Mapping the Underground City

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Introduction

This presentation will deal with:

• Project History
• Project Goals
• System Architecture
  ▪ Key Features
  ▪ Data constraints and mapping
  ▪ Database integration
  ▪ Development Methodology
• Operational Impacts
Project History

Some of the underlying factors driving the system redesign are:

• Capital Program Management (CPM) Capital Assets Management System (CAMS) GIS (1994-99)
• CAMS Spatial Database and (non-map) Tabular Report System (98-99)
• LaGuardia Airport Access Transit Project GIS Map Pilot (98-01)
• Integrated GIS Map Project (2000-present)
• WTC Lower Manhattan Area Subway Infrastructure GIS-CAD Map (9/11/2001 to Present)
CPM Capital Assets Management System GIS (CAMS)

CPM IT staff developed a planning level GIS application, based on:

- A schematic ROW centerline Linear Reference System (LRS)
- 64 mainline Control Sections of ascending “From-To” track stationing sequences
- An asset hierarchy “parent-child” data structure based on “20 Years Needs Assessment”.
- Asset repository consists of 80 to a 100 Asset database tables.

Initially implemented from 1994 - 1997 as a PC-based management and mapping production system.

Used for:

- Spatially visualizing the “20 Year Needs” asset inventory and condition assessments
- Map products for capital program decision support
CAMS GIS Spatial Database


Consisted of:

- Microsoft Access, peer based LAN system
- Provided daily planning support to the CP&B staff
- Enabled the production of reliable Division, Line or location reports of assets and related capital projects
- This information only shared in tabular report format (no mapping component).
NY City Base Map “NYCMAP”

NYCMAP consists of:

- Planometric base map layers
- Associated digital aerial orthophoto’s
- An engineering requirements for:
  - Project planning site studies
  - Preliminary design
  - Construction phase staging
  - Logistics
NYCMAP Landbase

NYC GIS Project 1995-present

Subway station entrances & other key surface landmarks for underground alignment collected in NYCMAP

NYCMAP provides near engineering quality multi-layer land base for:

- NYC Transit CAMS GIS integration
- Legacy infrastructure CADD alignment

Street Entrances

Main Entrance

Control House

(Surface structure feature in Battery Park)
Transit Facility Incorporation with NYCMAP

Transit Facilities are more accurately depicted within the City’s Community Streets and Infrastructure Grids.
LaGuardia Airport Access Transit Project GIS Map Pilot

Implemented from 1998 – 2001

An infrastructure GIS Pilot for:

• Legacy track and station CAD spatial alignment
• Database

Integration with “NYCMAP” to support site specific project planning studies
LaGuardia Airport Rail Link site studies

New York City Subway System

19th Avenue Alignment

MTA New York City Transit

INTERGRAPH
Mapping and Geospatial Solutions
NYCT Integrated GIS Project Goals

Service and Operations Planning:
- Who needs to go where and how do we help them?

Asset Management:
- What do we own?
- Where is it?
- What condition is it in?
- Which assets require remedial or planned maintenance?

Construction Planning, Project Analysis, and Preliminary Engineering:
- Which assets should be scheduled for capital program work?
- What new facilities should we build?
- How do we do it in a specific location?
System Architecture

The system architecture took into consideration the following variables:

- Development methodology
- Data constraints and mapping
- Database integration
- Desired features

These will be addressed in the following slides
Development Methodology

Several key factors considered in structuring the development methodologies:

• 1 ft accuracy requirement of the NYCMAP
• Constructed the GIS from engineering accuracy drawings
• Embrace common system standards such as:
  ▪ Geographic coordinate data for GIS applications converted from Lon/Lat to New York State Plane – Long Island
  ▪ Engineering reference base in survey feet rather than geographic angular degrees
  ▪ Capital projects referenced to local engineering survey grid regardless of GIS
• Maintain pointers back to:
  ▪ The engineering drawings
  ▪ Legacy text databases (i.e. Spear MOW Maintenance Systems)
• Ultimately cross link these two sources
Development Methodology

• In addition, the GIS database must contain information about:
  ▪ Fixed assets developed from engineering drawings
• Resolve permanent spatial vs. transient issues with GIS logical requirements. For example:
  ▪ Each track station has a permanent set of spatial configuration/asset hierarchy relationships over its life cycle (not effected by volatile factors such as funding sources and management jurisdictions).
  ▪ A station has a one to many relationship to:
    ▪ Platforms
    ▪ Tracks
    ▪ Stairs
    ▪ Escalators
  ▪ Stations have a many to many relationship to the lines they are located on if it’s at a point where two or more lines converge.
Data Characteristics and Constraints

Mandated to use existing engineering track CAD to define individual track lines. Data characteristics are as follows:

- X,Y local Cartesian grid with “0,0” origin (in lower left corner)
- CAD “large” scale detailed view (typically 1 inch to 50, 100 or 200ft), not drawn to ground units/scale
- “Landscape” project alignment coordinate frame
- CAD high resolution accuracy and precision (.001 or .0001 of a foot)
- Track geometry contains small non-topologic segments
  - When rail type changed the draftsman lifted the digitizer and started a new line element
- Non-intelligent vectors segments
- Thematic color coding visible in these files are associated with different types of track such as straight, curved, and guard rail
Data Characteristics and Constraints

