APTS Map Database User Requirements Specification

Version 1.0

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1. INTRODUCTION

In this Age of Information, the digital road network is as essential an element in systems providing customer information, analyzing system performance and marketing data, and monitoring public assets as the road network is to enabling the movement of people and goods through a city. Digital data drives most Advanced Public Transportation System (APTS) automated technologies; and by representing the real world, digital map databases furnish public transportation agencies and their customers with more powerful and efficient tools. The map database is the part of the infrastructure which integrates information from the various Intelligent Vehicle-Highway System user services, and eventually, in and between public transportation agencies. For these reasons, in November 1992, the Advanced Public Transportation Systems of ITS-America formed a working group to investigate the spatial data needs and requirements of APTS applications.

The APTS Map Database User Requirements Specification (MDURS) is composed of many parts, including a list of representative application classes, general function statements for each application class, the objects and major attributes required to perform the delineated functional tasks, and a consolidated list and description of spatial objects with their definition, description, attributes, and quality requirements.

1.1 Purpose

Over the past year, the Advanced Public Transportation (APTS) Map and Spatial Database Working Group (MSDWG) has developed map database requirements for public transportation applications. This MDURS is an open requirements document that provides the public and private sectors with specifications for defining and describing transit data elements in a consistent and transferable form. In so doing, this specification addresses integration issues encountered by public transportation database users, such as common definitions, common data entities and common relationships between data.

This specification will evolve over time. The Working Group expects that the industry will grow, generating a need to change in the future. These changes will be exhibited by adding new or removing obsolete application areas, spatial objects, features and entities, and adopting new industry map database standards related to transit entities.

1.2 Scope

This specification establishes a framework for APTS technologies to efficiently operate and monitor automated transit services, collect data for analysis, reporting, and other administrative tasks, and disseminate traveler information to effectively change mode choice. It addresses user requirements for APTS application areas which use map databases, spatial objects, and entities. The data requirements, derived from the functional requirements of APTS and traditional transit services, ensure the data's "fitness for use." For that reason, application areas, function statements, and tables tracing data to functions are included in this document. They are described in this document as an historic record. These function statements and feature/attribute tables were a means of understanding the activities of APTS as an enterprise. As most enterprises

change and evolve over time, we expect these functions to change from one agency to another, and from year to year. The core of this specification is contained in both Section 3 and Appendix 1 which define and list the spatial features, included terms, and attributes necessary for a better understanding of this document and the overall APTS User Requirements Specification process.

This document specifies spatial features whose underlying spatial representations are described by a generic set of spatial objects. Although, only five spatial objects (see Figure 1-1) are defined in this document, these objects are demonstrative of different classes of spatial objects, and were not intended to restrict map database developers from employing a "chain" instead of a "link," or a "graph" in place of a "plane." These concepts are explained in the following chapters.

A spatial feature includes a definition and description of a set into which similar entities are classified. Included terms represent fundamental spatial phenomena required for transit activities, including demand responsive systems, fixed route operations, customer information, and other traditional and APTS services. Included terms are given as suggested naming devices which typically represent transit phenomena. As the design hierarchy illustrates in Figure 1-1, transit agencies, and providers of services to transit agencies and their customers may customize their own databases with spatial feature instances based on the lists of features and included terms. Appendix I includes a list of included terms, attributes and their associated features. This list is not exhaustive, it is included to support and aid in developing a data dictionary. Finally, the database developer will need to specify the physical data format, including number of characters in each field, their relationship to other instances, and more. Data models, data formats and other development issues are application dependent, and thus, not specifically covered by this specification.

MAP DATABASE LAYER	SPECIFICATION LAYER	EXAMPLES
Transit Physical Layer	SPATIAL FEATURE INSTANCE	Bus Route 39, 59th Street Bridge Barrier
Transit Application Layer	INCLUDED TERM	Bus Stop, Fixed Route, Bicycle Path
Transit Concept Layer	SPATIAL FEATURE	Access Point, Segment, Transit Route
Geographic Layer	SPATIAL OBJECT	**Five P's**: Point, Piece, Polygon, Path, Plane

1.3 Background/Methodology

The map database requirements are derived from transit applications. Each spatial data element can be traced back to a specific application. After categorizing them into similar areas, the application classes were decomposed into functional statements. Next, the Working Group derived the features and attributes. In so doing, the Working Group developed a user-defined specification which is responsive to user analysis, planning and application data needs. As a

consequence, the "fitness for use" is embedded in the data and not just in the data model. The final step required identifying spatial and spatially related features and attributes, define them, describe their "default" attributes, and verify their quality requirements against "real world" examples. Each of these steps produced a section of the Map Database User Requirements Document.

Note on TIME

The APTS Map and Spatial Database Working Group recognizes that time is an important element in dynamic systems. Time may be described as an attribute of an spatial object, spatial feature, or as a third or fourth dimension. Currently, no standard exists for describing time. Most applications associate time as an attribute of a spatial feature, although certain features possess time as an inherent fourth dimension, such as person, vehicle or parcel. These features add to the argument that a new spatial object be created in which time is inherent, i.e., a spatial-temporal or dynamic spatial object. Additionally, applications describe time within different frames of reference, e.g., time series, velocity (magnitude and direction), frequency. As research on time evolves and new techniques are implemented to represent this phenomenon, this document will absorb those changes. Currently, time is treated as a desirable, though non-essential attribute. We did not explicitly deal with time in developing the user requirements.

Application Areas

Emerging APTS applications that depend on map databases are increasing in size and complexity. Applications that exchange information between transit and other transportation agencies require standardized interfaces, formats and data sets. If these systems are to be integrated and the data flow transparent, then the data requirements of each type of system must be scrutinized.

The Working Group categorized transit applications that use spatial data or map databases into seven major groups (see Section 2. Functional Decomposition). Function statements and constituent data requirements were developed for each application area, including Demand-Responsive Systems, Fixed Route Operations, Planning and Analysis and Customer Information. (The remaining three topics, Safety, Maintenance, and Transit Administration, require development.)

Function Statements

Function statements describe what the system does from the user perspective. The function statements describe -- in a user-defined language -- the day-to-day tasks of a transit agency. They were developed with the involvement of the those people who use or provide the service. The experience of transit professionals who perform the manual or semi-automated operations and those who use spatial analysis software tools was integral in this process as was the technical expertise of application developers and software engineers who map those operations to automated processing paradigms.

Top level function statements build the foundation on which the spatial feature instances of the map database are derived. The data were identified through the process of functional decomposition. This method decomposes application areas into functional parts and then into their data processing requirements. For example, the Fixed Route Operations Application Area contains at least two functions: Provide Service and Service Monitoring. Each function is composed of multiple function statements (see Section 2.x ii). The data or features and attributes (see Section 2.x iii) are derived from these processes.

