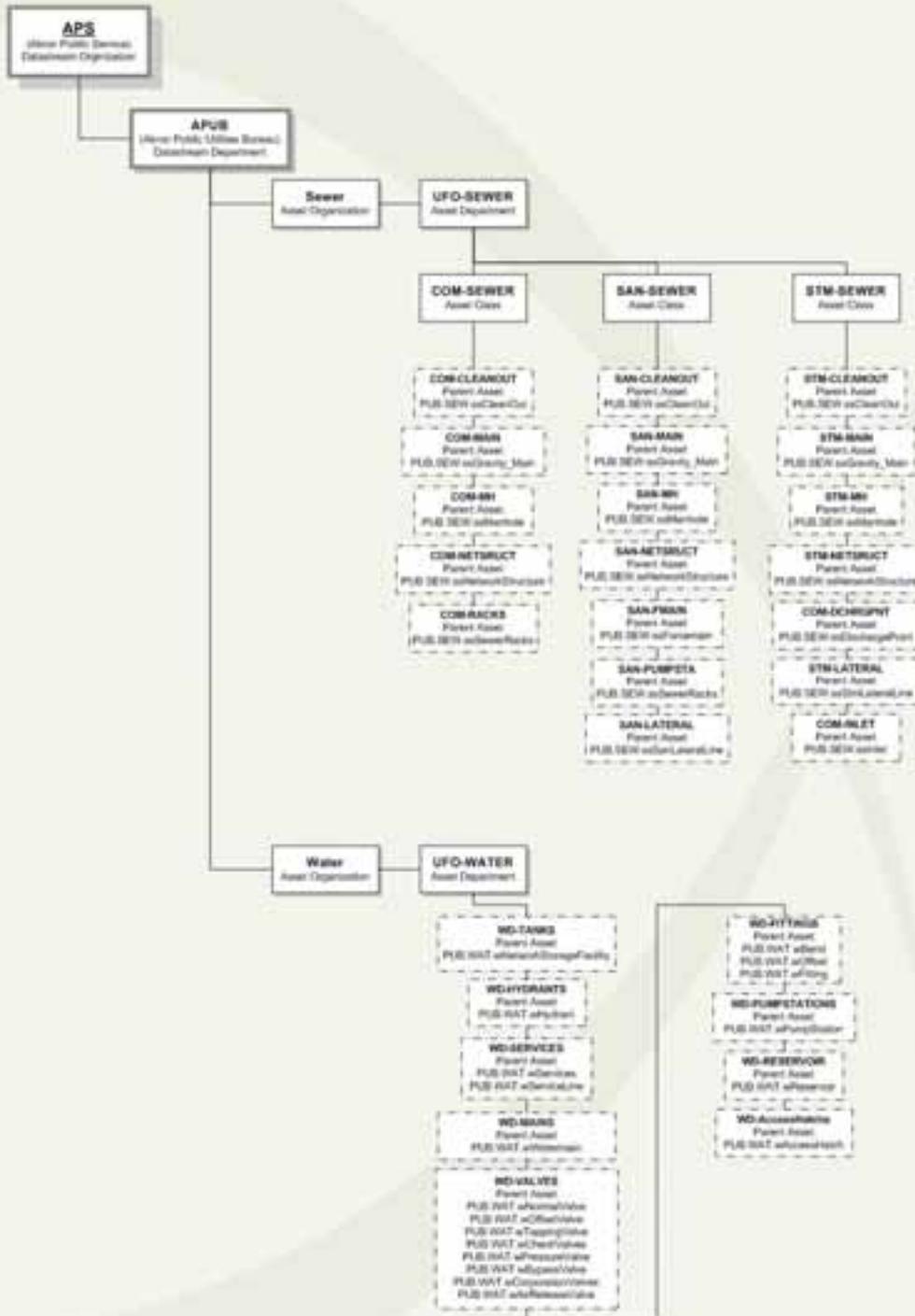
- **Asset Description**

An Asset Description is a verbose description of an asset. Though most Datastream users in APUB have access to the GIS interface, they may be provided a work order for an asset without an accompanying map. The purpose of the Asset Description is to provide a unique description for each asset so that it can be located and identified if the map is unavailable.

