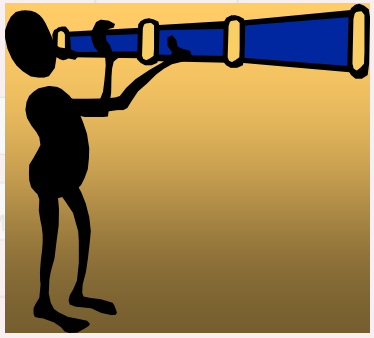
Malaysian ITS System Architecture?

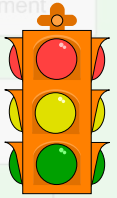
- To define, design and develop an ITS system architecture as to promote unity and ensure Inter-Operability and Compatibility in the deployment of ITS across modes (especially between System Components) throughout Malaysia and its region.
- Provide a framework where all the components and interconnections are identified – Seamless -Integration
- Provides the communication and information backbone that supports and unites the key ITS technologies as to enable them to work together and communicate with each other
- Identifies a unifying standards needed to support inter-operability across technology modes and jurisdiction.

Why Adapt the Architecture?

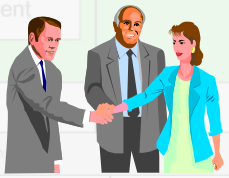
- Efficiently structure implementations
  - Identify information sharing opportunities
  - Prepare for future expansion
  - Leverage funding
  - Deploy projects consistent with plan



Why Adapt an Architecture for Local/Regional Applications? (2)



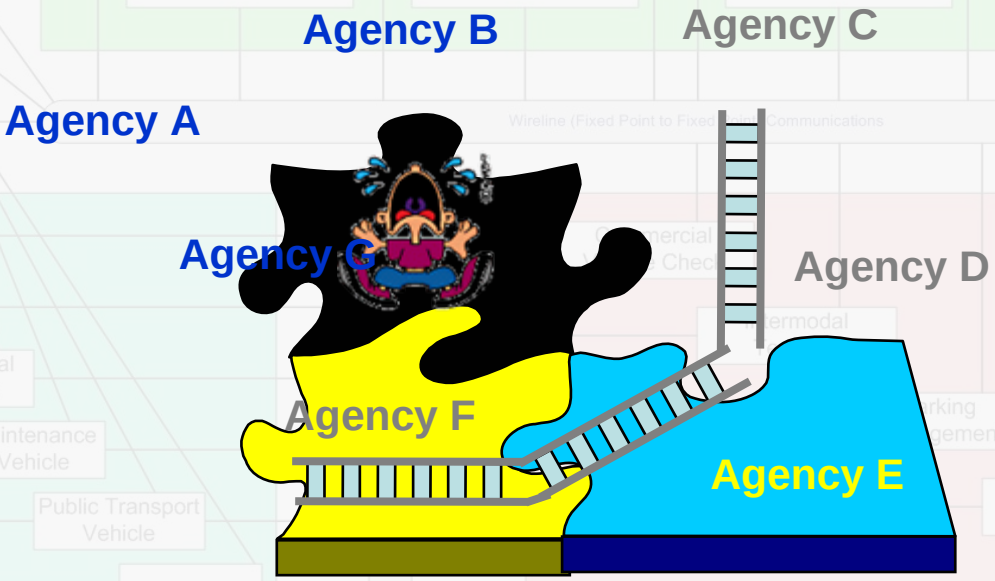
- Foundation for explicitly incorporating operations and management into decision-making
- Encourage stakeholder buy-in
  - Traditional and non-traditional players



- Assist in estimating funding needs

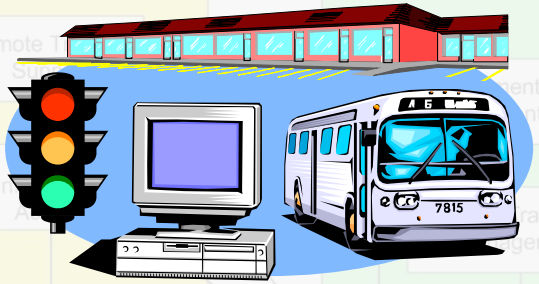
Why Adapt the Architecture?

- Serve as tool for education and encourage regional information exchange
- Assist in identifying gaps in existing services