By deriving the data from the function statements, we ensure coverage of the major tasks in an application area. In this way, the function statements can be used to maintain the feature and attribute list. When additional applications are created, the same method may be employed to develop new function statements, features, and attributes. And because they are user defined, the transit agency can update the lists. --Figure 1 -- Specification Layers--

Features, Attributes and the Data Dictionary

Features represent collections of real things. Attributes further describe elemental characteristics of the feature. Specifically, the map database spatial features (see Section 3.0) are abstract categories which are used to specify types of services and facilities. Some attributes apply to a class of spatial feature and some attributes apply only to one feature. For example, an *access point* has an included term called a *bus stop* and another called *pickup/dropoff point*. Both possess the location attribute and both serve the same function: *a point where passengers board or alight a vehicle*. Their specific characteristics differ: a bus stop sign is connected with a bus stop, no sign is associated with a pickup/dropoff point which may be someone¥s home or office. Only the *bus stop* has a default relationship to a *bus stop sign*.

Feature specification focuses on common functionalities. A transit term (such as route) in one transit agency does not necessarily mean the same thing in another. Transit professionals, even from the same organization, disagree on names and definitions of terms. Yet, all agencies providing public transportation services employ similar functionality in their systems. We chose terms that are generally understood by transit professionals and are defined such that they are *not* ambiguous. Feature definitions were chosen from standard reference documents {footnote 1} and refined to capture the essence of the APTS function.

The Feature specification may be compared to abstract data types which possess both general and specific characteristics. Each feature is assigned a name, identification, definition, spatial characteristics, and types. In addition, some Features contain unique attributes; for example, Run requires an attribute of Cost. The next few paragraphs describe general attributes. (Unique Feature attributes are defined in Table 3-2.)

Definition

The source of the definition is critical for maintaining the Map Database User Requirements document. There are two considerations in defining terms. The first is to choose a common usage so as not to confuse or "reinvent the wheel;" the second is to convey the precise meaning of each term.

Description

The description includes any report or additional comment which increases user understanding of a term. For example, the description may reference another database or document which further defines the types of facilities managed by a transit agency (e.g., Public Transportation Management System).

Type

The type item lists all the various Included Terms that reference a Feature. The Included Term inherits all the characteristics of its "parent" Feature.

Spatial Objects

Each spatial feature is designated with a spatial object. Spatial objects are mandatory inherited characteristics. There are five spatial objects which are compatible with digital map databases and geographical information systems. They are: point, piece, path, polygon, and plane. These spatial objects possess attributes of their own. Table 1-2 lists the object definitions and default attributes.

Table 1-2 Spatial Object Definitions and Default Attributes

Point	Piece	Polygon	Path	Plane
a unit of location	a line connecting start, end and shape points	two or more contiguous pieces with a common start and end point	one or more contigous poieces	topologically interrelated spatial elements
Representation of a point on a map, including geopolitcal, address, intersection, coordinates, milepost, offset from start of Piece	Start Point End Point Shape point(s)	Collection of pieces Adjacent Polygons	Sequence of pieces	Collection of component spatial elements Relationship of component spatial elements

1.4 How to Use this Document

A Data Dictionary contains descriptions, quality requirements and formats for all the types of elements that are in a database. This document can be used as an abstract spatial feature/entity component of a Data Dictionary because it describes Spatial Features and a significant set of Included Terms. It contains the definition and conceptual sections of the data dictionary. It does not contain the physical, lineage, and data quality requirements specific to an actual database nor does it specify formats or relationships between Features. When designing a map database, the transit agency may employ this specification to "instantiate" specific Feature Instances to be included in a database. These instances are fundamentally the same as the feature, that is, the

instance inherits characteristics of the Spatial Feature, and yet may possess its own unique attributes. Users may use the specification as a template, but all users will need to develop a Data Dictionary that describes their map database.

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2. FUNCTIONAL DECOMPOSITION

ITS User Services are divided into seven application areas. These application areas execute similar functionality and are logical divisions within transit agency current activity areas. The application areas are listed below.

List of APTS Application Areas that Use a Map Database

1. Demand-Responsive Systems
    - Computer Aided Dispatching and Fleet Control
    - Automatic Vehicle Location
    - Demand/Response Dispatching
2. Fixed Route Operations
    - Computer Aided Service Restoration/Route Deviation
    - Improved Transfer Points and Connections/Timed-Transfers
    - On-Time Performance Monitoring
3. Analysis and Planning
    - Service Planning
    - Market Analysis
    - Ridership Forecasting
4. Customer Information (Multimodal)
    - Kiosk
    - Itinerary Planning (telephone based)
    - Real-Time Updates
    - Park and Ride
    - Car and Van Pool Ride-sharing
5. Safety and Security
    - Police Operations
    - Accident/Incident Reporting
6. Maintenance
7. Transit Administration, *e.g.*, Section 15 Reporting

2.1 APPLICATION: Demand-Responsive Public Transportation Applications

2.1.1 Scope

Demand-responsive paratransit systems are defined as all forms of public transportation where services are more flexible and personalized than conventional fixed route, fixed schedule services. The vehicles are usually low capacity highway vehicles and offer service that is adjustable to a certain degree to the individual user's needs. {footnote 2} Furthermore, demand-

responsive systems are defined as transportation systems characterized by flexible routing and scheduling of relatively small vehicles to provide door-to-door, curb-to-curb, point-to-point transportation at the users demand. {footnote 3} The demand-responsive definition includes publicly and privately operated services.

Suppliers of transportation within the scope of this section includes taxis, limo/van services, and rental agencies from the private sector; Dial-a-Ride (including ADA) and (Industrial) Shuttles from the public sector; and car/van pools, ride-matching and other special services from the private/non-profit sector.

The users of paratransit consist of the daily commuters, disabled commuters, tourists, and business travelers. The person that makes the occasional, personal trip to the supermarket or doctor's office is also included. Access to paratransit systems is more flexible than that of fixed systems in that individual travel arrangements can be made easily over the phone or in many cases by flagging down a "paratransit" vehicle along the street or at an intersection. There are cases in paratransit where a potential user may be denied a ride. This might be due to limited availability or because a person is not properly pre-registered. The latter is commonplace in Dial-a-Ride services and car/van pools, primarily for security reasons.

2.1.2 Functions:

(those marked with * are possible subfunctions that reflect how the system *may* implement a superior function)

- Provide information to customer
  - Estimate fare
    - (given pickup and dropoff points, the time-of-day, the vehicle fare classification, the passenger fare classification, subsidies)
  - Compute fare
    - (given time-since-pickup, distance-since-pickup, and/or inputs to Estimate Fare, subsidies)
  - Estimate time-until-pickup
    - Contact customer if constraints cannot be met
- Process a reservation (obtain passenger-specific information)
  - Make a reservation
    - Verify pickup and dropoff points (i.e., find them in the GIS)
  - Cancel a reservation

Delete passenger-vehicle assignment from assignment list
Update vehicle route, removing pickup and dropoff points

Dispatch a vehicle

Select vehicles based on passenger needs and vehicle status minimum time-until- pickup, maintaining a geographic distribution of vehicles, or other optimization criterion)
*Update vehicle routes to include new pickup and dropoff points

For each vehicle, take the current route and compute a new route that includes the new pickup and dropoff points.