All of these fields must be defined and mapped prior to creating assets in the CMMS. They ensure that each asset being loaded from the GIS is properly organized in the CMMS asset hierarchy.

The following image shows the asset structure used by APUB to define the location of the GIS utility assets within Datastream's asset structure.

APUB Asset Structure

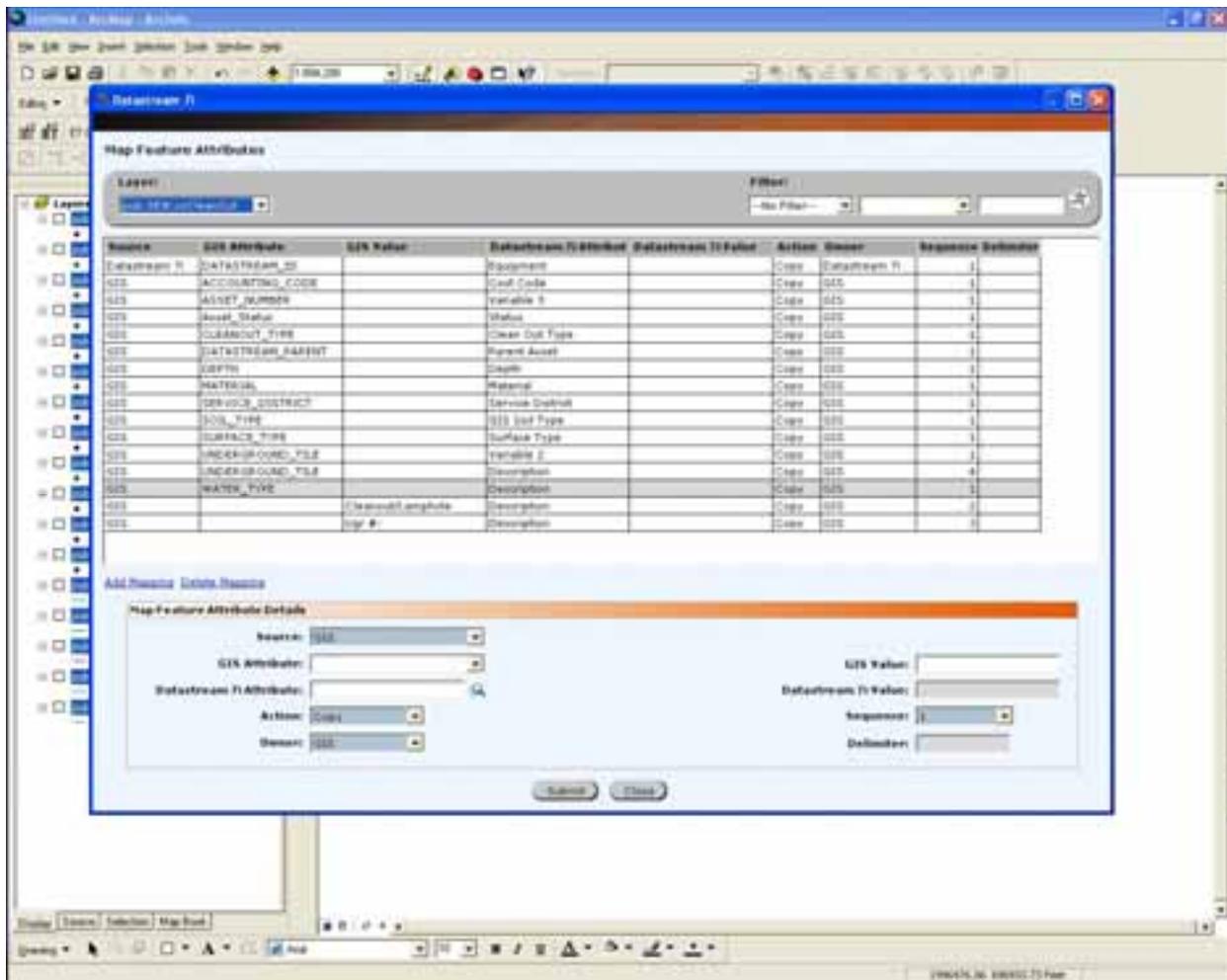


Mapping Custom Fields

Intuitively, the attribute fields assigned to a sewer manhole are different from those assigned to a water valve. However, as stated previously, all assets are loaded into a single table in the CMMS. In Datastream 7i, these unique fields are stored in a separate table and referred to as “Custom Fields”. As with the Asset Hierarchy fields described in the previous section, these fields need to be mapped prior to asset creation in the CMMS. The difference, however, is that these fields do not exist in the CMMS out of the box. Therefore, these custom fields must first be created before they can be mapped or accept data from the GIS.

