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Minnesota Intelligent Transportation Systems

Polaris Executive Summary

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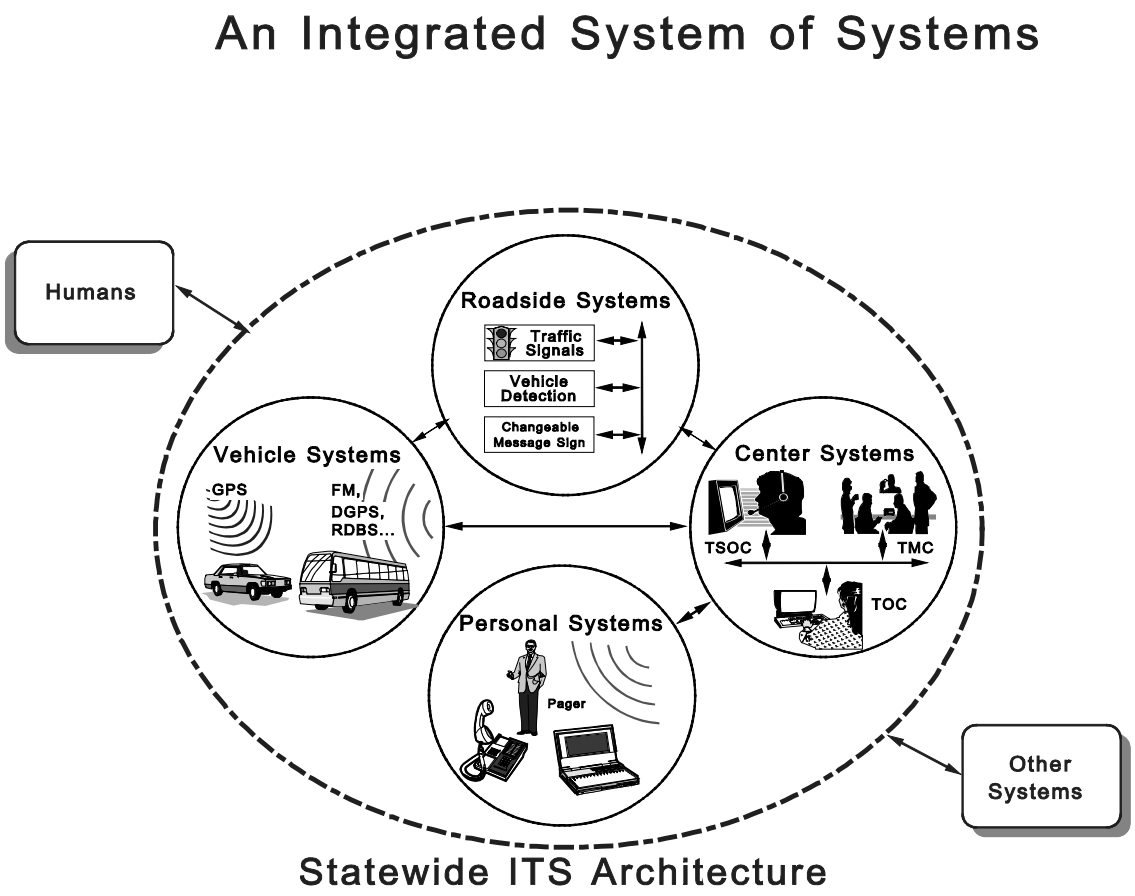
Polaris Executive Summary

Overview

Lockheed Martin Federal Systems was awarded a multi-phase contract by the Minnesota Department Of Transportation (MnDOT) to develop and deploy a Minnesota statewide transportation architecture project known as Polaris. The Minnesota Guidestar-s Polaris Project establishes a statewide architecture for an Intelligent Transportation System (ITS). An architecture is a framework that defines how multiple ITS Components interrelate and contribute to the overall ITS objectives and requirements. **Figure 1** provides an illustration of typical interrelationships associated with the architecture.



