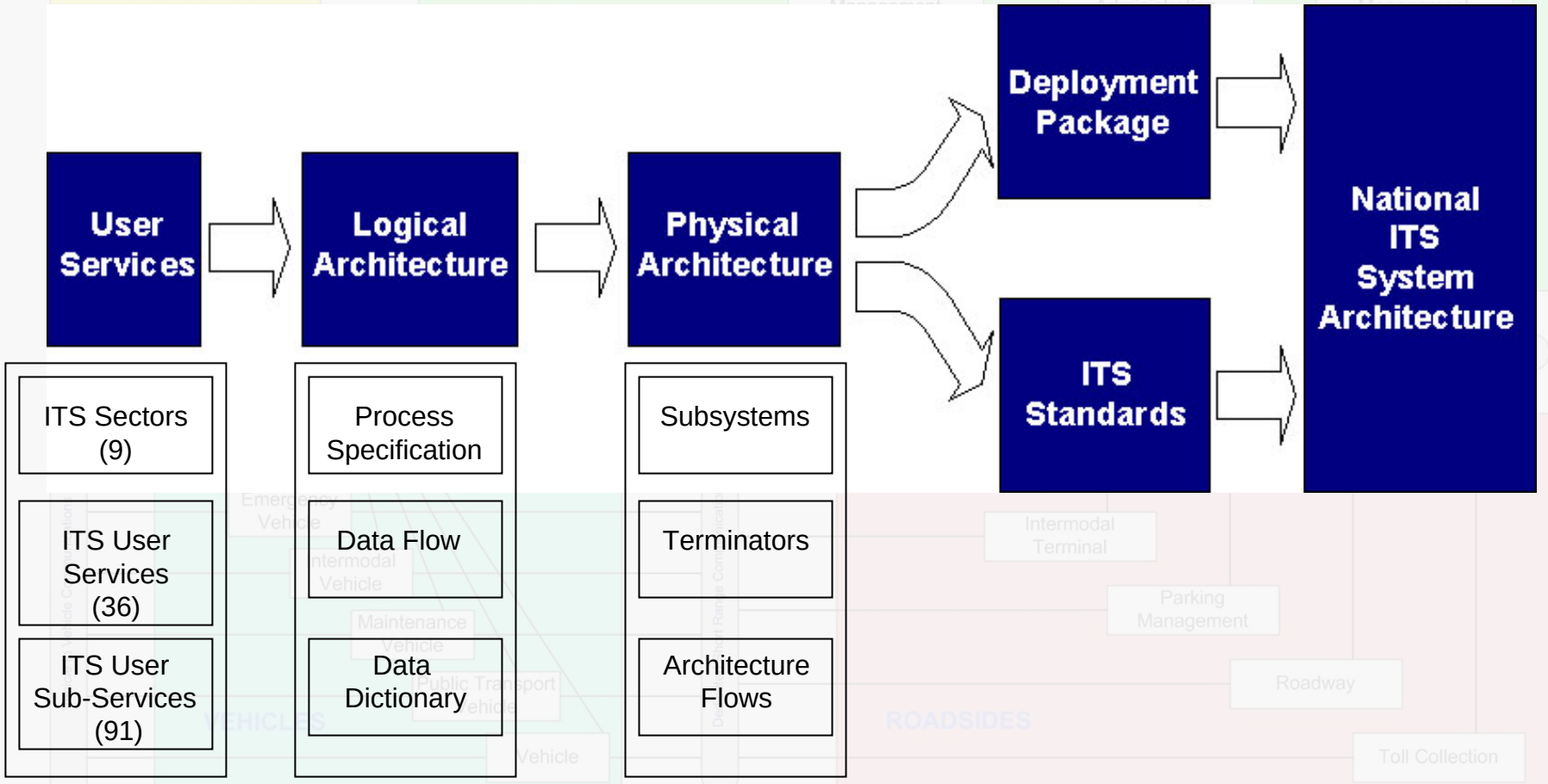
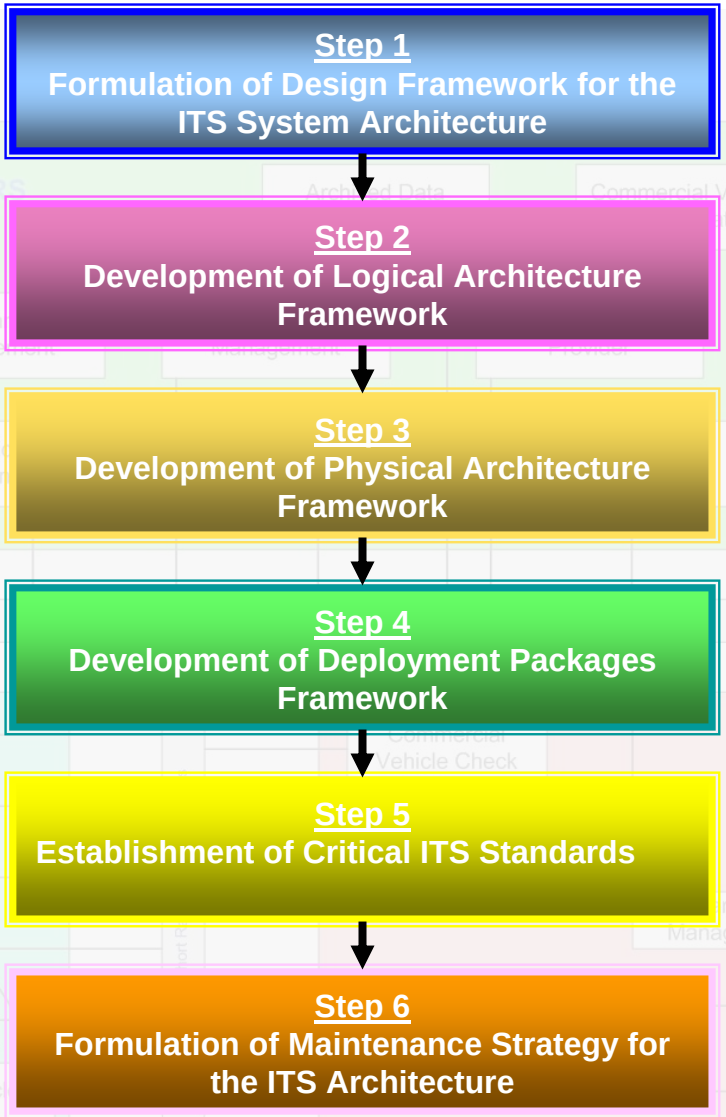
Establishing ITS System Architecture for Malaysia



The Development of ITS System Architecture

Development Steps



Formulation Of Design Framework for the ITS System Architecture

Step 1.1
Review of International Design Approach

- Review design approach for ITS SA in North America Europe, Japan, Australia and Taiwan.
- 2 basic design methodologies for ITS SA; Function based and Data based

Step 1.2
Formulation of Design Framework

Consideration for formulating Design Framework:

- Conditions affecting design under local environment or situation
- Technology available under short and long term scenarios in the local industry.
- The Information obtained from previous stakeholders workshop will be used.

The Development of ITS System Architecture

What does the ITS Architecture for Malaysia Consist of ?

User Services (User Service Requirements)

Requirements
e.g. Incident Management

ITS Architecture for Malaysia

Logical Architecture

WHAT functions?
e.g. Detect Incident, Verify Incident

WHERE are the functions?
e.g. Traffic Mgmt. Centre

Physical Architecture

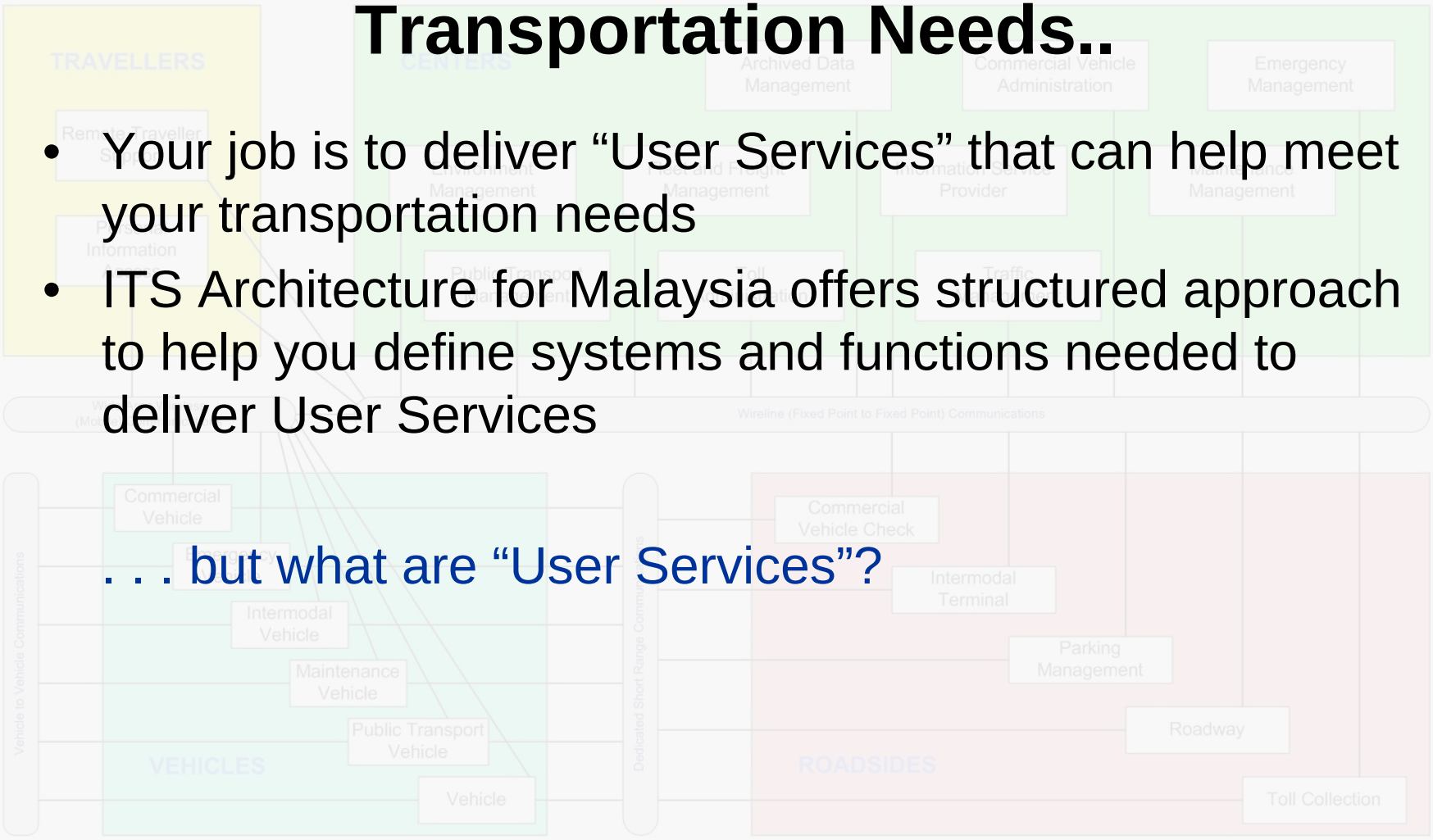
Deployment Packages

The Development of ITS System Architecture

Your Mission is to Satisfy Your Transportation Needs..

- Your job is to deliver “User Services” that can help meet your transportation needs
- ITS Architecture for Malaysia offers structured approach to help you define systems and functions needed to deliver User Services

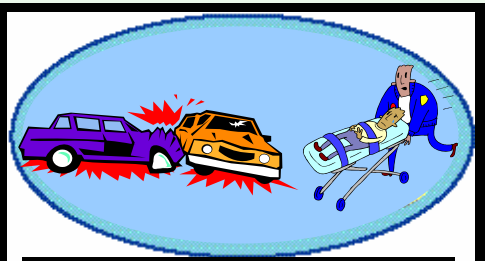
. . . but what are “User Services”?



The Development of ITS System Architecture

Transportation User Services Fall into Nine ITS Sectors

Traffic Management



Safety Systems

Public Transport

Traveller Information

Electronic Payment

Commercial Vehicle Operations

Advanced Vehicle Control

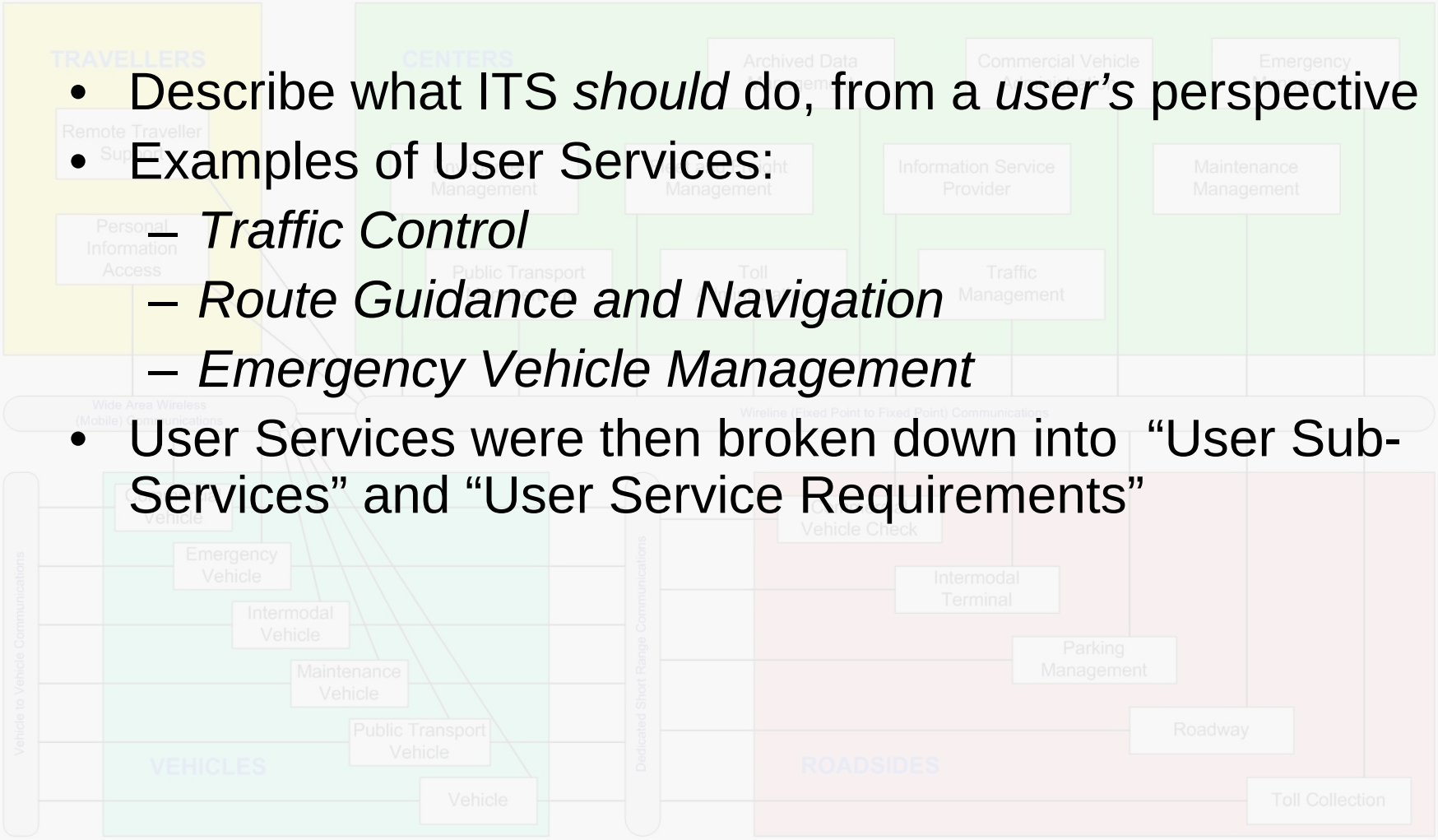
Emergency Management

Information Warehousing

The Development of ITS System Architecture

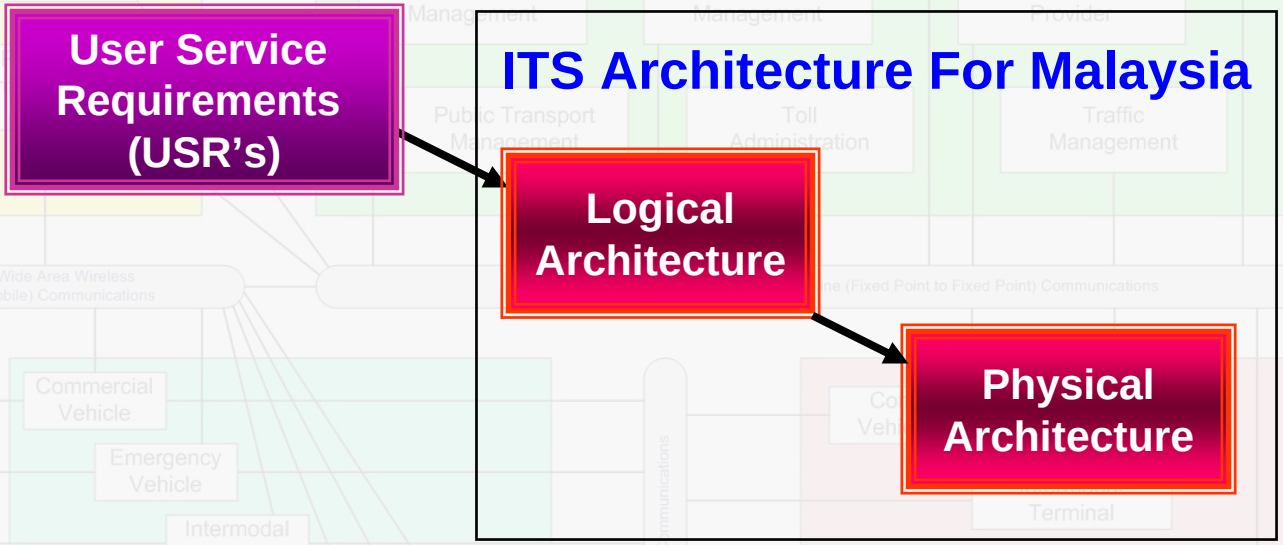
But what are User Services?