Existing control section GIS/LRS characteristics:

- Global lat/lon geographic projections
- “True North” orientation to compass direction (Manhattan tilt)
- GIS low resolution ranging from +/- 2 ft to +/- 180 ft
- Digitized from older aerial raster images
- GIS link/node topology
- Relational and object oriented data attribution
- Calibration sparse on long control sections

Calibration would be derived from existing control points and track stations.
Data Characteristics and Constraints

CAD versus GIS cross-referencing and alignment problems:

• Spatial disparity of two track data sources
• No locational reference components associated with engineering CAD
• Spatial discrepancy of station data used for calibration process
• Topological dissimilarities:
  ▪ CAD data short segments with no apparent pattern of construction
  ▪ CAD segments represent different track lines that are coincident (each maintain a different LRS key)
Database Structure (Collaboration)

NYC Transit database design collaborated with NYC OEM & DOITT leads to future GIS compatibility for emergency & capital project ops
Database Structure (Schema)

Database consists of:

- Transit surface features captured in the NYC GIS land base such as:
  - Platforms
  - Entrances
  - Emergency exits
  - Vents
  - “Hidden” mezzanine
- Track LRS
  - Centerline
  - Control/Calibration locations
- 100 plus capital asset tables from CAMS
Software Platform

The following software configuration is being used to building the GIS/LRS database:

• Intergraph MGE as the full life cycle GIS tool to build the spatial database (2001- present)
• Intergraph GeoMedia/Professional as client front end map development environment
• GeoMedia Web Map for future dissemination of spatial data throughout the enterprise
• To be implemented in an industry standard Oracle Spatial database
Data Sources for Integration

The following data sources have been used for the building the system:

- ROW centerline (CAMS – 2700 nodes & Links)
- Control section Route System (CAMS – 65 major track stationing ranges)
- Passenger station entrances
- Emergency exits
- Stations CAD - 468 Design Plots
- MOW track CAD files
- Capital Assets Management System (CAMS) GIS Asset Map Layers (100 LRS coded Asset Tables)
- NYC GIS 96’ aerial photos & 2001+ updates
System Construction Process

1. Geospatially register track centerline and platform files.

2. Digitize features into points, lines, and areas from high resolution aerial photography.
3. Separation of different categories of features into aligned thematic layers with database attributes.

Each City Agency, as well as NYC Transit, is creating its own set of map or thematic “layers,” which are commonly aligned to the same geographic framework, or grid.
System Construction Process

4. Integrate engineering CAD of underground infrastructure and utilities.
System Construction Process

4. Organizing structurally related features into an asset hierarchy of nested “Parent-Child” relationships.

1. YARD [YD#]
   / \
2. Facility- [RE#] \ Shop- [SH#] (370 Jay St) (CI Overhaul, CI Maintenance)
   / \ /\ /\ 
3. Sub-Facility [ID#] Structural Component Equip [ID#]
   Revenue Facility) (Elevator Banks or clusters)
   / \ / \ 
4. Elevator [ID#] Elevator [ID#]
System Construction Process

5. “Geocoding” dynamic events into additional layers by street address or offsets from known track landmarks.
System Construction Process

Examples of ROW landmarks used:

- Platform ends
- “Line segment” switch junctions
- “Route section” demarcations
Past, Present and Beyond

Past – CAMS Centerline

Beyond – All spatial and LRS data in Oracle Spatial

Present - Track Number used to establish a unique ID key for individual track GIS/LRS Route
System Operational Impacts

Several operational areas will be impacted by the implementation of the system.

Among the areas effected are:

- Capital Program Plans
- Construction Planning
- Emergency Management

Future:
- Outage Planning (Temporary service plan route changes)
Benefits derived include:

- MTA communicating transportation issues to elected leaders
- Aides MTA in securing federal and state transportation funds
- Aides MTA in conveying the benefits of capital projects to voters in order to dialog with the legislators who prioritize the capital projects
Construction Planning

Benefits include:

- Project decisions viewed with a programmatic “eye”
- Project research during preliminary engineering is more efficient and accurate
- Project assumptions are replaced with real project information
- Earlier heads-up on unforeseen issues helps eliminate the mis-spending of allocated funding
Emergency Management

The ground plan for the WTC buildings, prior to the 911 attack, overlaid with NYC Transit track and platform CAD.
Emergency Management

GIS rapidly enabled aerial photo overlay comparisons of conditions at Ground Zero before and after the 911 terrorist attacks.
Emergency Management

Post WTC 911 attack response effects:

- Aids in management of pedestrian and vehicular traffic restrictions effective 9/17/02
- Effective location of transit entrance/exit and vent map for dog rescue teams
Outage Planning Opportunity

Temporary Service Plan route changes to affected transit lines can be depicted on individual track routes.
Question
&
Answers