The Minnesota Statewide ITS architecture combines applicable existing systems with developing technologies from both the public and private sectors to create an interactive system with well defined interfaces between services, functions, and components. The Minnesota Statewide ITS architecture, composed of eleven services and over 50 components, contributes multiple benefits including:

- Optimization of the location of system functions
- Illustration of how associated systems can be integrated to share information and resources
- Provides opportunities to standardize communications and physical components, enabling interoperability, and allowing the system to easily incorporate new capabilities and technologies

The Minnesota Statewide ITS architecture was developed to help the various Minnesota transportation related agencies participate as a whole in deploying future transportation systems. The goals associated with this architecture include:

- Deliver a system that meets end-user and institutional needs
- Deploy projects efficiently by reducing duplication of effort among agencies
- Provide compatibility with transportation equipment and hardware that is used nationwide

To achieve these goals, the Minnesota Statewide ITS architecture was developed in such a manner that it:

- Incorporates what the traveler and institutional representatives stated they wanted and needed.
- Defines the system level requirements that the transportation system development engineers and public/private agency representatives can use to define new projects.
- Defines the component level requirements and interface baseline that serves as a basis for evaluation and control of system design changes.
- Provides requirements traceability to enable the transportation system engineer to accurately assess the impact of system enhancements and new technology, before deciding to implement a change.

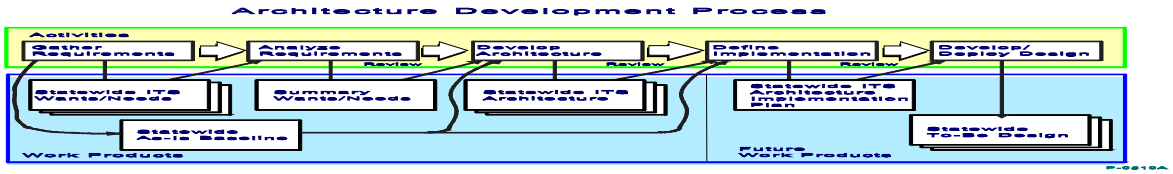
Polaris Project information, supporting analysis, and resulting architecture are documented in the deliverables shown in Table 1, Polaris Project Documentation.

Table 1 - Polaris Project Documentation

Document Name	Description
Minnesota Traveler Wants and Needs	Documents the transportation wants and needs information collected from Minnesota residents during 10 traveler sessions held across the state.
Minnesota Transportation Agency Wants and Needs	Documents the wants and needs information collected from Minnesota stakeholder agencies during 7 agency sessions held across the state.
ITS Architecture Wants and Needs Analysis	Uses the information from the *Minnesota Traveler* and *Transportation Agency Wants and Needs* documents to establish, prioritize and document ITS service requirements.
Statewide ITS As-Is Agency Reports for Minnesota	Documents information about existing transportation systems that establish the starting point for physical architecture trade-offs for the ITS Architecture Implementation Planning.
ITS System Specification	Identifies the functions, interfaces and requirements associated with the Minnesota ITS User Services and Components. Sources of requirements include the ITS National Architecture user services, traveler and agency wants and needs, and as-is infrastructure constraints.
ITS Component Specification	Identifies the physical interface and requirements allocation for each Minnesota ITS component.

Architecture Development Approach

An overview of the process associated with developing an architecture is shown in **Figure 2**. The Polaris Project utilized market research data collected from Minnesota travelers and institutional stakeholders to identify the most important transportation needs, service requirements, and levels of satisfaction with the current transportation system. This data was then integrated with National User Service Requirements to ensure that the Minnesota ITS architecture is aligned with National ITS Architecture requirements.