- Describe what ITS *should* do, from a *user's* perspective
- Examples of User Services:
  - *Traffic Control*
  - *Route Guidance and Navigation*
  - *Emergency Vehicle Management*
- User Services were then broken down into "User Sub-Services" and "User Service Requirements"



The Development of ITS System Architecture

USR's are Inputs to the ITS Architecture for Malaysia

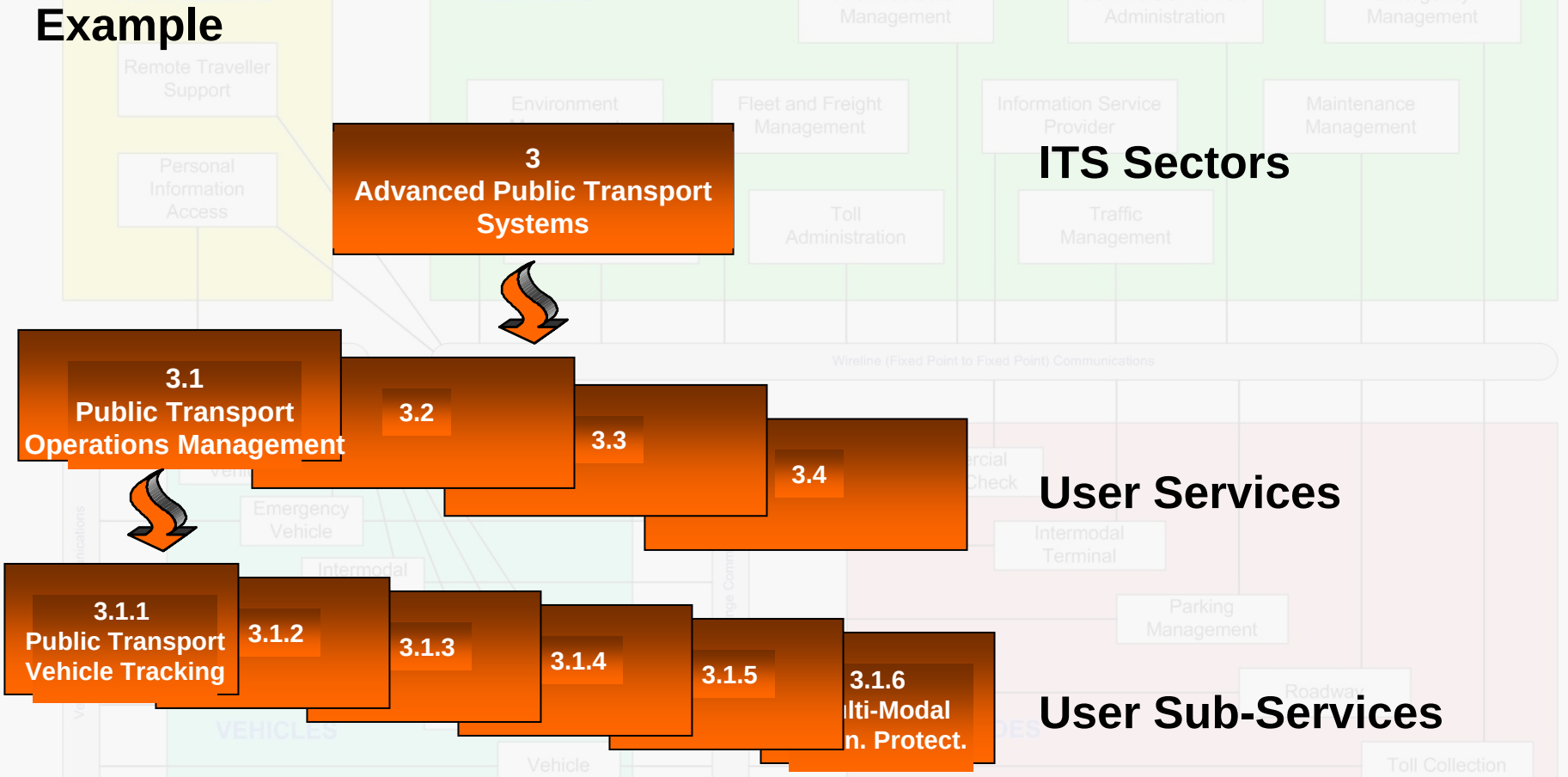


User Sub-Services

- Developed to allow the direct definition of the Architecture in support of the User Services
- Level of detail consistent with the Deployment Package definitions
- Examples of User Sub-Services
  - *Probe-Based Flow Monitoring*
  - *Dynamic Route Guidance*
  - *Emergency Vehicle Routing*

The Development of ITS System Architecture

User Service Hierarchy



The Development of ITS System Architecture

ITS Sectors
(from ITS Master Plan)

1. Advanced Traffic Management Systems
2. Safety Systems
3. Advanced Public Transport Systems
4. Advanced Traveller Information Systems
5. Electronic Payment Systems
6. Commercial Vehicle Operations Systems
7. Advanced Vehicle Control and Safety Systems
8. Emergency Management Systems
9. Information Warehousing Systems

The Development of ITS System Architecture

ITS USER SERVICES

ITS Sector	User-Services		
ITS Sector No.1: Advanced Traffic Management Systems	1	1.1	Urban Traffic Control
	2	1.2	Incident Detection and Management
	3	1.3	Travel Demand Management
	4	1.4	Environmental Conditions Management
	5	1.5	Operations and Maintenance
	6	1.6	Non-Vehicular Road User Safety
	7	1.7	Multi-Modal Junction Safety and Control
ITS Sector No.2: Safety Systems	8	2.1	Improved Accident Data Collection
	9	2.2	Automated Dynamic Warning and Enforcement
ITS Sector No.3: Advanced Public Transport Systems	10	3.1	Public Transport Operations Management
	11	3.2	Public Transport En-Route Information
	12	3.3	Demand Responsive Transport Systems
	13	3.4	Public Travel Security
ITS Sector No.4: Advanced Traveller Information Systems	14	4.1	Pre-Trip Traveller Information
	15	4.2	Route Guidance and Navigation
	16	4.3	Ride Matching and Reservation
	17	4.4	Traveller Services and Reservations
ITS Sector No.5: Electronic Payment Systems	18	5.1	Electronic Payment Services
ITS Sector No.6: Commercial Vehicle Operations Systems	19	6.1	Commercial Fleet Management
	20	6.2	Commercial Freight Management
	21	6.3	Commercial Vehicle Electronic Clearance
	22	6.4	Automated Roadside Safety Inspection
	23	6.5	On-board Safety Monitoring
	24	6.6	Commercial Vehicle Administrative Processes
ITS Sector No.7: Advanced Vehicle Control and Safety Systems	25	7.1	Vehicle-Based Collision Avoidance
	26	7.2	Infrastructure-Based Collision Avoidance
	27	7.3	Sensor-Based Driving Safety Enhancement
	28	7.4	Safety Readiness
	29	7.5	Pre-Collision Restraint Deployment
	30	7.6	Automated Vehicle Operation
ITS Sector No.8: Emergency Management Systems	31	8.1	Emergency Notification and Personal Security
	32	8.2	Hazardous Material Incident Response
	33	8.3	Disaster Response and Management
	34	8.4	Emergency Vehicle Management
ITS Sector No.9: Information Warehousing Systems	35	9.1	Weather and Environmental Data Management
	36	9.2	Archived Data Management

The Development of ITS System Architecture

USER SUB-SERVICES

ITS Sector	User-Services			User Sub-Services		
ITS Sector No.1: Advanced Traffic Management Systems	1	1.1	Urban Traffic Control	1	1.1.1	Traffic Network Flow Monitoring
				2	1.1.2	Surface Street Control
				3	1.1.3	Highway Control
				4	1.1.4	Regional Traffic Control
				5	1.1.5	Traffic Information Dissemination
				6	1.1.6	Virtual TMC
				7	1.1.7	Probe-Based Flow Monitoring
				8	1.1.8	Traffic Estimation and Prediction
	2	1.2	Incident Detection and Management	9	1.2.1	Incident Management Co-ordination
				10	1.2.2	Incident Prediction System
	3	1.3	Travel Demand Management	11	1.3.1	High Occupancy Vehicle Lane Management
				12	1.3.2	Reversible Lane Management
				13	1.3.3	Predictive Demand Management
	4	1.4	Environmental Conditions Management	14	1.4.1	Roadway Environmental Sensing
				15	1.4.2	Emissions Management
				16	1.4.3	Road Weather Information System
				17	1.4.4	Vehicle-Based Sensing
	5	1.5	Operations and Maintenance	18	1.5.1	Infrastructure Maintenance Management
				19	1.5.2	Smart Work Zones
	6	1.6	Non-Vehicular Road User Safety	20	1.6.1	Mixed Use Warning Systems
				21	1.6.2	Automated Non-Vehicular Road User Protection
	7	1.7	Multi-Modal Junction Safety and Control	22	1.7.1	Basic At-Grade Crossing Control
				23	1.7.2	Advanced At-Grade Crossing
				24	1.7.3	Modal Operations Co-ordination
ITS Sector 2: Safety Systems	8	2.1	Improved Accident Data Collection	25	2.1.1	Accident Data Management
	9	2.2	Automated Dynamic Warning and Enforcement	26	2.2.1	Dynamic Roadway Warning
				27	2.2.2	Variable Speed Limit and Enforcement
				28	2.2.3	Signal Enforcement

The Development of ITS System Architecture

USER SUB-SERVICES

ITS Sector	User-Services			User Sub-Services		
ITS Sector No.3: Advanced Public Transport Systems	10	3.1	Public Transport Operations Management	29	3.1.1	Transit Vehicle Tracking
				30	3.1.2	Transit Fixed-Route Operations
				31	3.1.3	Passenger and Fare Management
				32	3.1.4	Transit Maintenance
				33	3.1.5	Multi-Modal Co-ordination
				34	3.1.6	Multi-Modal Connection Protection
	11	3.2	Public Transport En-Route Information	35	3.2.1	En-Route Transit Information
	12	3.3	Demand Responsive Transport Systems	36	3.3.1	Demand Responsive Transport Systems
	13	3.4	Public Travel Security	37	3.4.1	Public Travel Security
ITS Sector No.4: Advanced Traveller Information Systems	14	4.1	Pre-Trip Traveller Information	38	4.1.1	Broadcast Traveller Information
				39	4.1.2	Interactive Traveller Information
				40	4.1.3	Real-Time Ridesharing Information
	15	4.2	Route Guidance and Navigation	41	4.2.1	Autonomous Route Guidance
				42	4.2.2	Dynamic Route Guidance
				43	4.2.3	ISP-Based Route Guidance
				44	4.2.4	Traffic Estimation and Prediction
				45	4.2.5	In-Vehicle Signing
	16	4.3	Ride Matching and Reservation	46	4.3.1	Ride Matching
				47	4.3.2	Real-Time Ride Matching
	17	4.4	Traveller Services and Reservations	48	4.4.1	Traveller Yellow Pages
				49	4.4.2	Services Purchases and Reservations
				50	4.4.3	Parking Facility Management
				51	4.4.4	Regional Parking Management
ITS Sector No.5: Electronic Payment Systems	18	5.1	Electronic Payment Services	52	5.1.1	Electronic Toll Collection
				53	5.1.2	Electronic Parking Payment
				54	5.1.3	Transit Services Payment
				55	5.1.4	Traveller Services Payment

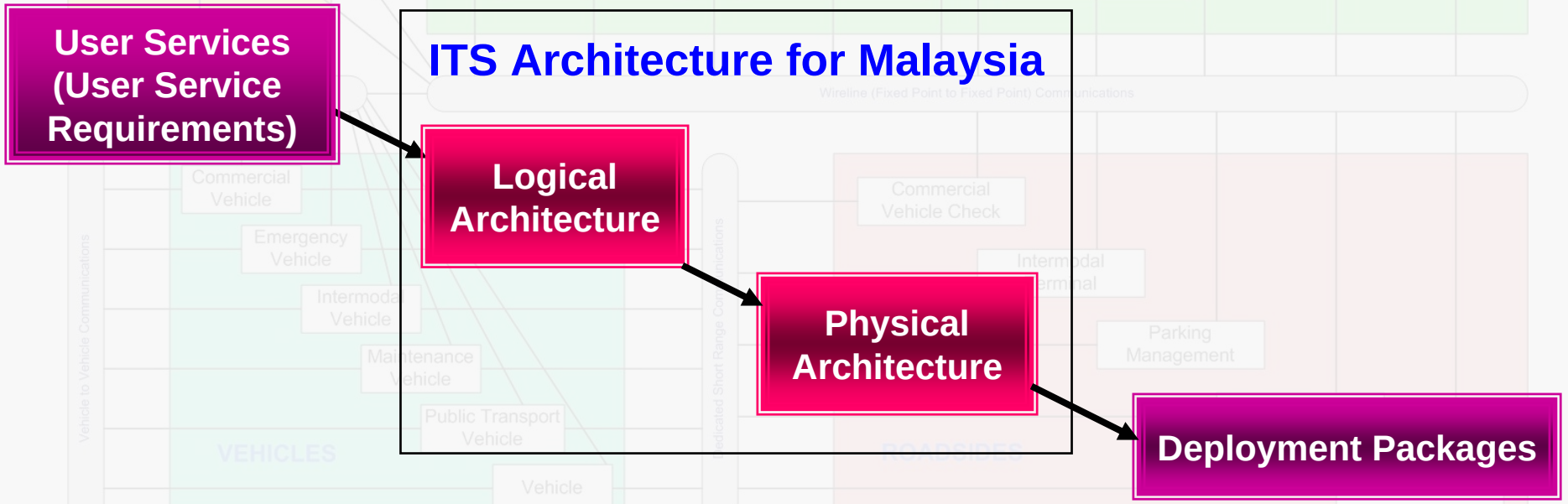
The Development of ITS System Architecture

