Roles That GIS Plays in Transit Enterprise IT To Support Transit Operations and Management

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Roles That GIS Plays in Transit Enterprise IT To Support Transit Operations and Management

- WMATA and WMATA GIS
- GIS in Public Transit – Transit View
- GIS in IT – IT View
- GIS as A System in Information Management
- GIS as An Authoritative Source for Location Information
- Development of Location Referencing Framework in Transit GIS
- Development of Location Services for Other Transit Business Systems (Non-GIS systems)
- GIS in Enterprise IT Environment in a Transit Agency
- Advanced GIS Technologies for Public Transit Agencies
- Conclusions
WMATA provides passenger transit rail, bus and paratransit services for DC and surrounding areas of MD and VA (1,500 sq mi).

**Rail:** 117 mi track; 91 stations; 1,100 railcars; 217M annual ridership

**Bus:** 11,000 stops; 350 routes; 1,480 buses; 124M annual ridership

**Paratransit:** 600 vehicles; 2.4M annual ridership

**Infrastructure:** Structures, track, power, signals, HVAC, drainage, IT networks, etc.
Who we are:
- An IT Division within WMATA Enterprise IT
- Provides one consistent platform agency-wide for maps and data on WMATA’s infrastructure, transit service networks, and support services;
- Is WMATA’s sole and authoritative repository for geospatial information;
- Enforces spatial data consistency across other IT systems;
- A unique and critical component of WMATA’s overall IT architecture, and a critical resource for infrastructure asset management, service planning and analysis, incident management, and public information.

Staff: 12 fulltime GIS professionals

Software: ESRI suite of software with ArcGIS Server 10.2.2 and Oracle 12c, ArcGIS Desktop 10.1, 10.2, and number of extensions: Network Analyst, Spatial Analyst, 3D Analyst, GeoEvents, CityEngine, etc.
WMATA GIS

Business Customers:

- **Rail**
  - Infrastructure and Maintenance
  - Operation Control (ROCC)
  - Rail Scheduling
  - Asset Management

- **Bus**
  - Bus Planning
  - Bus Stop Maintenance
  - Operation Control (BOCC)

- **MetroAccess (Paratransit)**
  - Planning and Scheduling
  - Accessibility Analysis

- **Transit Planning and Development**
  - Long Range Planning
  - Real Estate and Station Planning

- **Police and Safety**
  - MTPD Police
  - MTPD Office of Emergency Management
  - Office of Safety

- **Administrative**
  - Customer Service
  - Office of Performance
GIS in Public Transit – Implementation Status

- **GIS Application Areas in Public Transit**
  - Service Planning (Bus and Rail)
  - Asset Maintenance (Bus and Rail)
  - Market Analysis (e.g., Ridership Analysis, Service Area Analysis)
  - Map Production
  - Realtime Bus/Train Location Display
  - Safety and Emergency Management
  - Transit Scheduling
  - Travel Itinerary Map Display
  - Paratransit Applications (planning, scheduling, market analysis, etc.)

- **GIS Technology Scale of Implementation in Public Transit**
  - **Single use of GIS**
    - Desktop based
    - Decentralized
    - Embedded in single department (e.g., Planning)
  - **Federate model**
    - Desktop based
    - Decentralized installation
    - Centralized data sharing (file based)
  - **Single Server Model**
    - Single Server based
    - Server based data storage and application
    - GIS centric application development (no integration with other systems)
    - Isolated IT environment
    - Not in highly-available environment
  - **Enterprise Server based**
    - Enterprise GIS database in highly-available environment
    - Enterprise Data Maintenance Process
    - Embedded in Enterprise IT
GIS in IT – IT View

• GIS as a system in information management
• GIS is a spatial data management system
• GIS is an application development platform
• GIS is compliant with SOA architecture and IT standards
• GIS supports other advanced IT initiatives
  – Cloud implementation
  – Mobile implementation
  – Big data implementation
GIS as A System in Information Management

• Information Management Systems in Transit
  – Asset and Maintenance Information (Work Orders)
  – Scheduling and Operation Information
  – Safety Information
  – Engineering Information
  – Location Information
  – Business Intelligent (BI) Information

• Location is a Common Denominator in Information Management

• GIS provides
  – Standard Location Names, Location Contents and Naming Conventions
  – Standard Location Referencing Systems and Framework

• GIS becomes an integral component in Transit Information Management

• GIS becomes a System Integrator across multiple business information systems in Transit
GIS as An Authoritative Source for Location Information in Transit

- GIS Provides Location Referencing Framework in Transit
  - What is Location Referencing System?
    - Location Referencing System is a set of **office and field rules and procedures** that includes one or more location referencing methods that defines standard location contents
  - What are the Location Referencing Methods?
    - Coordinate Referencing
    - Linear Referencing
    - Address Referencing
    - Feature Referencing (also called Common Place Name Referencing)

- GIS Provides Location Services for Non-GIS Business Applications
  - Standard Location Names, Location Hierarchy and Location Content Definition (Required fields for location based on location referencing methods)
  - On-line location referencing method services:
    - Address geocoding
    - Location lookup (point or line) based on linear referencing method
  - Hybrid Location Map Services for Various Location Referencing Methods
    - Address Geocoding
    - Highway Interchange Location Reference
    - Facility Location Reference
    - Track Chain Marker Location Reference
    - Reverse Location Referencing by point geometry (click on the map)
Development of Location Referencing Framework in GIS