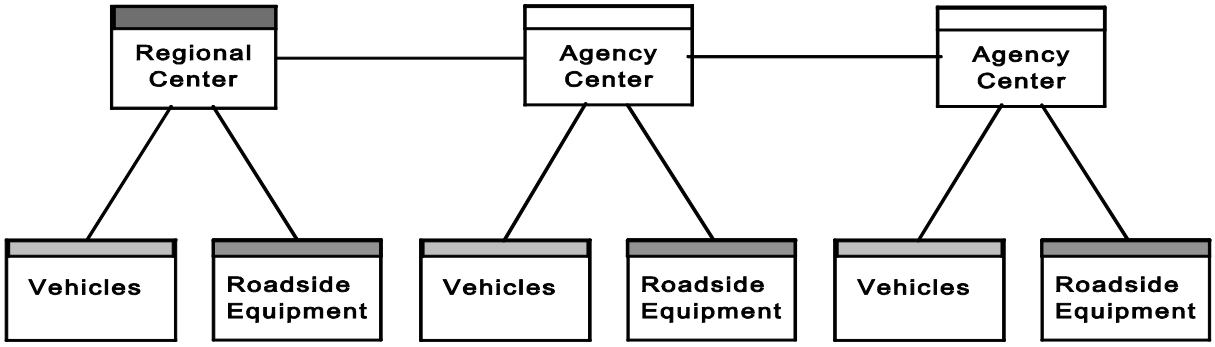
A set of top-level system requirements was generated to define what each service should do. Traceability to the original requirement sources was captured to support future maintenance of the architecture. Functions, subfunctions, and data flows between services and functions were then synthesized from the requirements for each service to define the functional architecture.

The Physical architecture development began by evaluating the As-Is physical architecture that currently exists. Existing service components were analyzed to determine their roles and what data was exchanged between the various service components. The result of this effort was captured on the As-Is physical architecture diagrams. The As-Is diagrams were then modified to produce a series of physical architecture candidates to show how multiple Minnesota components (e.g.; Freeway Traffic Management Center, State Patrol Dispatch Center, etc.) could interact with each other to meet the service requirements. Physical architecture candidates included a distributed approach (see **Figure 3** for a typical view of a distributed architecture), a hybrid approach (see **Figure 4** for a typical view of a hybrid architecture), and a centralized approach (see **Figure 5** for a typical view of a centralized architecture) for most services.

The physical architecture candidates were reviewed with working teams comprised of agencies that provide the current services. Advantages and disadvantages for each architectural candidate as well as evaluation criteria were collected from the working teams. The trade-off process shown in **Figure 6** was then used to determine the optimum physical architecture for each Minnesota service.

System requirements and data flows were then allocated to the components for each service based on the selected physical architecture. The result of this activity includes the documented component interfaces and requirements needed to implement the Minnesota ITS architecture.

Eight of the eleven services are completely described in the January 1997 deliverable documentation. The remaining three services (i.e. Maintenance, Training, and Public Travel Security/Enforcement) are defined to the functional level only.



Distributed Architecture Approach

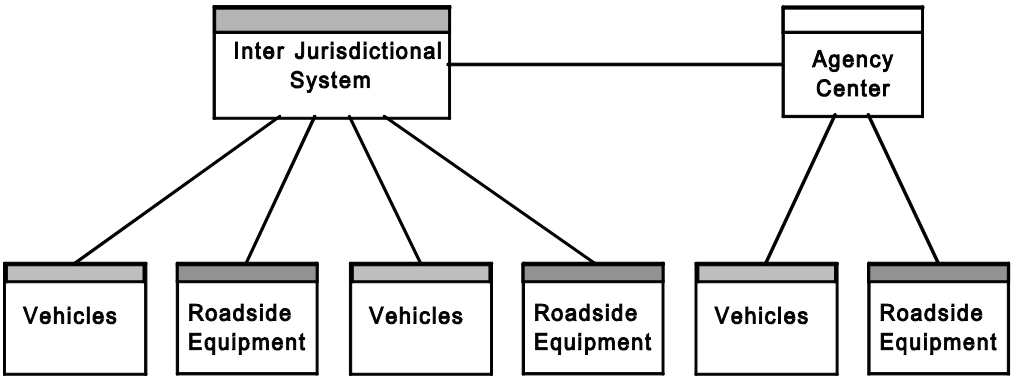
- Coordinate activities by sharing information across independent systems
- Distribute management among centers