USER SUB-SERVICES

ITS Sector	User-Services			User Sub-Services		
ITS Sector No.6: Commercial Vehicle Operations Systems	19	6.1	Commercial Fleet Management	56	6.1.1	Fleet Administration
				57	6.1.2	Freight Administration
				58	6.1.3	CVO Fleet Maintenance.
	20	6.2	Commercial Freight Management	59	6.2.1	Freight In-Transit Monitoring
				60	6.2.2	Intermodal Interface Management
	21	6.3	Commercial Vehicle Electronic Clearance	61	6.3.1	Electronic Clearance
				62	6.3.2	International Border Crossing Clearance
				63	6.3.3	Weigh-In-Motion (WIM)
	22	6.4	Automated Roadside Safety Inspection	64	6.4.1	Inspection Support Systems
				65	6.4.2	Automated Vehicle Safety Read Out
	23	6.5	On-board Safety Monitoring	66	6.5.1	On-Board Safety Monitoring
	24	6.6	Commercial Vehicle Administrative Proces	67	6.6.1	Commercial Vehicle Administrative Processes
ITS Sector No.7: Advanced Vehicle Control and Safety Systems	25	7.1	Vehicle-Based Collision Avoidance	68	7.1.1	Lateral Warning Systems
				69	7.1.2	Lateral Collision Avoidance
				70	7.1.3	Longitudinal Warning Systems
				71	7.1.4	Longitudinal Collision Avoidance
	26	7.2	Infrastructure-Based Collision Avoidance	72	7.2.1	Intersection Collision Warning
				73	7.2.2	Intersection Collision Avoidance
	27	7.3	Sensor-Based Driving Safety Enhancemen	74	7.3.1	Sensor-based Driving Safety Enhancement
	28	7.4	Safety Readiness	75	7.4.1	Vehicle Safety Monitoring
				76	7.4.2	Driver Safety Monitoring
	29	7.5	Pre-Collision Restraint Deployment	77	7.5.1	Pre-Collision Restraint Deployment
	30	7.6	Automated Vehicle Operation	78	7.6.1	Automated Vehicle Operation
ITS Sector No.8: Emergency Management Systems	31	8.1	Emergency Notification and Personal Security	79	8.1.1	Personal Security
				80	8.1.2	MAYDAY Support
	32	8.2	Hazardous Material Incident Response	81	8.2.1	Hazardous Material Planning Incident Response
	33	8.3	Disaster Response and Management	82	8.3.1	Disaster Command and Control
				83	8.3.2	Disaster Information Dissemination
	34	8.4	Emergency Vehicle Management	84	8.4.1	Emergency Response Management
				85	8.4.2	Emergency Vehicle Routing
ITS Sector No.9: Information Warehousing Systems	35	9.1	Weather and Environmental Data Manager	86	9.1.1	Roadway and Weather Data Fusion
				87	9.1.2	Environmental Information Dissemination
				88	9.1.3	Roadway Meso and Micro Prediction
	36	9.2	Archived Data Management	89	9.2.1	Archived Data Mart
				90	9.2.2	Archived Data Warehouse
				91	9.2.3	Archived Data Virtual Warehouse

Logical Architecture

- Defines the Functions or Processes needed to deliver User Services
- Defines the Information or Data Flows that are shared between the Processes



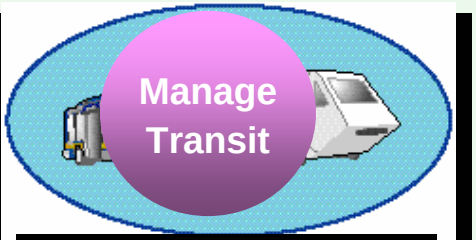
The Development of ITS System Architecture

Logical Architecture

(Defines the Functions or Processes needed to deliver User Services)

Traffic Management

Safety Systems



Public Transport

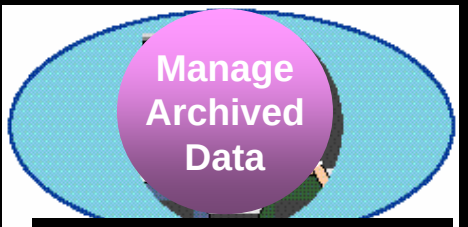
Traveller Information

Electronic Payment

Commercial Vehicle Operations

Advanced Vehicle Control

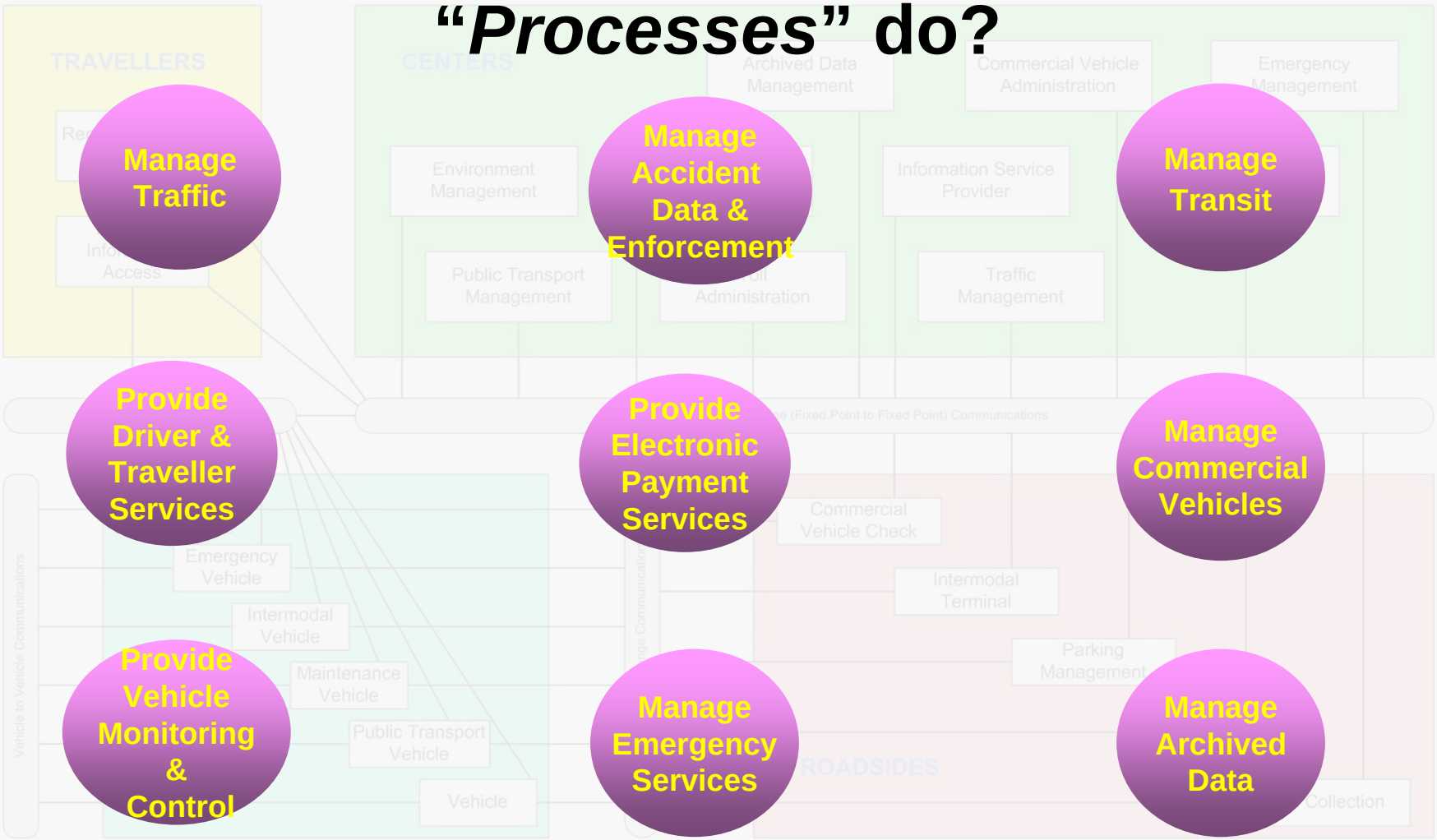
Emergency Management



Information Warehousing

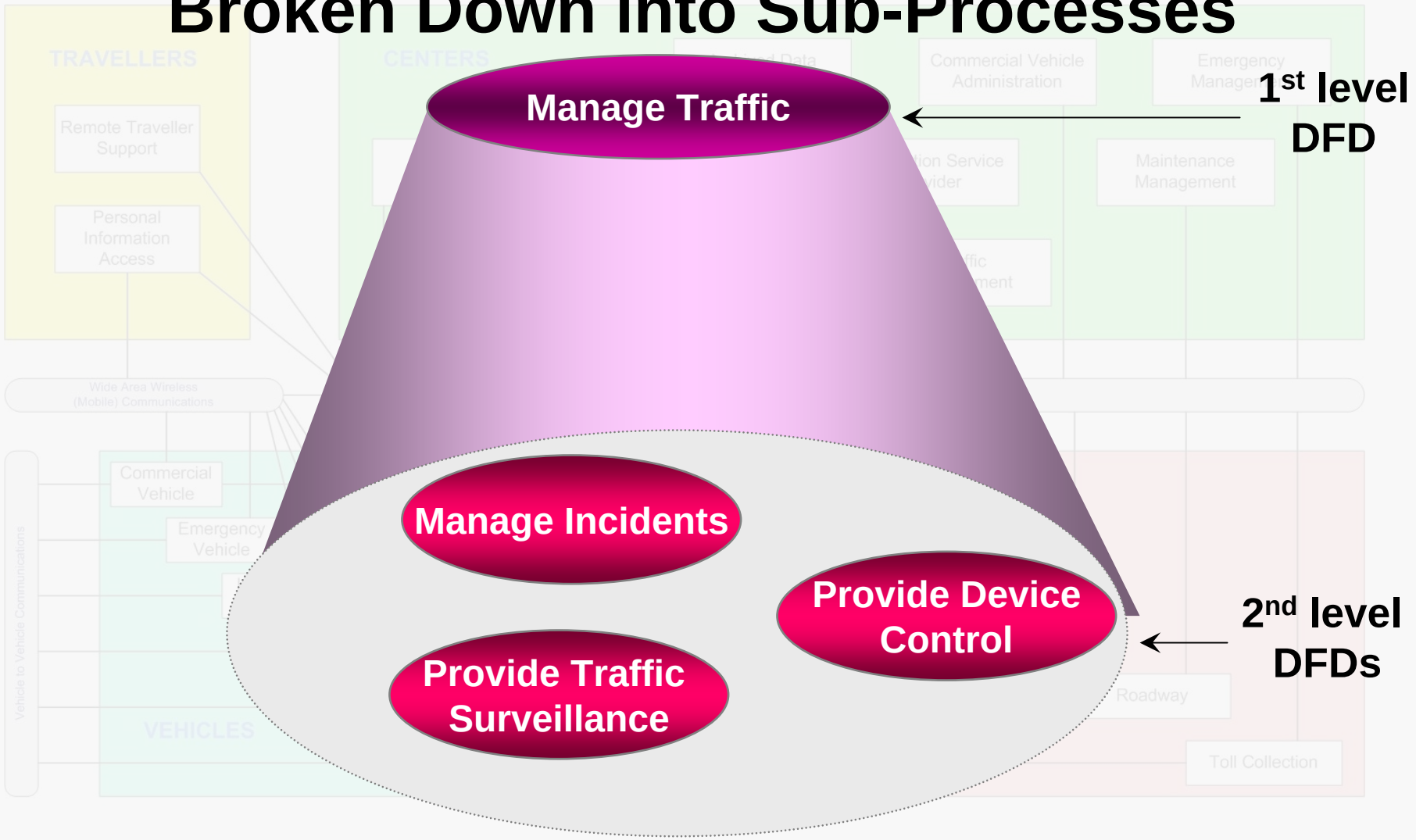
The Development of ITS System Architecture

Logical Architecture - W**hat do these "*Processes*" do?**

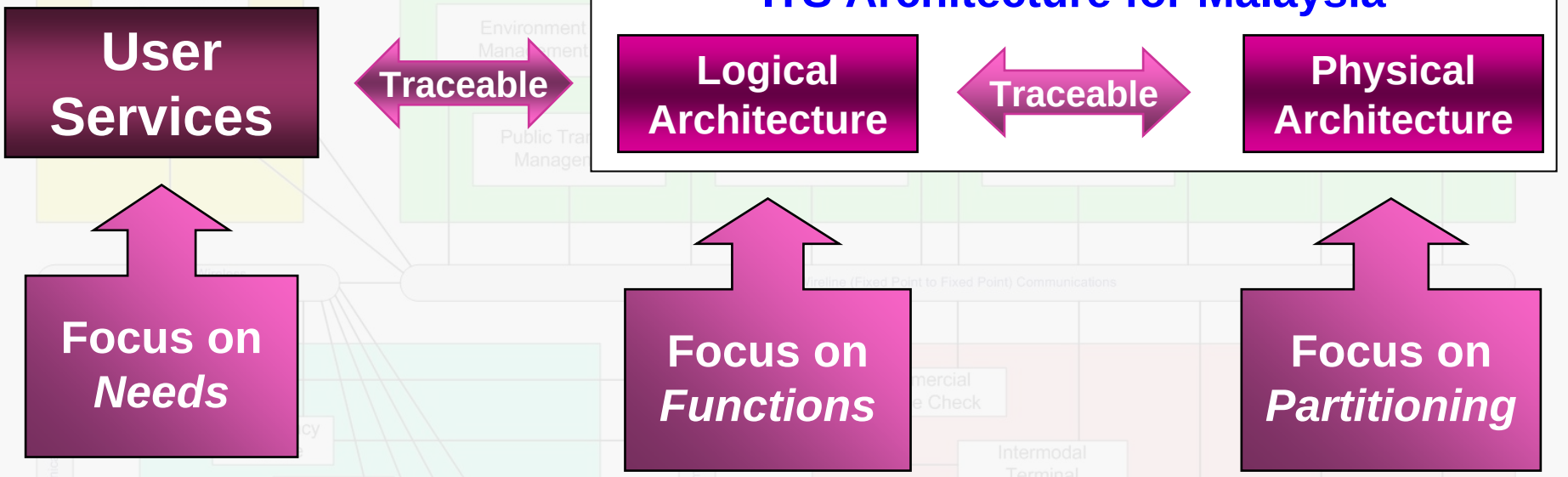


The Development of ITS System Architecture

Logical Architecture - **Processes can be Broken Down into Sub-Processes**



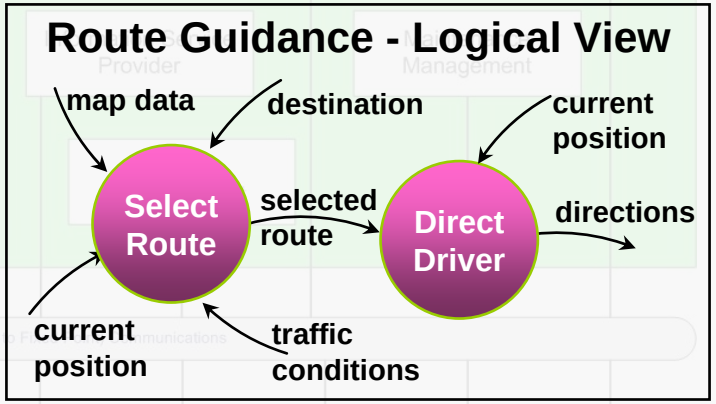
Logical Architecture- **Focus and Relationships**

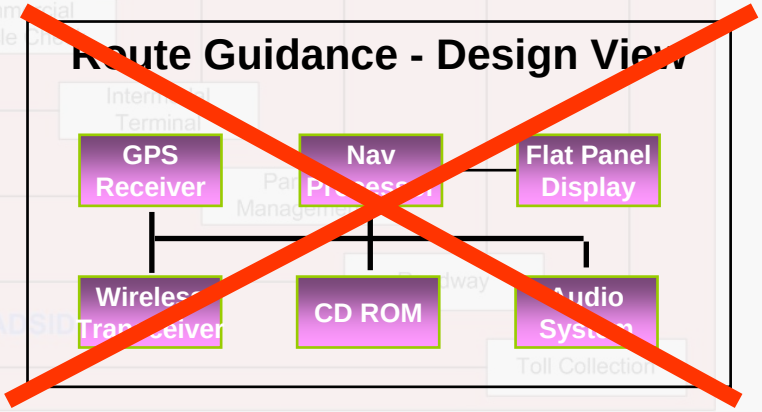


- Covers all User Services
- Technology independence
- Tool for controlled change