Once the required fields were identified, this brought about an interesting challenge for the team. In order for the fields to be created in the CMMS, the CMMS subject matter experts needed to understand the GIS data structure, and the GIS subject matter experts needed to understand the CMMS data structure. This was somewhat analogous to having someone who only speaks Greek to describe something to someone who only understands Chinese. There was a tremendous amount of discussion and re-discussion until we finally came to a common understanding. Once a common understanding was reached, the custom fields were created in the CMMS, then mapped from the GIS using the Datastream 7i integration toolset.

The following images shows an example of how the Datastream’s integrated toolset functions look and work within ArcMap while mapping GIS fields into Datastream.



Designing for Optimal Synchronization

The interface between the GIS and CMMS is a two-way interface. In other words, once the field mappings were created, the data could either be edited in the GIS or the CMMS, then synchronized between the two systems. However, we discovered that in order to synchronize between the two systems, there must be a process to determine the differences in each assets set. This process performs a full table scan of all records to determine the differences. As might be expected, this full scan is a very long process and is not efficient enough to be performed on a routine basis.

We discovered that we could perform synchronization on only those records selected in the GIS. This would shorten the query time considerably. However, we needed to determine which records to select on the GIS side. To accomplish this, we created a field for last modification date, and a database level trigger that time stamped each modified record in the GIS. Then we could select only those records that have been modified since the last synchronization.

The benefit of this approach is that it shortens the synchronization time considerably. The downside, however, was that it basically eliminated the two-way interface because there is no analogous capability on the CMMS side.

Summary

Designing a water/wastewater geodatabase is a significant challenge in and of itself. However, integration of the geodatabase with a CMMS can be substantially more challenging. It became apparent early in the process that two key paths must be followed to accomplish the objectives of this integration project.

➤ **Definition of the Requirements**

All requirements of the GIS/CMMS integration must be clearly defined. The key requirements identified included:

- The GIS must have ownership of the assets.
- Users of the CMMS must be able to create, update, view and query work orders through a GIS interface
- Assets to which work orders may be attached must exist in both the GIS and CMMS
- A database link must be created between the GIS assets and their counterparts in the CMMS
- The synchronization process must be flexible enough to be performed on a routine timetable.
- Assets created in the GIS must be properly placed in the CMMS asset hierarchy during synchronization
- Attribute fields that must be accessed from both systems must be mapped to one another to ensure accurate synchronization

These requirements were identified through a series of interviews and workshops with the end users. After identifying the requirements, it was critical to ensure that the geodatabase design included all attribute fields necessary to support the business and technical requirements.

➤ **Collaboration**

Designing the geodatabase to support the business and functional requirements was a collaborative, interactive approach. Subject matter experts from the utility were

included during all phases of design from the initial workshops through the end user system testing.

This collaborative process was followed throughout the implementation and helped us to make great strides in achieving the goals for this project. We know, however, that this collaboration must continue in order to further enhance this integration and continue to reap greater rewards in the future.

Prior to implementation of the GIS and the geodatabase, the Public Utilities Bureau has managed asset related data in several separate, disconnected systems. Now that GIS has been implemented, it will play a central role for managing the Bureau's asset data. Though the Bureau will continue to use various systems to manage different aspects of the data, the GIS will serve as a hub for integrating these systems. By integrating the GIS with the CMMS and other enterprise systems, the Bureau will minimize data redundancy, while increasing the accuracy and availability of the most current data.

Relevant Links:

- <http://www.datastream.net/english/products/datastream7i.aspx>
- <http://www.esri.com/>
- <http://www.esri.com/software/arcgis/arcscde/index.html>
- <http://www.esri.com/software/arcgis/arcims/index.html>
- <http://usa.autodesk.com/>
- <http://office.microsoft.com/en-us/visio/>
- <http://www.systemsandsoftware.net/>
- <http://www.wachsco.com>
- <http://www.cuesinc.com>

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