



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

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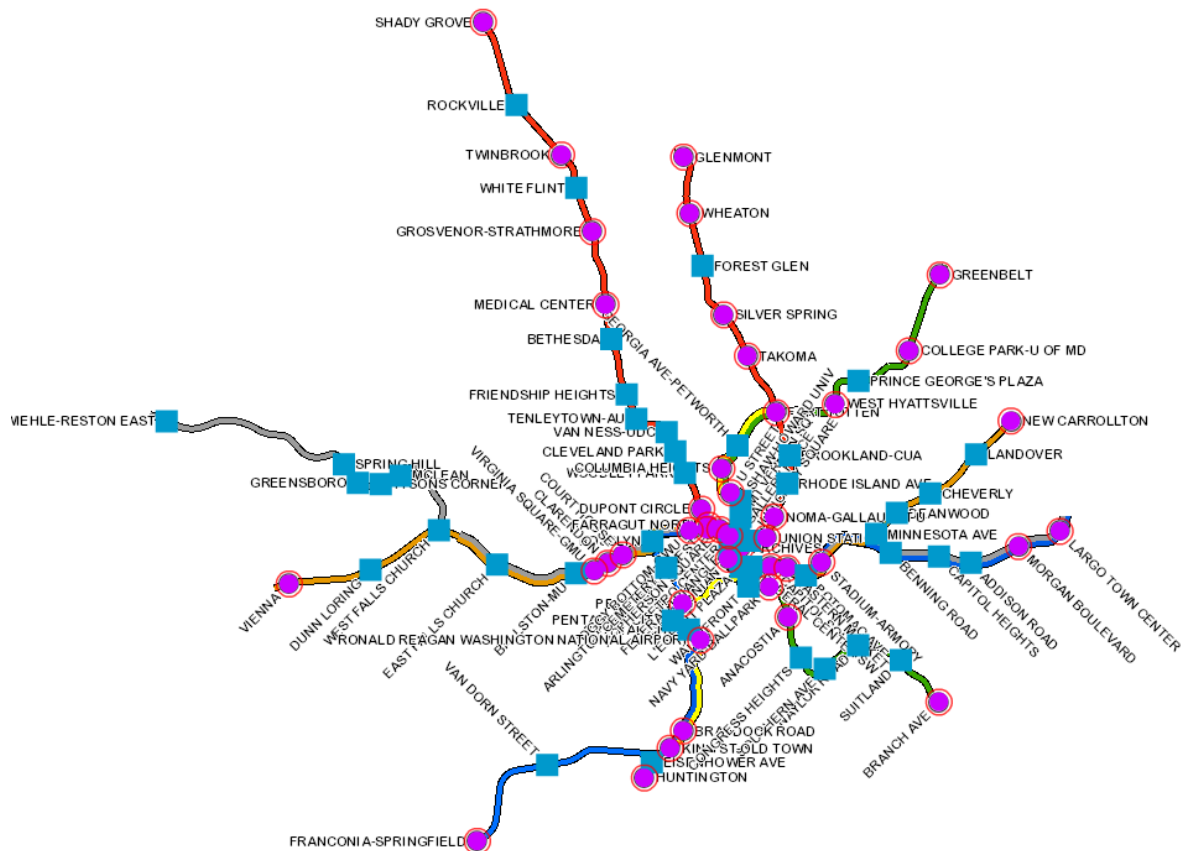