Advantages

- Direct Agency to Agency Interface
- Softer failure modes

Disadvantages

- Duplicate Data Storage
- More Complex Design



Hybrid Architecture Approach

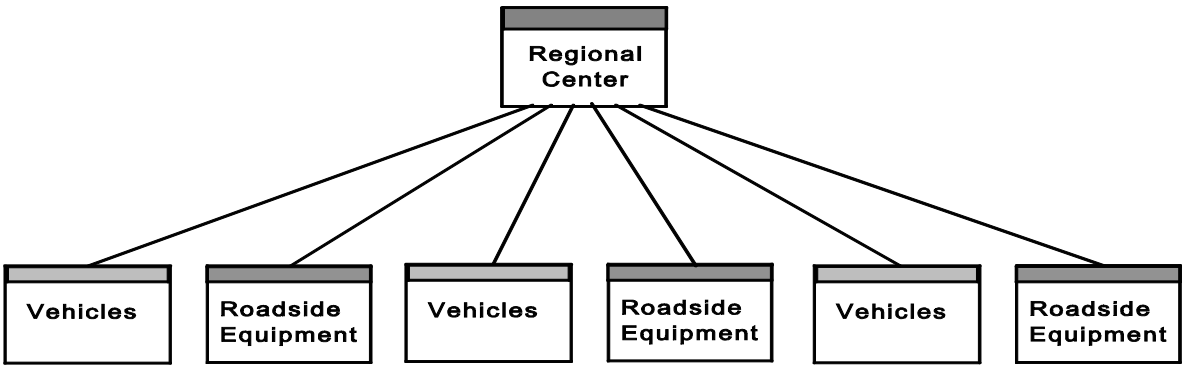
- Use selected features of centralized and distributed structures

Advantages

- Maximizes the benefits of both centralized and distributed approaches
- Flexible

Disadvantages

- Some additional interfaces and data storage.



Centralized Architecture Approach

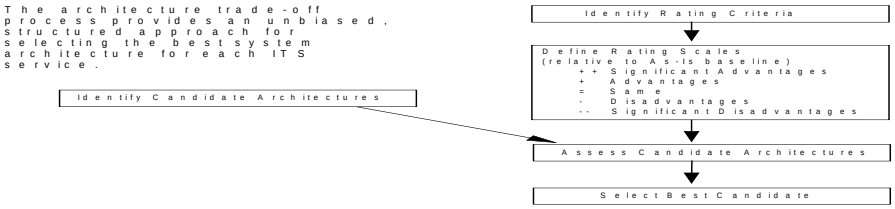
- Provide centralized management control and/or information distribution
- Coordinate using a single central system

Advantages

- Simpler Control
- Least Number of Interfaces
- Consolidated Operations Staff

Disadvantages

- Single Point Failures


The architecture trade-off process provides an unbiased, structured approach for selecting the best system architecture for each ITS service.
Identify Candidate Architectures
Identify Rating Criteria
Define Rating Scales
(relative to As-Is baseline)
++ Significant Advantages
+ Advantages
= Same
- Disadvantages
-- Significant Disadvantages
Assess Candidate Architectures
Select Best Candidate

Minnesota Wants and Needs Documentation

The Polaris Project collected, analyzed, and prioritized the wants and needs information from travelers and key transportation system agencies from both metropolitan and rural areas. This data is contained in the Minnesota Statewide Intelligent Transportation Systems Wants and Needs document and is organized into sections on Minnesota Traveler Wants and Needs, Minnesota Transportation Agency Wants and Needs, and ITS Architecture Wants and Needs Analysis.