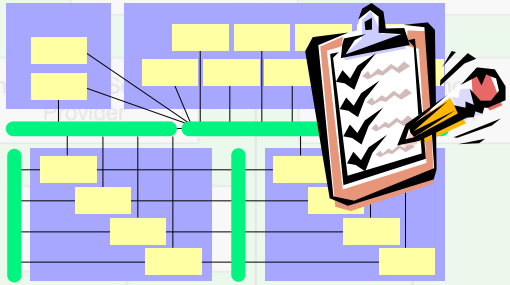
Applying the ITS Architecture

Planning

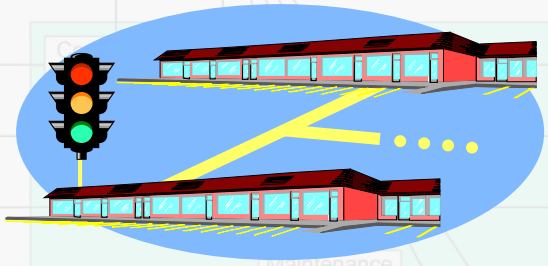


- Agencies
- Systems

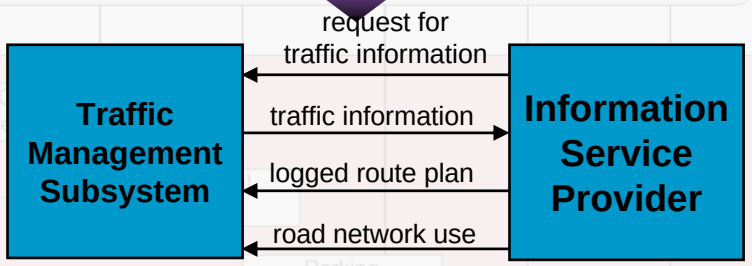
Physical Architecture



- Subsystems
- Terminators



- System Interfaces



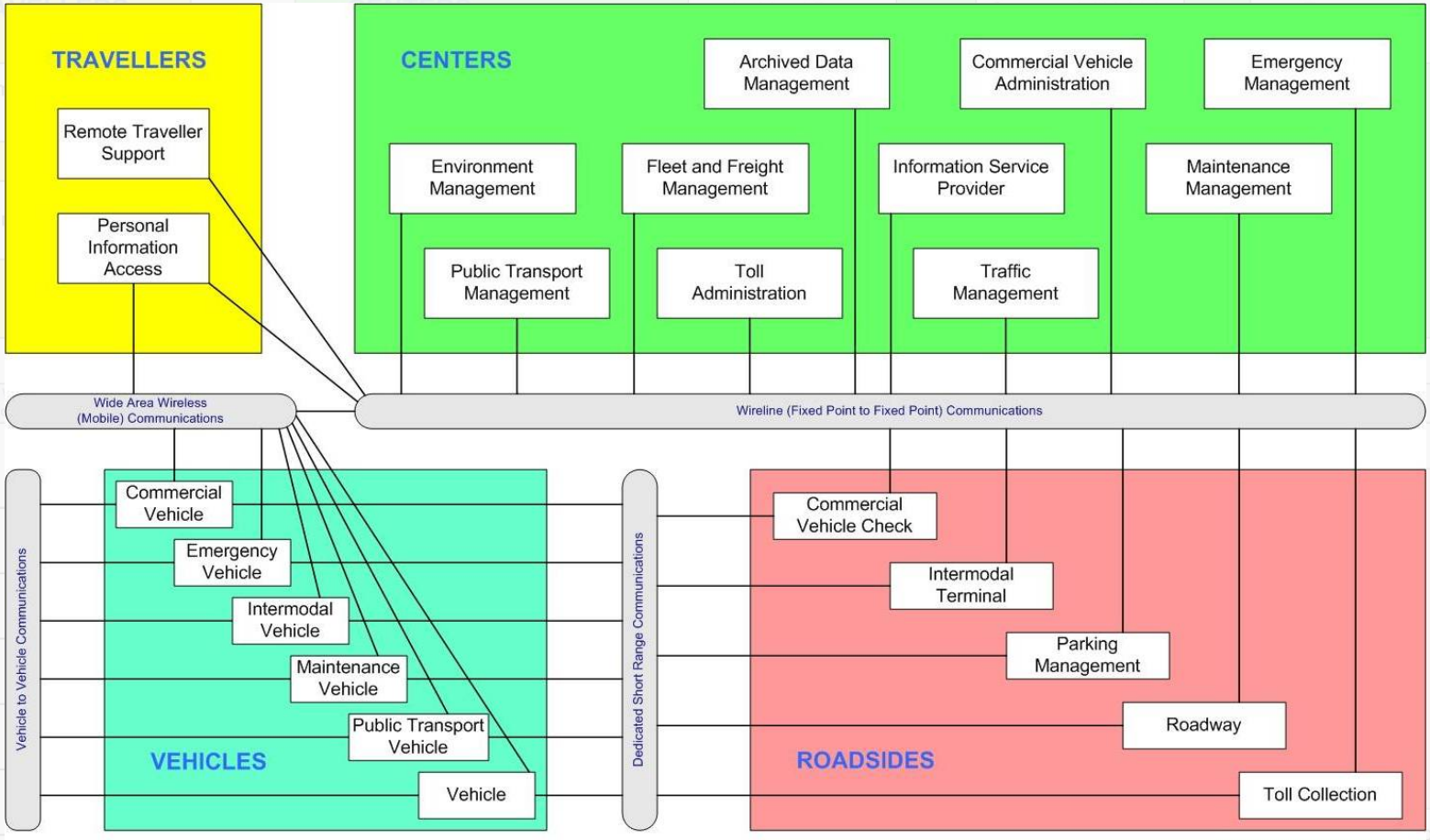
- Architecture Flows

To Project Specifications

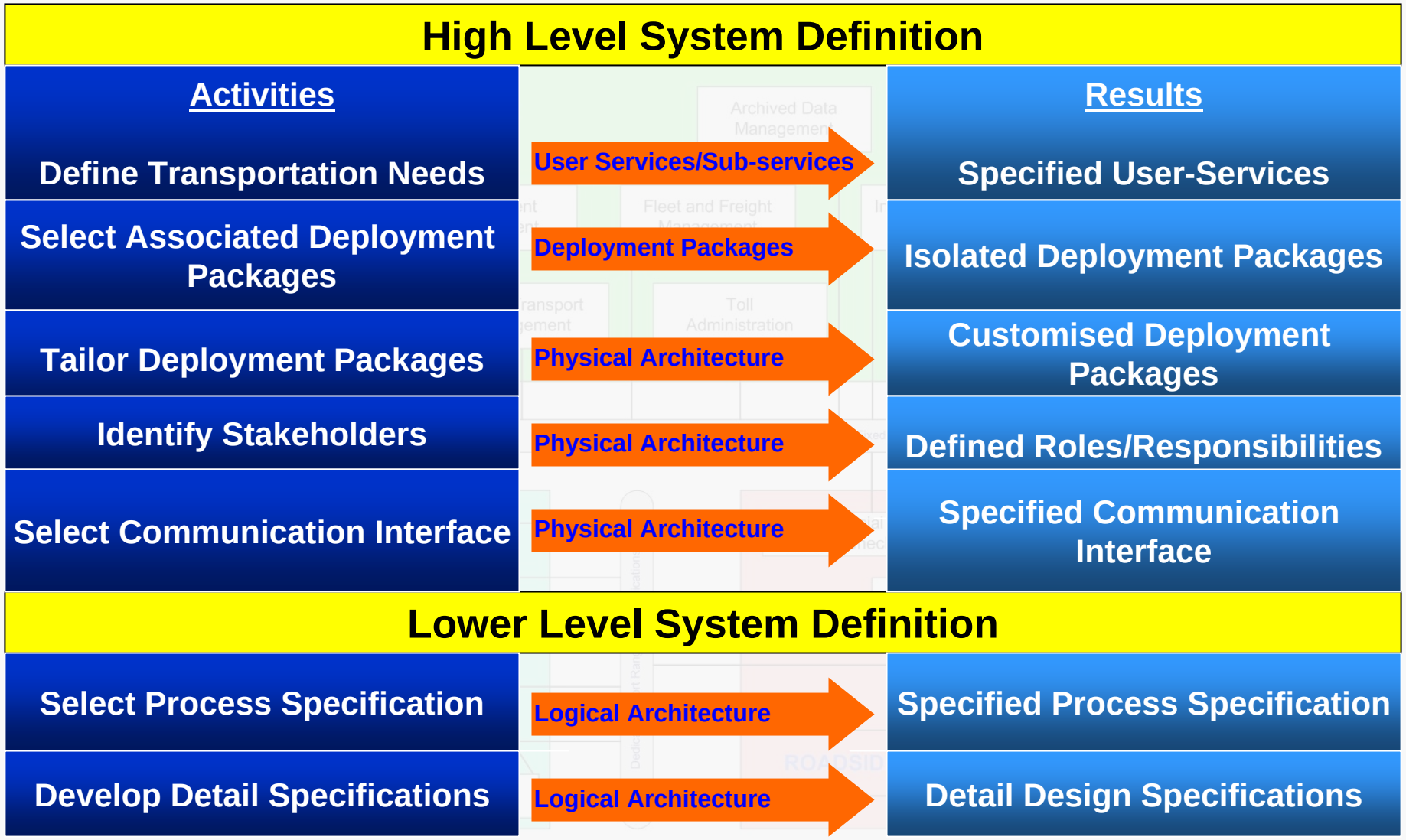
To Logical Architecture

The Development of ITS System Architecture

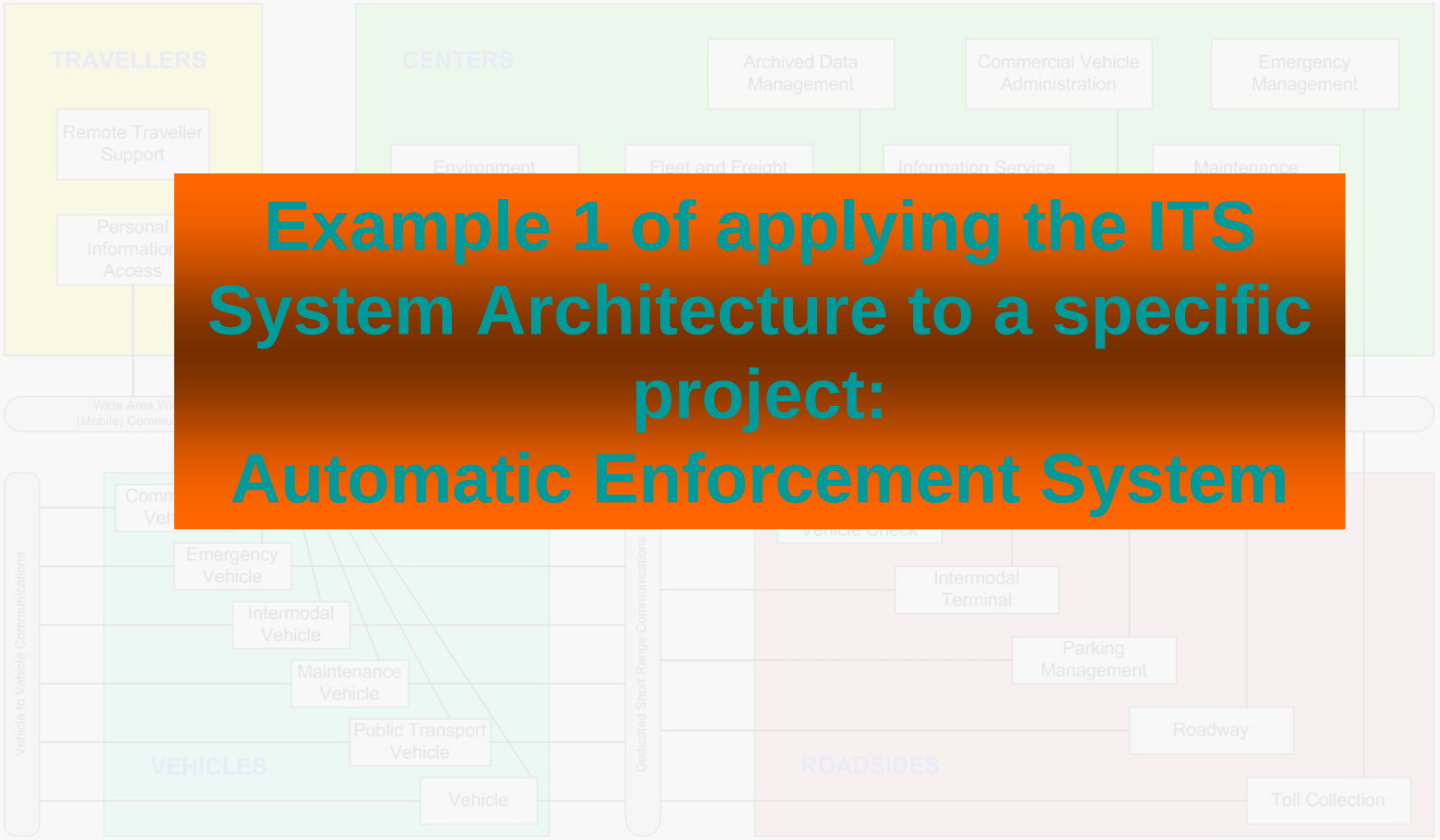
Begin with the Architecture...



The Development of ITS System Architecture



The Development of ITS System Architecture



Example 1 of applying the ITS System Architecture to a specific project: Automatic Enforcement System

High Level System Definition

1. Identify ITS User Sub-Service

Define the transportation project scopes and identify the ITS User Sub-Services that best describe the specific transportation needs. The step isolates the portion of the Architecture that applies to the specific project.

The following ITS Sector, User Services and User Sub-services address the specified transportation needs:

ITS Master Plan for Malaysia – TN1 User Services

Sector No.1: Advanced Traffic Management Systems	
1.1	Urban Traffic Control
1.2	Incident Detection and Management
1.3	Travel Demand Management
1.4	Environmental Conditions Management
1.5	Operations and Maintenance
1.6	Non-Vehicular Road User Safety
1.7	Multi-Modal Junction Safety and Control
Sector No.2: Safety Systems ⇦	
2.1	Improved Accident Data Collection
2.2	Automated Dynamic Warning and Enforcement ⇦
Sector No.3: Advanced Public Transport Systems	
3.1	Public Transport Operations Management
3.2	Public Transport En-Route Information
3.3	Demand Responsive Public Transport
3.4	Public Travel Security
Sector No.4: Advanced Traveller Information Systems	
4.1	Pre-Trip Traveller Information
4.2	Route Guidance and Navigation
4.3	Ride Matching and Reservation
4.4	Traveller Services and Reservations
Sector No.5: Electronic Payment Systems	
5.1	Electronic Payment Services
Sector No.6: Commercial Vehicle Operations Systems	
6.1	Commercial Fleet Management
6.2	Commercial Freight Management
6.3	Commercial Vehicle Electronic Clearance
6.4	Automated Roadside Safety Inspection
6.5	On-board Safety Monitoring
6.6	Commercial Vehicle Administrative Processes
Sector No.7: Advanced Vehicle Control Systems	
7.1	Vehicle-Based Collision Avoidance
7.2	Infrastructure-Based Collision Avoidance
7.3	Sensor-Based Driving Safety Enhancement
7.4	Safety Readiness
7.5	Pre-Collision Restraint Deployment

7.6	Automated Vehicle Operation

	Sector No.8: Emergency Management Systems
8.1	Emergency Notification and Personal Security
8.2	Hazardous Material Incident Response
8.3	Disaster Response and Management
8.4	Emergency Vehicle Management

	Sector No.9: Information Warehousing Systems
9.1	Weather and Environmental Data Management
9.2	Archived Data Management

ITS Sector 2 – Safety Systems
Safety Systems will include user-services that relate directly to the compilation, analysis and dissemination of accident data, and the intelligent enforcement of violators. This is an attempt to reduce accidents and improve safety.

User Services 2.2 - Automated Dynamic Warning and Enforcement
The Automated Dynamic Warning and Enforcement user-service will provide systems, which warn vehicles or motorists of imminent danger, and provide electronic enforcement of traffic control and regulations.

ITS Master Plan for Malaysia – TN2 User Sub-Services

Sector No.1: Advanced Traffic Management Systems			
1.1	**Urban Traffic Control**	*1.1.1*	*Traffic Network Flow Monitoring*
		1.1.2	*Surface Street Control*
		1.1.3	*Highway Control*
		1.1.4	*Regional Traffic Control*
		1.1.5	*Traffic Information Dissemination*
		1.1.6	*Virtual TMC*
		1.1.7	*Probe-Based Flow Monitoring*
		1.1.8	*Traffic Estimation and Prediction*
1.2	**Incident Detection and Management**	*1.2.1*	*Incident Management Co-ordination*
		1.2.2	*Incident Prediction System*
1.3	**Travel Demand Management**	*1.3.1*	*High Occupancy Vehicle Lane Management*
		1.3.2	*Reversible Lane Management*
		1.3.3	*Predictive Demand Management*
1.4	**Environmental Conditions Management**	*1.4.1*	*Roadway Environmental Sensing*
		1.4.2	*Emissions Management*
		1.4.3	*Road Weather Information System*
		1.4.4	*Vehicle-Based Sensing*
1.5	**Operations and Maintenance**	*1.5.1*	*Infrastructure Maintenance Management*
		1.5.2	*Smart Work Zones*
1.6	**Non-Vehicular Road User Safety**	*1.6.1*	*Mixed Use Warning Systems*
		1.6.2	*Automated Non-Vehicular Road User Protection*
1.7	**Multi-Modal Junction Safety and Control**	*1.7.1*	*Basic At-Grade Crossing Control*
		1.7.2	*Advanced At-Grade Crossing*
		1.7.3	*Modal Operations Co-ordination*

Sector No.2: Safety Systems			
2.1	**Improved Accident Data Collection**	*2.1.1*	*Accident Data Management*
2.2	**Automated Dynamic Warning and Enforcement**	*2.2.1*	*Dynamic Roadway Warning*
		2.2.2	*Variable Speed Limit and Enforcement*
		2.2.3	*Signal Enforcement*

User Sub-Service 2.2.2 - Variable Speed Limit and Enforcement

Variable Speed Limit and Enforcement user sub-service supports the ability to dynamically vary speed limits in response to roadway conditions. This may include lowering speed limits due to cross-winds, weather or traffic conditions, to reduce the risk of accidents. This user sub-service also relates to the "Smart Work Zones" user sub-service to aid in traffic calming around roadwork areas. A key capability of this user sub-service is the ability to provide automated speed limit enforcement by detecting and conveying violation information to law enforcement. This user sub-service can be used to build on the capability of Dynamic Roadway Warning sub-service to create an enforceable lowering of the speed limit in response to transient, localized roadway conditions.

User Sub-Service 2.2.3 - Signal Enforcement

Signal Enforcement user sub-service supports the detection and enforcement of roadway control signals. A common implementation of this capability is "red light enforcement" for signalised intersections. Information documenting a vehicle disobeying a traffic signal is captured and conveyed to law enforcement. This user sub-service is a logical predecessor to "Intersection Safety Warning" and "Intersection Collision Avoidance", where the signal violation detection is also used to reduce the likelihood of a traffic accident. This same relationship also exists to "Mixed Use Warning Systems" and "Automated Non-Vehicular Road User Protection", since pedestrians, bicyclists, and other non-vehicle traffic may be threatened by signal violations.

2. Select Deployment Packages

Trace the relevant deployment packages for the specific ITS User Sub-services identified in the previous step. This step translates the transportation needs into deployable packages and provides a deployment oriented view of the project to the policy planners and project managers.