# Roles That GIS Plays in Transit Enterprise IT To Support Transit Operations and Management

- 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



# Washington Metro Area Transit Authority



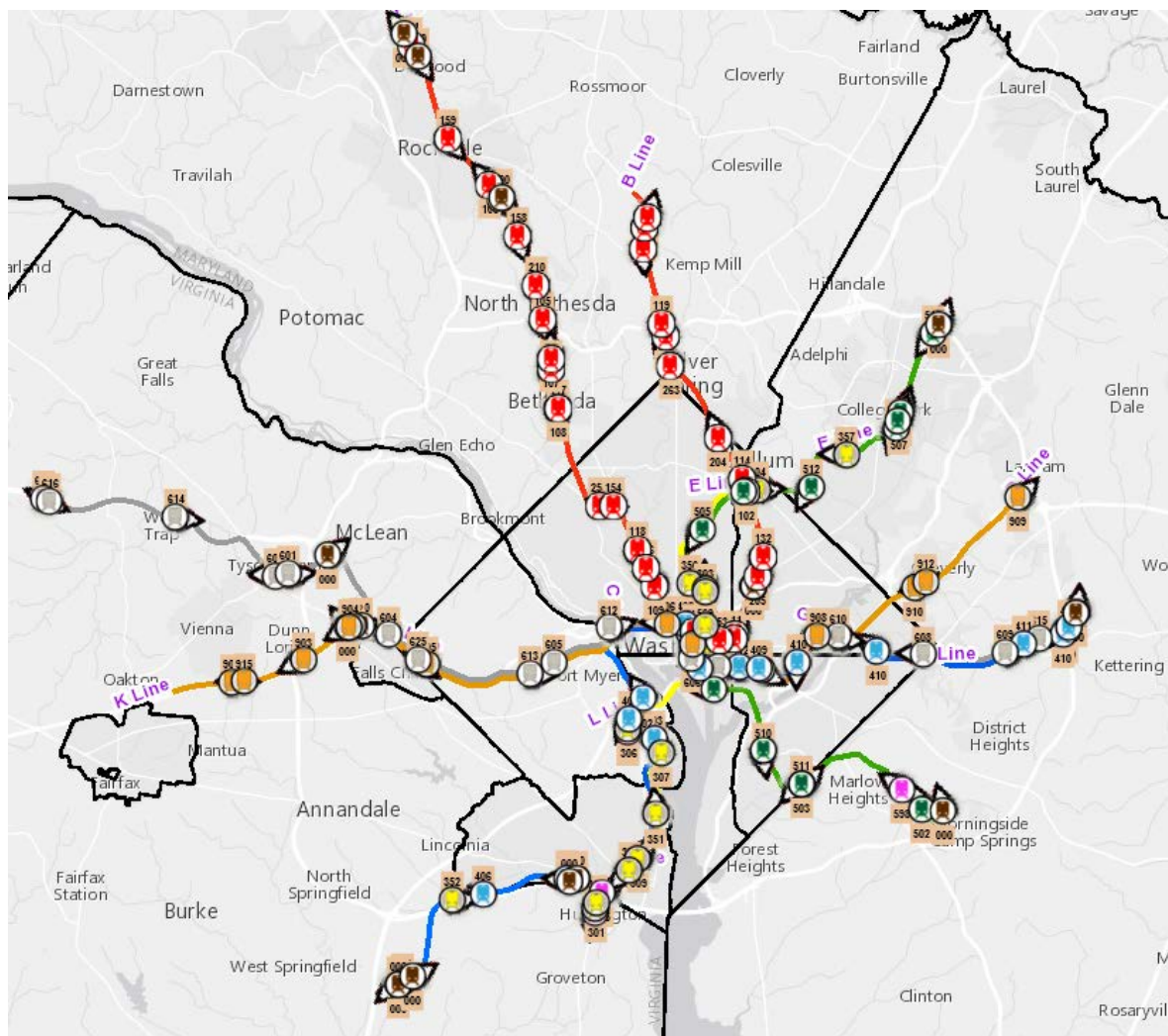
*WMATA provides passenger transit rail, bus and paratransit services for DC and surrounding areas of MD and VA (1,500 sq mi).*