*Eliminate vehicles that cannot meet their time constraints

Estimate ETA at each PUDO point
Compare ETA to time constraints

Assign a vehicle to pickup the passenger

Add passenger-vehicle assignment to assignment list
Update vehicle route to include pickup and dropoff points

Pickup/Dropoff a passenger

Verify identification
Update vehicle status
Update vehicle route

Maintain vehicle status database

Query vehicle status
Receive vehicle status and update database

Update vehicle route

based on changes in traffic conditions
based on changes in vehicle status

Monitor performance

Time-based
Passenger count (via Automated Passenger Counting system)

2.1.3 Feature Tables

FEATURES AND ATTRIBUTES:	NEEDED BY FUNCTION
Passenger	
ID	
Time (that reservation was made)	--Monitor
Pickup Point	Performance
Dropoff Point	-- Dispatch
Identification (for driver)	-- Dispatch
Number of passengers	-- Pickup/verify
Amount of luggage	-- Dispatch
Pickup time constraints (e.g., ASAP, not before 9 a.m.)	-- Dispatch
Pickup instructions (e.g., ring side door buzzer)	-- Dispatch
Dropoff time constraints (e.g., not after 10 a.m.)	-- Pickup
ADA validation number (if any)	-- Dispatch
Contact information (if any)	-- Dispatch
Special Services Qualification(s)	
ADA Passenger (inherits from passenger) (persistent data)	
ADA validation number	
Special needs (e.g., wheelchair lift)	
Special instructions (e.g., drive around back,ring bell, open door)	-- Dispatch -- Pickup
Vehicle	
ID	
Status	-- Dispatch
Time of report	-- Maintain Status
Current location	
Current speed	
Current route	
number of passengers	
amount of luggage	
amount of fuel	
mechanical status (e.g., OK, low-on-fuel, breakdown)	
emergency status (e.g., OK, emergency)	-- Dispatch
Capacity	

maximum number of passengers luggage capacity fuel capacity Fare classification (e.g., taxicab vs. van) Special capabilities (e.g., wheelchair lift)	-- Compute fare -- Dispatch
Assignment ID Passenger ID Vehicle ID Time (that assignment was made)	
Pickup/Dropoff Passenger ID Vehicle ID Arrival time (of vehicle at location) Dwell time (of vehicle at location)	 -- Monitor Performance -- Monitor Performance
Operator (Call taker, Dispatcher) location type of station	

2.2 APPLICATION: Fixed Route Operations Applications

2.2.1 Scope

Fixed route transit operations can be defined as the provision and management of transit service along routes with fixed stops. *Providing service* involves several basic functions, including:

- Assign vehicles and drivers daily ("starter function")
- Dispatch vehicles
- Pick-up and drop-off passengers
- Deadhead {footnote 4}

The frequency of service is expressed either in terms of headways, i.e., the elapsed time between the arrival of transit vehicles on a specific route, or in terms of the number of vehicles per time period, e.g., vehicles per hour.

Other aspects of providing service are to restore service if there is an interruption, and to provide opportunities for transfers and connections. The specific subfunctions of service restoration, and transfers and connections are listed in Section 2.2.2.

Managing service involves the monitoring of service and the collection of data to determine operational efficiencies, such as the optimal headway on a particular route, or the schedule adherence. Service monitoring can be divided into the following activities:

- Data Collection:
    - Vehicle position
    - Schedule adherence
    - Route adherence
    - Headway adherence
    - Passenger data (e.g., passenger count)
    - Status of vehicle components
    - Traffic and weather conditions
- Calculation and analysis:
    - Vehicle performance and loading
    - Driver preference
    - Schedule/route/headway adherence
    - Estimated time of arrival at a specific point or stop
    - Passenger statistics (e.g., passengers per vehicle, per stop, etc.)
    - System-wide statistics (e.g., overall on-time performance)

Service Restoration involves the replacement or immediate repair of a disabled vehicle (which was in revenue service), and the activities necessary to restore the schedule from which the disabled vehicle was operating. Service restoration can involve the following activities:

- Repair disabled vehicle and continue revenue service
- Dispatch vehicle to replace disable vehicle
- Restore vehicle schedule by
    - Rerouting the vehicle
    - Adjust vehicle dwell time at particular stops/locations (e.g., at transfer points)
    - Adjust vehicle schedule
    - Perform adaptive traffic signal control

Transfers and connections allow passengers to travel on multiple transit lines by transferring from a vehicle operating on one route to another operating on a different route at a facility in which each vehicle makes a stop. Often the most common transfers cause the transit agency to develop a timed transfer system "in which vehicles from different routes are routed and scheduled to meet simultaneously at common stops to facilitate no-wait or minimum-wait passenger transfers." {footnote 5} The functions involved in transfers/connections are:

- Identify the specific vehicle that is making a connection at a transfer facility
- Adjust the station dwell time for a vehicle to ensure the proper connection
- Communicate this adjustment to the vehicle operator and other vehicle dispatchers/operators that may be affected by a dwell time adjustment.
- Communicate this adjustment to the transit rider whose ability to make a transfer/connection may be affected by a dwell time adjustment.

- Identify potential schedule changes that would make the transfer/connection process more efficient.

2.2.2 Functions

Function: Provide Service

Function Statements:

- Maintain headway
- Dispatch Buses
- Deadhead
- Pickup/Drop off passengers (Stop at access point)
- Assign buses and drivers daily ("starter" function)

Function: Service Monitoring (Transit Operations Efficiency for Fixed Route Vehicles)

Function Statements:

- Determine vehicle position
- Determine schedule adherence/deviation (current, pro-active, retroactive)
- Determine route adherence/deviation
- Determine headway adherence
- Determine Scheduled Time of Arrival (TOA)
- Determine ETA
- Determine vehicle load (passenger count based on capacity)
- Gather information (passenger count, driver performance, route/schedule/headway adherence/deviations, etc.)
- Display/present same information to driver, dispatcher, supervisor, customer, management reports)
- Determine driver performance (route, schedule adherence, safety factors, etc.)
- Determine vehicle performance (engine/electrical/mpg/hardware/etc. monitoring)
- Determine traffic/weather conditions
- Generate/report traffic conditions from the vehicle
- Determine route performance, collect data on load/segments, schedule adherence.