The ITS User Sub-services identified from the previous step are served by the following deployment packages:

ITS Architecture for Malaysia – TN5 Deployment Packages

Deployment Package ID	Deployment Package Name	Associated User Sub-Services
AD1	Archived Data Mart	9.2.1
AD2	Archived Data Warehouse	9.2.2
AD3	Archived Data Virtual Warehouse	9.2.3
AD4	Accident Data Management	2.1.1
APTS1	Public Transport Vehicle Tracking	3.1.1
APTS2	Public Transport Fixed-Route Operations	3.1.2
APTS3	Demand Responsive Public transport	3.3.1
APTS4	Passenger and Fare Management	3.1.3/5.1.3
APTS5	Public Travel Security	3.4.1
APTS6	Public Transport Maintenance	3.1.4
APTS7	Multi-Modal Co-ordination	3.1.5
APTS8	En-Route Public transport Information	3.2.1
APTS9	Multi-Modal Connection Protection	3.1.6
ATIS1	Broadcast Traveller Information	4.1.1
ATIS2	Interactive Traveller Information	4.1.2
ATIS3	Autonomous Route Guidance	4.2.1
ATIS4	Dynamic Route Guidance	4.2.2
ATIS5	ISP-Based Route Guidance	4.2.3
ATIS6	Dynamic Traffic Assignment	4.2.4/1.1.8
ATIS7	Traveller Services Payment and Reservation	4.4.1/4.4.2/5.1.4
ATIS8	Ride Matching	4.1.3/4.3.1/4.3.2
ATIS9	In-Vehicle Signing	4.2.5
ATMS01	Traffic Network Flow Monitoring	1.1.1
ATMS02	Probe-Based Flow Monitoring	1.1.7
ATMS03	Surface Street Control	1.1.2
ATMS04	Highway Control	1.1.3
ATMS05	HOV Lane Management	1.3.1
ATMS06	Traffic Information Dissemination	1.1.5
ATMS07	Regional Traffic Control	1.1.4
ATMS08	Incident Risk Prediction System	1.2.1/1.2.2
ATMS09	Predictive Demand Management	1.3.3
ATMS10	Electronic Toll Collection	5.1.1
ATMS11	Emissions Management	1.4.2
ATMS12	Virtual TMC and Vehicle-Based Sensing	1.1.6/1.4.4
ATMS13	Basic At-Grade Crossing Control	1.7.1
ATMS14	Advanced At-Grade Crossing	1.7.2
ATMS15	Modal Operations Co-ordination	1.7.3
ATMS16	Electronic Parking Payment and Parking Facility Management	4.4.3/5.1.2
ATMS17	Reversible Lane Management	1.3.2
ATMS18	Road Weather Information System	1.4.3
ATMS19	Regional Parking Management	4.4.4

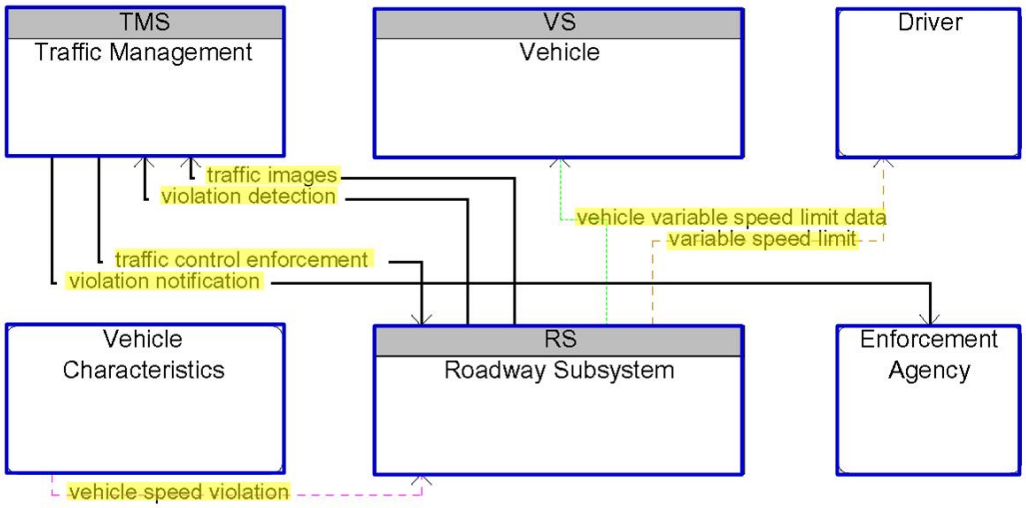
Deployment Package ID	Deployment Package Name	Associated User Sub-Services
ATMS20	Roadway Environmental Sensing	1.4.1
ATMS21	Roadway and Weather Data Fusion	9.1.1
ATMS22	Environmental Information Dissemination	9.1.2
ATMS23	Roadway Micro-Prediction	9.1.3
ATMS24	Maintenance Fleet Management	1.5.1
ATMS25	Smart Work Zones	1.5.2
ATMS26	Dynamic Roadway Warning	2.2.1
ATMS27	Variable Speed Limit and Enforcement	2.2.2
ATMS28	Signal Enforcement	2.2.3
ATMS29	Mixed Use Warning Systems	1.6.1
ATMS30	Automated Non-Vehicular Road User Protection	1.6.2
AVSS01	Vehicle Safety Monitoring	7.4.1
AVSS02	Driver Safety Monitoring	7.4.2
AVSS03	Longitudinal Warning Systems	7.1.3
AVSS04	Lateral Warning Systems	7.1.1
AVSS05	Intersection Collision Warning	7.2.1
AVSS06	Pre-Collision Restraint Deployment	7.5.1
AVSS07	Sensor-Based Driving Safety Enhancement	7.3.1
AVSS08	Longitudinal Collision Avoidance	7.1.4
AVSS09	Lateral Collision Avoidance	7.1.2
AVSS10	Intersection Collision Avoidance	7.2.2
AVSS11	Automated Vehicle Operation	7.6.1
CVO01	Fleet Administration	6.1.1
CVO02	Freight Administration	6.1.2
CVO03	Electronic Clearance	6.3.1
CVO04	Commercial Vehicle Administrative Processes	6.6.1
CVO05	International Border Crossing Clearance	6.3.2
CVO06	Weigh-In-Motion (WIM)	6.3.3
CVO07	Roadside CVO Safety	6.4.1/6.4.2
CVO08	On-Board Safety Monitoring	6.5.1
CVO09	CVO Fleet Maintenance	6.1.3
CVO10	Hazardous Material Incident Response	8.2.1
CVO11	Freight In-Public transport Monitoring	6.2.1
CVO12	Freight Terminal Management	6.2.2
EM1	Emergency Response Management	8.4.1
EM2	Emergency Vehicle Routing	8.4.2
EM3	Personal Security and MAYDAY Support	8.1.1/8.1.2
EM4	Disaster Command and Control	8.3.1
EM5	Disaster Information Dissemination	8.3.2

3. Customize Deployment Packages

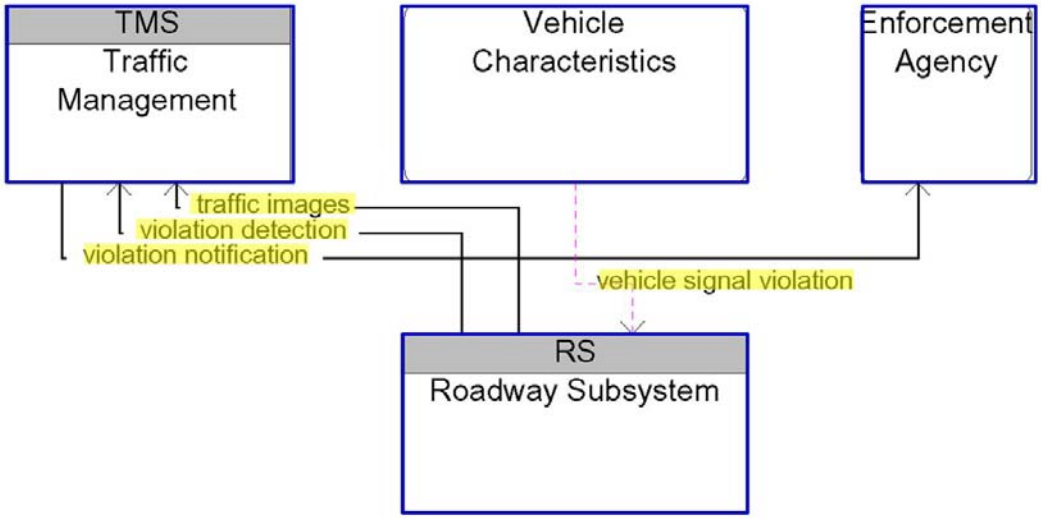
Examine the architecture elements from the selected deployment packages and identify those currently exist in the region and those that are considered for future options. This tailoring process further refines and combines the packages to precisely match the scope of the project.

The applicable physical entities and architecture flows from the deployment packages are highlighted:

ATMS27 - Variable Speed Limit and Enforcement



ATMS28 - Signal Enforcement



The following architecture flows are identified to support the Automatic Enforcement System:

ITS Architecture for Malaysia – TN4 Physical Architecture Volume IV

traffic control enforcement
Settings for parameters that dictate what conditions constitute a violation of speed limits and traffic signals.

traffic images
High fidelity, real-time traffic images suitable for surveillance monitoring by the operator or for use in machine vision applications.

variable speed limit
Legally enforceable speed limit information presented to a driver that can be varied as appropriate for roadway and weather conditions.

vehicle speed violation
Detection of a vehicle violating a speed limit.

vehicle signal violation
Detection of a vehicle violating a control signal.

vehicle variable speed limit data
Current speed limit in effect, conveyed to in-vehicle equipment.

violation detection
Roadside detection of a vehicle violating a speed limit, traffic signal, or control signage.

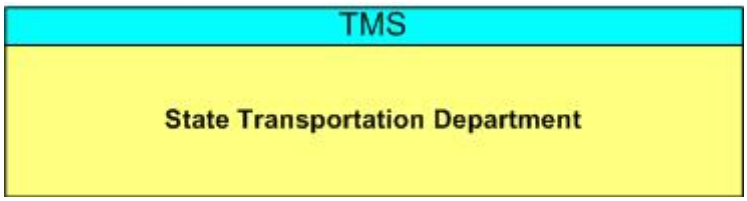
violation notification
Notification to enforcement agency of violation of a traffic law, emission requirement, or commercial vehicle regulation.

4. Identify Stakeholders

Identify the key stakeholders and institutions responsible for service delivery, the functions they need to perform, and degree to which they will need to cooperate and share information with other stakeholders and institutions to fairly allocate costs, benefits, control, and liability.

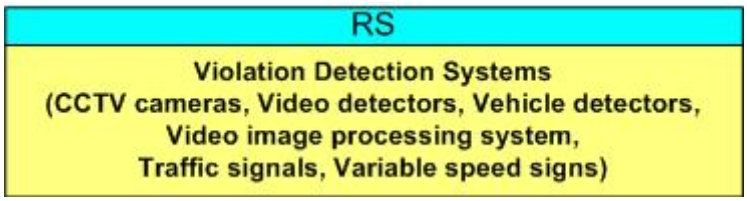
Mapping between the Architecture and the existing agencies:
ITS Architecture for Malaysia – TN3 Subsystems and Terminator

Traffic Management Subsystem



The Traffic Management Subsystem operates within a traffic management centre or other fixed location. This subsystem communicates with the Roadway Subsystem to monitor and manage traffic flow. The subsystem supports road weather information systems which utilise inputs from environmental (or road surface) sensors and weather forecast information. Incidents are detected and verified, response plans are implemented, and incident information is provided to the Emergency Management Subsystem, travellers (through Roadway Subsystem Highway Advisory Radio and Dynamic Message Signs), and to third party providers. The subsystem supports HOV lane management and co-ordination, road-pricing, and other demand management policies that can alleviate congestion and influence mode selection. The subsystem communicates with Maintenance Management Subsystems for co-ordination of road closure and maintenance actions. The subsystem also manages reversible lane facilities, and processes probe vehicle information. The subsystem communicates with other Traffic Management Subsystems to co-ordinate traffic information and control strategies in neighbouring jurisdictions. It also co-ordinates with rail operations to support safer and more efficient highway traffic management at highway-rail intersections. Finally, the Traffic Management Subsystem provides the capabilities to exercise control over those devices utilised for AHS traffic and vehicle control

Roadway Subsystem

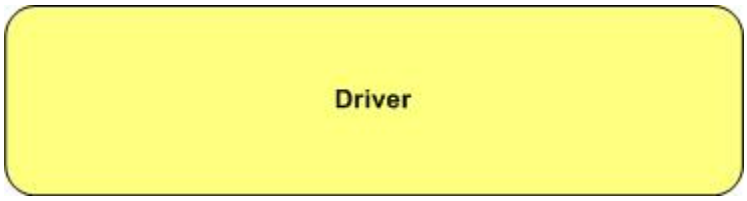


This subsystem includes the equipment distributed on and along the roadway which monitors and controls traffic. Equipment includes highway advisory radios, dynamic message signs, cellular call boxes, CCTV cameras and video image processing systems for incident detection and verification, vehicle detectors, traffic signals, grade crossing warning systems, and freeway ramp metering systems. The subsystem provides support for smart work zone deployments through support of portable monitoring and control devices, as well as the capability to have one roadside device (such as a sensor and local processor) control the outputs of another roadside device (such as a portable dynamic message sign). This subsystem also provides the capability for emissions and environmental condition monitoring including weather sensors, pavement sensors, haze, etc. In support of Traffic Management System and other Centre Subsystems, high occupancy vehicle (HOV) lane management, reversible lane management, transit priority, and emergency vehicle pre-emption functions are also available. In advanced implementations, this subsystem supports automated vehicle safety systems by safely controlling access to and egress from an Automated Highway System (AHS) through monitoring of, and communications with, AHS vehicles. Intersection collision avoidance functions are provided by determining the probability of a collision in the intersection and sending appropriate warnings and/or control actions to the approaching vehicles. Advanced sensor systems are supported which provide automated protection for non vehicular road users, and users in such vehicles as bicycles and motorcycles.