***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.*

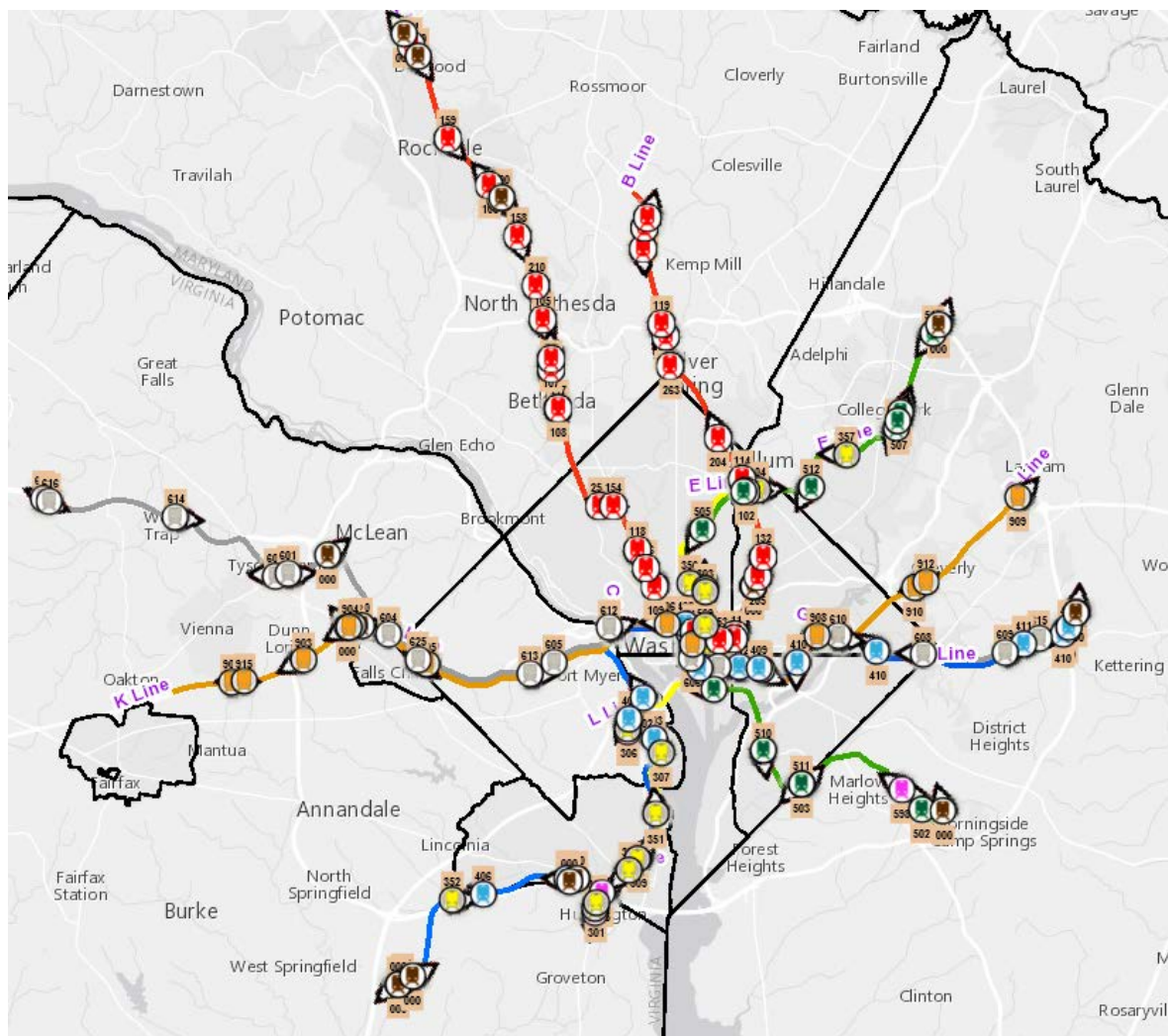


## **Who we are:**

- *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.