Logical Architecture - **Defines Functions and Relationships**

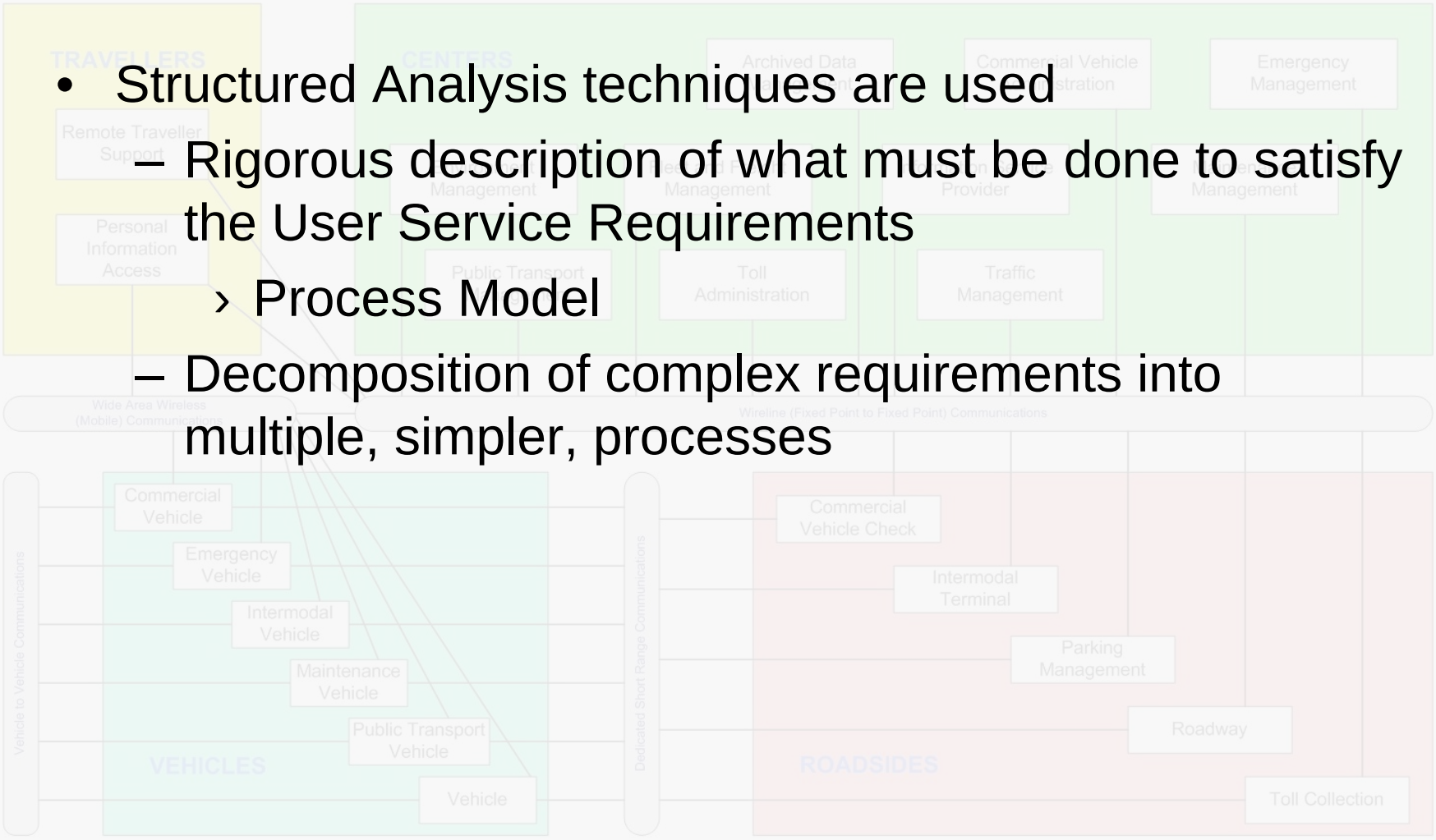
- A Logical Architecture defines:
  - The Architecture *boundary*
  - The *functions* to be performed (circles)
  - The *data* that flows between functions (arrows)
- It does NOT define:
  - *Where* the functions are performed
  - *How* the functions are implemented





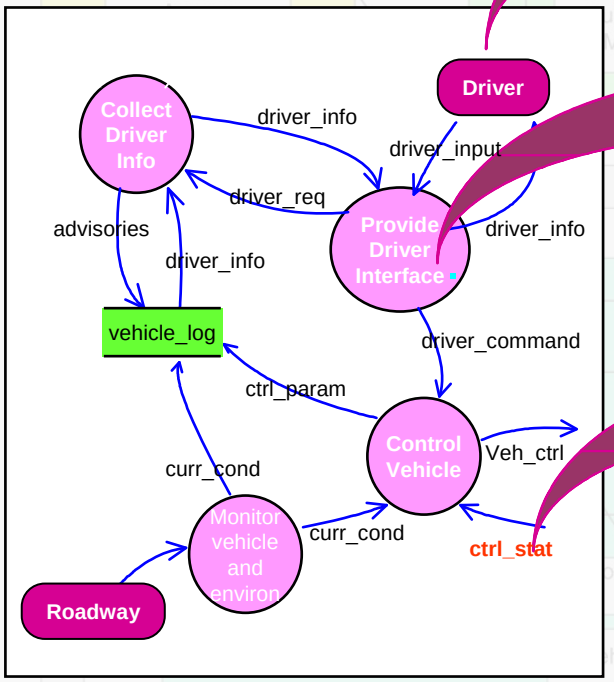
The Development of ITS System Architecture

- Structured Analysis techniques are used
  - Rigorous description of what must be done to satisfy the User Service Requirements
    - › Process Model
  - Decomposition of complex requirements into multiple, simpler, processes



Logical Architecture Elements

Data Flow Diagrams



Symbol Definitions

Terminator Name

Identifies the external entities the system must support

Process Name

Represents the function performed by the system

data name

ws name and direction of information flow between processes

data store name

Indicates a data repository within the system

Process Specifications

Process Name:
Input Flows:
Output Flows:
Description:

User Service Requirements:
Dynamics Assumptions:

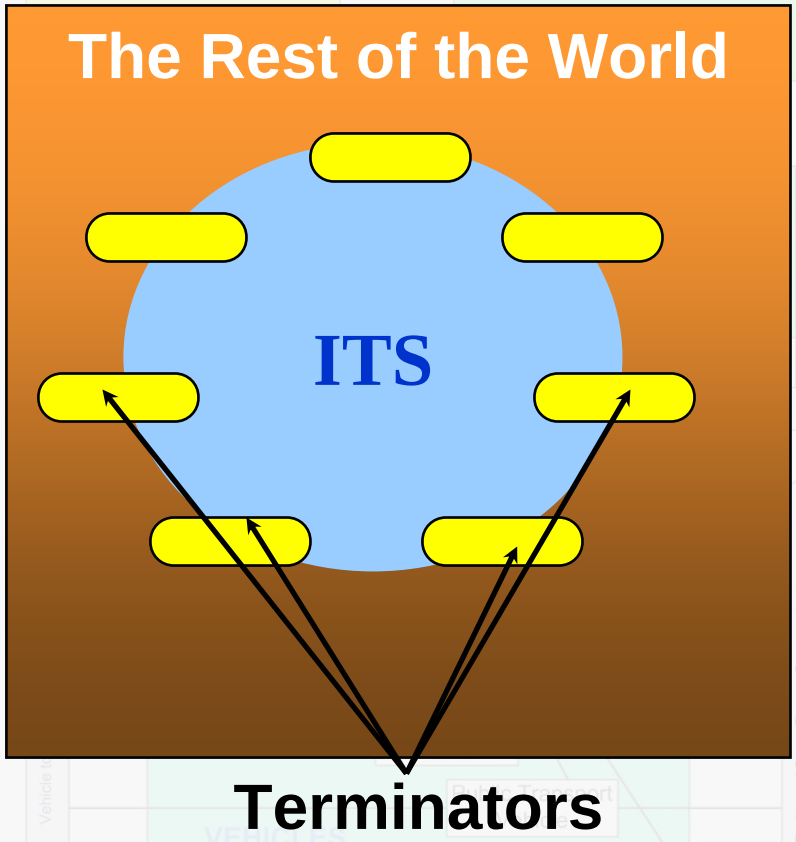
Data Dictionary

Name

Definition
Description

Sizing Assumptions

Logical Architecture Terminators



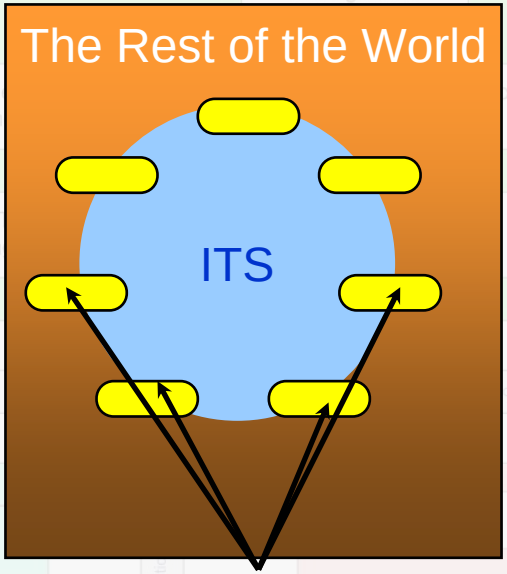
- Terminators defines the Architecture Boundary in the Real World
- No functional requirements are allocated to terminators.
- The Terminators represent:
  - Environment
  - Humans
  - Systems
  - Other Systems

  that interface to ITS

Types of Terminators

Environment

7 Terminators:
- Environment
- Roadway
- Etc.

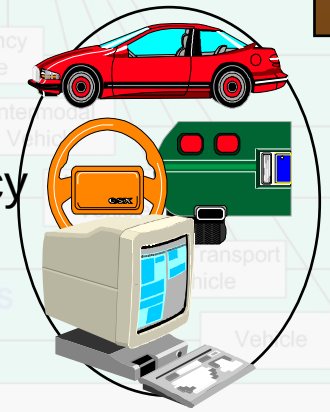


Humans

22 Terminators:
- Driver
- Traveller
- Maint Vehicle Driver
- Etc.

Systems

32 Terminators:
- Customs Agency
- Financial Inst.
- Etc.



Other Systems

10 Terminators:
- Other Vehicle
- Other Traffic Mgt
- Etc.

ITS Architecture for Malaysia Terminators

SYSTEMS
- Archived Data User Systems
- Basic Vehicle
- Commercial Vehicle
- Customs Agency
- CVO Information Requestor
- Department of Motor Vehicles
- Disaster Command Authority
- Distribution & Logistics Management Provider
- Emergency Telecommunications System
- Enforcement Agency
- Event Promoters
- Financial Institution
- Freight Consolidation Station
- Government Administrators
- Government Reporting Systems
- Intermodal Chassis
- Location Data Source
- Maintenance Vehicle
- Map Update Provider
- Media
- Medical Facility
- Meteorological Service Provider
- Multimodal Crossings
- Multimodal Transportation Service Provider
- National Meteorological Service
- Other Data Sources

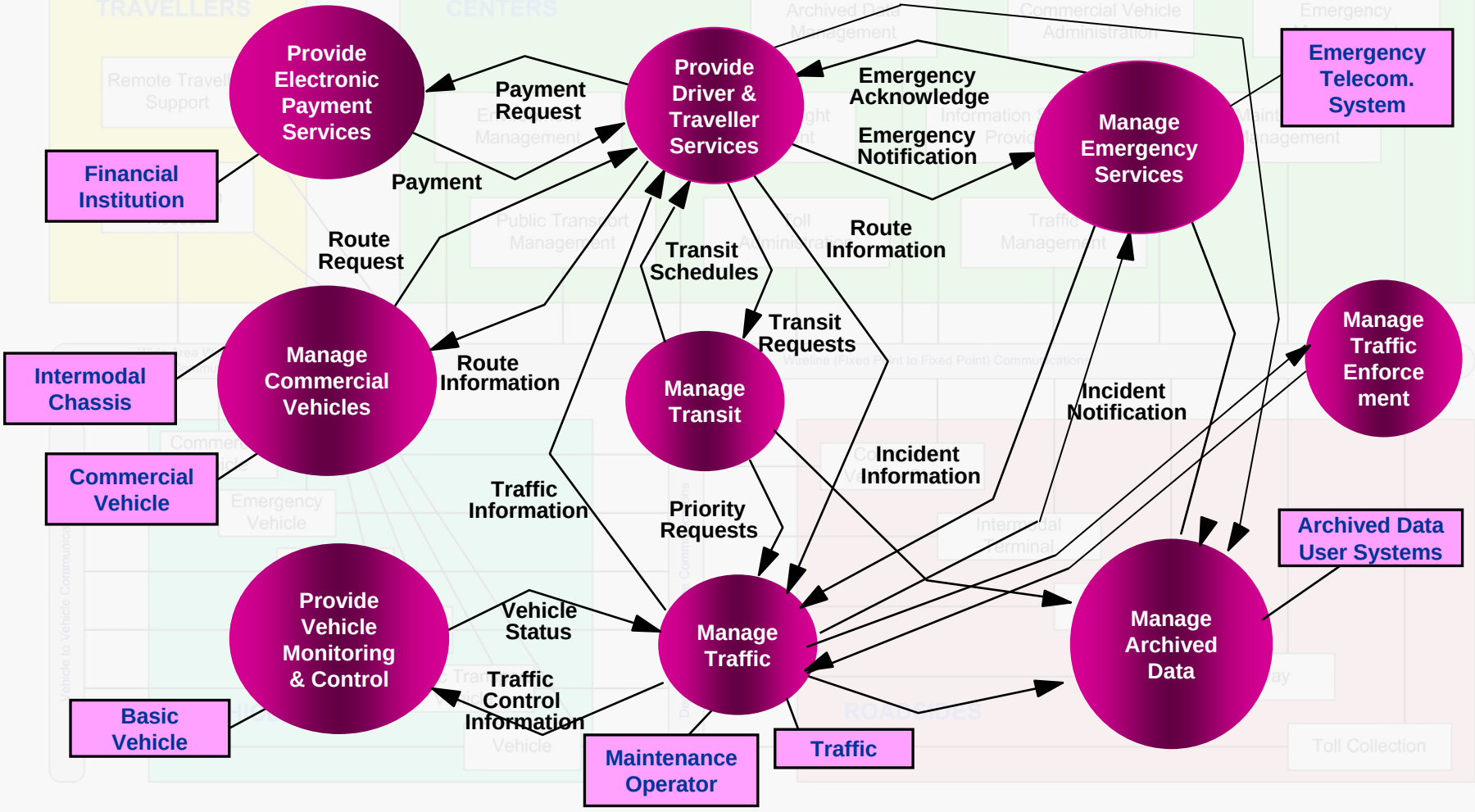
SYSTEMS (Cont.)
- Payment Instrument
- Rail Operations
- Railside Equipment
- Transit Vehicle
- Yellow Pages Service Providers

OTHER SYSTEMS
- Other Archives
- Other CVAS
- Other EM
- Other ISP
- Other Intermodal Fleet Management System
- Other Parking
- Other Roadside
- Other TM
- Other TRM
- Other Vehicle

ENVIRONMENT
- Environment
- Potential Obstacles
- Roadway
- Roadway Environment
- Secure Area Environment
- Traffic
- Vehicle Characteristics