Function: Service Restoration

Function Statements:

- Restore vehicle to schedule-
- Substitute vehicle (dispatch additional vehicle)
- Reroute the vehicle
- Adjust the nominal schedules (set system offset to account for system wide delays)
- Deviate from route/schedule in response for on-demand stop requests
- Restore to schedule after transfer connection or on-demandstop

- Perform adaptive traffic signal control
- Adjust schedule or dispatch additional vehicle in response to a vehicle exceeding its maximum load

Function: Transfer Points and Connections -- Timed Transfers

Function Statements:

- Identify vehicle that requires a connection-
- Protect the connection (hold departing vehicle)-
- Instruct driver of the decision/adjusted time of departure

2.2.3 Feature Table

FEATURES AND ATTRIBUTES:	-- NEEDED BY FUNCTION
Vehicle (fixed route) Vehicle ID Status (OK, out-of-service) Passenger Capacity Type Block, Route, Drive IDs Direction time point (location/time) passenger count route adherence/deviation schedule adherence/deviation	--All --Service Monitoring --Service Monitoring --Service Monitoring
Transit Route *Static* ID or Route Number Collection of segments (pattern) Collection of Access Points Collection of Time Points Signals (control) Pre-planned deviations Ridership (demographics) Transfer/interlining/through routing Fixed schedule *Dynamic* Detour/Blockage Road Conditions Weather Conditions Schedule adherence/deviation (ETA)	--All

Fleet • Vehicle • Headways	--All
Block ID Route(s) Route Deviation Schedule Deviation Interlining/through routing Layover Driver run Vehicle run	--All

2.3 APPLICATION: Analysis and Planning

2.3.1 Scope

Planning and Analysis is emerging as an application area for Advanced Public Transportation System applications. In particular, many APTS applications deal with collecting and disseminating information in realtime, a functionality just recently used as part of Planning and Analysis activities. As ITS and APTS systems mature, Transit Planners will find increased uses for the vast amount of data collected by Advanced Vehicle Location systems, Automated Vehicle Identification products, intermodal Smart Cards, and many other APTS concepts. Keeping future uses in mind, Transit Planning and Analysis has a central role in the information requirements of this document.

Planning and Analysis can be defined as the Service Planning and Performance Analysis of public transportation systems. Both planning and analysis activities can be divided into a supply side (transit agency perspective) and a demand side (market perspective), as follows:

Service Planning

- Supply
  - route
  - vehicle
  - access points (bus stops, terminal, etc.)
- Demand
  - multimodal network
  - trip
  - trip-maker

Performance Analysis

- Supply
  - run
  - vehicle
  - operator
  - other assets/facilities
- Demand
  - boarding
  - alighting
  - trip length
  - fare payment

The demand-side includes functions such as market analysis of ridership and use of transit services. The supply-side includes functions such as service planning based on market requirements. This might include planning for corridor studies (e.g., HOV lanes), special needs vehicle, routes, and regulatory compliance. The functions listed in Section 2.3.2 represent a broad brush of the areas described above. We divided the functions into the four categories:

- Market Analysis
- Long-Range Ridership Forecasting (Regional Transportation Planning and Integration of Transit and Highways)
- Transit Operations Planning
- Transit Service Planning

In doing so, the functional areas remain consistent with the organization and activities of many transit agencies. This document does not deal with Transit System Planning {footnote 6} at this time.

2.3.2 Functions:

FUNCTION: Market Analysis

Function Statements:

- Market Analysis shall determine who will or might use transit services.-
- Market Analysis shall identify strategies for attracting new riders (promotions) and forecasting a change in ridership..
- Market Analysis shall determine existing customer satisfaction and how the existing services are meeting the demand.

FUNCTION: Long-Range Ridership Forecasting (Regional Transportation Planning and Integration of Transit and Highways)

Function Statements:

- Ridership forecasting shall identify major corridors where transit is needed.
- Ridership forecasting is a subset of multimodal metropolitan and statewide transportation planning.
- Regional transportation planning may result in expansion of the transportation infrastructure

FUNCTION: Transit Operations Planning (Transit Supply)

Function Statements:

- Transit operations planning determines critical operational parameters such as number of vehicles required for peak period operations, stations spacing, headways, etc.-
- Transit operations planning shall monitor and provide analysis and recommendations for changing existing services or adding new services.-
- Transit operations planning shall make recommendations to meet regulatory compliance (clean air act, ADA)

FUNCTION: Transit Service Planning (Transit Demand)

Function Statements:

- Transit service planning shall identify what transit services are needed new routes, schedule changes)
- Transit service planning shall identify the origins and destinations of current and potential transit users.
- Transit service planning shall identify special needs users, their locations (origins and destinations), and special requirements.
- Transit service planning shall identify, recommend changes in transportation infrastructure to facilitate transit operations (e.g., signal control, HOV lanes, waivers)
- Transit service planning shall monitor and analyze transit performance (ridership and operations, passenger counting)
- Transit service planning shall identify and plan ways to mitigate transit demand requirements for emergencies and special events.
- Transit service planning shall provide data to meet Federal (and state and local) reporting and management systems requirements.

2.3.3 Feature Table

FEATURES AND ATTRIBUTES:	-- NEEDED BY FUNCTION
Run ID Route Distance	-- Performance Analysis

Total travel time Running time Dwell time Deadheading Layover Schedule adherence Pull out Pull in Incident data	
Vehicle ID Seat/Standing capacity Type Lift utilization Run ID Fuel consumption Maintenance history Amenities Size	-- Performance Analysis, Route Planning
Assets/Facilities ID Type Location	-- Performance Analysis
Access Points/Bus Stops/Stations/Terminals ID Name Intersection Type Vehicle gate(s) Location Accessibility Connections (routes and to other modes)	-- Route Planning
Route (Pattern)	-- Route Planning

ID Name Speed limit Distance Segment characteristics Frequency of service Cost of provision Schedule(s) Vehicle requirements Anticipated load/minimum and maximum load	
Segment Characteristics Turning point Signals (control) Curb space Width of right of way Vertical clearance Turing radius Paving material Grade No. Lanes/Tracks Turnout Use of shoulder Reversible lanes Waivers (for traffic restrictions)	-- Route Planning
Trip Type Mode(s) Cost Travel time Frequency Tripmaker(s)	-- Market Analysis
Node Name Type (e.g., residence, intersection, work) Volume (traffic) Location	- Market Analysis, Service Planning (Transit Demand)

2.4 APPLICATION: Customer Information

2.4.1 Scope

Customer Information encompasses a very large section of both APTS and ATIS applications. In its broadest sense, Customer Information can represent any data distribution to any customer from the APTS/ATIS system. The "customer" is not restricted to "End-Users" (travelers). It can be anyone who needs information about the system such as:

- Non-users requesting information about potential use, or being enticed by customer information based advertising.
- End-users requesting information about fares, routes, discounts, schedules, maps, etc.
- System workers requesting information about system status, worker status, system efficiency, and more.
- Local or federal government requiring data about system usage, system operation or mandate compliance.
- Remote APTS systems whose "customers" are soliciting data for any reason, including those listed above.

A common reaction to the size of this subject is to try to limit "customers" to the End-User and Non-User areas. However, all of these functions require common data and are highly interdependent. Isolated applications for each area would create a vast amount of redundant information. It might also miss significant data relationships that are crucial to proper system administration.

