Constructing WMATA’s Enterprise GIS:
Strategy, Action, Issues

Ed Wells, GIS Manager
Anurag Mehta, GIS Architect

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Present WMATA case study in implementing an enterprise transit GIS

– Setting strategy
– Reengineering business processes
– Building on legacy data assets
– Delivering and maintaining GIS in a dispersed agency
– Integrating GIS with other IT applications
WMATA: Scope and Scale of Services

- Provides passenger transit rail, and paratransit services for DC and surrounding areas of MD and VA (1,500 sq mi).
- **Rail:** 103 mi track; 86 stations; 217M annual ridership
- **Bus:** 350 routes; 1,480 buses; 1M annual ridership
- **Paratransit:** 600 vehicles; 2.4M annual ridership
- Police force; planning; real est; environmental responsibilities
**Purpose:** Enterprise GIS integrates mapping and databases to support consistent information across the enterprise, efficient operations, and informed stakeholders.

**Role:** GIS is a service, not an application.

GIS owns few business processes and supports many:

- Geographic data base display
- Geographic analysis
- Geographic data capture
- Data integrity testing
- Data integration
**IT Span of GIS**

**Software** – ESRI ArcGIS 9.3.1 (upgrading to 10 this year)

**Hardware**
- Production, staging, dev environments; education and map production environments
- Managed storage (SAN and NAS)

**Applications**

**Data**

**Integration** – Maximo and Trapeze in progress

**Web services** – Agency-wide intranet viewer

**Business processes**

**User support**
2008  Strategic plan

2009  Enterprise Architecture
Enterprise GIS software installation; as-is data loading

2010  WebADDF GIS web viewer and core data

2011  Flex GIS web viewer
Integrated bus stop and route database
Bus stop and route data posted to public web site
Rail linear referencing system for mainline track
Began integrating GIS with asset/work order management system (Maximo)
Upgrade to ArcGIS 10/Oracle 11g/Windows 2008

GIS-MMMS integration: design, software implementation; data

Construct the transit route network and obtain software tools to maintain it

Add data sets and services to the internet viewer; deploy web services for application integration

Show bus stops and route maps on WMATA’s public website.

Map rail station and bus garage interiors

Offer expanded user support, metadata, and training
Setting Strategy: A Portfolio Approach

Strategic Portfolio of GIS

40% Fixed Asset Management

40% Transit Operations

20% Support Operations

- Stops, time points, chain markers, waypoints
- Patterns, routes, lines, transfers
- Performance (vehicles, trips, blocks)

Rail, Bus, Van, Road Network

Parcel Facility Amenity

MTPD, Plan, Real Estate; Environmental, IT
Key Principles in Building GIS Relations with User Departments

IT is a support department

Keep the domain expert in charge of information decisions

Keep IT in charge of data and system architecture decisions

Do not start applications unless the data is compiled

Do not compile data you are not jointly prepared to maintain

Make it easy for the domain expert to feed information to the GIS staff

Use the maintenance process to drive business process reengineering
Business Process Reengineering: The Payoff

Use the maintenance process to drive business process reengineering.

Work incrementally:

– Add GIS to the existing data flow at first
– Let GIS become the source for authoritative data
– Then build GIS data maintenance into a revised workflow
– Use the interim process to define more automated interfaces and applications
Legacy Data Are An Asset

Choices

- Compile new
- Convert one existing data source
- Convert multiple sources, cross-check, and reconcile the discrepancies

Keep what is good

Use geography to cross-check legacy data

Break down the silos

Aim toward consistent information across the enterprise
Functional vs Non-Functional Needs
- WMATA GIS needs are atypical

Architecture Strategy
- Upstream vs. Downstream GIS

Tactical View
- Order to “prongs” of Architecture

Snapshot
- High level Architecture through Deployment
<table>
<thead>
<tr>
<th>Enterprise GIS Construction: Functional Needs</th>
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<tr>
<td><strong>GIS NEED</strong></td>
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<tr>
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</tr>
<tr>
<td>Data Access</td>
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<tr>
<td>Referencing System</td>
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<td>Access and publication</td>
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**Notes:**

- NA services indicate that the service is not applicable to the given business areas.
- For some services, the offering is specific to users such as FARS desktop software users.
FIRST (SIMPLE) STEPS

– Gather, organize and serve available data
  – *CAD, documents, GIS data, basemaps etc.*

– Make simple apps available
  – *Desktop software, web viewers, dashboards, reports*

– Define and set standards/practice/key datasets
  – *Metadata, QA tests, common base layers, remove duplication*