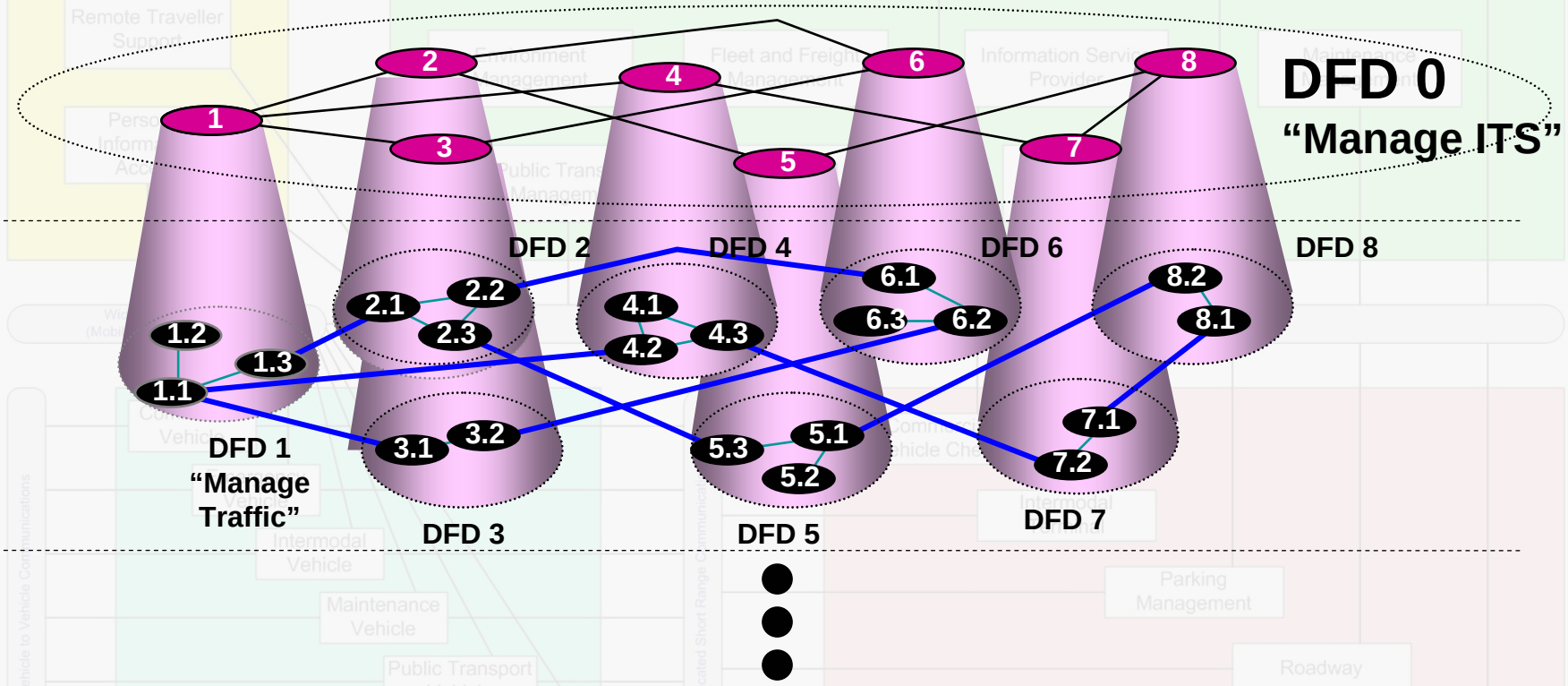
HUMAN
- Archived Data Administrator
- Commercial Vehicle Driver
- Commercial Vehicle Manager
- CVO Inspector
- Driver
- Emergency Personnel
- Emergency System Operator
- Intermodal Customer
- Intermodal Terminal Operator
- ISP Operator
- Maintenance Operator
- Maintenance Vehicle Driver
- Parking Operator
- Pedestrians
- Toll Administrator
- Toll Operator
- Traffic Operations Personnel
- Transit Driver
- Transit Fleet Manager
- Transit Maintenance Personnel
- Transit System Operators
- Transit User
- Traveller

Simplified Top-Level Data Flow Diagram (DFD)



The Development of ITS System Architecture

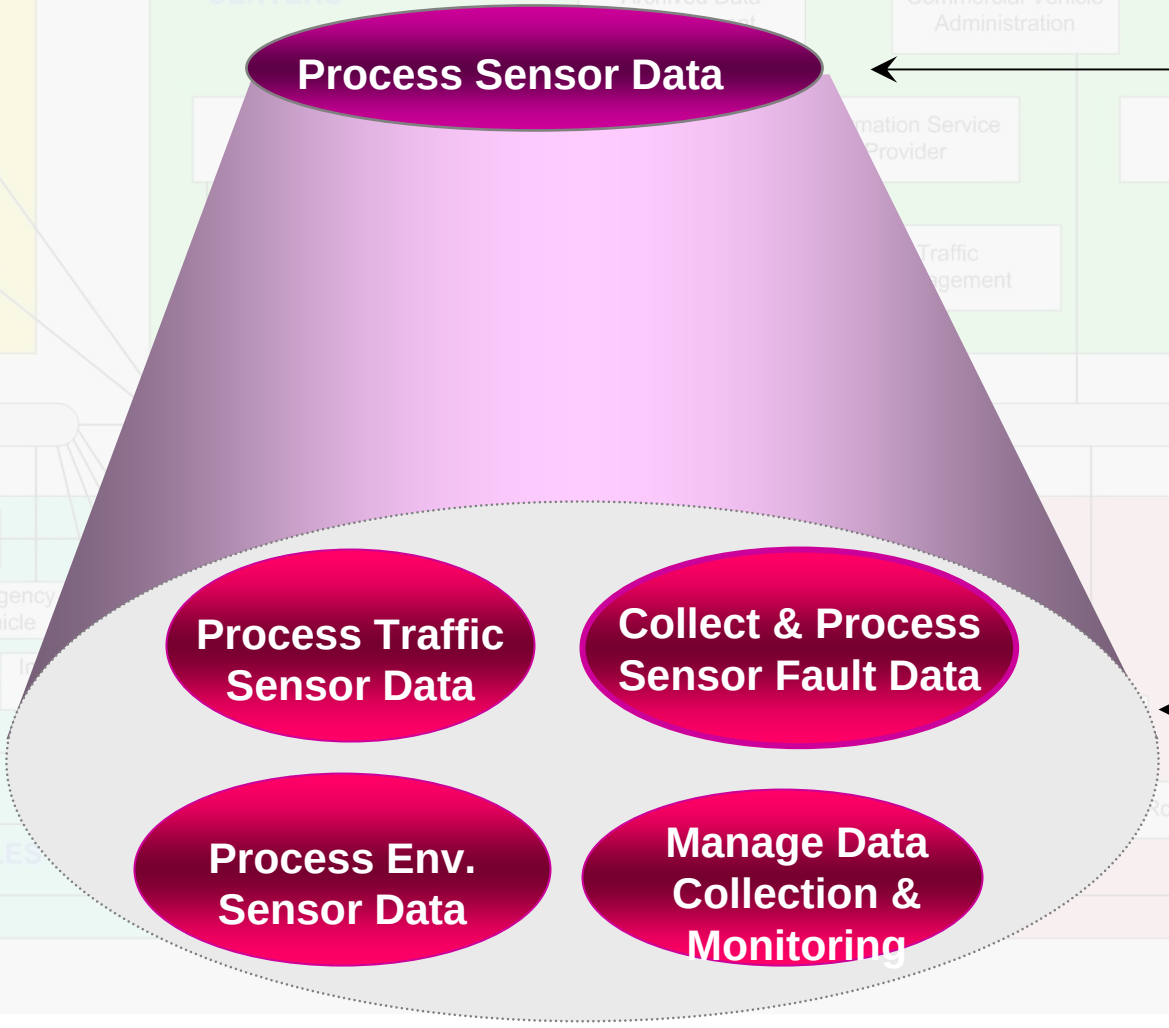
Multi-Layer Logical Architecture Definition



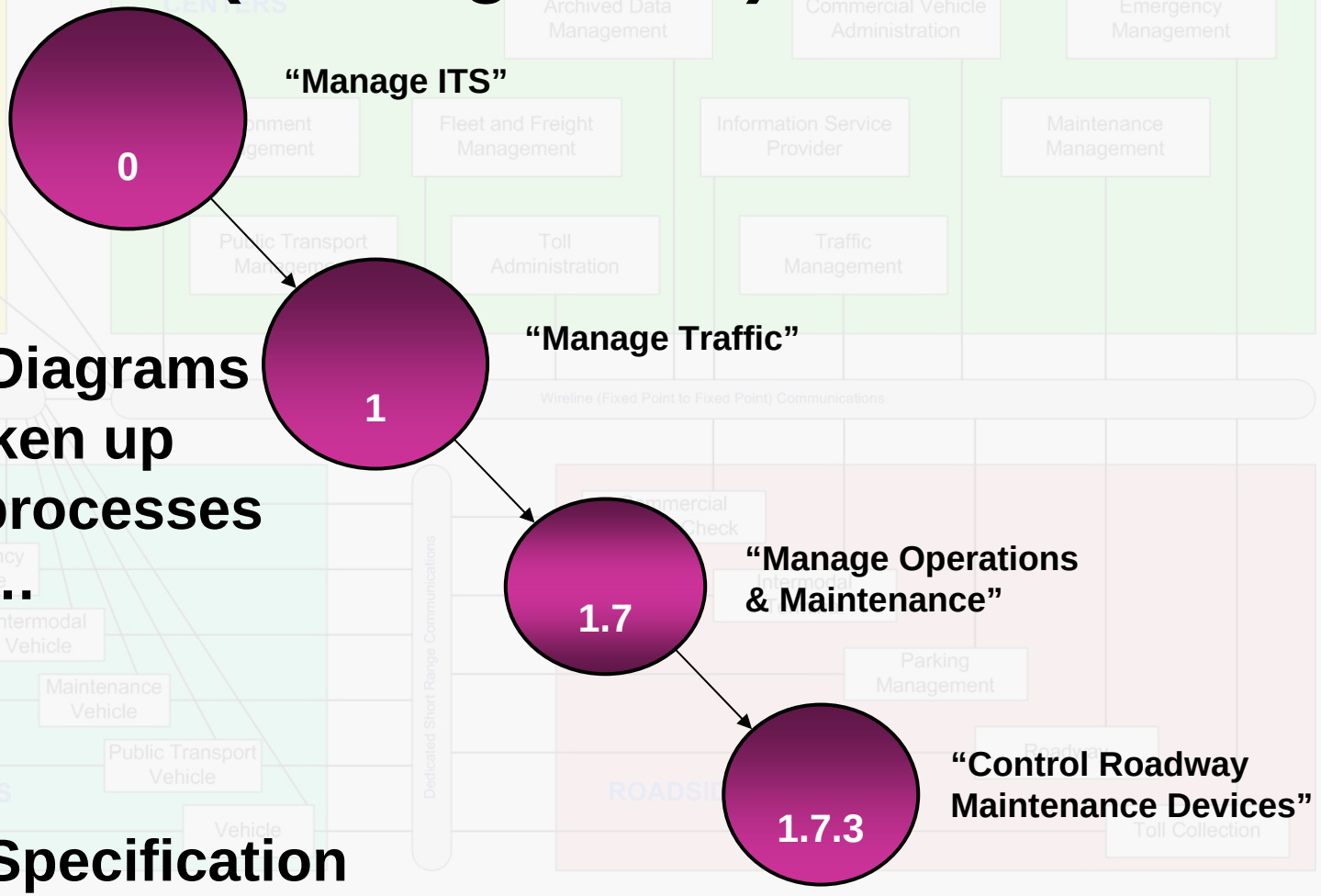
Definition continues through successively lower levels of functional detail

The Development of ITS System Architecture

Logical Architecture – **Further break down of Sub-Processes into "Process Specifications"**



Process Decomposition (Drilling Down)



Data Flow Diagrams can be broken up into more processes down to a …

…

…

…

a Process Specification

Process Specification Structure

1.7.3 Control Roadway Maintenance Devices

Description:

Overview: This process is controlling assets located at or alongside the roadway that can be used to monitor and control traffic around work zones. This process takes in traffic and environmental data from the field and based on inputs from the Schedule Maintenance Activity function sends control data out to the traffic devices in the field. This process can send traveler information via dynamic message signs or highway advisory radios. This process sends updated information regarding the roadway assets being used to the Manage Assets process.

In Subsystem: **Maintenance Management**

In Market Package: **ATMS25**

Data Flows:

Input Flows

environmental_maintenance_status
information_device_fault_status
maintenance_activity_device_control
traffic_control_device_status
traffic_sensor_maintenance_data
traffic_sensor_maintenance_status

Output Flows

highway_device_control_for_maintenance
highway_information_maintenance_data
road_device_control_for_maintenance
road_information_maintenance_data
roadway_asset_status
roadway_maintenance_activity_data
surveillance_control_data_for_maintenance

We will focus on this next

User Service Requirements Mapped to PSpec:

USR = C2.5.2.1;
USR = C2.5.2.2;
USR = C2.5.2.3;
USR = C2.5.2.5;
USR = C2.5.2.6;

Description:

- Overview: This process is controlling assets located at or alongside the roadway that can be used to monitor and control traffic around work zones. This process takes in traffic and environmental data from the field and based on inputs from the Schedule Maintenance Activity function sends control data out to the traffic devices in the field. This process can send traveller information via dynamic message signs or highway advisory radios. This process sends updated information regarding the roadway assets being used to the Manage Assets process.

Select (Click on) Output flow

'highway_information_maintenance_data'

⊗

Data Flow Hierarchy

highway_information_maintenance_data

This data flow from the Control Roadway Maintenance Devices function contains the data to be used alongside freeways for highway advisory radio, dynamic message signs or other means of information dissemination to travellers around a work zone. It consists of the following items each of which is defined in its own DDE:

dms_data_for_highways
+ har_data_for_highways.

har_data_for_highways

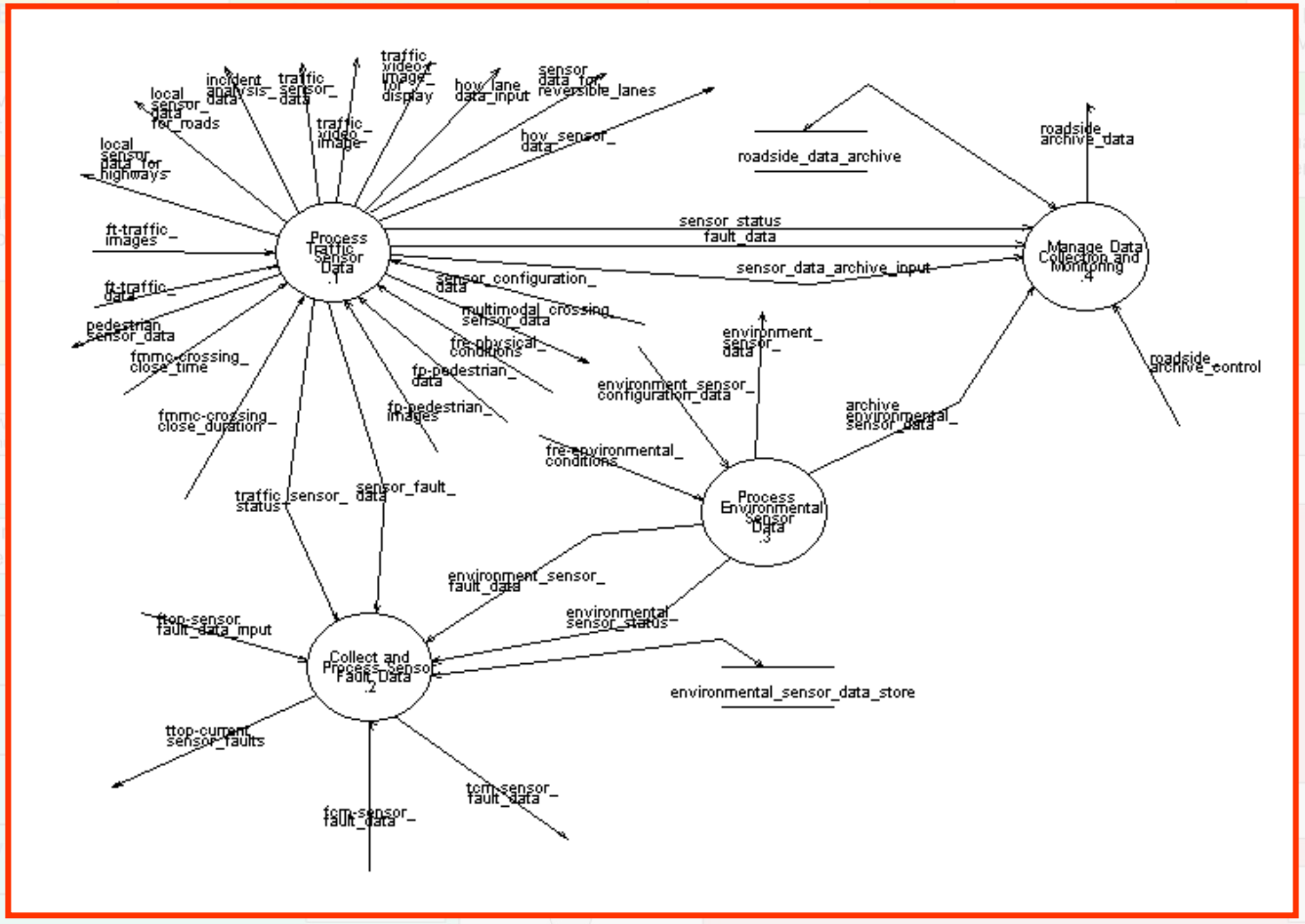
This data flow contains the HAR data, both program and management, used to define the output of a Highway Advisory Radio (HAR) operating at the roadside on highways in the geographic and/or jurisdictional area(s) served by the function. It consists of the following data items each of which is defined in its own DDE:

har_identity
+ har_program
+ har_management_data.