## 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 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)

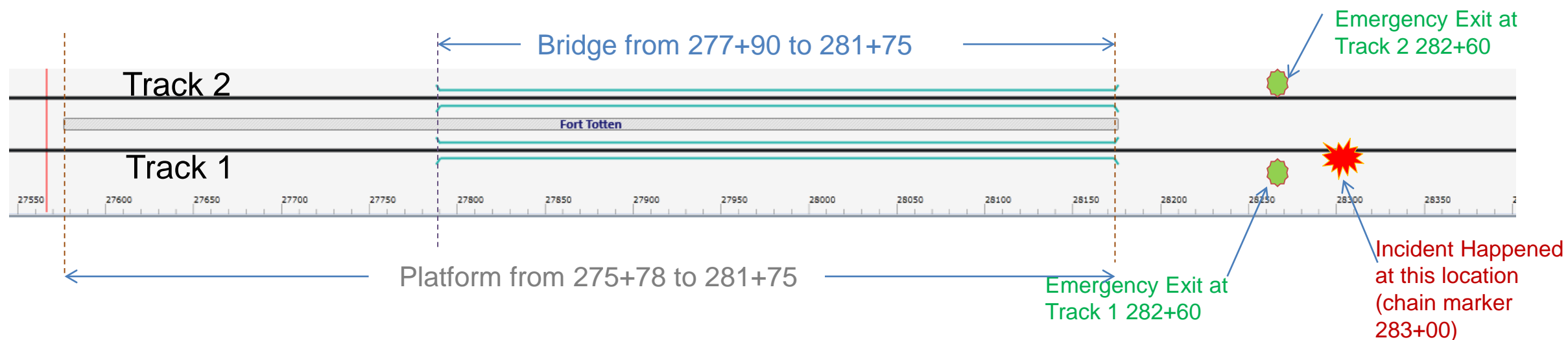


# Development of Location Referencing Framework in GIS

- **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:

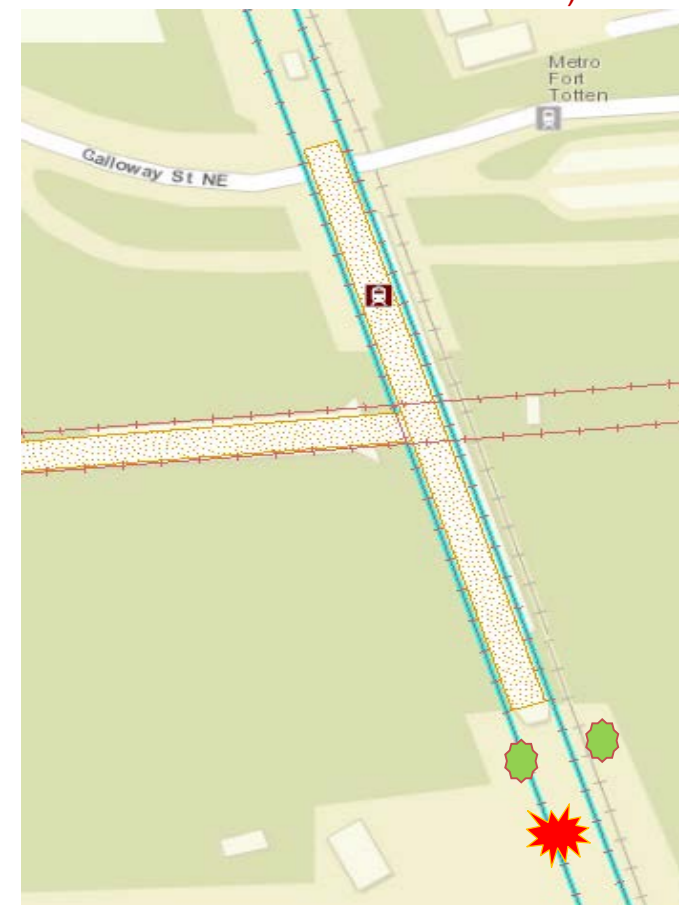
- Bridge: location from 27790 ft to 28175 ft on Track line A1 & A2
- Platform: location from 27578 ft to 28175 ft on Track line A1 & A2