– Enable mobile architecture
  – *Hand-held devices, versioning*
ATYPICAL GIS

– Bulk data from automated sources
  – *On board equipment* – bus and rail
  – *Field data* – Inspections and Situational Awareness
– Real time Operational use vs. Downstream Analysis
  – *Why is my bus/rail delayed?*
  – *How has on-time performance been over X timespan?*
– Data and Applications use
  – *Desktop, (GIS/Non-GIS), Web Apps (all APIs), SQL calls, Mob*
  – *(Handheld and onboard devices)*
– Publication
  – *Website, Applications, LED Signs, more*
DESIGN CONSIDERATIONS

- Low level integration
  - *Oracle SQL Calls: Spatial functions + SQL insert, update etc.*

- High level integration
  - *Interface to interface: ArcGIS-Maximo services cross calls*

- Systems/Data integration
  - *Data exchange, maintenance, overnight updates, Oracle jobs: AVL, Asset Mgmt.; Document repository upkeep*

- Enterprise environment
  - *Automated deployments, patch management, license management*

- Nimble application development
  - *Architectural changes, service provider integration*
UPSTREAM vs. DOWNSTREAM GIS

- GeoDatabase becomes first stop
  - Large volume feature creation
  - Spatial and relations constraints
- Data relationships established at GIS level
  - Primary/Foreign Key Joins in place of spatial algorithms
  - “Canned” most frequently used relationships
- Data outputs for integration and consumption
  - Web Services
  - Stored Procedures
- Application Layer
  - Display, Analysis, Query, Publication
Enterprise GIS Architecture: Architecture Tactics

EA Design Methodology: Order is important

- Architecture Strategy and Design
  - What are the information flows and standards
- Infrastructure and Systems Architecture
  - How will physical realization occur, how will users interact
- Data Architecture
  - What data will be stored, reported, how?
- Process Architecture
  - How will data be maintained and standards enforced
- Applications Architecture
  - How will information be used, how will value addition occur
High Availability Architecture

- **GeoDatabase positioned** Upstream
- **Large number of** Scaled web services
- **Key services**: ChainMarker Locator, Bus AVL etc.
- **Multiple Applications Platforms**: Desktop, Web, Mobile
- **Support for Multiple Development APIs**
- **Illustration of a spatial function call**:

```sql
SELECT bt.bus_id
from bustable bt, counties ct
where bt.avltime=(SELECT CURRENT_TIMESTAMP from DUAL
    and
    ct.name = 'Arlington' and
    sde.st_within (bt, ct) = 1;
```
GIS High Level Design
Delivering GIS Across the Enterprise

Web services and Web APIs to make the GIS accessible to non-technical users agency-wide

Deploying and administering client ArGIS software for powerful data access by power users

The center of the enterprise:

– Servers
– Storage
– Redundancy
– Security
Application Integration

Key Integration Points

**Rail, Asset Management:** Plant, Elevator/Escalator, Power, ATCS, AFC, Track and Structure Maintenance, IT-Communications

**Applications:** Maximo, AutoCAD

**Bus:** Bus Planning, Scheduling, Bus Technology

**Applications:** Maximo, Trapeze, Clever, Trip Planner, Farebox

**Support:** MTPD

**Applications:** Dispatch, Crime Records
MetroView
MetroView: Chain Marker Locator
MetroView: Chain Marker Locator
Questions and Discussion

Washington (DC) Metropolitan Area Transit Authority

Ed Wells, ewells@wmata.com

Anurag Mehta, amehta@wmata.com
Goal: Ensure consistent asset inventories between GIS and MMMS; provide mapping capabilities to MMMS.

Benefits:
- Safety: what is near an emergency that must be protected?
- Efficiency: Improved deployment and reduced travel time

Cost: $707,674

Deliverables/Timeline:
- 8/11 – Geodatabase design implemented; data conversion plan defined
- 12/11 – Maximo Spatial in development environment
- 6/12 – Key asset classes mapped

Risks/Mitigation:
- Maximo Spatial has few large installations; none under 7.5; and none for transition
  Mitigation: Retain good consultants that can resolve unexpected problems
- Legacy data may be inconsistent/incomplete
  Mitigation: Cross-check all data sources
Web viewers vs. ArcGIS client software

Scale: Entire service area to engineering detail

Core Data
- All mainline and yard track
- Rail station platforms and entrances
- Bus stops and routes
- Compact jurisdiction boundaries
- Base maps and imagery

Basic functionality: Search, identify, measure, print

Web service links:
- Public services: Google StreetView, Bing imagery
- WMATA internal: Maximo, other applications

Document retrieval

Sketch tools
Enterprise system

System of record and data maintenance
  - All mapping data
  - Bus stop and route attributes