Vehicle Subsystem

This subsystem resides in a vehicle (usually in an automobile, but any vehicle not covered by another subsystem) and provides the sensory, processing, storage, and communications functions necessary to support efficient, safe, and convenient travel by personal vehicle. Information services provide the driver with current travel and weather conditions and the availability of services along the route and at the destination. Both one-way and two-way communications options support a spectrum of information services from low-cost broadcast services to advanced, pay for use personalised information services.

Driver

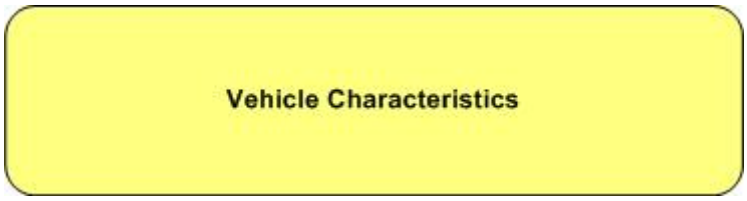


This terminator represents the human entity that operates a vehicle on the roadway. Included are operators of public transport vehicles, commercial vehicles, maintenance vehicles, emergency vehicles and other vehicles, where the data being sent or received is not particular to the type of vehicle. This general description of the person who operates a vehicle could apply even to riders of motorcycles or bicycles. Thus this terminator originates driver requests and receives driver information that reflects the interactions that might be useful to all drivers, regardless of vehicle classification.

Enforcement Agency

This terminator represents an external entity which receives reports of violations detected by various ITS facilities, e.g. individual vehicle emissions, toll violations, speed or red light running violation, CVO violations, etc.

Vehicle Characteristics



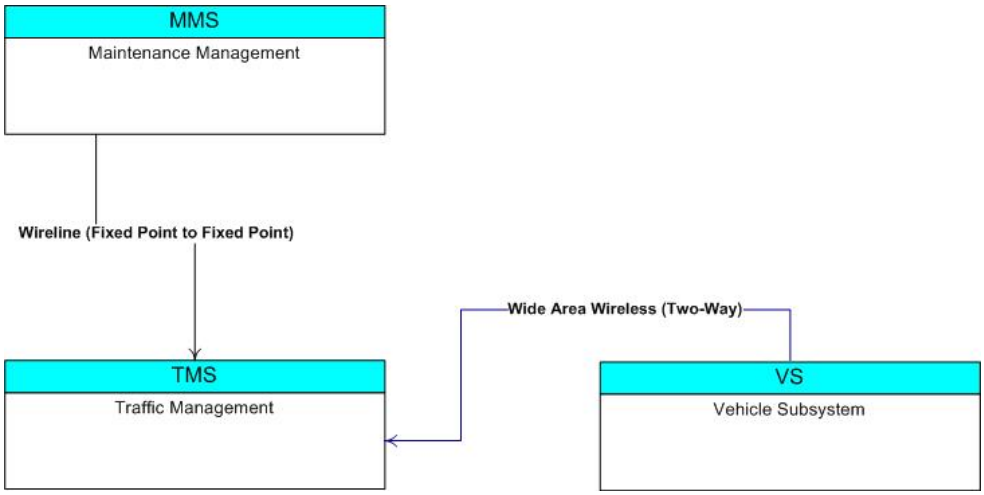
This terminator represents the external view of an individual vehicle. It includes vehicle characteristics such as height, width, length, weight, and other properties (e.g., magnetic properties, number of axles) that allow an individual vehicle to be detected and measured or classified. This external view of an individual vehicle is also used as a source of visible data that supports individual vehicle imaging requirements in the Architecture. The vehicles represented by this terminator include automobiles, trucks, buses, motorcycles, bicycles, and any other form of motorised vehicle (e.g., trencher, golf carts, etc).

ITS subsystems at the roadside sense these characteristics and generate ITS data flows. These individual vehicle characteristics are important for toll collection, parking management, and other applications that identify and measure individual vehicles.

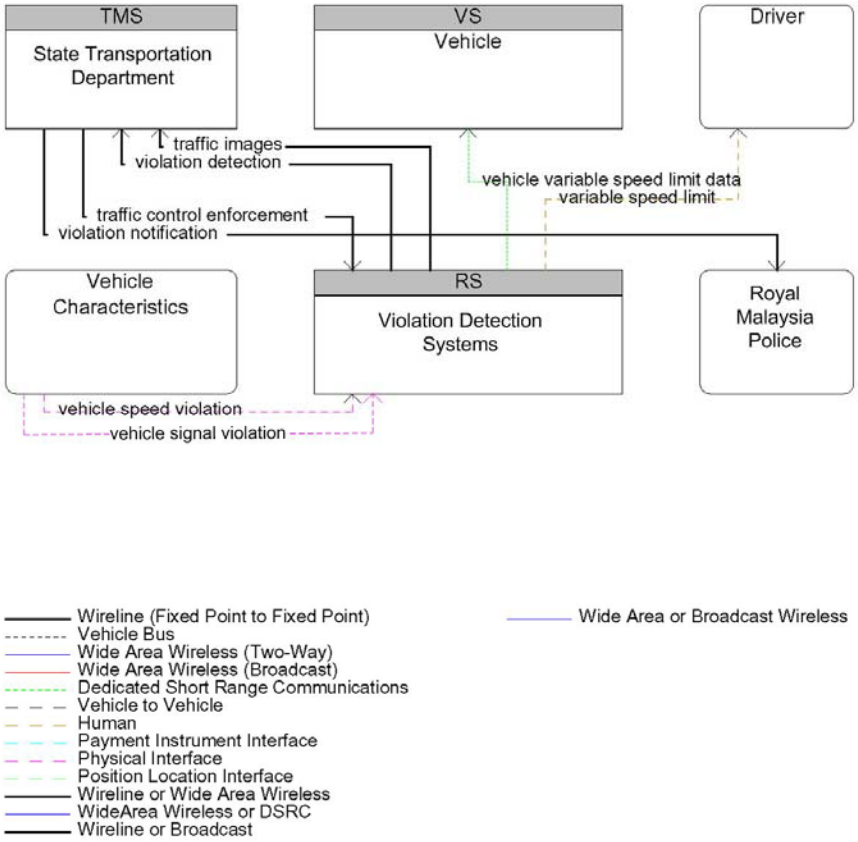
5. Select Communications Interfaces

Define key subsystem interfaces and the opportunities for systems integration.

Example: Specified communications interfaces between subsystems.



The customized deployment package for the **Automatic Enforcement System** is shown below:



Traffic Management Center

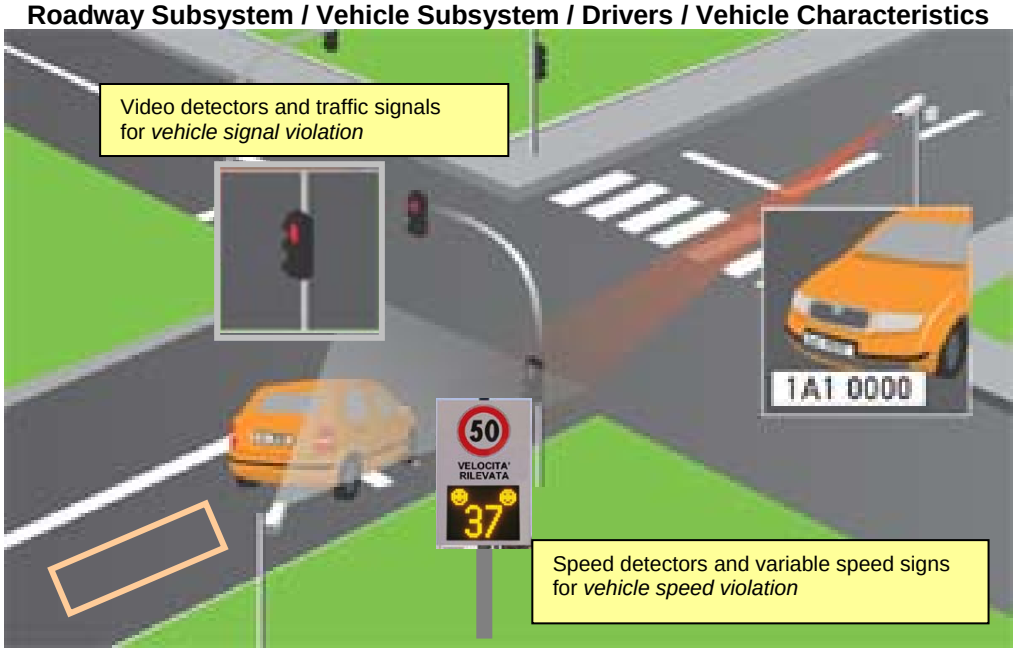
violation notification

Enforcement Agency

Royal Malaysia Police

variable speed limit
traffic control enforcement
traffic images
violation detection

Roadway Subsystem / Vehicle Subsystem / Drivers / Vehicle Characteristics



Lower Level System Specification

6. Select Process Specifications

Examine the Process Specifications (P-Specs from the Logical architecture) associated with the subsystems defined in the deployment package and identify those that are required to cover the functionality for the project.

The applicable P-Specs for the identified Subsystems are highlighted.
ITS Architecture for Malaysia – Traceability Matrix

VS	Vehicle
3.1.1	Produce Collision and Crash Avoidance Data
3.1.2	Carry-out Safety Analysis
3.1.3	Process Vehicle On-board Data
3.2.1	Provide Driver Interface
3.2.2	Provide AHS Control
3.2.3.1	Provide Command Interface
3.2.3.2	Manage Platoon Following
3.2.3.3	Process data for Vehicle Actuators
3.2.3.4.1	Provide Speed Servo Control
3.2.3.4.2	Provide Headway Servo Control
3.2.3.4.3	Provide Lane Servo Control
3.2.3.4.4	Provide Change Lane Servo Control
3.2.3.4.5	Provide Vehicle Control Data Interface
3.2.3.5	Process Vehicle Sensor Data
3.2.3.6	Communicate with other Platoon Vehicles
3.2.4	Process Sensor Data for AHS input
3.3.2	Provide Communications Function
3.3.3	Build Automatic Collision Notification Message
3.4	Enhance Driver's Vision
6.2.2	Prepare and Output In-vehicle Displays
6.2.5	Provide Driver Interface
6.7.1.1	Build Driver Personal Security Message
6.7.1.2	Provide Driver In-vehicle Communications Function
6.7.2.1.1	Determine In-vehicle Guidance Method
6.7.2.1.2	Provide Dynamic In-vehicle Guidance
6.7.2.1.3	Provide Autonomous In-vehicle Guidance
6.7.2.2	Process Vehicle Location Data
6.7.2.3	Provide Driver Guidance Interface
6.7.2.4	Update Vehicle Navigable Map Database
7.1.4	Provide Driver Toll Payment Interface
7.1.7	Provide Payment Instrument Interface for Tolls
7.2.4	Provide Driver Parking Lot Payment Interface
7.2.7	Provide Payment Instrument Interface for Parking
7.5.1	Provide Vehicle Payment Instrument Interface