...ETC.

Logical Architecture

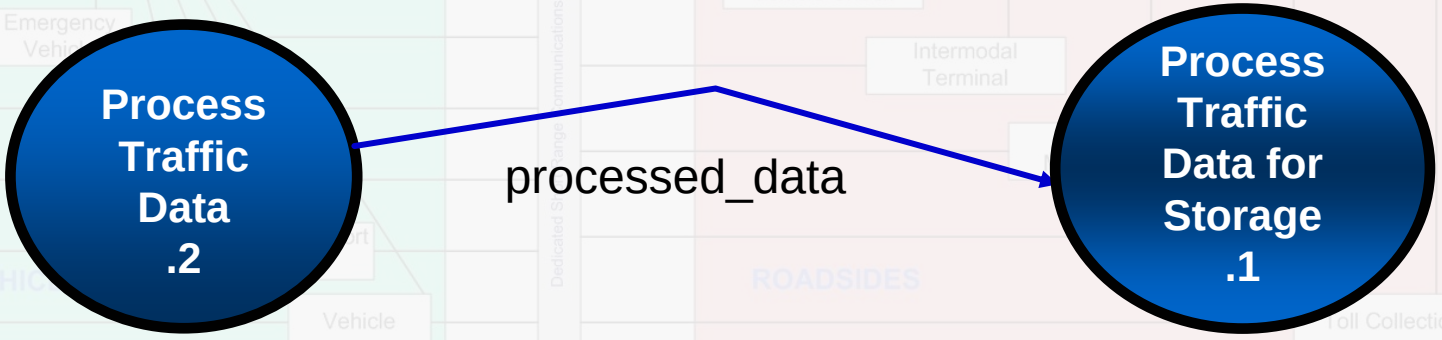
Sample DFD – Process Sensor Data



DFD 1.1.1 – Process Sensor Data

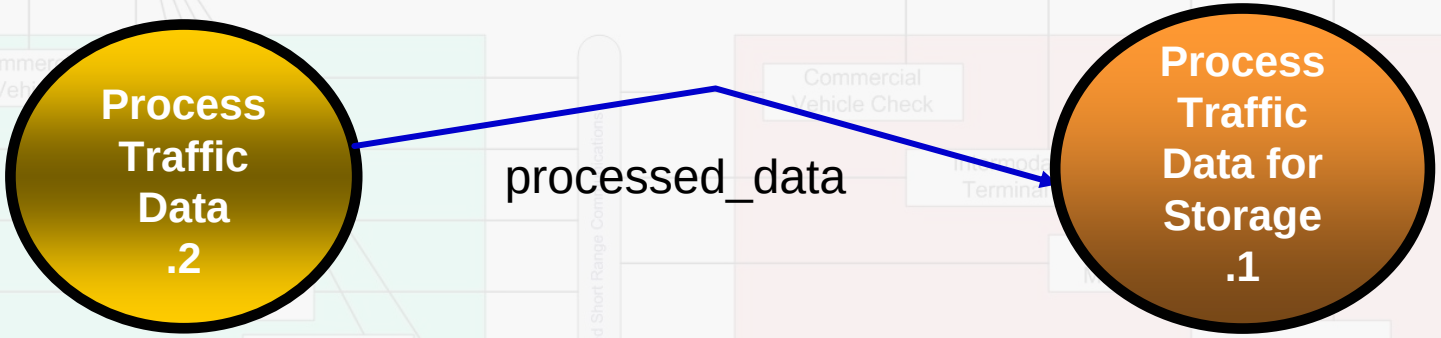
Summary: Concepts to Remember

- Process
  - Defines a function (e.g. Provide Traffic Control)
  - Graphically expressed as a “bubble”
- Process Specification (PSpec)
  - Textual definition of function Process performs



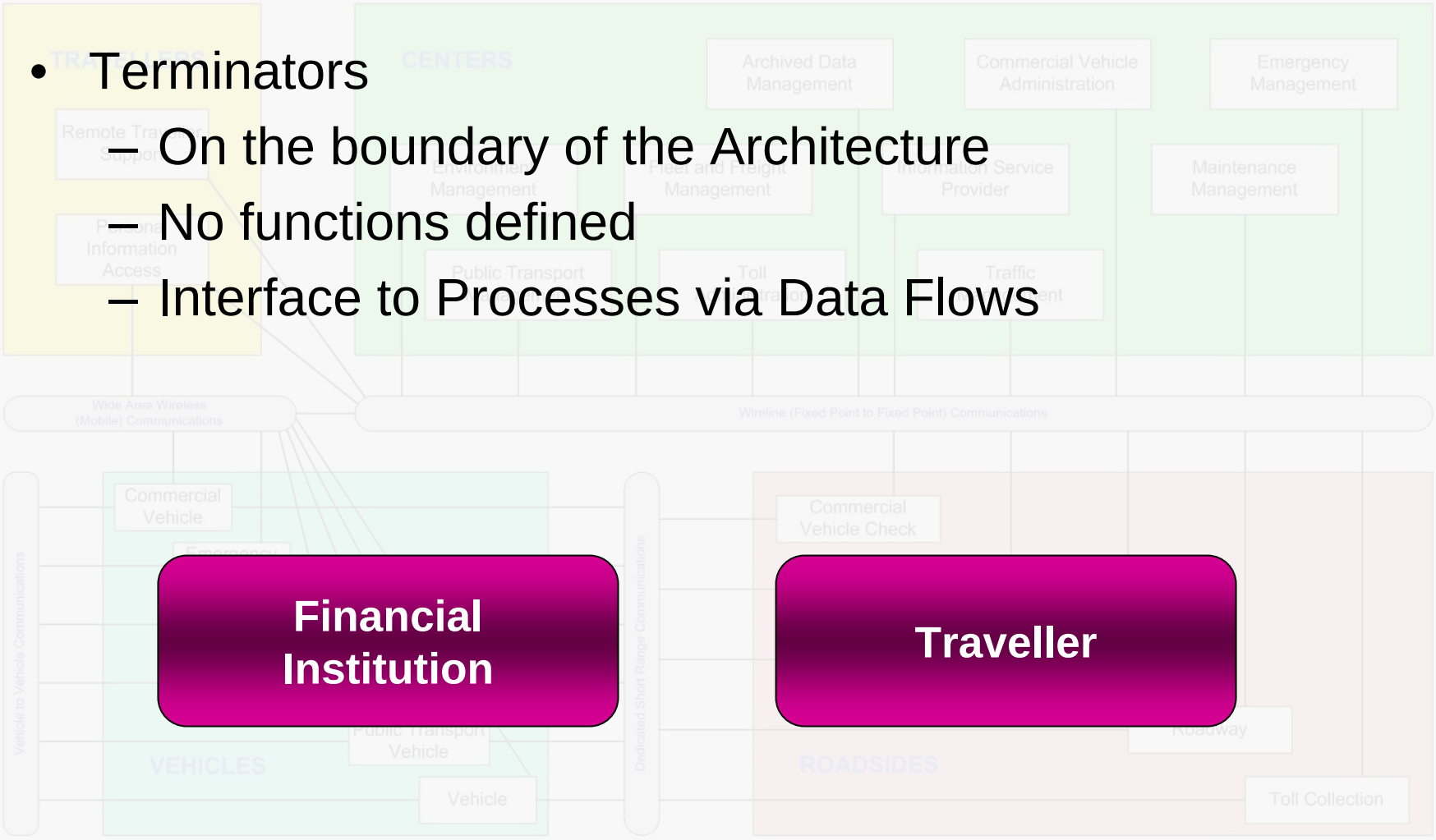
Concepts to Remember (2)

- Data Flow
  - Defines exchange of information between processes (e.g. incident_video_image)



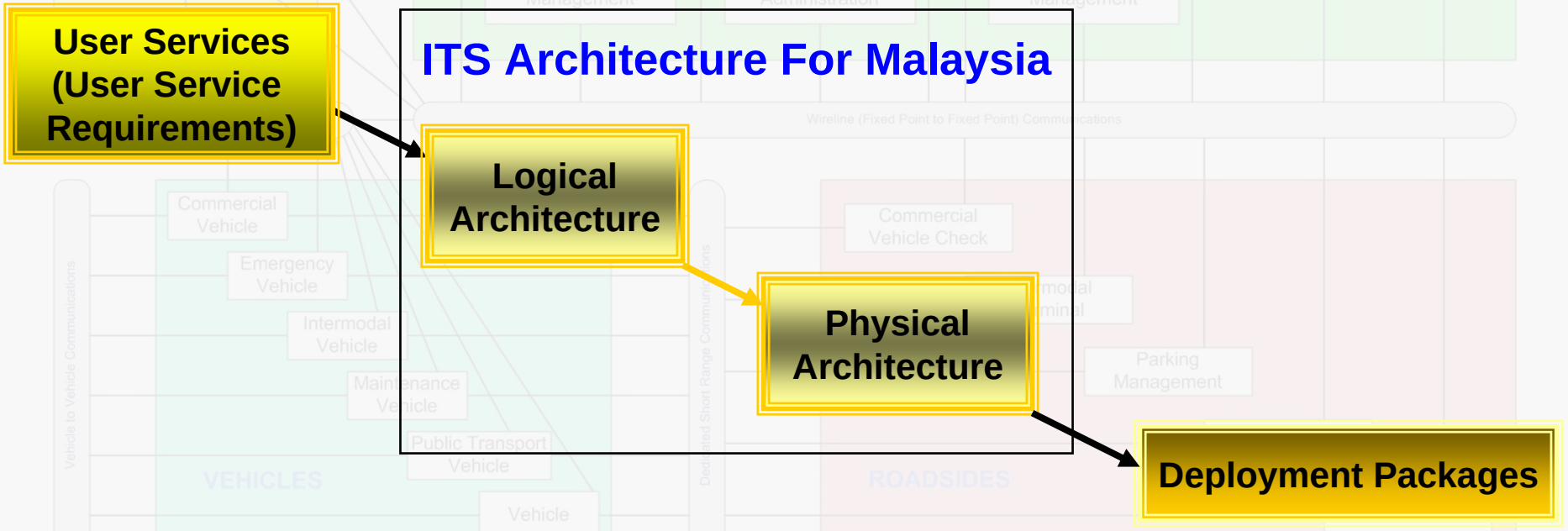
Concepts to Remember (3)

- Terminators
  - On the boundary of the Architecture
  - No functions defined
  - Interface to Processes via Data Flows



Physical Architecture

- Defines where Functions are performed - "Subsystems" & "Terminators"
- Defines the Interconnections



The Development of ITS System Architecture

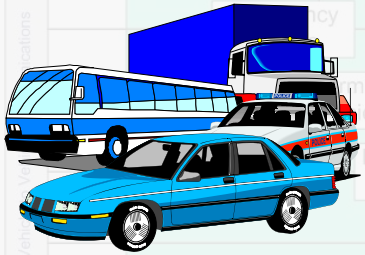
Physical Architecture

Travellers

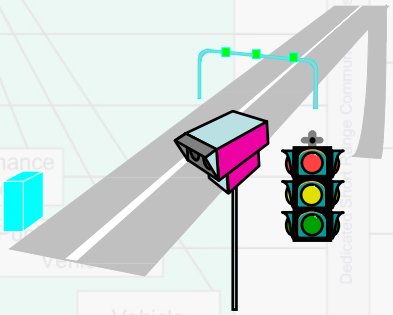
Centres

- *Subsystems*
  - 4 Classes: Centres, Roadside, Vehicle, and Traveller Subsystems
  - Inside system boundary

Vehicles

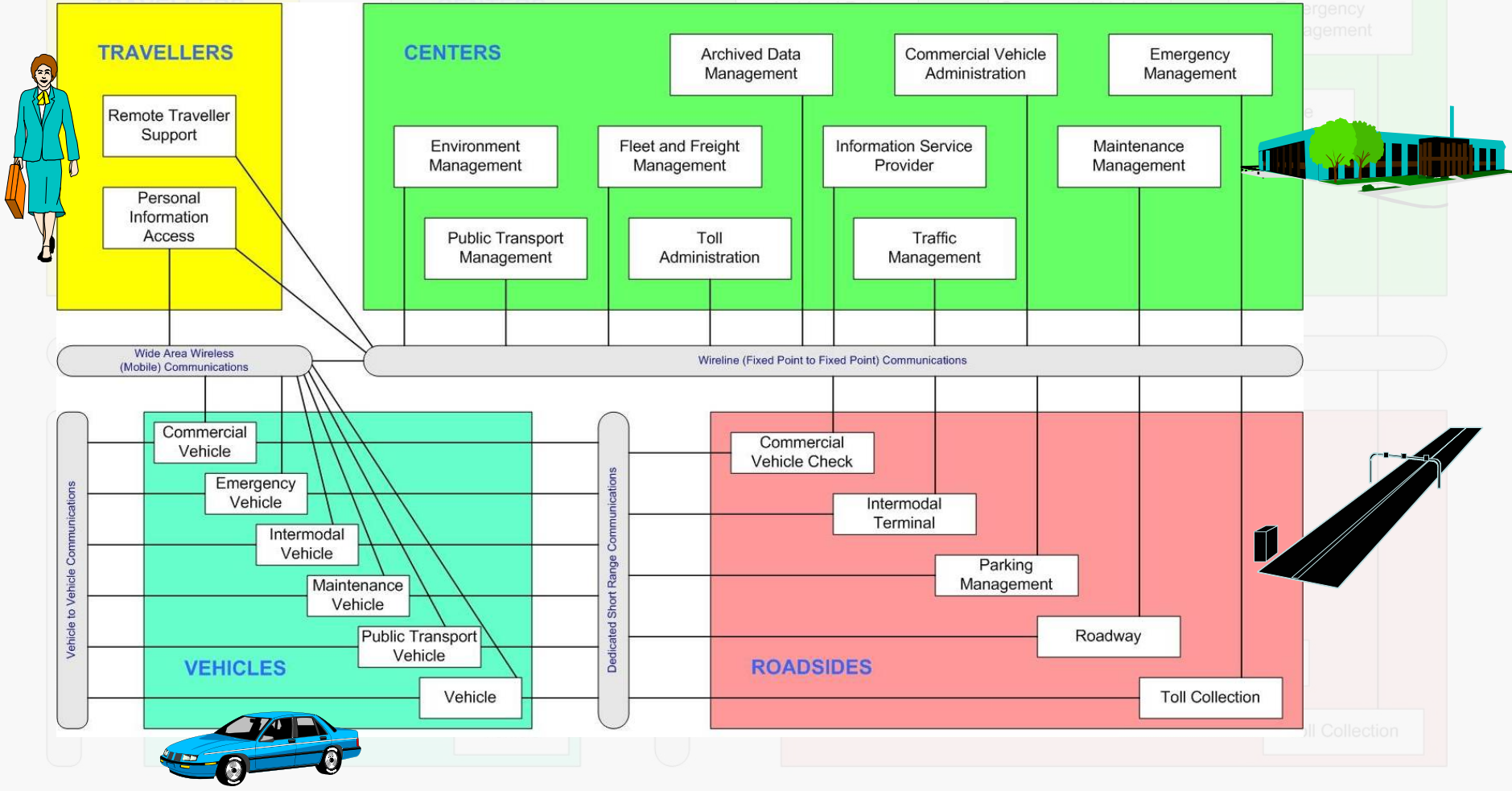


Roadside



- *Terminators*
  - Define system boundary
  - Same Terminators as in Logical Architecture