System integration driver

Data integration driver

Geographic and RDBMS data integrity enforcement driver

Data display and analysis tool
**TG 3: Transit Route Network**

**Goal:** From stop and route data, create a routable network of WMATA and rail services

**Benefits:** Supports integrated maintenance and QC of WMATA stop, timepoint, pattern, and route data

**Cost:** $602,534

**Deliverables/Timeline:**
- 10/11 – Evaluate/procure available software tools
- 12/11 – Linear referencing added to bus routes
- 3/12 – Transfer segments added to bus and rail routes
- 6/12 – Network topology added to bus and rail routes

**Risks/Mitigation:**
- Linear reference networks are complex to build and require specialized software to manage. Only one GIS-based vendor is known. Timing of vendor upgrade to A10 is not known. Mitigation: Be prepared to create tools in house if the product does not meet spec requirements.
**Goal:** Add functionality and data to GIS viewer. Support Silverlight and APIs. Create web services for application data integration

**Benefits:** Increased use of GIS viewer within WMATA. Provision of GIS and map controls to other applications. Consistent data across applications.

**Cost:** $200,000

**Deliverables/Timeline:**
- 9/11 – Bus AVL and train location data shown displayed in web viewer.
- 9/11 – Silverlight GIS API is available to other applications
- 12/11 – GIS – Trapeze data exchange web service defined and tested

**Risks/Mitigation:**
- Trapeze data exchange capability is untested. Mitigation: Include QC and verification of data exchange.
**Goal:** Add bus stop and route maps to wmata.com website.

**Benefits:** Bus system becomes more familiar to the public. Bus stop data is accessible to MetroAccess customers.

**Cost:** $100,000

**Deliverables/Timeline:**
- 9/11 - Application available internally
- 12/11 – External security and design complete
- 3/12 – Internal testing of public application
- 6/12 – Application available publicly

**Risks/Mitigation:**
- Public interface testing/marketing approval process is not known. Mitigation: Adjust schedule for technical development, but accommodate approval process.
TG 6: Building Interior Mapping

**Goal:** Georeference rail station floor plans and site plans and add to GeoStation. Create 3-D imagery and floor plans of bus garages (no plans exist now).

**Benefits:** Provides a base for in-station infrastructure mapping. Supports more intelligent crime mapping. Supports better

**Cost:** $609,821

**Deliverables/Timeline:**
- 3/12 – Rail station georeferencing procured and completed.
- 6/30 – Bus garage mapping procured and completed.

**Risks/Mitigation:**
- AutoCAD files for rail station plans have not been reviewed. Mitigation: if data is incomplete, determine how best to create or update it.
- 3-D mapping is new technology. Mitigation: one pilot test has been done.
- 3-D data requires a custom data viewing add-on. Upgrade plans to ArcGIS 10 are known. Mitigation: Defer action until WMATA and vendor upgrade plans are known.
**Goal:** Support GIS use in WMATA departments via tech support, creating map publications, metadata, and training courses.

**Benefits:** Use justifies WMATA’s investments

**Cost:** $350,000

**Deliverables/Timeline:**
- 12/11 – Bus route map series completed
- 3/12 – Training course offered in WMATA GIS resources and use
- 6/12 – Training course offered in basic GIS concepts
- 6/12 – Complete metadata compiled for all feature classes shown in the web view

**Risks/Mitigation:**
- Hiring restrictions preclude adding FTEs. Mitigation: Use contract services, and/or adjust goals to fit reduced capacity.
Goal: Make GIS available to field maintenance and emergency response personnel

Benefits: Integrates GIS into field operations

Cost: $850,000

Deliverables/Timeline:
- 12/11 – Hire mobile GIS Analyst/PM
- 3/12 – Proof of concept test done
- 6/12 – Pilot field test done

Risks/Mitigation:
- Depends on additional capital funding from rail. Mitigation: If not funded, defer to FY13.
- Requires deployment of field devices, servers, and security. Mitigation: Pilot test for scaling up
- Requires business process changes and training. Mitigation: involve the users; test first, go live
<table>
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<th>Strengths</th>
<th>Weaknesses</th>
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<th>Threats</th>
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| • Tested, scalable IT architecture and infrastructure  
• Support from all stakeholders  
• Rail lines, station entrances, platforms, bus stops and routes are precisely mapped and accessible across the intranet  
• Rapidly increasing use of GIS and intranet mapping | • Lack of data integration processes across applications  
• Small team – FTE staff increase is critical to FY12 success  
• Multiple inconsistent legacy data sources  
• No documentation of data (metadata) | • Map key infrastructure assets for ready access in routine work and emergency response  
• Integrated management and maintenance of WMATA stop and route data  
• Provision of GIS data and functions to other applications via web service (for data synchronization) or web APIs (for embedded map controls)  
• Add data to intranet viewer: AVL, infrastructure  
• Increase public familiarity with bus system by putting stop and route maps on the public website | • Competing funding priorities  
• Personnel hiring restrictions  
• Complexity and interdependencies of ArcGIS 10 upgrade |
Questions and Discussion