The **Minnesota Traveler Wants and Needs** were collected through a series of group discussions and telephone surveys with people from metropolitan, suburban, and rural areas. This research was conducted in a manner that did not predispose ITS as a potential solution, but rather sought to define transportation needs in a language free of implementation or solutions. During these discussions and surveys, participants discussed their top positive and negative experiences with the existing transportation system, and the most important benefits that would result from having an ideal transportation system in place. From these discussions and surveys, the following list of traveler wants and needs was generated:

- Choice of travel modes
- Best route plan based on specific criteria
- Travel mode is available whenever needed
- Travel mode is available wherever needed
- Timely, accurate accident, traffic and congestion information
- Timely, accurate weather and road conditions information
- Clear, timely directions to follow desired route
- Get to destination directly without unnecessary stops, delays
- Safe from accident, injury, theft, or violence
- Timely information on alternatives to avoid delays
- Easy access to comprehensive travel services and information
- Timely, accurate road construction, maintenance information
- Free of stressful experiences
- Able to make good use of travel time
- Good value for cost
- Get help quickly in event of accident, emergency, or breakdown
- Comfortable and easy to use
- Fair, aggressive law enforcement
- Easy access for everyone
- Not disruptive to environment or communities

The **Minnesota Transportation Agency Wants and Needs** were collected through a series of group discussions with representatives from various transportation related agencies from three large metropolitan areas (i.e. the Twin Cities, Duluth, Rochester). During these discussions and surveys, participants discussed their top positive and negative experiences with operating the existing transportation system, and the most important benefits that would result from having an ideal transportation system in place. From these discussions, the following list of Minnesota Transportation Agency wants and needs was generated:

- Effective interagency teamwork, cooperation, coordination
- Optimize use of intra/interagency resources
- Access to needed intra/interagency information
- Avoid information duplication among agencies
- Integrated across jurisdictional boundaries
- Involve/inform public as needed
- Not adversely affected by politics
- Policies encourage desired behavior
- Well understood, documented customer needs
- Expandable, flexible, adaptable to change
- Cost-effective to operate and maintain
- Dependable, reliable, easy to maintain
- Provide measurable benefits to users
- Balance transportation needs with community needs
- Provide multi-modal options
- Involve private sector
- Employ efficient, effective processes
- Provide access to all
- Does not adversely affect environment

The **ITS Architecture Wants and Needs Analysis** documents the results of various analysis performed on the quantitative traveler wants and needs information. Assessments included evaluation of the importance of, and level of satisfaction with, the various wants and needs. Opportunities for improvement were analyzed by a demand weight formula to generate a list of the top ten wants and needs opportunities which include:

1. Fair, aggressive law enforcement
2. Timely, accurate construction, maintenance information
3. Free of stressful experiences
4. Get help quickly in event of accident, emergency, or breakdown
5. Timely information on alternatives to avoid delay
6. Timely, accurate accident, traffic, and congestion information
7. Timely, accurate weather and road conditions information
8. Safe from accident, injury, theft, violence
9. Best route plan based on specified criteria
10. Choice of travel modes

Statewide ITS As-Is Agency Reports for Minnesota

The Polaris Project collected, analyzed, and organized existing AAs-Is@ transportation systems information to establish the baseline for architecture deployment. This information describes systems that are in-place today. The Statewide Intelligent Transportation Systems As-Is Agency Reports for Minnesota document consists of a collection of 38 individual system survey reports related to transportation systems. The 38 systems were selected as best representatives from a list of 121 pre-survey candidates. These systems were assumed to provide a diverse base of information for use in developing the Minnesota Statewide ITS Architecture. The document is divided into eight volumes, with each volume addressing systems of a specific area of interest and a common set of appendices. Content of each volume is shown in Table 2, Statewide Intelligent Transportation Systems As-Is Agency Reports.