Fundamental applications in this area may include the following:

- User Information Systems
    - Fare, schedule & map distribution
    - Fare collection (fare cards, etc.)
    - Traveler route generation
    - Special services (ADA, etc.) availability
    - Additional services (ATM, Ticketing, Reservation, Local Information, Sales, etc.)
- User Acquisition Systems
    - On-line public to private transportation comparisons
    - Special advertisements via user terminals
    - Customer information marketing campaign
- Management Information Systems
    - On-line efficiency and evaluation reporting
    - On-line system monitoring System scheduling System administration
- Worker Information System
    - Schedule/assignment reporting
    - Vehicle & run data gathering

Any of these services could be provided to customers via any of the following technologies:

- Administrative workstations
- Public and private accessible kiosks and terminals
- Public vehicle displays
- Depot displays
- Home PCs
- Transmission to private vehicles
- Transmission and downloading to hand held devices(PPATIS)

These fundamental systems represent only a minimal outline. They do not suggest a limitation of Customer Information potential.

2.4.2 Functions

- Select a Destination
    - Intersection
    - Street or Postal Address
    - Point of Interest - Advertising
    - Point in Space
- User and System Criteria
    - Mode
    - Schedule
    - Transfers
    - Detours
    - Walkability
    - Barriers
    - Costs
    - Speeds
    - Time
    - Scenic
    - Other Preference
    - ADA
- Route Selection
    - Modes
    - Convenience
    - Time
    - Cost
    - Various Routing Data
- Customer Transactions
    - Reservations
    - Ticketing
    - Service Requests
    - Emergency Assistance
    - Banking and Non-Banking
    - Goodwill, Non-Profit
    - System Information

2.4.3 Feature Table

FEATURES AND ATTRIBUTES:	-- NEEDED BY FUNCTION
Location Name Intersection Quadrant Coordinate Pairs Street names Milepost Geopolitical location Address	-- Criteria, Routing & Information
Access Point ID Name Location	-- Criteria, Routing & Information
Detour Area Affected Location (to and from) Duration	-- Criteria, Routing & Information
Barrier Area Affected Location (to and from) Duration	-- Criteria, Routing & Information
Trip Origin Destination Travel time Speed designation Mode(s)	-- Criteria, Routing & Information

Facilities ID Name Location	-- Criteria, Routing & Information
Ramp ID Name Descriptor Accessibility	-- Criteria, Routing & Information
Hold Over Waiting Time Location	-- Criteria, Routing & Information
Segment Characteristics Mode Traffic Restrictions Cost Roadway class Speed limit Crime rate Quality of service Travel time	-- Criteria, Routing & Information
Map	-- Criteria, Routing & Information

2.5 APPLICATION: Maintenance [TBD]

(i) Scope

(ii) Functions

(iii) Feature/Attribute Tables

2.6 APPLICATION: Safety and Security [TBD]

(i) Scope

(ii) Functions

(iii) Feature/Attribute Tables

2.7 APPLICATION: Administration [TBD]

(i) Scope

(ii) Functions

(iii) Feature/Attribute Tables

2.8 APPLICATION: Other [TBD]

3.0 SPATIAL FEATURES AND FEATURE TYPES

Basic Spatial Object Types

There are five basic spatial objects for which features are specified (see Table 3-1). These objects represent classes of spatial objects. Users should not be constrained by their literal definition. Instead, they should serve to classify different types of like objects. For example, a point describes a zero dimensional object. A node is an alternative to a point. Descriptions of each "P" is listed below. The precise definition was listed in Table 1-2 and again in Table 3-2. However, users are constrained by the spatial features. Any spatial object must conform to the strict definition of one of the spatial features.

Table 3-1
Basic Spacial Objects:
Five P's

Point

A point is a zero-dimensional element that specifies location. Typically a point is specified by a pair of coordinates (e.g., Latitude/Longitude). Additional dimensions can be represented by including more attributes (e.g., elevation, time).

Default Attributes: Representation of a point on a map, including geopolitical, address, intersection, coordinates, milepost, offset from start of Piece.
Examples: End points of a piece (see below). Bus stop,bridges, toll booth, dwell point, Maintenance Garage.
Alias: Node

Piece

A piece is a one-dimensional element that connects two or more points. A piece is specified by at least two pairs of coordinates identifying the locations of its end points. Additional coordinates can be used to specify intermediate shape points.

Default Attributes: Start point, End point, Shape point(s).
Examples: Road segment, mass transit route segments.
Aliases: Arc, Segment, Link, Line

Path

A path is a one-dimensional element consisting of a connected sequence of two or more pieces. A path is specified by at least three points identifying the endpoints of the component pieces (one point is shared by the two connected pieces).

Default Attributes: Sequence of pieces.
Examples: trip, transit route, run
Alias: [none]

Polygon A polygon is a two-dimensional element bounded by a connected sequence of pieces. A polygon is specified by the points that make up the bounding pieces and by a unique identifier associated with each bounding piece that defines on which side the piece of the polygon is located.

Default Attributes: Collection of Pieces, Adjacent Polygons.
Examples: Transit service areas, buildings, lakes, political jurisdictions
Alias: Boundary

Plane

A plane is a set of topologically interrelated elements (i.e., points, pieces, paths, or polygons) that conform to a set of defined rules. A plane is specified by the component spatial elements that make it up, along with the rules that interrelate them.

Default Attributes: Collection of component spatial elements, Relationship of component spatial elements.
Examples: urban street network, mass transit network, census tract boundary
Aliases: graph, network, layer, view, 2-D manifold

Spatial Features

A total of 19 features are specified for use with transit applications. These features were derived from the functional decomposition of application areas. Some features are defined for multiple spatial objects. The total set of 26 features are listed in Table 3-2.

The Spatial Features are the core of this Specification. These features contain all types of Included Terms required by transit agencies to deploy APTS User Services. This architecture takes an object oriented approach to describing phenomena. As illustrated in Table 1-1, the Spatial Objects are the foundation on which Spatial Features are built. These Features inherit the characteristics of the instantiated object. As a consequence, the spatial features contain an inherent data model based on their spatial object relationships. These topologic relationships link the simple spatial objects, like point to piece, piece to polygon and path, and aggregate point, piece, polygon and path into a plane.

The Spatial Features represent core transit elements which require spatial representation; they should cover Included Terms needed for transit applications. Included Terms represent various ways transit agencies can describe their spatial feature instances. For example, route alignment activities require normal travel time, turning radius at intersections, and number of lanes of routes, while runcutting or scheduling activities require the current status of detours and blockages along a route. Each instance of a Spatial Feature may have one or more of the characteristics of Included Terms or attributes, though all instances must have the inherited characteristics of the Spatial Feature.

A list of included terms and attributes associated with each spatial feature is included in Appendix I. This list is not exhaustive; it serves as a template for users and developers to expedite database and interface development.