RS	Roadway Subsystem
1.1.1.1	Process Traffic Sensor Data
1.1.1.3	Process Environmental Sensor Data
1.1.1.4	Manage Data Collection and Monitoring
1.1.1.5.2	Provide Other Roadside Inputs
1.1.1.5.3	Process Roadway Warning Data
1.1.1.5.4	Process Road User Protection
1.1.2.6	Process Collected Vehicle Smart Probe Data
1.1.6	Collect Vehicle Tag Data for Link Time Calculations
1.1.7	Collect Vehicle Smart Probe Data
1.2.7.1	Process Indicator Output Data for Roads
1.2.7.2	Monitor Roadside Equipment Operation for Faults
1.2.7.3	Manage Indicator Preemptions
1.2.7.4	Process In-vehicle Signage Data
1.2.7.5	Process Indicator Output Data for Freeways
1.2.7.6	Provide Intersection Collision Avoidance Data
1.2.7.7	Process Vehicle Smart Probe Data for Output
1.2.7.8	Receive Other Roadside Inputs
1.2.7.9	Display Roadway Warnings
1.3.1.3	Process Traffic Images
1.5.5	Process Vehicle Pollution Data
1.5.6	Detect Roadside Pollution Levels
1.6.1.1	Detect Roadway Events
1.6.1.2.1	Control HRI Traffic Signals
1.6.1.2.2	Control HRI Warnings and Barriers
1.6.1.2.3	Provide SSR Device Controls
1.6.1.2.4	Provide HSR Device Controls
1.6.1.2.5	Manage Device Control
1.6.1.2.6	Maintain Device State
1.6.1.3	Perform Equipment Self-Test
1.6.1.4.1	Generate Alerts and Advisories
1.6.1.4.2	Provide Closure Parameters
1.6.1.4.3	Report Alerts and Advisories
1.6.1.4.4	Report HRI Status on Approach
1.6.1.5	Detect HRI Hazards
1.6.1.6.1	Close HRI on Detection
1.6.1.6.2	Detect Imminent Vehicle/Train Collision
1.6.1.7.1	Control Vehicle Traffic at Passive HRI
1.6.1.7.2	Control Vehicle Traffic at Active HRI
1.6.1.7.3	Close HRI on Command
1.6.3.1	Interact with Wayside Systems
1.6.3.2	Advise and Protect Train Crews
1.6.3.3	Provide ATS Alerts
1.6.5.1	Provide Interactive Interface
1.6.5.2	Determine HRI Status
1.6.5.3	Maintain HRI Closure Data
3.2.5	Check Vehicle for AHS eligibility
3.2.6	Manage AHS Check-in and Check-out
9.1	Detect and Classify Speed Violations
9.3	Post Speed Limit
9.6	Detect and Classify Signal Violations

TMS	Traffic Management
1.1.1.2	Collect and Process Sensor Fault Data
1.1.2.1	Process Traffic Data for Storage
1.1.2.2	Process Traffic Data
1.1.2.3	Update Data Source Static Data
1.1.2.4	Monitor HOV lane use
1.1.2.5	Process Tag/AVL Data for Link Time Data
1.1.2.7	Monitor Reversible Lanes
1.1.3	Generate Predictive Traffic Model
1.1.4.1	Retrieve Traffic Data
1.1.4.2	Provide Traffic Operations Personnel Traffic Data Interface
1.1.4.3	Provide Direct Media Traffic Data Interface
1.1.4.4	Update Traffic Display Map Data
1.1.4.7	Manage Traffic Archive Data
1.1.5	Exchange data with Other Traffic Centres
1.2.1	Select Strategy
1.2.2.1	Determine Indicator State for Freeway Management
1.2.2.2	Determine Indicator State for Road Management
1.2.6.1	Maintain Traffic and Sensor Static Data
1.2.6.2	Provide Static Data Store Output Interface
1.2.8.1	Collect Indicator Fault Data
1.2.8.2	Maintain Indicator Fault Data Store
1.2.8.3	Provide Indicator Fault Interface for C and M
1.2.8.4	Provide Traffic Operations Personnel Indicator Fault Interface
1.3.1.1	Analyze Traffic Data for Incidents
1.3.1.2	Maintain Static Data for Incident Management
1.3.2.1	Store Possible Incident Data
1.3.2.2	Review and Classify Possible Incidents
1.3.2.3	Review and Classify Planned Events
1.3.2.4	Provide Planned Events Store Interface
1.3.2.5	Provide Current Incidents Store Interface
1.3.3	Respond to Current Incidents
1.3.4.1	Retrieve Incident Data
1.3.4.2	Provide Traffic Operations Personnel Incident Data Interface
1.3.4.3	Provide Media Incident Data Interface
1.3.4.4	Update Incident Display Map Data
1.3.4.5	Manage Resources for Incidents
1.3.5	Manage Possible Predetermined Responses Store
1.3.6	Manage Predetermined Incident Response Data
1.3.7	Analyze Incident Response Log
1.4.1	Provide Traffic Operations Personnel Demand Interface
1.4.2	Collect Demand Forecast Data
1.4.3	Update Demand Display Map Data
1.4.4	Implement Demand Management Policy
1.4.5	Calculate Forecast Demand
1.6.2.1	Exchange Data with Rail Operations
1.6.2.2	Manage Alerts and Advisories
1.6.2.3	Manage Rail Traffic Control Data
1.6.4.1	Manage HRI Closures
1.6.4.2	Exchange Data with Traffic Management
3.2.7	Manage AHS Operations
5.4.1	Process TM Detected Violations
9.2	Collect and Verify Speed Violations
9.4	Set Speed Limit
9.5	Establish Violation Parameters
9.7	Collect and Verify Signal Violations

The applicable P-Specs for the Automatic Enforcement System are as follows:
ITS Architecture for Malaysia – TN2 Logical Architecture Volume II

1.1.1.5.3 Process Roadway Warning Data

Overview: This process collects data using sensors alongside the roadway to detect hazardous conditions and sends the information to other processes to warn approaching drivers. The inputs collected by this function include roadway conditions, environmental hazards, obstacles in or near the roadway such as animals, or vehicle characteristics. This process notifies other traffic management functions including enforcement functions to warn drivers to adjust speed to avoid a dangerous driving situation. Inputs from traffic operators may include forecast whether conditions to use in determining appropriate warning parameters. This process detects the characteristics of oncoming vehicles and determines whether conditions dictate a warning such as a high-profile commercial vehicle approaching an area of high cross winds.

1.1.4.2 Provide Traffic Operations Personnel Traffic Data Interface

Overview: This process shall provide the interface through which traffic operations personnel can obtain access to the data stored by other processes in the Provide Traffic Surveillance facility of the Manage Traffic function, and set up the parameters that govern the data that is available to non-traffic operations people via a separate process to the media operator. This stored data shall comprise current and long term (historic) data on traffic conditions, weather conditions and roadside equipment activity, plus prediction estimates of traffic conditions. The data shall apply to some or all of the surface street and freeway network served by the specific instance of the Manage Traffic function. Where appropriate and/or requested by the traffic operations personnel, the process shall provide the data output in the form of an overlay onto a map of the relevant part(s) of the surface street and freeway network served by the instance of the function. The process shall obtain the map from a local data store, which it shall enable the traffic operations personnel to update as and when required.

1.2.6.2 Provide Static Data Store Output Interface

Overview: This process shall provide updates of static data to other processes in the Provide Traffic Control facility of the Manage Traffic function. An update of the data shall only be provided when this process has been notified by another process that the contents of the store of static data has been changed. This process shall provide updates to the map update provider about changes to the static data of a particular region.

1.2.7.1 Process Indicator Output Data for Roads

Overview: This process shall implement the indicator output data generated by other processes within the Manage Traffic function for use on the roads (surface streets) served by the function. It shall perform the functions needed to provide control at intersections or pedestrian crossings, generate the output for dynamic message signs (dms) and highway advisory radios (HAR), or provide the interface for data to be sent to the units (or systems) that manage multimodal crossings. The dms may be either those that display variable text messages, or those that have fixed format display(s)(e.g. vehicle restrictions, or lane open/close).

5.4.1 Process TM Detected Violations

Overview: This process shall manage the details of high occupancy vehicle (HOV) lane use, wrong-way vehicle detection in reversible lanes, and pollution violations reported by the Manage Traffic function. The process shall use the parameters in the store of traffic management (TM) violation (enforcement) data to obtain the vehicle registration data from the appropriate State Department of Motor Vehicles (DMV) office, before sending all of the received information to the correct law enforcement agency. This process shall also maintain the TM enforcement data store, entering all information received from other processes.

6.2.2 Prepare and Output In-vehicle Displays

Overview: This process shall provide in-vehicle advisory and broadcast data for output to drivers and transit users. The process shall format requests from users for advisory data and output the requests to other processes. The request for advisory data shall allow the user to request only information relevant to the location of the vehicle. The request may be repeated, periodically, or when the vehicle changes location by a distance determined by the implementation. Data broadcast to the driver shall include traffic related data(incidents, link data and in-vehicle signage),

as well as data from the vehicle itself. This vehicle data includes vehicle conditions, smart probe data, safety and position warnings, and enhanced vision images. Safety and warning messages shall be prioritized by the process to supersede advisory and broadcast messages. The process shall also support the transfer of reservation requests from the users in vehicles for other services such as yellow pages.

9.1 Detect and Classify Speed Violations

Overview: This process is responsible for detecting and classifying speed violations at the roadside using a combination of a speed sensor and a vehicle identification device. This process is governed by parameters regarding speed thresholds to be considered as violations.

9.2 Collect and Verify Speed Violations

Overview: This process collects data from the Detect and Classify Speed Violations and verifies that they are in fact violations. The data collected by this process includes video or other data used to identify individual vehicles as well as telemetry data from the field such as speed and time of day. Once this process has verified the violations it forwards the data to the Process Traffic Violations function. This process can be run as an intermmediate step before issuing tickets for speed violations.

9.3 Post Speed Limit

Overview: This process posts safe speed limits to passing motorists through use of such means as variable speed limit signs, invehicle signing functions, highway advisory radio broadcasts. These safe speed limits are defined by the Set Speed Limit function but they may also gather input from the local roadway conditions to determine the safe speed based on weather or other environmental conditions from the Process Roadway Warning Data function. The safe speed is also output to the function to Detect and Classify Speed Violations to use to enforce the new speed limit.

9.4 Set Speed Limit

Overview: This process determines the safe speed limit for a given segment of the road network based on the roadway characteristics such as the geometry of the roadway, the current conditions of the roadway including recent weather conditions that may be provided by the Provide Traffic Operations Personnel Traffic Data Interface function. This process maintains a log of all of the speed limit settings including when changes were made to the speed limit on a given roadway segment. This information can be used to support the verification of speed violations.

9.5 Establish Violation Parameters

Overview: This process establishes the parameters by which violations of speed limits and signals are measured. The inputs to this process from the Provide Traffic Operations Personnel Traffic Data Interface function and the Set Speed Limit function allow the things that constitute a violation to be varied based on road, weather, or traffic conditions. This process sends its output to the functions that detect and classify speed and signal violations.

9.6 Detect and Classify Signal Violations

Overview: This process is responsible for detecting and classifying signal violations at the roadside using a combination of a presence sensor and a vehicle identification device. This process is governed by parameters that dictate the conditions to be considered as violations. Data on violations is collected and can be stored for retrieval in a stand-alone device or communicated to the Collect and Verify Signal Violations.