Table 2 - Statewide Intelligent Transportation Systems As-Is Agency Reports

Volume/Section	Contents
Volume 1	Mn/DOT Metropolitan Division
1.1	Generic closed Loop Traffic Control Signal System
1.2	Mn/DOT Advanced Portable Management System
1.3	Mn/DOT Portable Traffic Management System
1.4	Mn/DOT Metro Division Lane Closure Information System
1.5	Mn/DOT Metro Division Construction Information System
Volume 2	Mn/DOT Traffic Management Center
2.1	Mn/DOT TMC Ramp Meter System
2.2	Mn/DOT TMC Video Surveillance System
2.3	Mn/DOT TMC Changeable Message Sign System
2.4	Mn/DOT TMC Communications System
2.5	Mn/DOT TMC Highway Helper AVL System
Volume 3	Operational Tests
3.1	AUSCI - Adaptive Urban Signal Control and Integration System
3.2	ICTM - Integrated Corridor Traffic Management System
3.3	Divert Incident Management System
3.4	Advanced Parking Information System
Volume 4	Metropolitan Council Transit Operations and Metro Mobility
4.1	MCTO Trapeze Scheduling/Planning System
4.2	MCTO Automated Passenger Counting System
4.3	MCTO Electronic Fare Collection System

4.4	MCTO TIC Bus Line System
4.5	MCTO TIC Customer Phone Line Service System
4.6	Metropolitan Council Metro Mobility Reservation/Scheduling/Dispatch System
4.7	MCTO Construction Information System
Volume 5	City of Minneapolis
5.1	City of Minneapolis Fortran Traffic Signal Control System
5.2	City of Minneapolis Parking Management System
5.3	City of Minneapolis Construction Information System
Volume 6	City of St. Paul
6.1	City of St. Paul Computran Traffic Signal Control System
6.2	City of St. Paul Construction Information System
Volume 7	Minnesota State Patrol
7.1	Minnesota State Patrol Mobile Data Terminal System
7.2	Minnesota State Patrol Laptop Mobile Data Terminal System
7.3	Minnesota State Patrol Emergency 911 Dispatch System
Volume 8	Miscellaneous
8.1	Minnesota Travel Partners Kiosk System
8.2	Mn/DOT Pavement Conditions and Weather Reporting System
8.3	Hennepin County Medical Center Emergency Vehicle Dispatch System
8.4	Metropolitan Airports Commission Parking Management and AVI System
8.5	Gopher State One-Call Excavation Notification System
8.6	Mn/DOT Statewide Construction Information System
8.7	Hennepin County Construction Information System
8.8	Ramsey County Construction Information System
8.9	Mn/DOT ESS Gopher State One-Call Access System

ITS System Specification

The System Specification describes the functional and physical architectures associated with each of the Minnesota ITS Services. The functional architecture describes **what** the services need to do, and the physical architecture describes **how** the service functions will be implemented in Minnesota .

The 11 integrated services which define the Minnesota ITS functional architecture include:

Travel Conditions Information (TCI) provides current and/or forecast (future) travel conditions for a specific area or along a specific single mode or multi-modal route. Travel conditions information includes traffic speeds and congestion levels, weather, road surface conditions, accidents, construction, planned events, transit conditions, and parking lot status. The effects these conditions have on travel are also reported, including delay times, reduced speeds, dangers/hazards, road/ramp closures, detours, parking availability, and expected duration of the conditions (start time and end time). Travel conditions information can be tailored to a user=s needs through use of a profile. Travel conditions information is provided to travelers prior to their trip, or en route, through a variety of devices.

Trip Planning and Directions (TPD) provides the ability to build the optimum single or multi modal route, directions or trip itinerary based on a mix of user-specified criteria such as origin/destination, travel mode(s), departure time, arrival time, trip duration, preferred route type, cost, etc. Trip Planning and Directions supports "what if" route planning based on different criteria combinations. This service recommends alternate routes/route segments based on user criteria or travel conditions changes. Detour routes are determined for public transit agencies by this service in order to keep transit vehicles on schedule.