Physical Architecture – Subsystems



Subsystems

- Provide management, administration and support functions
- Co-ordinate with other Centre Subsystems
  - Between modes
  - Across jurisdictions
- Communicate with Wayside, Vehicle, and Traveller Subsystems

Centres

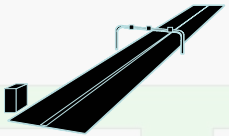
- Archived Data Management Subsystem
- Commercial Vehicle Administration Subsystem
- Emergency Management Subsystem
- Environment Management Subsystem
- Fleet and Freight Management Subsystem
- Information Service Provider Subsystem
- Maintenance Management Subsystem
- Toll Administration Subsystem
- Traffic Management Subsystem
- Public Transport Management Subsystem

Traffic Management Subsystem (TMS)

- Monitor and Manage Traffic Flow
  - Highway Management and Traffic Signal Control
  - Incident Detection and Verification
  - Traffic Information Dissemination
    - Variable Message Signs, Media (Electronic)
  - Traffic Surveillance Strategies
    - Loops, Automated Vehicle Location
  - Control Automated Highway System Traffic and Vehicle Control Devices
  - Demand Management policies
    - High Occupancy Vehicle Lanes, Road Pricing
- TMC Co-ordination
  - Other Traffic Management Centers, Emergency Management Centers, Maintenance Management Centers, Toll and Parking Operators

The Development of ITS System Architecture

Subsystems



- Intelligent infrastructure distributed on or along the transportation network
- Perform surveillance, execute control plans, and supply information
- Operation governed by corresponding centres
- Direct interface to vehicles

Roadside

- Commercial Vehicle Check Subsystem
- Intermodal Terminal Subsystem
- Parking Management Subsystem
- Roadway Subsystem
- Toll Collection Subsystem

The Development of ITS System Architecture

- Equipment used by travellers to access ITS services
  - Pre-trip and en-route
- PIAS represents “Personal” devices (e.g. PC’s, PDA)
- RTS represents “Public” devices (e.g. kiosks)

Travellers

- Personal Information Access Subsystem
- Remote Traveller Support Subsystem

Subsystems

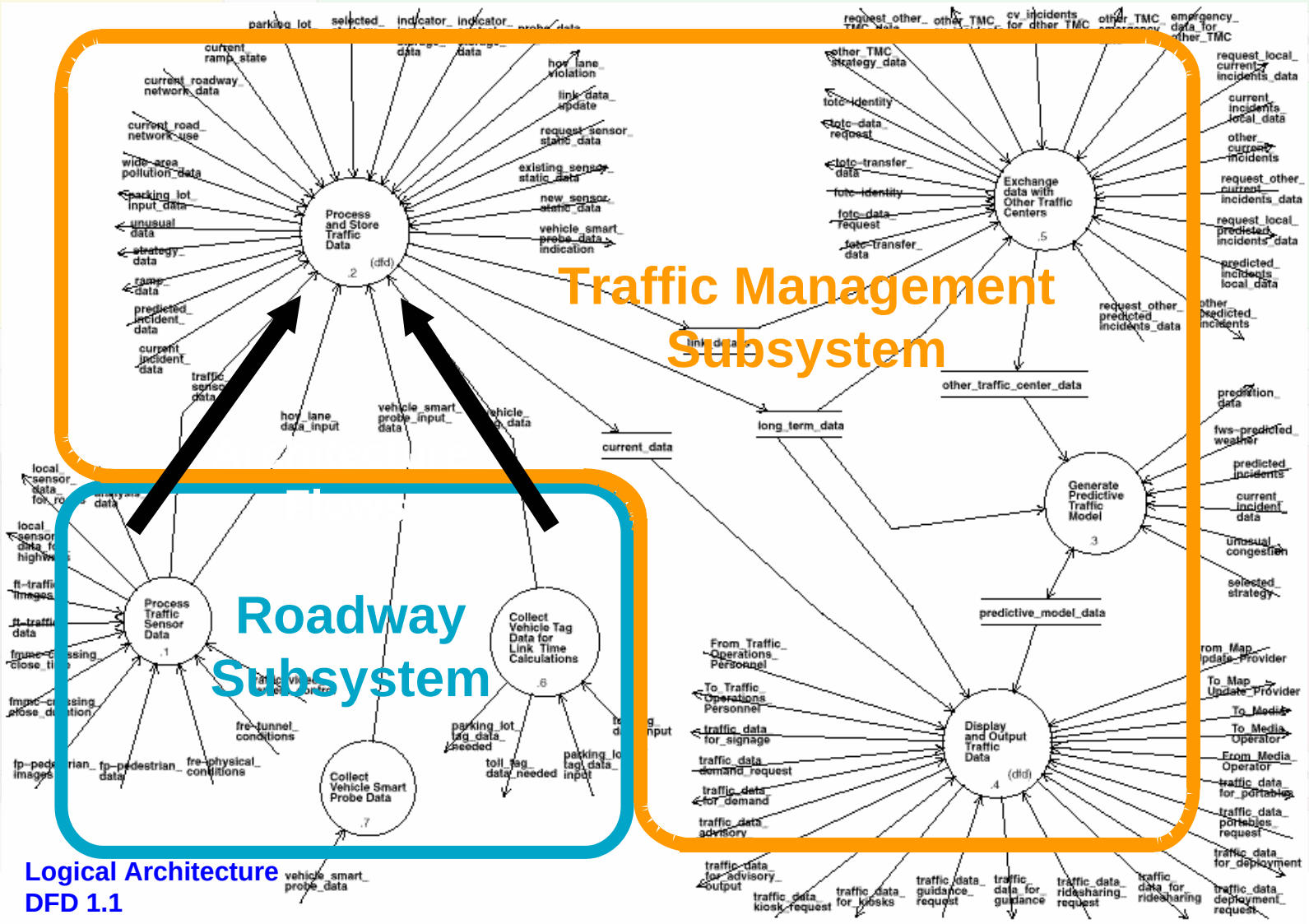
- Only covers ITS-related elements on vehicle platforms
- Includes general driver information and safety systems as applicable for all vehicle types
- For fleet vehicle subsystems and intermodal container
  - Add ITS capabilities unique to special vehicles

Vehicles

- Commercial Vehicle Subsystem
- Emergency vehicle Subsystem
- Intermodal Container Subsystem
- Maintenance Vehicle Subsystem
- Public Transport Vehicle Subsystem
- Vehicle Subsystem

The Development of ITS System Architecture

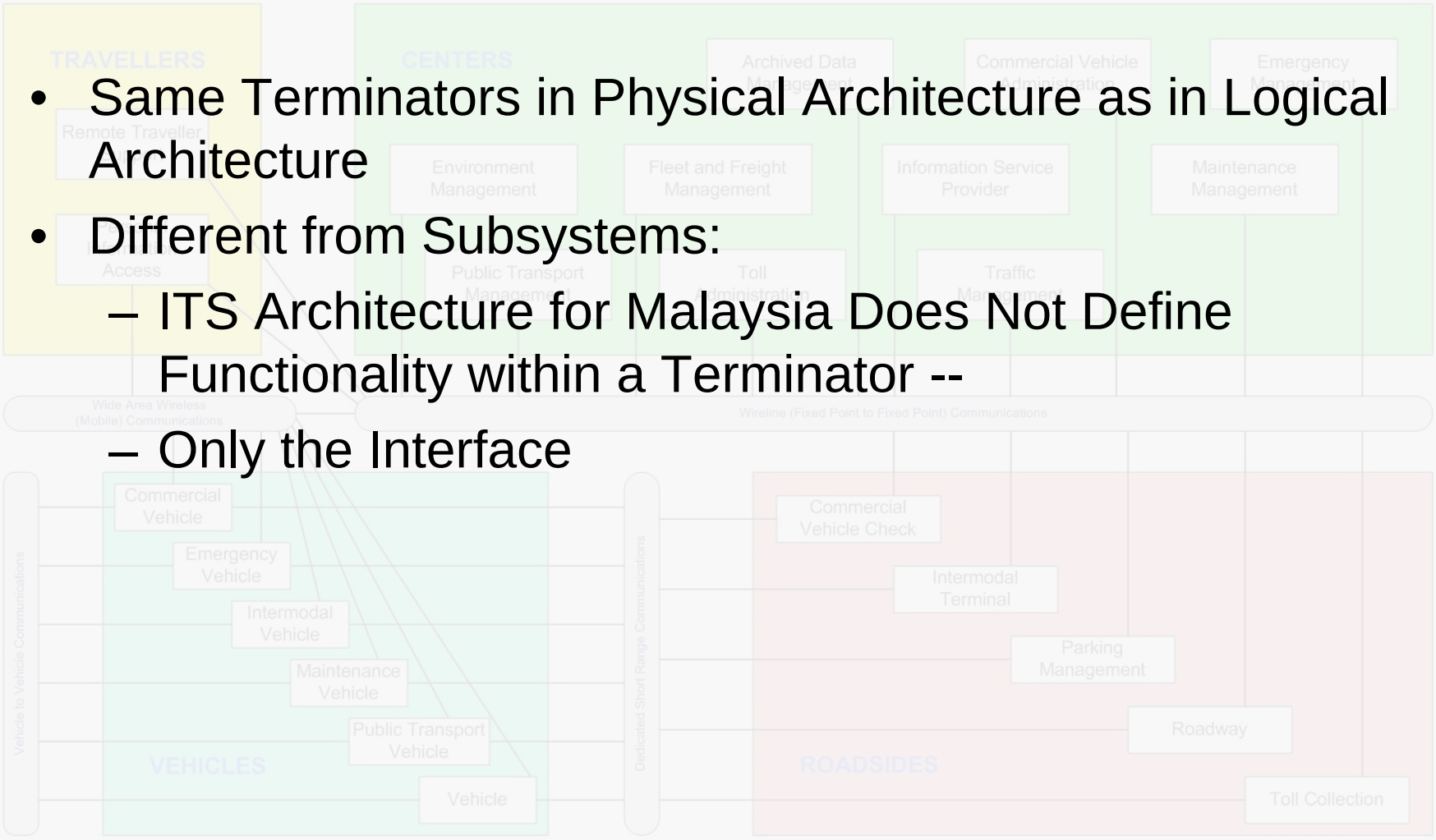
Subsystems are a Product of Partitioning and Allocating the Logical Architecture



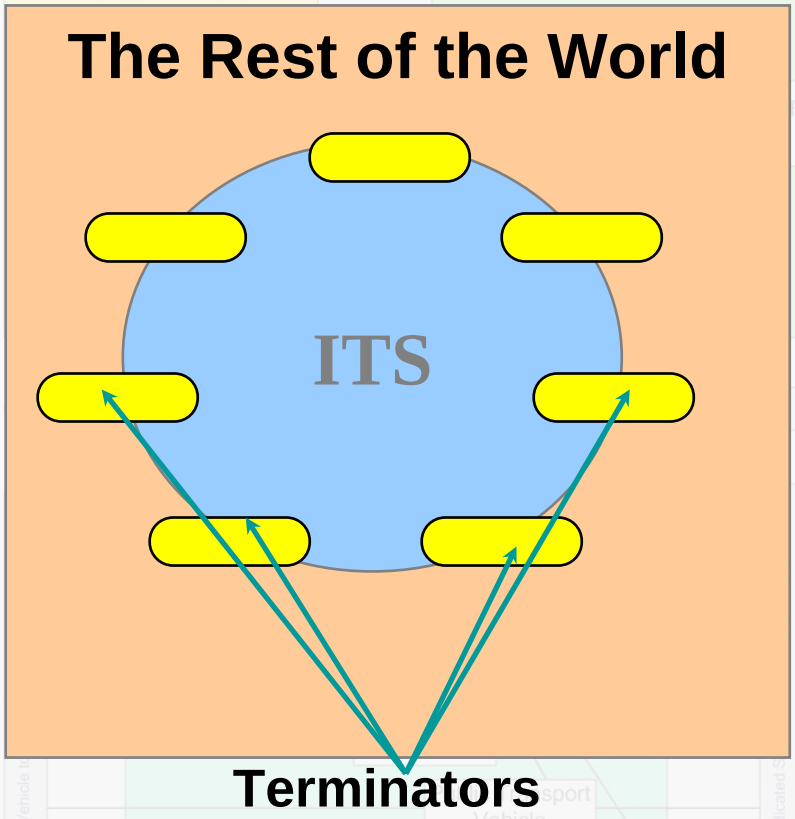
Logical Architecture
DFD 1.1

Terminators

- Same Terminators in Physical Architecture as in Logical Architecture
- Different from Subsystems:
  - ITS Architecture for Malaysia Does Not Define Functionality within a Terminator --
  - Only the Interface



Revisit: Terminators Define the Architecture Boundary



- Terminators establish the Architecture Boundary in the real world
- Four types of Terminators
  - Environment
  - Humans
  - Systems
  - Other Systems

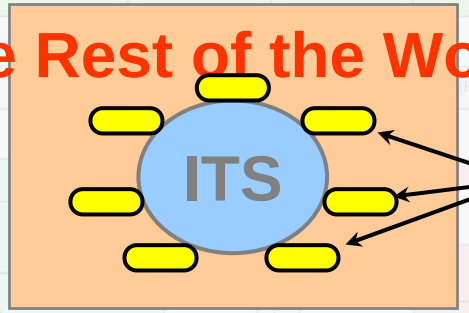
Physical Architecture – Terminators

Environment

- Environment
- Roadway
- Etc.

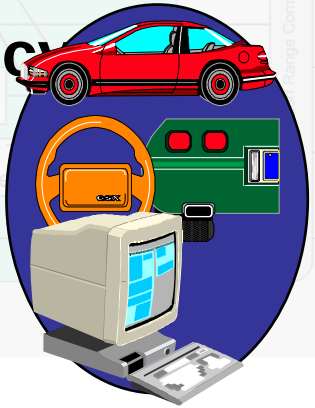
Humans

- Driver
- Transit User
- Etc.



Systems

- Customs Agency
- Financial Inst.
- Etc.



Other Systems

- Other Vehicle
- Other Traffic Mgt
- Etc.