## 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

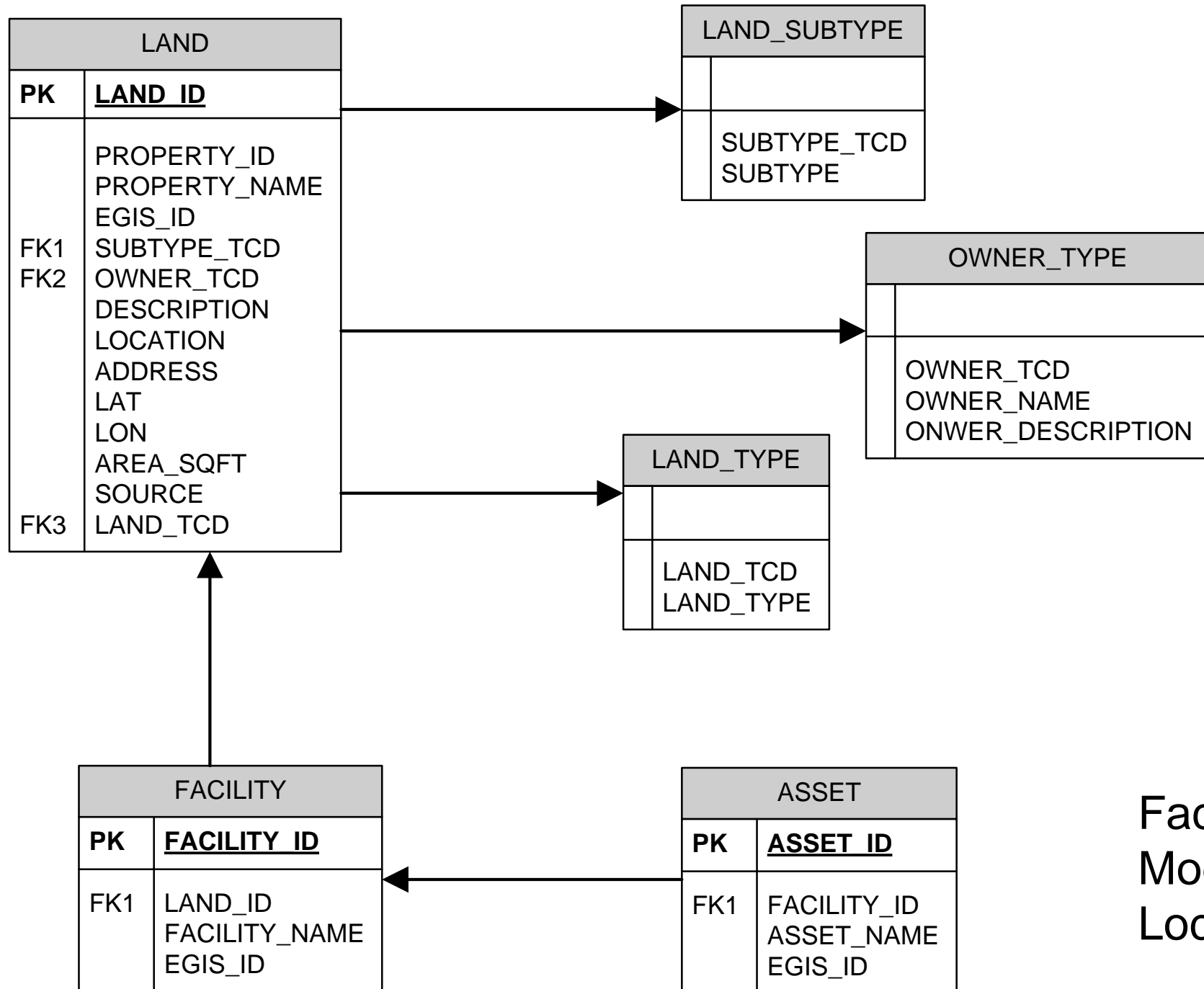
(Example is fictitious)