The Trip Planning and Directions Service also provides the ability to get step-by-step directions, in text and/or map form, for any route or user-specified destination. Optionally, this service provides automated location and guidance through a set of directions. This service can assemble tailored trip itineraries which include a route highlighted on a map, directions, schedule and date information (if required), information about destination point(s) and information about points of interest along a route.

Ride Matching and Reservations (RMR) provides riders with information about rideshare options (such as express bus, car pool, vanpool, paratransit or other specialized service), based on user-specified criteria (such as date/time of pick-up/drop-off, origin, destination, and specific restrictions and preferences). This service provides real-time matching of rider needs with services available from providers, and it provides riders with the capability to reserve rides in advance or in real-time when additional capacity is available.

Traveler Services Information (TSI) provides travelers with access to "yellow pages" information such as restaurants, lodging, vehicle services, tourist sights, shopping and special events. Users can request and receive traveler services information that is tailored to their specific request, their preferences (such as price, provider, cuisine, etc.) and/or a location perspective (such as nearest to my current location, at this exit, along my route, at my destination, etc.). This service also provides the traveler with the capability to make reservations or purchase tickets. The Traveler Services Information service can interact with the Trip Planning and Directions service to provide users with routes, directions and/or a trip itinerary that is based on the traveler services that were requested.

Traffic Control (TC) provides the capabilities to optimize traffic movement on freeways, highways, and arterials throughout jurisdictions and multi-jurisdictional areas. This service provides for coordinated traffic flow via pre-planned traffic control plans. Signal timing and message signing are adaptable based on control plans and real-time traffic conditions feedback.

Public Transit Fleet Management (TFM) monitors real-time schedule adherence of public transit vehicles, and provides assistance in getting transit vehicles back on schedule when schedule deviations occur. This service also develops transit routes and schedules, dispatches vehicles, allocates drivers to vehicles and routes, provides real-time guidance directions to drivers of transit vehicles when needed, and monitors vehicle systems.

Account Management (AM) provides the capability for users to maintain travel services account information including personal profiles. It also establishes fees for transportation services and tracks billing and payments for services used. This is a key enabling service for embracing privatization of services by Independent Service Providers.

Incident Management (IM) provides the capability to detect and acknowledge reported incidents and travel emergencies. This service provides for coordinated multi-jurisdictional incident response via preplanned action plans and procedures. Emergency resources (vehicles, personnel and equipment) are assigned based on incident response needs and available resources. This service also provides for real-time monitoring, recording and reporting of incident information and response status.

Public Travel Security/Enforcement (PTSE) provides for the planning and implementation of public travel security policies, plans and procedures such as the establishment of secure areas for public transit riders and the monitoring of public areas for security incidents. The establishment and enforcement of regulations for HOV lanes, railroad crossings and construction work zones, are also provided. Violations records are kept and statistics are analyzed to determine any needed updates to security policies, plans or procedures.

Maintenance (MNT) compares vehicle mileage and other vehicle condition data with preventative maintenance schedules to develop a prioritized list of maintenance tasks. Personnel availability and skill levels are then compared to the prioritized and unscheduled (i.e. vehicle breakdown) maintenance tasks to a) assign mechanics to vehicle maintenance tasks, and b) request vehicles be assigned to a maintenance garage. Vehicle maintenance and condition history information is maintained to assist the mechanic in performing maintenance tasks.

Training (TNG) provides a capability to educate both transportation service provider personnel and public users of transportation services. For transportation service provider personnel, training compares personnel training records with periodic training and certification requirements to develop a prioritized list of training tasks. Personnel availability is then compared to the prioritized list of training tasks and course availability information to assign personnel to courses. Personnel training and certification history information is maintained to plan future training activity, and to assist various regulatory agencies by providing easy access to credential information.