Objects and Feature Types: Definition, Description and Default Attributes

POINT a unit of location location		
ACCESS POINT (transfer point) *A point where passengers board or alight a vehicle.* ID Name Descriptor Location Type (Bus stop, park and ride, tracks, platform, pickup/dropoff)	BARRIER *Any object that precludes or prevents movement through a part of the transportation network.* ID Name Descriptor Location Type (curb, see DOT definitions)	CENTROID *A representative point for a polygon* ID Name Descriptor Location Type ( )

FACILITIES/ ASSETS *Things that transit cares about* ID Name Descriptor Location Type (bus stop, signs, etc.)	NODE *A (topological) connection between pieces, or the starting or end point of a segment.* ID Name Descriptor Location Type* (Intersection, time point)	ORIGIN/ DESTINATION *The beginning or end of a trip-maker's trip.* ID Name Descriptor Location Type (Origin, Destination)
POINT OF INTEREST (POI) *A point of interest* ID Name Descriptor Location Type (landmark, observation point)	STANDBY, HOLDOVER LOCATION *A point where a non operating vehicle waits for an assignment (other than its storage facility)* ID Name Descriptor Location Type ( )	TOLL *A point at which a toll is collected or accumulated* ID Name Descriptor Location Type (plaza, smart card reader)
PERSON *A human being* ID Name Descriptor Location Type (tripmaker, operator, customer)	TRANSIT VEHICLE *A motorized conveyance owned by a transit agency.* ID Name Descriptor Location Type (bus, articulated vehicle, auto, van)	PARCEL *A package or group of packages or things.* ID Name Descriptor Location Type (wheelchair, bicycle, luggage)

PIECE a combination of start, end and shape points Start Point End Point Shape Point(s) Linear Reference {footnote 9}	
BARRIER *Any object that precludes or prevents movement through a part of the transportation network.* ID Name Descriptor Start Point	FACILITIES/ ASSETS *Things that transit cares about* ID Name Descriptor Start Point End Point

End Point Shape Point(s) Linear Reference Type ()	Shape Point(s) Linear Reference Type ()
SEGMENT *A piece in a network.* ID Name Descriptor Start Point End Point Shape Point(s) Linear Reference Type (road, bicycle, rail, communication, foot, "transit", "transportation")	TRANSIT VEHICLE *A motorized conveyance owned by a transit agency.* ID Name Descriptor Start Point End Point Shape Point(s) Linear Reference Type (train)

POLYGON two or more contiguous pieces with a common start and end point Collection of pieces Adjacent Polygons		
ACCESS ZONE *A buffer surrounding a transit route or access point.* ID Name Descriptor Collection of pieces Adjacent Polygons Width/Radius Type (pedestrian, vehicle, proximity zone)	ADMINISTRATIVE/POLITICAL/STATISTICAL REGION ID Name Descriptor Collection of pieces Adjacent Polygons Type (census tracts, zip code areas, area code regions, etc.)	FACILITY/ASSET *Things that transit cares about* ID Name Descriptor Collection of pieces Adjacent Polygons Type (real estate, station, see PTMS)

FARE ZONE *An area partitioned by a transit agency for fare pricing* ID Name Descriptor Collection of pieces Adjacent Polygons Type	POI *A polygon of interest* ID Name Descriptor Collection of pieces Adjacent Polygons Type(mall, hospital, landmark)	SERVICE AREA *A legal, jurisdictional or functional area in which a transit agency provides its service.* ID Name Descriptor Collection of pieces Adjacent Polygons Type(full, commuter, ADA, access)

PATH one or more contiguous pieces			
BLOCK *The sequence of trips made by a transit vehicle (also called a vehicle run)* ID Name Descriptor Sequence of pieces Type	DETOUR *A temporary series of (geographic) sequential, contiguous segments* ID Name Descriptor Sequence of pieces Duration{footnote 11} Service{footnote 12} Type (straight, swing, part-time, tripper, etc.)	STREET *A collection of road pieces that have a common name.* ID Name Descriptor Sequence of pieces Type (see hwy manual)	TRANSIT ROUTE *A collection of patterns {footnote 13} ("paths") in a revenue service* *ID Name* *Descriptor* *Route number{footnote 14}* *Sequence of pieces* *Collection of Time Points* *Collection of Access Points* *Type (Bus, Light Rail, Commuter Rail, Heavy Rail, emergency, fixed, variable, express, limited, supplemental service, etc.)*
TRIP *A one-way movement of a person or vehicle between two points*. ID Name Descriptor Sequence of	additional attributes for Person Trip *(includes part of a trip that is not part of transit service)* type (linked, unlinked) Collection of origin(s) and destination(s)	additional attributes for Vehicle Trip *(includes deadhead, pull in, pull out)* type (revenue, non-revenue) Collection of	

pieces Type (person, vehicle)		time points Collection of access points	

PLANE topologically interrelated spatial elements Collection of component spatial elements Relationship of component spatial elements	
MAP *A graphical representation on a plane of certain selected features of a part or the whole of the surface of the Earth or any other entity.* ID Name Descriptor Collection of component spatial elements Relationship of component spatial elements Type (Bicycle paths, Transit Routes)	NETWORK *A collection of points and pieces that have a relationship to each other* ID Name Descriptor Collection of component spatial elements Relationship of component spatial elements Type (road, transit, transportation, bicycle, pedestrian, communication)

4.0 Minimum Performance Requirements: Data Quality Standards and Future Enhancements

In addition to conformity with the spatial feature types defined in Section 3.0, spatial databases for APTS applications should meet minimum data quality standards with respect to geographic accuracy, topology, and attribute completeness. It is also likely that as new APTS applications emerge, these initial data quality standards will have to be modified and enhanced to meet new requirements.

4.1 Geographic Accuracy

Geographic accuracy refers to the ability to locate spatial features on a map database within a specified distance of their true physical location on the ground. Geographic accuracy is typically expressed as a horizontal distance (e.g., 50 meters) which indicates that the location of any spatial object depicted in the map database can be expected (within a certain confidence level) to be no more than 50 meters from its true physical location on the Earth's surface. Since each spatial database layer has its own geographic accuracy, the relative geographic accuracy of any

measurement between two spatial database layers is somewhat worse than the absolute geographic accuracy of the less accurate database layer alone.

Better than 50 Meters	Better than 10 Meters

• Customer Information (Multimodal)
  o Kiosk
  o Itinerary Planning (telephone based)
  o Park and Ride
  o Car and Van Pool Ride-sharing
• Analysis and Planning
  o Service Planning
  o Market Analysis
  o Ridership Forecasting
• Maintenance
• Transit Administration
• Safety
  o Accident/Incident Reporting
	• Demand-Responsive Systems
	  o Computer Aided Dispatching and Fleet Control
	  o Automatic Vehicle Location
	  o Demand/Response Dispatching
	• Customer Information (Multimodal)
	  o Kiosk
	  o Real-Time Updates
	  o Park and Ride
	  o Car and Van Pool Ride-sharing
	• Fixed Route Operations
	  o Computer Aided Service Restoration/Route Deviation
	  o Improved Transfer Points and Connections/Timed-Transfers
	  o On-Time Performance Monitoring
	• Safety
	  o Police Operations

4.2 Topology

Topology pertains to the mathematical relationships between spatial objects which are invariant to scale or transformations to different map projections. Topological relationships include adjacency (i.e., what object is next to another object) and connectivity (i.e., what objects are connected).