# GIS Location Referencing Framework for Transit

## – Transit – Asset Spatial Data Model



Facility-Asset Spatial Data Model for Feature Based Location Referencing



# GIS of Location Referencing Framework for Transit – Highway Location Referencing

**Street Address / Highway Search**

Address  Street Intersection  Highway

**Search Filter**

Highway \* :  
I-270

Direction \* :  
SOUTH

County \* :  
MONTGOMERY COUNTY

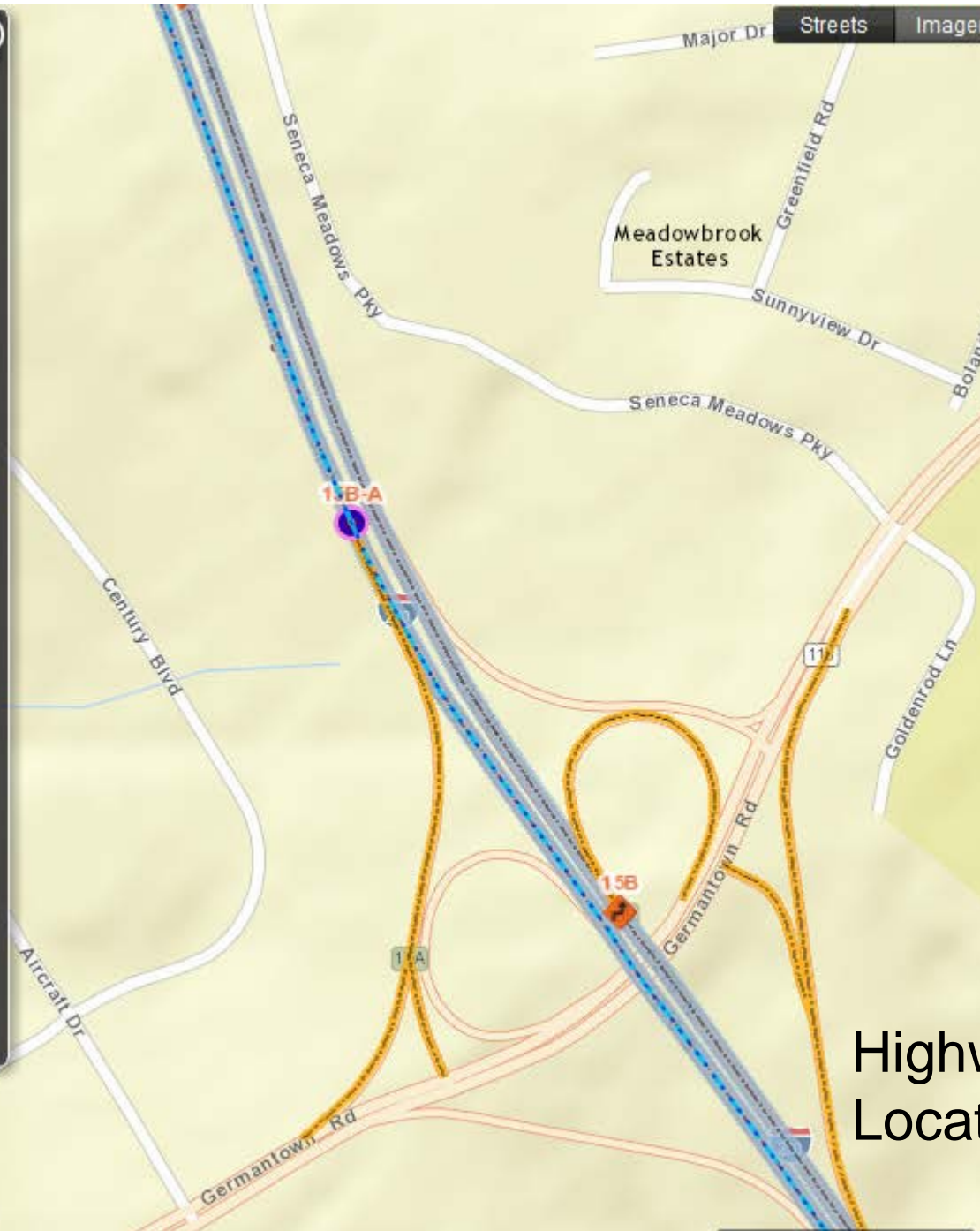
Exit :  
EXIT 15B-A, I-270 SOUTH TO MD-118

OR

Ramp :  
Select Ramp

**Results**

Exit: EXIT 15B-A, I-270 SOUTH TO MD-118  
Highway: I-270 SOUTH  
Region: MONTGOMERY COUNTY  
State: MARYLAND  
Longitude: -77.25826235201995  
Latitude: 39.188557879448176



Highway Interchange  
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

## ArcGIS REST Services Directory

[Home](#) > [services](#) > [Public](#) > [RailLRSDef \(MapServer\)](#) > [SOE\\_LRSsegment](#) > [Segment\\_Operation](#)

## Segment\_Operation ArcGIS REST Services Directory

Trackname	A1
Chainmarker_Start	2000
Chainmarker_End	2200
Format (f)	html
Segment_Operation (GET)	

[Home](#) > [services](#) > [Public](#) > [RailLRSDef \(MapServer\)](#) > [PointQueryRest](#) > [SpatialQuery](#)

## SpatialQuery( Public/RailLRSDef )

Trackname	A1
Chainmarker	2000
Format (f)	html
SpatialQuery (GET)    SpatialQuery (POST)	