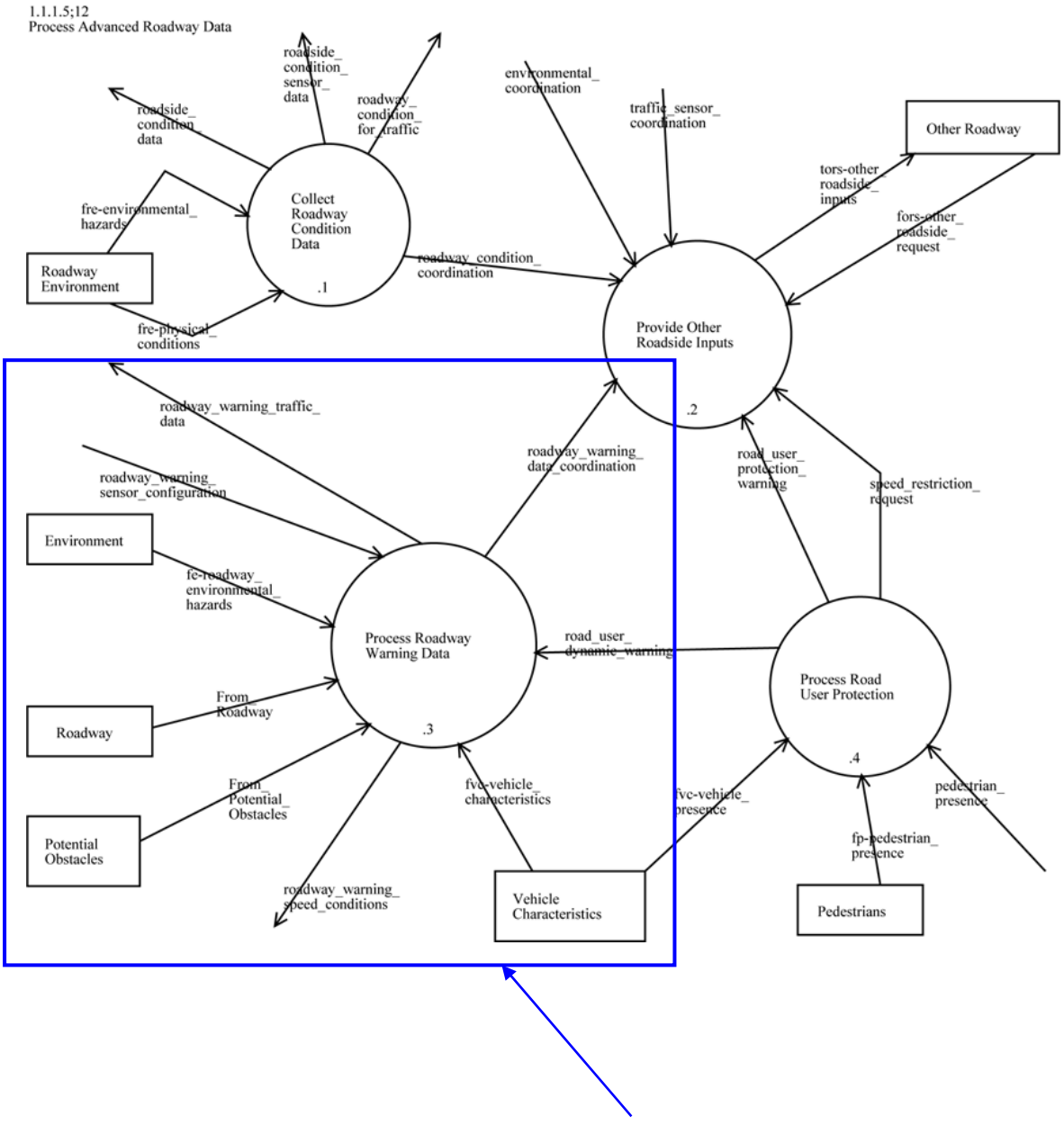
9.7 Collect and Verify Signal Violations

Overview: This process collects data from the Detect and Classify Signal Violations and verifies that they are in fact violations. The data collected by this process includes video or other data used to identify individual vehicles as well as telemetry data from the field such as loop data and time of day. Once this process has verified the violations it forwards the data to the Process Traffic Violations function. This process can be run as an intermmediate step before issuing tickets for signal violations.

7. Develop Detail Specification

Identify the Data Flow Diagrams (DFDs) and the associated data flows for the selected P-Specs. Short list the data flows according to the project functionalities and extract the data definitions from the Data Dictionary. These DFDs, data flows and the data definitions form the detail design specifications of the project.

Example: Parent DFD 1.1.1.5 for the P-Spec 1.1.1.5.3
ITS Architecture for Malaysia – TN2 Logical Architecture Volume I



Data flows associated with the P-Spec 1.1.1.5.3 - Process Roadway Warning Data

Example: Data Dictionary for the data flows associated with P-Spec 1.1.1.5.3
ITS Architecture for Malaysia – TN2 Logical Architecture Volume II and III

fe_roadway_environmental_hazards
This data flow from the Environment terminator includes analog sensor data used by the roadside devices to recognize hazards in the roadway.

From_Potential_Obstacles
This data flow is sent from potential obstacles to the Provide Vehicle Monitoring and Control function. It contains analog data that provides information on potential obstacles that can be encountered by a vehicle.

From_Roadway
This data flow contains analog information about the roadway. It is sent to the Provide Vehicle Monitoring and Control function and the Manage O&M function where sensors on-board maintenance vehicles detect road characteristics.

fvc_vehicle_characteristics
This data flow is sent from the vehicle characteristics terminator. It represents the presence of a vehicle near a sensor, which allows the sensor to create an output that can be used to identify a particular vehicle and its characteristics, such as the number of wheels, size, pollution parameters, etc., for toll payment and parking lot charging purposes. The sensor may also determine the visible characteristics of a vehicle and use that data to obtain information about toll and parking lot charge violators.

road_user_dynamic_warning
This data flow from the Process Road User Protection contains warning information concerning the presence of vehicles in close proximity of non-vehicle users such as pedestrians and bicyclists.

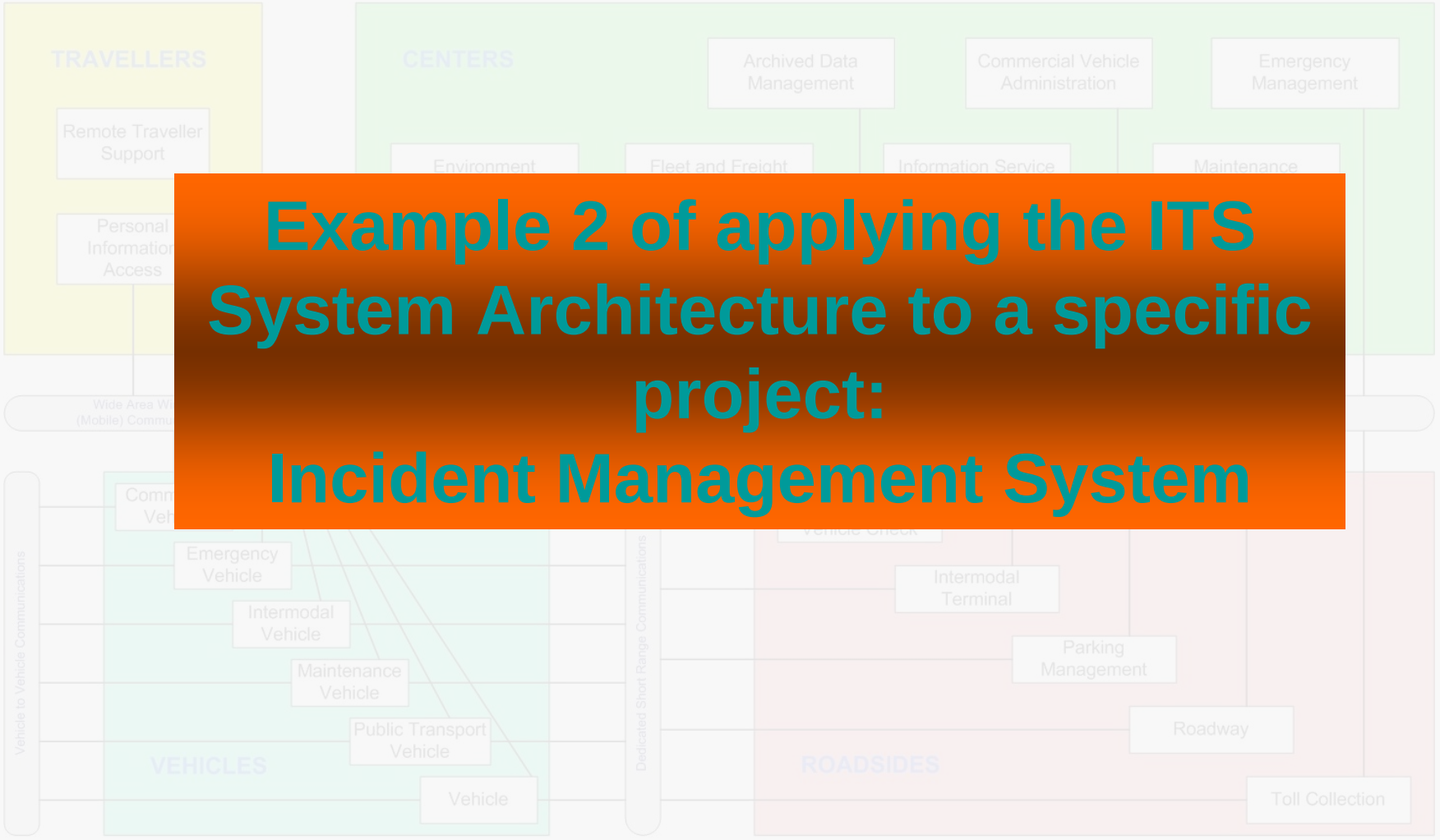
roadway_warning_data_coordination
This data flow within the Process Advanced Roadway Data function contains information to be passed onto adjacent roadside elements. This information may include warnings concerning hazardous conditions or reduced visibility that need to be coordinated with other devices nearby for output to drivers.

roadway_warning_sensor_configuration
This data flow from the Provide Traffic Operations Personnel Traffic Data function contains the sensor configuration data to control how data is gathered for the dynamic roadway warning devices. This may include the threshold values to determine icy conditions, unsafe speed parameters, or other calibration information. This may also include information based on forecast weather conditions for the location.

roadway_warning_speed_conditions
This data flow from the Process Roadway Warning Data function is used by the Post Speed Limit function to determine the maximum safe speed given the current road conditions.

roadway_warning_traffic_data
This data flow contains data for dynamic roadside warnings. This data is collected at the roadside and passes to the Process Traffic Data function to allow operators to generate roadside warnings to drivers. This data may include environmental hazards, roadway conditions, obstacles, or vehicles driving in an unsafe manner for conditions at the time.

The Development of ITS System Architecture



Example 2 of applying the ITS System Architecture to a specific project:
Incident Management System

1. Identify ITS User Sub-Service

Define the transportation project scopes and identify the ITS User Sub-Services that best describe the specific transportation needs. The step isolates the portion of the Architecture that applies to the specific project.

Example: Region 'A' requires an Incident Management System that keep track of both traffic and hazardous material incidents. The following User Sub-services address the specified transportation needs:-

1.2.1 Incident Management Co-ordination

The Incident Management Co-ordination User Sub-service manages both scheduled and unscheduled incidents so that the impact to the transportation network and traveller safety is minimized. This User Sub-service provides Traffic Management Subsystem and Maintenance Management Subsystem equipment that supports traffic operations/maintenance personnel in developing an appropriate response in co-ordination with emergency management and other incident response personnel to confirmed incidents. The response may include traffic control strategy modifications and dissemination of information to affected travellers. Co-ordination between traffic and maintenance operations (i.e. Tow trucks) is also served by this User Sub-service

1.2.2 Incident Prediction System

The Incident Prediction System User Sub-service predicts incidents so that the impact to the transportation network and traveller safety is minimised.

8.2.1 Hazardous Material Planning and Incident Response

Hazardous Material Planning and Incident Response user sub-service integrates incident management capabilities with commercial vehicle tracking to assure effective treatment of HAZMAT material and incidents. The Fleet and Freight Management Subsystem performs HAZMAT tracking and notify the Emergency Management Subsystem when an incident is detected. The EMS also co-ordinates the emergency plan in response to the incident. The response is tailored based on information that is provided as part of the original incident notification or derived from supplemental information provided by the Fleet and Freight Management Subsystem.