Connectivity is particularly critical in many transportation applications. Virtually all network pathfinding algorithms are based on the assumption that network pieces are connected to adjacent pieces via a common endpoint. Even though two pieces may appear to be connected by visual inspection, if they don't share the same endpoint, then pathfinding algorithms will treat them as disconnected. Therefore, for applications requiring the use of pathfinding, such as para-transit and emergency vehicle routing, travel demand forecasting, or dynamic customer information systems providing origin-to-destination trip information, network databases must provide full connectivity for all connected pieces.

Connectivity is not necessary for applications where the network base-map simply provides a visual background for orienting users. Such applications include: vehicle tracking displays, transit facilities inventories, or static customer information displays showing transit routes and key points of interest.

Required	Optional
Demand-Responsive Systems Computer Aided Dispatching and Fleet Control Automatic Vehicle Location Demand/Response Dispatching Fixed Route Operations Computer Aided Service Restoration/Route Deviation Improved Transfer Points and Connections/Timed-Transfers On-Time Performance Monitoring Analysis and Planning Service Planning	Analysis and Planning Market Analysis Ridership Forecasting Customer Information (Multimodal) Kiosk Itinerary Planning (telephone-based) Real-Time Updates Park and Ride Car and Van Pool Ride-sharing Safety Police Operations Accident/Incident Reporting Maintenance Transit Administration

4.3 Barriers

Closely related to network connectivity is the identification of travel barriers. Travel barriers may be actual physical barriers, such as rivers, overpasses, dead end streets, or sidewalks without curb cuts, or they may be regulatory barriers, such as one-way streets or turn prohibitions. For applications requiring the use of pathfinding, all relevant barriers must be explicitly identified and coded in a manner that can be utilized by the specific pathfinding algorithms. Such coding may involve the creation of node, or link-to-link attribute tables indicating what movements are not permissible for various travel modes. Without such barriers explicitly identified, pathfinding algorithms may find solutions which are physically unfeasible or illegal. The same application areas requiring connectivity/topology relationships also need these "turn" tables.

4.4 Address Coverage

Most locations in an urban area are identified in terms of a specific street address. However, existing public domain transportation network databases such as TIGER/Line Files are incomplete, both in terms of coverage and currentness. For those applications requiring the ability to geographically locate specific addresses, such as paratransit vehicle dispatching or dynamic customer information systems, the road network base-map should include a complete and current set of valid address ranges.

Many potential origins and destinations cannot be located using street addresses alone. These include such locations as vanity addresses (e.g., One Penn Plaza) post office boxes, or local points of interest (e.g., Union Station). For most applications, address ranges on the road network will have to be supplemented by a local point of interest database which can be topologically linked to the road network for pathfinding.

Required	Optional
Demand-Responsive Systems Automatic Vehicle Location Fixed Route Operations Computer Aided Service Restoration/Route Deviation Improved Transfer Points and Connections/Timed-Transfers On-Time Performance Monitoring Maintenance Transit Administration	Demand-Responsive Systems Automatic Vehicle Location Fixed Route Operations Computer Aided Service Restoration/Route Deviation Improved Transfer Points and Connections/Timed-Transfers On-Time Performance Monitoring Maintenance Transit Administration

4.5 Future Enhancements

Current spatial data technology is predominantly planar (i.e., 2-dimensional). While this limitation is acceptable for most current APTS applications, future applications may require graphic displays and analyses in three, or even four dimensions where vertical elevation and time are considered.

While most the enhancements required to address multi-dimensional displays and analyses need to be made to GIS software, transportation network databases may need to be enhanced to provide efficient storage and retrieval for time-sensitive transportation features or attributes, such as high-occupancy vehicle (HOV) reversible lanes, or peak versus off-peak headways on bus routes. In the meantime, many application areas require time-tagged information, in particular, dynamic customer information services and travel times for demand-responsive systems. This specification does not preclude organizations from attaching a time-related attribute to any spatial feature or feature instance.

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Appendix

APPENDIX I Data Templates-Point Objects

POINT Objects	**Included Terms**	**Attributes**
ACCESS POINT (transfer point)	transit stop bus stop airport gate platform station intermodal transfer point intramodal transfer point park Ôn ride	transit provider (carrier code) shelter local traveler density dwell time associated transit routes daily passenger activity security incident rate injury rate boarding rate amenities electronic message/annunciator parking capacity bicycle parking capacity pedestrian access ratio transit vehicle capacity condition date of last inspection date/time of last update
BARRIER	minimum clearance bottleneck traffic incident weight restriction traffic signal curb	applicable vehicle types restrictivity effective dates/times date/time of last update
CENTROID	town	(as established by polygon)
FACILITIES / ASSETS	sign station bridge controlled location control center	carrier code facility capacity injury rate capital cost expected life

	communications center garage shop yard shelter transit information kiosk	actual life operating cost maintenance cost security incident rate last inspection date facility condition facility status facility occupancy date/time of last update
NODE	intersection interchange branch point interlocking communications node intermodal transfer point intramodal transfer point terminal station airport park Ôn ride time point	adaptive signal controller design flow capacity last inspection date current actual capacity current flow rate design storage capacity current storage capacity date/time of last update
ORIGIN / DESTINATION	origin destination	origin address destination address type of trip PUDO times
PARCEL	wheelchair bicycle luggage	owner arrival time size weight condition date/time of last update current time
PERSON	traveler operator supervisor trip maker customer traveler client	home/work address status satisfaction rating date/time of last update current time
POINT OF INTEREST (POI)	employment center school recreation center shopping center/mall police station zoo	potential trips per day actual trips per day hours operation date/time of last update

	landmark traffic operations center	
STANDBY, HOLDOVER LOCATION	layover point recovery point	capacity current occupancy applicable routes date/time of last update
TOLL	toll facility fare collection box	fee flow speed dwell time number of lanes/aisles date/time of last update
TRANSIT VEHICLE	bus rail car van ferry maintenance supervisory police other non-revenue	owner (carrier code) operator condition status date last inspected reliability (MTBF) maintenance cost capital cost seated capacity maximum capacity passenger load expected vehicle life actual vehicle life securement positions ambulatory seats electronic message/annunciator customer information kiosk date/time of last update current time

APPENDIX I Data Templates-Piece Objects

PIECE Objects	**Included Terms**	**Attributes**
BARRIER	congestion bottleneck minimum clearance ÒJerseyÓ barrier island fence	applicable vehicle types restrictivity effective time/date date/time of last update
FACILITIES / ASSETS	viaduct tunnel train right of way	owner (carrier) operator capital cost

		maintenance cost expected life actual life last inspection date facility condition facility status date/time of last update
SEGMENT	roadway bicycle railway communications way tramway subway water-way right-of-way foot "transit" Òtransportation"	class no. lanes/tracks speed limit average speed (by time of day) traffic volume signal controller density (occupancy) turning radius signals curb space (shoulder) width of right of way weight limit min. vertical clearance paving material reversible lane traffic restrictions waivers accessibility crime rate level of service quality of service capital cost per mile depreciated rate expected life actual life maintenance cost/distance distance (mile, kilometer) operating cost/distance last inspection date average age or rail/pavement condition maximum grade water tolerance snow tolerance amenities actual flow speed design capacity

		reliability (MTBF) date/time of last update
	transit route segment	base headway commercial speed quality of service customer satisfaction ridership seated capacity maximum capacity scheduled deviation productivity date/time of last update
TRANSIT VEHCILE	train	carrier operator condition status capacity passenger load securement positions ambulatory seats date/time of last update