The main body of the System Specification is organized by service and provides a description of the service goals and objectives followed by a description of the functional architecture. Functional architecture and service interface diagrams are provided to show the flow of data within the service and to other services. The functional architecture description is followed by one or more sample operational scenarios that depict the flow of control and data during typical operations. Finally a description of the physical architecture is provided along with a physical architecture diagram.

System Specification Appendix A summarizes the information that was utilized to describe the As-Is architecture and architectural candidates and to select a preferred architecture. It includes:

- overview of the service function descriptions
- architecture approach summary chart which highlights variations in the architecture candidates
- As-Is and physical architecture candidates descriptions and diagrams
- supporting information used in selecting an architecture for the service

System Specification Appendix B provides detailed information about service requirements. This data is presented in a table that identifies the service, function, subfunction, requirement sequence number, the detailed requirement, and the source of the requirement.

System Specification Appendix C provides detailed information about service function inputs and outputs. This information is presented in a series of tables for each service and function. The data includes the data flow name, a detailed definition of the data flow, and the source or destination of the data.

System Specification Appendix D provides detailed information about service physical interfaces. This table of information ties back to the physical architecture diagram in the main body of the System Specification and identifies the service, the tag number of the component interface that is shown on the physical architecture diagram, the source component of the data, the destination component of the data, the data flow name, and the interface type.

ITS Component Specification

The Component Specification documents the physical Polaris Architecture Components from the perspective of requirements and interfaces. The main body of the document is organized alphabetically by component or group name. Each group contains a list of the components allocated to that group. Each component has a summary description as well as descriptions of the service subfunctions that have been allocated to that component.

A component is a tangible entity in the real world that is thought of as one unit. These components include Centers (e.g.; Freeway Traffic Management Center, Traffic Signal Centers, Dispatch Centers, etc.), Inter-jurisdictional systems that operate across multiple agencies, Roadside Equipment (e.g.; Freeway Roadside Equipment, Toll Collection Roadside Equipment, Parking Management Roadside Equipment, etc.), Vehicles (e.g.; Transit Vehicles, Emergency Vehicles, Commercial Vehicles, etc.), and User Interface Equipment (e.g.; telephone, computer, pager, kiosk).

Component Specification Appendix A provides detailed information about the requirements that have been allocated to each component. This data is presented in a table that lists the component, service, function, subfunction, requirement sequence number, requirement, and source of the requirement.

Component Specification Appendix B provides detailed information about input data flows for each component. This data is presented in a table that lists the destination component of the data, data flow name, data flow definition, and the source component of the data.

Component Specification Appendix C provides detailed information about output data flows for each component. This data is presented in a table that lists the source component of the data, data flow name, data flow definition, and the destination component of the data.

ITS Implementation Plan

The ITS implementation Plan is intended to recommend future projects, identify technology dependencies, determine required resources, outline organizational roles, and analyze cost versus benefit of deployment of projects. It will also serve as a guide to program managers in scheduling ITS projects. This plan will be generated at future time and will be a living document that will require continuous maintenance to incorporate rapidly developing technology and ideas as experience is gained in ITS.

Acronym List

AM	Account Management
AUSCI	Adaptive Urban Signal Control and Integration System
AVL	Automatic Vehicle Location System
HOV	High Occupancy Vehicle
ICTM	Integrated Corridor Traffic Management System
IM	Incident Management
ITS	Intelligent Transportation System
MCTO	Metropolitan Council Transit Operations and Metro Mobility
MnDOT	Minnesota Department Of Transportation
PTSE	Public Travel Security/Enforcement
RMR	Ride Matching and Reservation
TC	Traffic Control
TCI	Travel Conditions Information
TFM	Public Transit Fleet Management
TIC	Traveler Information Center
TMC	Traffic Management Center
TNG	Training
TPD	Trip Planning and Directions
TSI	Traveler Services Information
USR	User Service Requirements