### Geometry: (1)

paths: (1)  
(201)

(2)

-857  
4707

(2)

-857  
4707

(2)

-857  
4707

(2)

-857  
4707

(2)

-857  
4707

(2)

-8575503.028830353  
4707169.6775959935

(2)

-8575503.377630217  
4707169.855323345

(2)

-8575503.726430083

### Geometry: (1)

**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



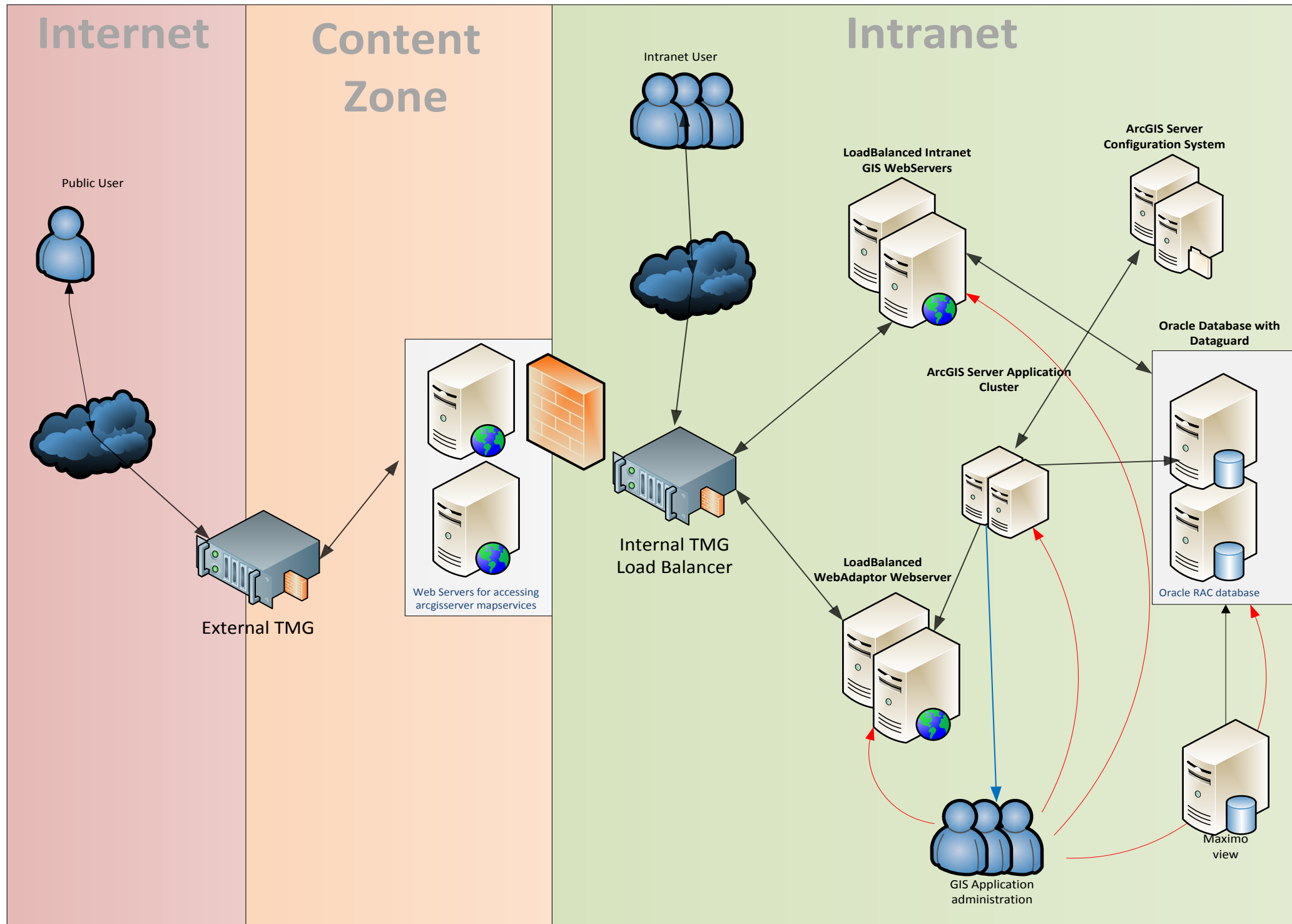