APPENDIX I Data Templates-Polygon Objects

Polygon Objects	**Included Terms**	**Attributes**
ACCESS ZONE	vehicle pedestrian	population jobs land use/zoning policy recreational capacity commercial capacity date/time of last update
ADMINISTRATIVE / POLITICAL / STATISTICAL REGION	Zip Code Area County State Municipality demographic kernel demographic region Census Tract Area Code Region	demographics/population jobs land use/zoning policy recreational capacity pedestrian accessibility automobile ownership date/time of last update
FACILITY / ASSET	real estate station parking lot garage depot	capital cost maintenance cost current value last inspection date facility condition

		facility status date/time of last update
FARE ZONE	zone	applicable routes date/time of last update
POI	Community of Place	population density job density land use/zoning policy recreational capacity commercial capacity pedestrian accessibility date/time of last update
SERVICE AREA	full commuter ADA	carrier demographics productivity level of service date/time of last update

APPENDIX I Data Templates-Path Objects

PATH Objects	**Included Terms**	**Attributes**
BLOCK	block	carrier total length (distance) productivity time/date of last update vehicle id day of week
DETOUR	detour	length (distance) speed limit travel time applicable routes maximum grade bypassed access points duration (see footnote 10)
MODE PATH	bike trail/path pedestrian path/walkway HOV lanes bus only lanes railway subway tramway waterway (ferry) communications way	mode/service designation minimum clearance maximum grade maximum weight limit average speed travel time travel cost tolls/fees water tolerance snow tolerance/removal security incidents/year

		nominal capacity actual capacity condition date last inspected date/time of last update responsible jurisdiction (carrier) responsible agency
	railway	main track siding secondary industrial track abandoned owner operator
RUN	straight swing part-time tripper	carrier operator/drive id cost duration effective operation period (start & end) scheduled recovery time actual recovery time average speed average schedule deviation customer satisfaction no. of complaints date/time of last update
STREET	street road interstate county road state road divided highway arterial local	responsible jurisdiction responsible agency alternate name/alias class
TRANSIT ROUTE	Bus Ferry Light Rail Commuter Rail Heavy Rail emergency fixed variable express limited	Carrier effective operation period (start & end) status (suggested, pending, in test, active) Expected travel time travel time variability Vehicle type base headway commercial speed

	supplemental service circulator regional feeder connecting intercity intracity rural shadow evacuation contingency	quality of service customer satisfaction ridership maximum grade water tolerance snow tolerance seated capacity maximum capacity productivity reliability (MTBF) cost efficiency no. of complaints date/time of last update.
TRIP	person vehicle	linked, unlinked revenue, non-revenue travel time expected departure time expected arrival time actual departure time expected arrival time duration speed waiting time cost modes utilized travel satisfaction purpose (e.g., business, pleasure, appointment)

APPENDIX I Data Templates-Plane Objects

Plane Objects	**Included Terms**	**Attributes**
MAP	Way profile Population profile Employment profile Commerce profile Service profile Trip profile Land use profile Bicycle paths Transit Routes	dynamic trend projected values date/time of last update

NETWORK	road system transit system transportation system bicycle system pedestrian/walkway system communication system	capital cost maintenance cost operating cost cost effectiveness utilization traveler satisfaction

APPENDIX II Glossary

2-D Manifold

Also, two dimensional manifold. A planar graph and its associated two dimensional objects.

APTS

Advanced Public Transportation Systems enhances the ability of public transportation systems to satisfy customer needs and improve operating efficiency.

APTS User Service

APTS applications grouped together based on user centered services. There are seven related to APTS, including: Pre-Trip Travel Information, Ridematching and Reservation, En-Route Transit Information, Public Transportation Management,Personalized Public Transit, Public Travel Security, Electronic Payment Services.

Attribute

Defined characteristic of a Feature.

Entity

A spatial phenomenon that represents something thatexists in space.

Function or
Function Statement

Description of what a process or system does

Included Term

A term or label of a Feature or attribute that is cross-referenced to a standard term of a Feature or attribute. {footnote17}

ITS

Intelligent Transportation Systems applies advanced and emerging technologies in such fields as information processing, communications, control, and electronics to multimodal surface transportation needs.

Spatial Feature

A defined phenomenon and its spatial object representation. (An entity and its object representation.)

Instance

An occurrence of a spatial feature

Spatial Object

A digital representation of geographic phenomenon (or Feature).

FOOTNOTES

Footnote 1 - Most terms were adapted from TRB Urban Public Transportation Glossary, 1989 and FTA, Glossary of Transit Terms for Section 15. We found that most glossaries adapted definitions from the TRB publication

Footnote 2 - Urban Public Transportation Glossary. Transportation Research Board, National Research Council, Washington, D.C., 1989.

Footnote 3 - Ibid.

Footnote 4 - Deadheading is the movement of a transit vehicle without passengers, such as to and from a garage or yard, or from the end of one revenue trip to the beginning of another.

Footnote 5 - SYSTAN, Inc., Timed Transfer: An Evaluation of Its Structure, Performance and Cost. prepared for UMTA, Office of Technical Assistance and Safety, August 1983, Report No. UMTA-MA-06-0049-83-6, documentation page.

Footnote 6 - Transit System Planning refers to planning for new rail and bus facilities, and the physical elements of these.

Footnote 7 - Representation of a point on a map, including geopolitical, address, intersection, coordinates, milepost,offset from start of Piece

Footnote * - Dependent on function of segment.

Footnote 8 - Time Point: A location at which time is measured.

Footnote 9 - Representation of an address range, milepost, point or marker, link id or standard location reference id.

Footnote 10 - Duration: Period during which the detour lasts. Values include short/long term, start/end time, start/end date.

Footnote 11 - Cost: Outlay of monetary value to operate a run.

Footnote 12 - Service: Refers to day of week to which run applies: 1 = weekday, 2 = Saturday, 3 = Sunday, 4 = Holiday.

Footnote 13 - Pattern: A series of contiguous segments linking origins to destinations.

Footnote 14 - Route number: A unique identifier assigned to a transit route

Footnote 15 - Statistically, the relative error in distance between spatial objects in two databases having known geographic errors is equal to the square root of the sum of the errors squared. For

example, the relative error between two databases with geographic errors equal to 50 meters and 10 meters, respectively is: (502 + 102)1/2 ~ 51 meters

Footnote 16 - An entity no larger than can be traversed in a leisurely 30 minute walk (about 1 mile across).

Footnote 17 - Similar to definition cited by FIPS 173, Spatial Data Transfer Standard.