- **Linear Referencing System (LRS)**
  - Definition: Location Referencing based on linear distance
    - Distance along specific route (track) and from the defined starting point
    - Locating points and linear events along specific route (track)
  - Key components
    - LRS route (track): track network segment with spatial coordinates and measurements: e.g., track segment with chain markers
    - LRS event: attribute tables with linear referencing data items: LRS route identifier (track LRS segment) and measurements (Chain Maker values): incidents, assets along track
  - Implementation of LRS in Transit
    - Track Network
    - Drainage Network
    - Communication Network
    - Power Network

- **Facility-Asset Spatial Data Model for Feature Based Location Referencing**
  - Facility as location container (space): e.g., Escalator Bank
  - Asset as location occupant: e.g., Escalator
  - Facility and Asset identifiers match Maximo Location and Asset identifiers

- **Highway Interchange Location Referencing**
  - Highway network: Interstation route segment, ramps and Interchange nodes
  - Interchange Referencing hierarchy:
    - Interstate->Direction->County->Exit/Ramp
GIS of Location Referencing Framework for Transit

Linear Events:
- Bridge: location from 27790 ft to 28175 ft on Track line A1 & A2
- Platform: location from 27578 ft to 28175 ft on Track line A1 & A2

Point Events:
- Emergency Exit: location at 28260 ft on Track A1 & A2
- Incident: location at 28300 ft on Track A1

Linear Referencing System for Transit Network such as Track Network

(Example is fictitious)
Facility-Asset Spatial Data Model for Feature Based Location Referencing
GIS of Location Referencing Framework for Transit – Highway Location Referencing
Development of Location Services in GIS

• Purposes of Developing Location Services
  – SOA compliance
  – System integration with other business systems
  – Data sharing

• Location Service Types
  – Map Services for Transit Asset Location Display and Query
    • Map display (require ArcGIS APIs)
    • JSON (JavaScript Object Notation) formatted representation
  – RESTful (Representational State Transfer) Web Services for spatial data query and spatial functions
    • SOAP compliant
    • JSON (JavaScript Object Notation) formatted representation

• SOE (Server Object Extension) Services
  – SOE: custom built code to extend base functionality of ArcGIS Server by using ArcObjects
  – SOE service example: linear referencing service to locate a point/line event or asset along the LRS track

• Hybrid Location Services
  – Location Services
  – Map Interface
  – Can be embedded within non-GIS application, or
  – Communicated through URL call
GIS Location Services for Transit – Custom Built Web Services

SpatialQuery( Public/RailLRSDef )

- **Trackname**: A1
- **Chainmarker**
  - **Start**: 2000
  - **End**: 2200
- **Format (f)**: html

Geometry: (1)

Paths: (1)

- (2)
  - 4707
  - -857
  - 4707
- (2)
  - 4707
- (2)
  - 4707
- (2)
  - -857
  - 4707
- (2)
  - -857
  - 4707
- (2)
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  - 4707
- (2)
  - -857
  - 4707
- (2)
  - -857
  - 4707
  - 4707
  - 4707
  - 4707
  - 4707

**Geometry**: 102100

- x: -8575501.284831027
- y: 4707168.788959234
- m: 2000
- spatialReference: 102100
GIS in Enterprise IT Environment

• Leverage on Enterprise IT Resources
• Design of GIS Enterprise Architecture
• Accessing ArcGIS Server Resources
• Enterprise Data Maintenance Workflow
Leverage on Enterprise IT Resources

- GIS Enterprise systems are hosted on Virtual Infrastructure supported by the enterprise IT infrastructure management team (DCI)
- GIS Geodatabases are hosted on Oracle RAC Databases and supported by the enterprise Database team
- GIS services are monitored by the IT Enterprise Monitoring Center (MEMC)
- GIS application security is controlled and managed by the enterprise IT security team
GIS Enterprise Architecture
Design of GIS Enterprise Architecture

• Enterprise GIS Architecture
  – Handle Load Balancing within Server Cluster
  – Enable Automatic Failover
  – Compliant with Security Policy across Different Security Zones
  – Highly Available Environment
Methods of Accessing GIS Server Resources

• ArcGIS Server Web map services through Web Adaptor with Rest Endpoint (for Web applications and desktop users)
• ArcGIS Desktop users access the Read only replica SDE of the datasets
• Citrix users with ArcGIS desktop
• External users secured access (limited to applications through Content Zone)
Data Maintenance Workflow

WMATA Versioning Workflows

Second Generation
- Editor Version
- ArcGIS Desktop Editing
- Mobile editing Version

First Generation
- Rail Features
- Bus Features

Application Support
- Disconnected file gdb
- Read-only Replica

One-way Replication

Default Version
- Parent SDE

Disconnected or field Editing
Advanced GIS Technologies in Transit

• ArcGIS Online and Cloud Services
  – Online Mapping and Data Collection without Firewall restriction
  – Hybrid Mapping and Web Application Development Platform
  – Mapping and data Sharing Platform

• Mobile GIS
  – Disconnected Asset Data Collection for Underground Stations and Tracks
  – Single Code source for Multiple Mobile Platforms Deployment
    • ArcGIS JavaScript API and Cordova

• Big Data - Potential Use Cases
  – Smarttrip Card transaction for Customer Origin-Destination Analysis
Demo - Mobile Data Collection for Underground Transit Facility
Conclusion

- GIS is not just a mapping tool, it is an integral component in information management for Public Transit agencies.
- GIS plays important roles in Enterprise IT as
  - an authoritative source for location information
  - a system integrator among other business systems:
    - To spatially enable non-GIS information to be visible on a map
    - To provide standard location information and location contents for non-GIS business systems
    - To provide location based business intelligence for business decision makers
- The key to success for GIS in Transit is the development of a location referencing framework, which
  - defines business procedures and standards for collecting location information within a transit agency
  - provides location services for other non-GIS business systems