Sector No.1: Advanced Traffic Management Systems			
1.1	**Urban Traffic Control**	*1.1.1*	*Traffic Network Flow Monitoring*
		1.1.2	*Surface Street Control*
		1.1.3	*Highway Control*
		1.1.4	*Regional Traffic Control*
		1.1.5	*Traffic Information Dissemination*
		1.1.6	*Virtual TMC*
		1.1.7	*Probe-Based Flow Monitoring*
		1.1.8	*Traffic Estimation and Prediction*
1.2	**Incident Detection and Management**	*1.2.1*	*Incident Management Co-ordination* ⇦
		1.2.2	*Incident Prediction System* ⇦
1.3	**Travel Demand Management**	*1.3.1*	*High Occupancy Vehicle Lane Management*
		1.3.2	*Reversible Lane Management*
		1.3.3	*Predictive Demand Management*
1.4	**Environmental Conditions Management**	*1.4.1*	*Roadway Environmental Sensing*
		1.4.2	*Emissions Management*
		1.4.3	*Road Weather Information System*

		1.4.4	*Vehicle-Based Sensing*
1.5	**Operations and Maintenance**	*1.5.1*	*Infrastructure Maintenance Management*
		1.5.2	*Smart Work Zones*
1.6	**Non-Vehicular Road User Safety**	*1.6.1*	*Mixed Use Warning Systems*
		1.6.2	*Automated Non-Vehicular Road User Protection*
1.7	**Multi-Modal Junction Safety and Control**	*1.7.1*	*Basic At-Grade Crossing Control*
⋮		*1.7.2*	*Advanced At-Grade Crossing*
		1.7.3	*Modal Operations Co-ordination*
Sector No.8: Emergency Management Systems			
8.1	**Emergency Notification and Personal Security**	*8.1.1*	*Personal Security*
		8.1.2	*MAYDAY Support*
8.2	*Hazardous Material Planning and Incident Response*	*8.2.1*	*Hazardous Material Planning and Incident Response* ⇦
8.3	**Disaster Response and Management**	*8.3.1*	*Disaster Command and Control*
		8.3.2	*Disaster Information Dissemination*
8.4	**Emergency Vehicle Management**	*8.4.1*	*Emergency Response Management*
		8.4.2	*Emergency Vehicle Routing*

2. Select Deployment Packages

Trace the relevant Deployment packages for the specific ITS User Sub-services identified in the previous step. This step translates the transportation needs into deployable packages and provides a deployment oriented view of the project to the policy planners and project managers.

Example: The ITS User Sub-services identified from the previous step are served by the following Deployment packages:

ATMS08 - Incident Risk Prediction System
This Deployment package manages both predicted and unexpected incidents so that the impact to the transportation network and traveller safety is minimized. Information from various sources are collected and correlated by this deployment package to detect and verify incidents and implement an appropriate response. Appropriate responses are coordinated via this deployment package according to the information gathered.

CVO10 - Hazardous Material Incident Response
This deployment package integrates incident management capabilities with commercial vehicle tracking to assure effective treatment of HAZMAT material and incidents. HAZMAT tracking is performed by the Fleet and Freight Management Subsystem. The Emergency Management Subsystem is notified by the Commercial Vehicle if an incident occurs and co-ordinates the response. The response is tailored based on information that is provided as part of the original incident notification or derived from supplemental information provided by the Fleet and Freight Management Subsystem. The latter information can be provided prior to the beginning of the trip or gathered following the incident depending on the selected policy and implementation.

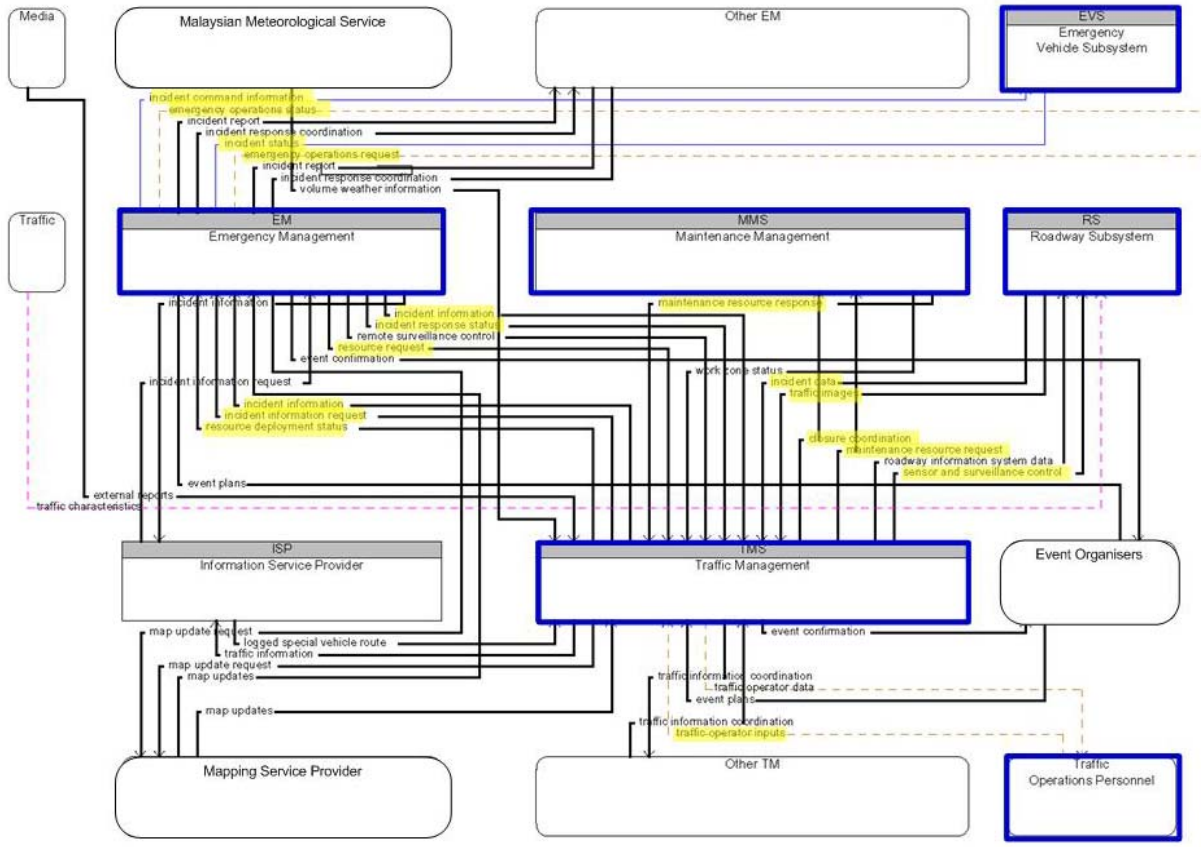
Deployment Package ID	Deployment Package Name	Associated User Sub-Services
ATMS01	Traffic Network Flow Monitoring	1.1.1
ATMS02	Probe-Based Flow Monitoring	1.1.7
ATMS03	Surface Street Control	1.1.2
ATMS04	Highway Control	1.1.3
ATMS05	HOV Lane Management	1.3.1
ATMS06	Traffic Information Dissemination	1.1.5
ATMS07	Regional Traffic Control	1.1.4
ATMS08	Incident Risk Prediction System	1.2.1/1.2.2
ATMS09	Predictive Demand Management	1.3.3
ATMS10	Electronic Toll Collection	5.1.1
CVO01	Fleet Administration	6.1.1
CVO02	Freight Administration	6.1.2
CVO03	Electronic Clearance	6.3.1
CVO04	Commercial Vehicle Administrative Processes	6.6.1
CVO05	International Border Crossing Clearance	6.3.2
CVO06	Weigh-In-Motion (WIM)	6.3.3
CVO07	Roadside CVO Safety	6.4.1/6.4.2
CVO08	On-Board Safety Monitoring	6.5.1
CVO09	CVO Fleet Maintenance	6.1.3
CVO10	Hazardous Material Incident Response	8.2.1
CVO11	Freight In-Public transport Monitoring	6.2.1
CVO12	Freight Terminal Management	6.2.2
EM1	Emergency Response Management	8.4.1
EM2	Emergency Vehicle Routing	8.4.2
EM3	Personal Security and MAYDAY Support	8.1.1/8.1.2
EM4	Disaster Command and Control	8.3.1

3. Customize Deployment Packages

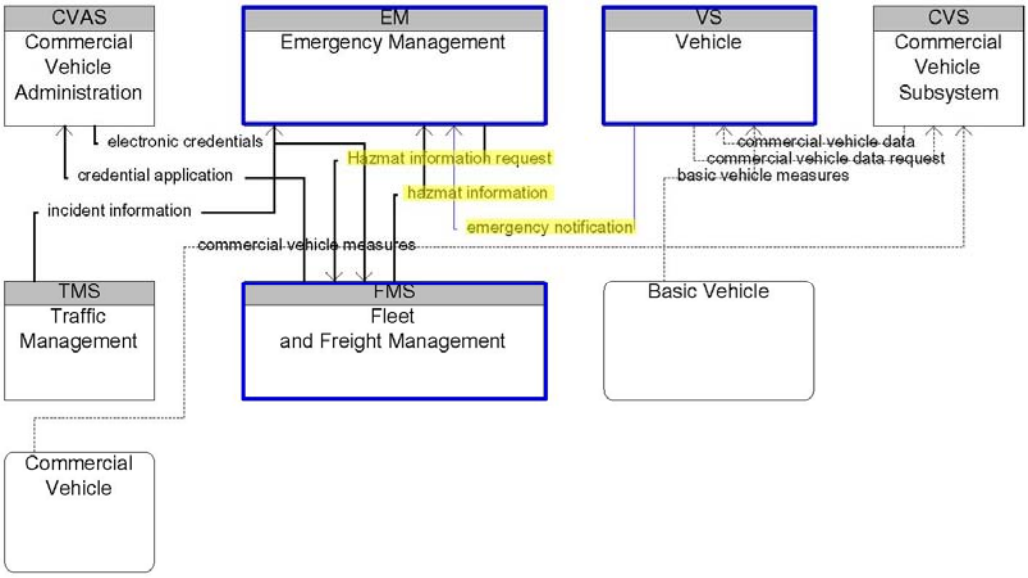
Examine the architecture elements from the selected deployment packages and identify those currently exist in the region and those that are considered for future options. This tailoring process further refines and combines the packages to precisely match the scope of the project.

Example: The applicable physical entities and architecture flows from the two deployment packages are highlighted.

ATMS08 - Incident Risk Prediction System



CVO10 - Hazardous Material Planning and Incident Response



4. Identify Stakeholders

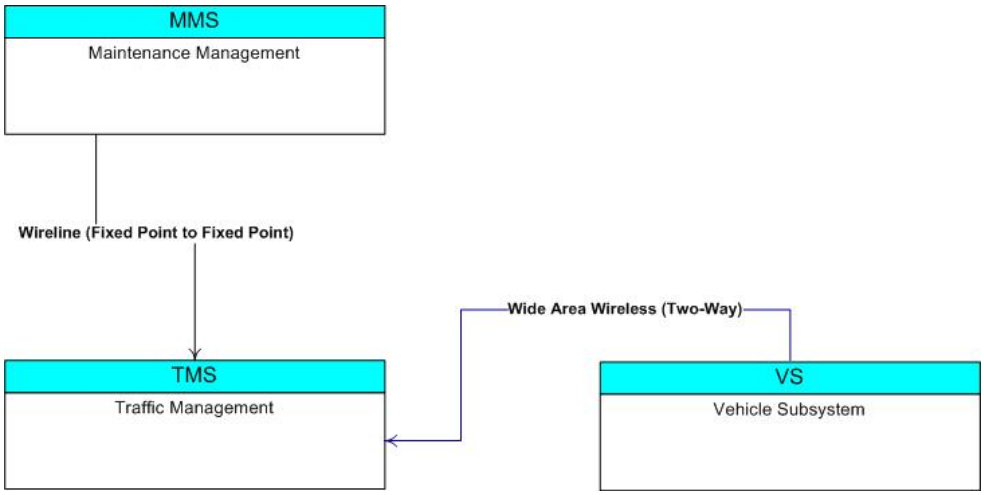
Identify the key stakeholders and institutions responsible for service delivery, the functions they need to perform, and degree to which they will need to cooperate and share information with other stakeholders and institutions to fairly allocate costs, benefits, control, and liability.

Example: Mapping between the Architecture and the existing agencies.