# Leverage on Enterprise IT Resources

- 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

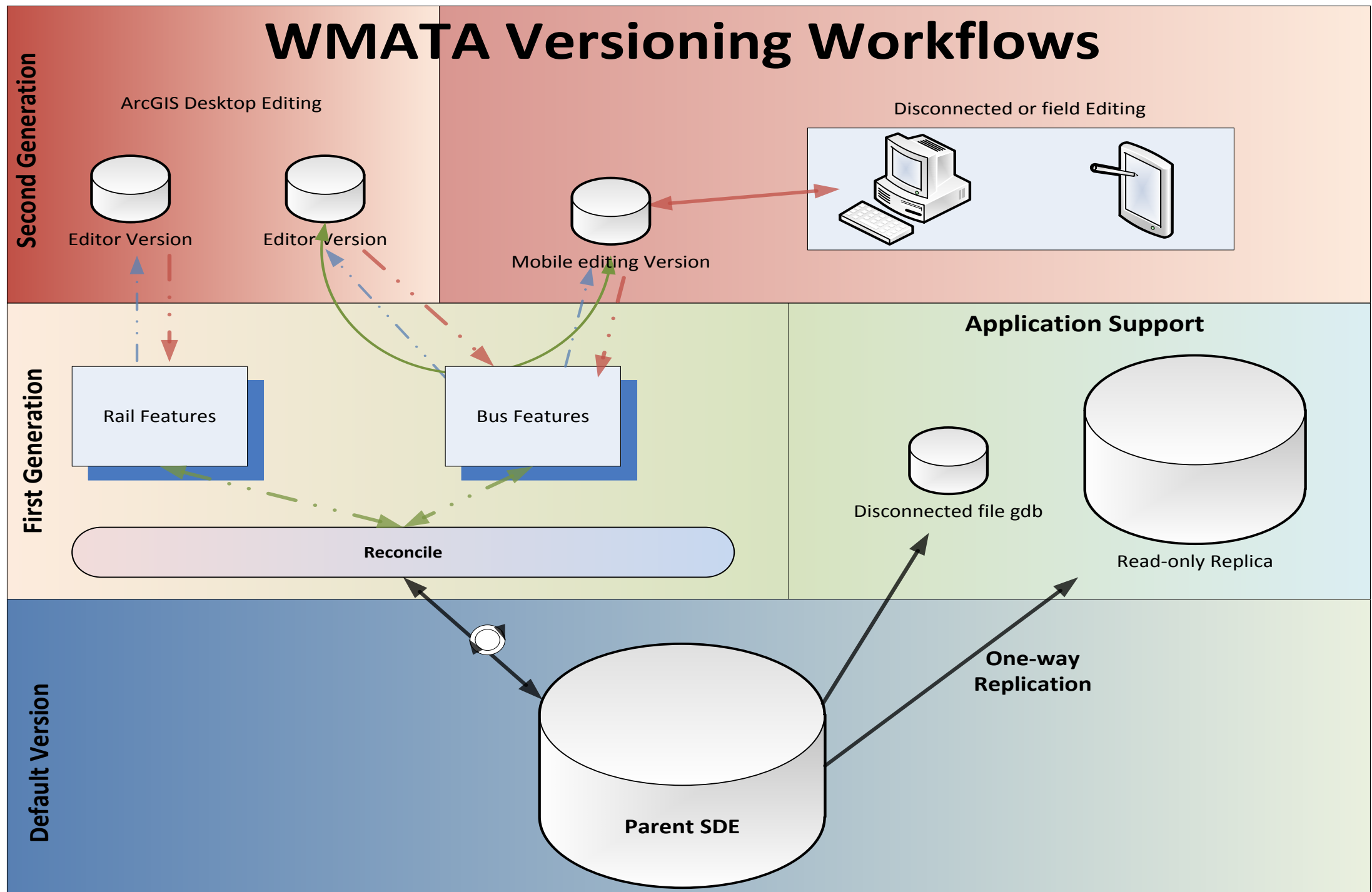


# Methods of Accessing GIS Server Resources

- 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





# 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



# Advanced GIS Technologies in Transit

## 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