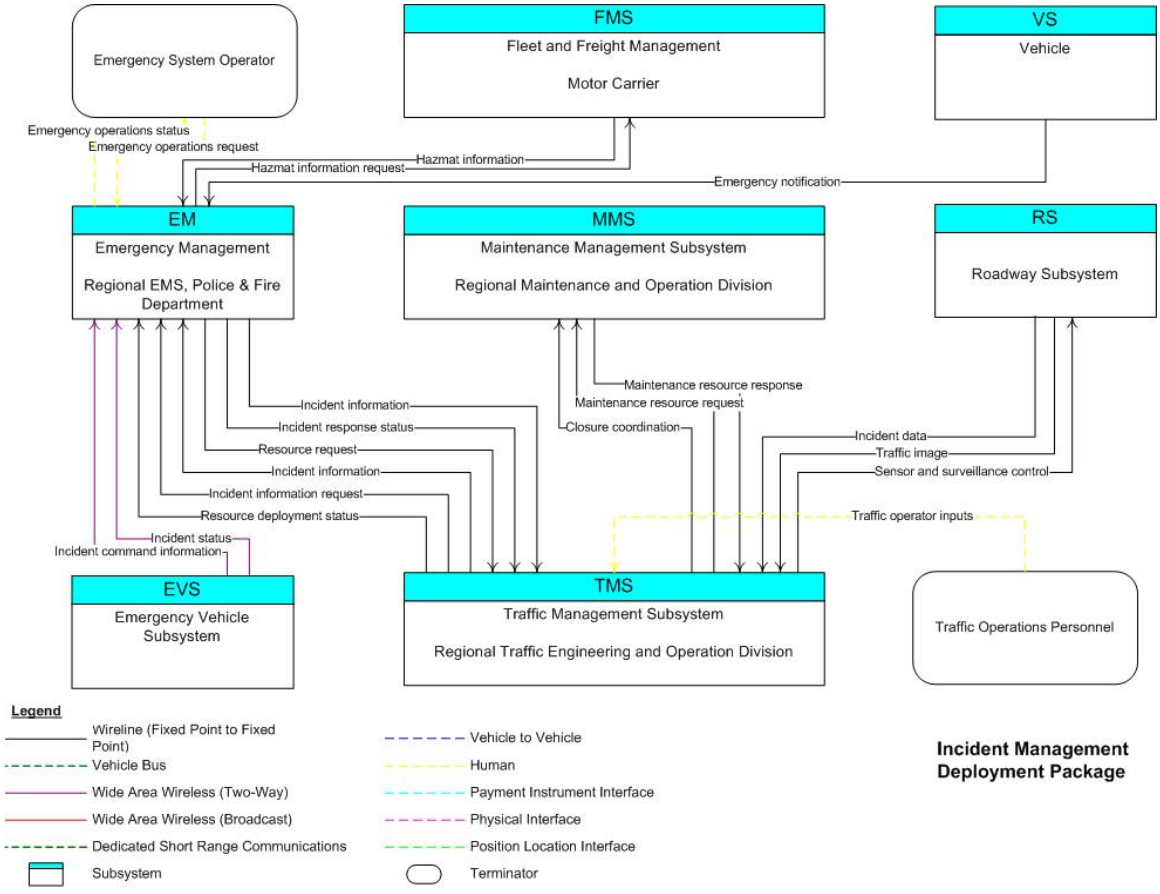
5. Select Communications Interfaces

Define key subsystem interfaces and the opportunities for systems integration.

Example: Specified communications interfaces between subsystems.



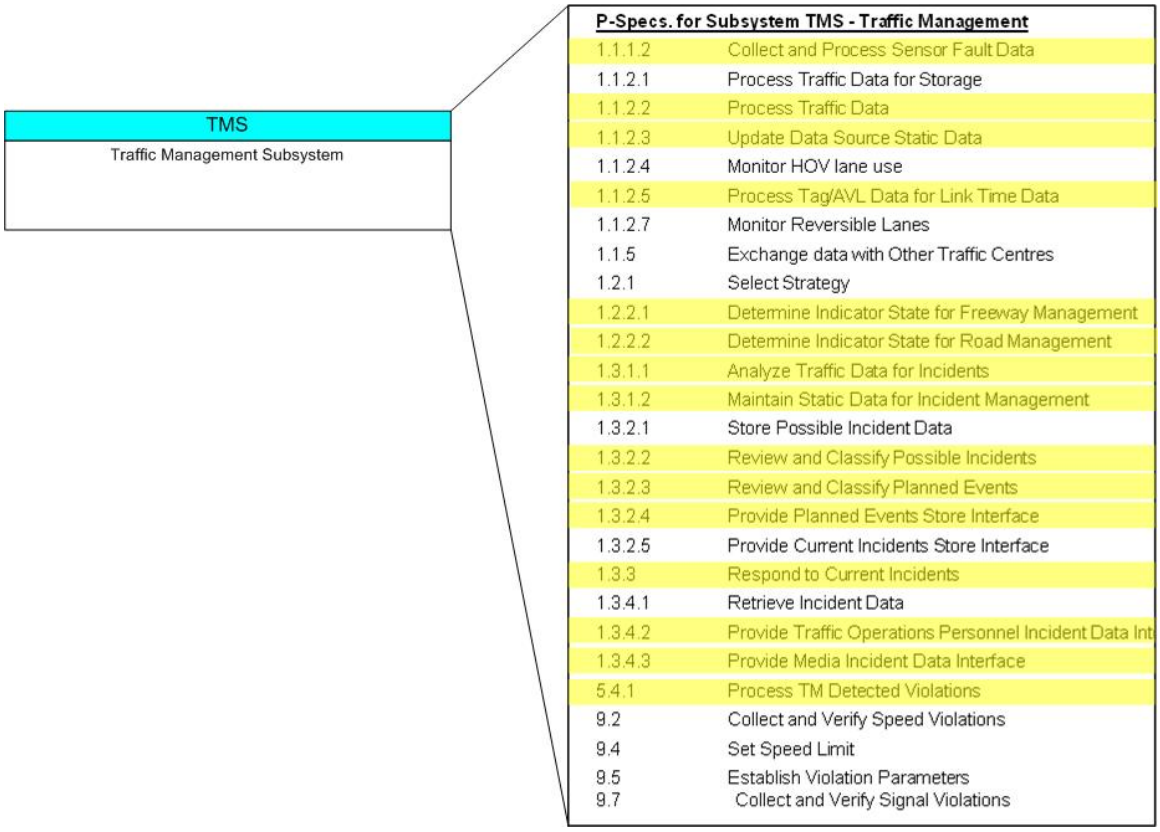
The customized deployment package for the proposed ITS project is shown below:



6. Select Process Specifications

Examine the Process Specifications (P-Specs from the Logical architecture) associated with the subsystems defined in the deployment package and identify those that are required to cover the functionality for the project.

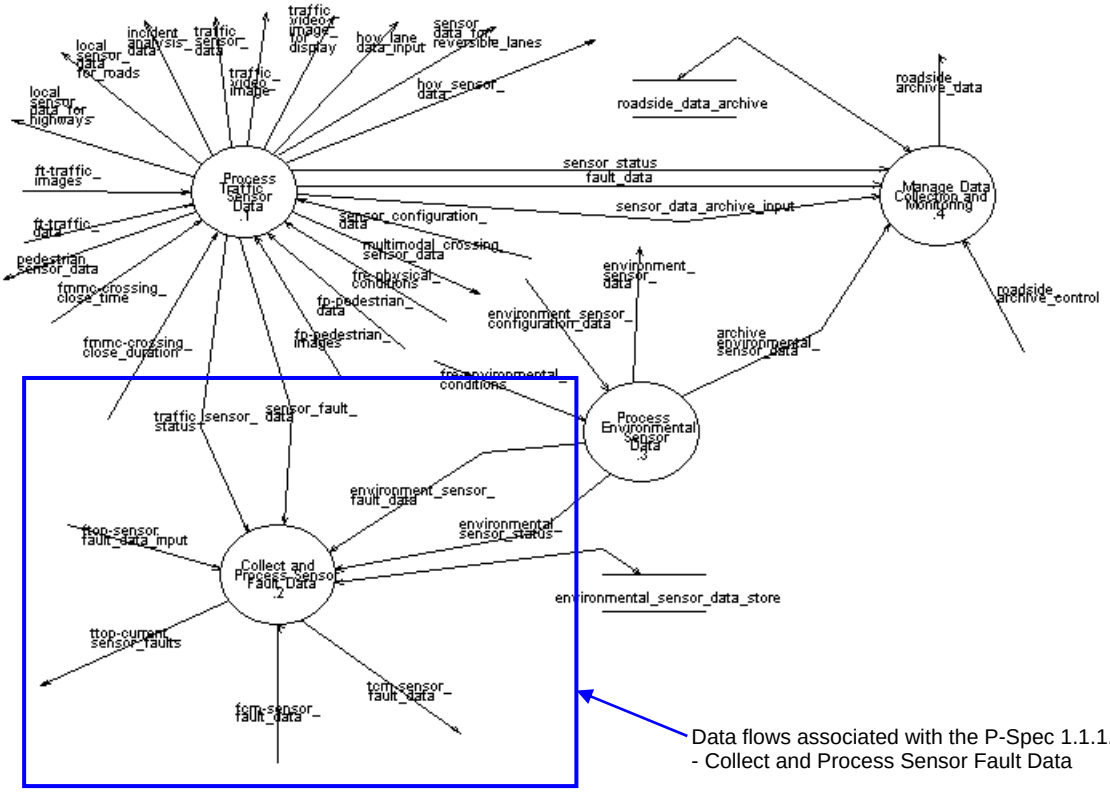
Example: The applicable P-Specs for the Subsystem TMS are highlighted.



7. Develop Detail Specification

Identify the Data Flow Diagrams (DFDs) and the associated data flows for the selected P-Specs. Short list the data flows according to the project functionalities and extract the data definitions from the Data Dictionary. These DFDs, data flows and the data definitions form the detail design specifications of the project.

Example: Parent DFD for the P-Spec 1.1.1.2



DFD 1.1.1 - Process Sensor Data

Example: Sample of the Data Dictionary for the data flows

environment_sensor_configuration_data
This data flow is used within the Manage Traffic function to provide environmental sensor control commands. It consists of the following data items each of which is defined in its own DDE:

environment_sensor_data
This data flow is used within the Manage Traffic function and contains a set of outputs from individual environment sensors. It consists of the following data items each of which is defined in its own DDE:

list_size
+ list_size{station_id + sensor_identity + environment_sensor_output}.

environment_sensor_fault_data
This data flow is used within the Manage Traffic function to show that an environment sensor has developed a fault that means it is not operating correctly. The fault will have been found by a process that is local to the sensor itself.

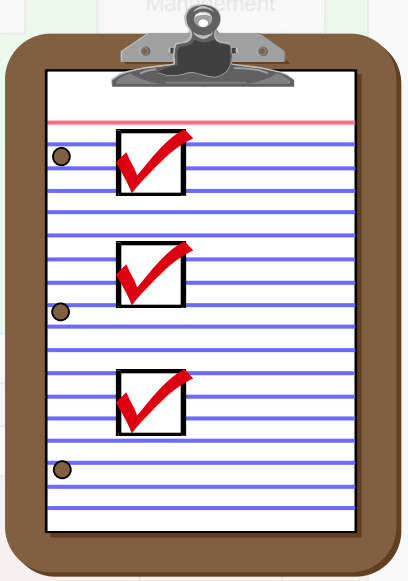
environment_sensor_output
This data flow contains the raw data collected from a single sensor. This data flow could include data pertaining to wind, temperature, humidity, precipitation, radiation (sun), visibility, and pavement sensor information.

environmental_coordination
This data flow from the Process Environmental Sensor Data function contains information about environmental conditions detected by roadside devices that can be used to output to drivers using other roadside devices. This data may include fog detection, temperature information, or icy conditions that could be used to warn drivers as they approach the area.

The Development of ITS System Architecture

Next Steps ?

- Capacity Building
- Local refinement
- Operating agreements between stakeholders
- Identification of interface
- Implementation
- Monitoring / evaluation



Summary

- To define a *Project Architecture*:
  - Review Deployment Packages
  - Explore interconnection options presented in the ITS System Architecture
  - Tailor to local needs
  - Review / refine functional requirements (PSpecs) implied by Deployment Packages

Benefits

- Project Architectures provide important *Benefits*
  - Encourage stakeholder buy-in
  - Present integration opportunities
  - Outline future direction and incremental systems growth
  - Minimize redesign for expansion
  - Ensure systems work together in harmony
  - Provide insight into organizational and administrative requirements needed to support technical solutions