Terminators

Human

- Archived Data Administrator
- Commercial Vehicle Driver
- Commercial Vehicle Manager
- Commuter
- CVO Inspector
- Driver
- Emergency Personnel
- Emergency System Operator
- Information Service Provider Operator
- Intermodal Terminal Operator
- Maintenance Operator
- Maintenance Vehicle Driver
- Parking Operator
- Pedestrians
- Public transport vehicle Driver
- Public transport Fleet Manager
- Public transport Maintenance Personnel
- Public transport System Operators
- Toll Administrator
- Toll Operator
- Traffic Operations Personnel
- Traveller

Terminators

Environment

- Environment
- Potential Obstacles
- Roadway
- Roadway Environment
- Secure Area Environment
- Traffic
- Vehicle Characteristics

Other Systems

- Other Archives
- Other Commercial Vehicle Administration Subsystem
- Other Emergency Management
- Other Information Service Provider
- Other Intermodal Fleet Management System
- Other Parking
- Other Public transport Management
- Other Roadside
- Other Traffic Management
- Other Vehicle

Terminators

Systems (1)

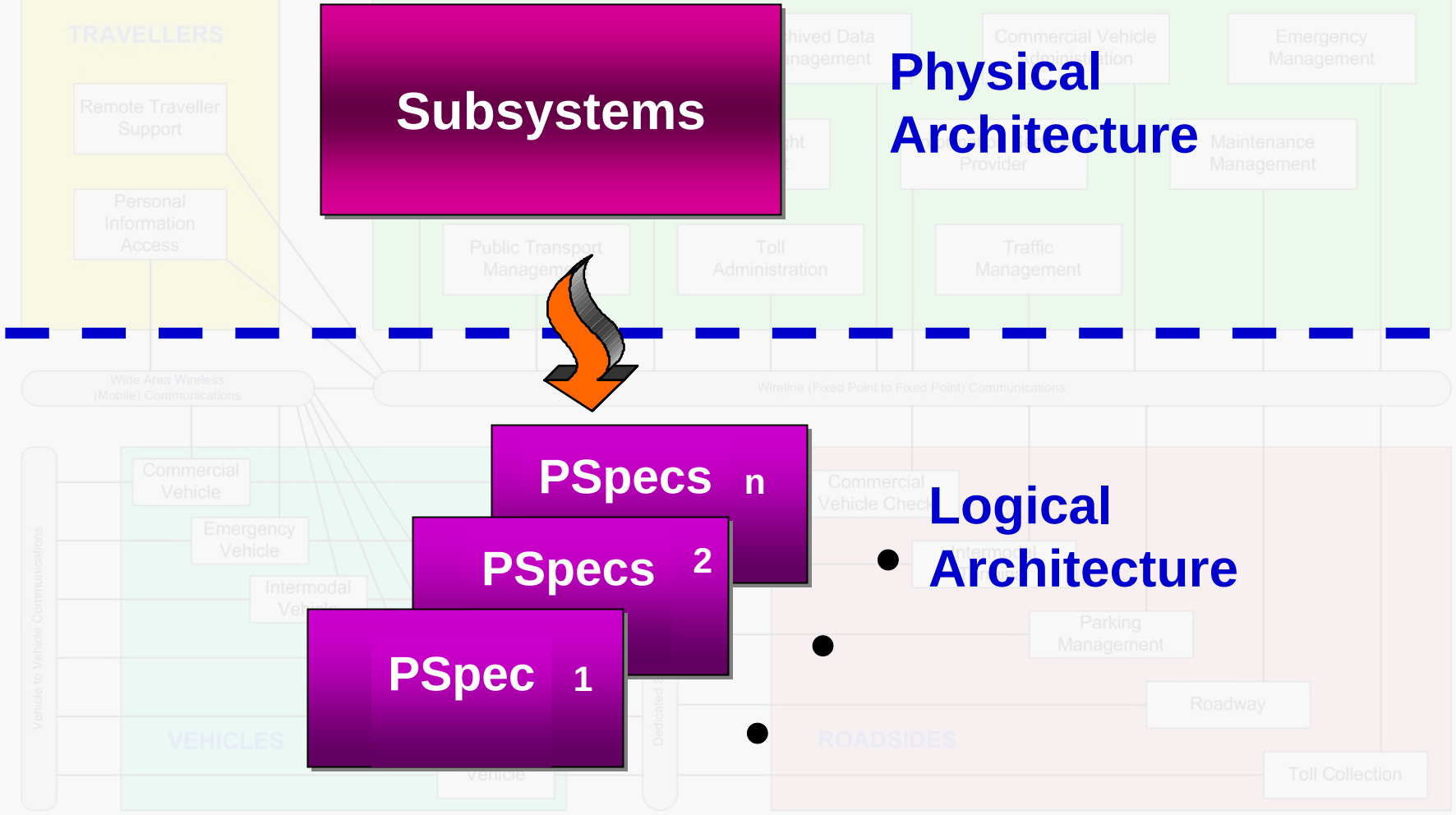
- Archived Data User Systems
- Basic Vehicle
- Commercial Vehicle
- CVO Information Requestor
- Disaster Command Authority
- Emergency Telecommunications System
- Enforcement Agency
- Event Organizers
- Financial Institution
- Freight Consolidation Station
- Government Administrators
- Government Reporting Systems
- Intermodal Chassis
- Intermodal Customer
- Location Data Source
- Logistics Solutions Provider

Terminators

Systems (2)

- Maintenance Vehicle
- Malaysian Meteorological Services
- Mapping Service Provider
- Media
- Medical Facility
- Meteorological Services Provider
- Multimodal Crossings
- Multimodal Transportation Service Provider
- Other Data Sources
- Payment Instrument
- Public Transport Vehicle
- Rail Operations
- Railside Equipment
- Road Transport Department
- Royal Customs Malaysia
- Yellow Pages Service Providers

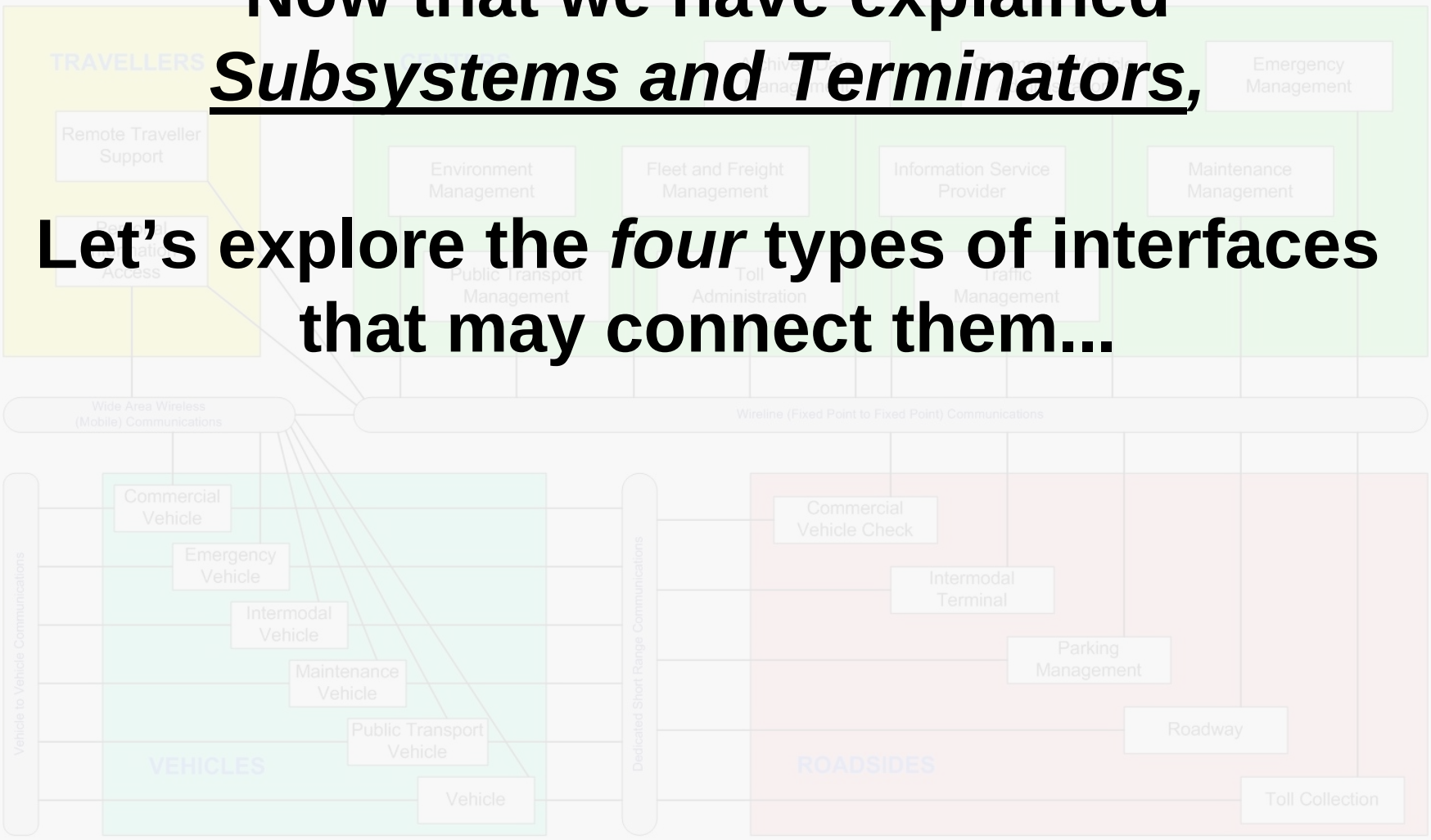
Hierarchy of Entities



The Development of ITS System Architecture

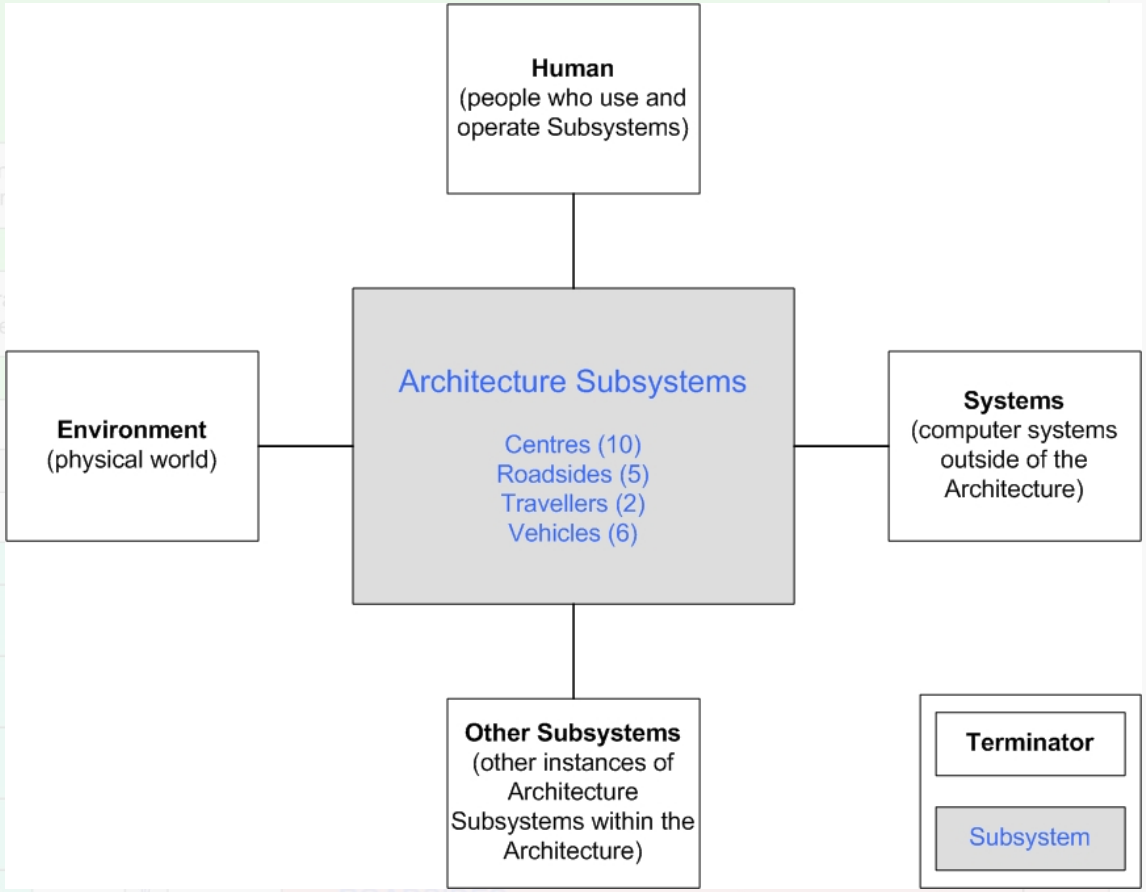
Now that we have explained *Subsystems and Terminators*,

Let's explore the *four* types of interfaces that may connect them...

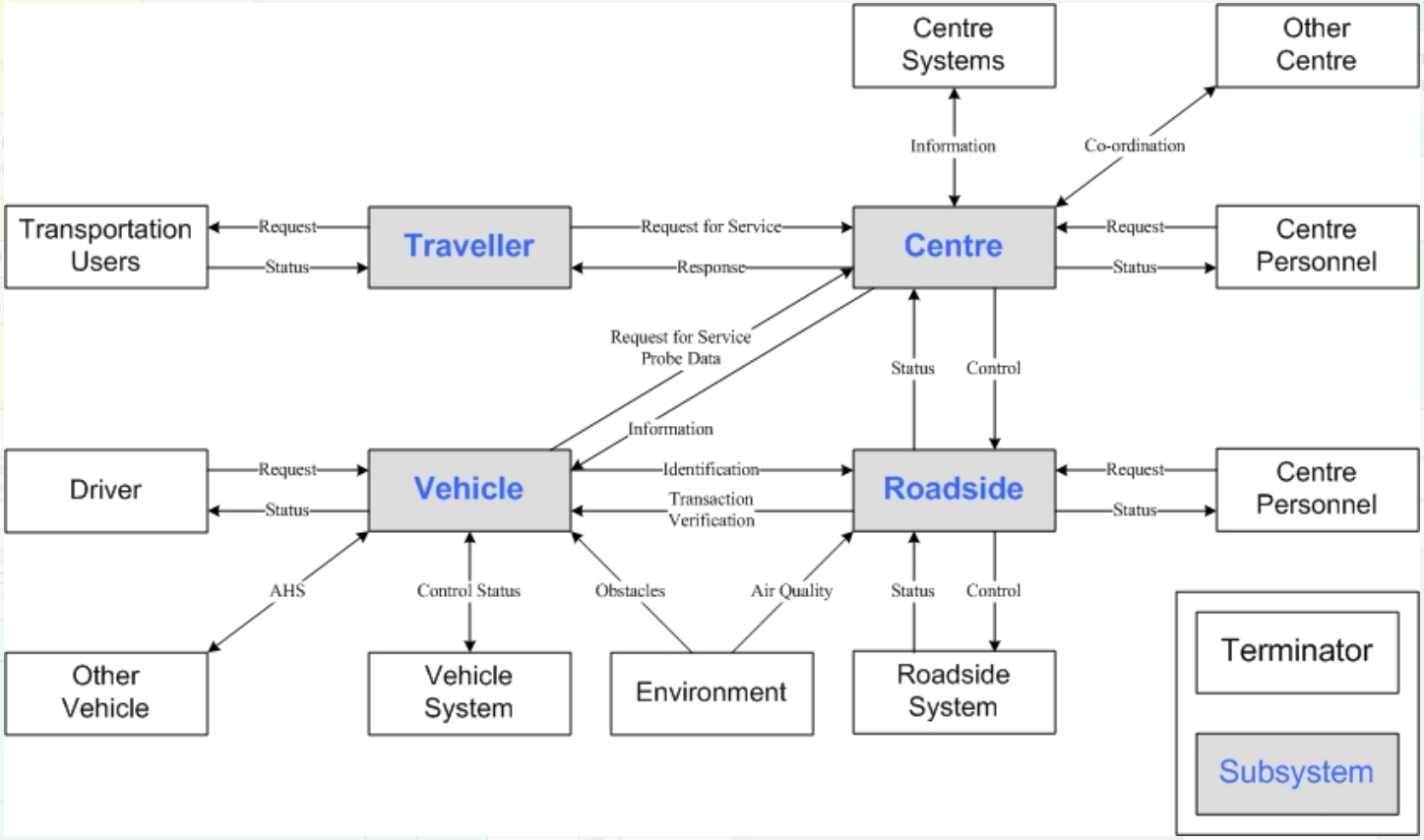


Top Level Physical Architecture

- Box in the center represent the Architecture Subsystems
- Outside box are Terminators with which the Subsystems Interact
- The Lines between the boxes represent at high level the Interface to the ITS

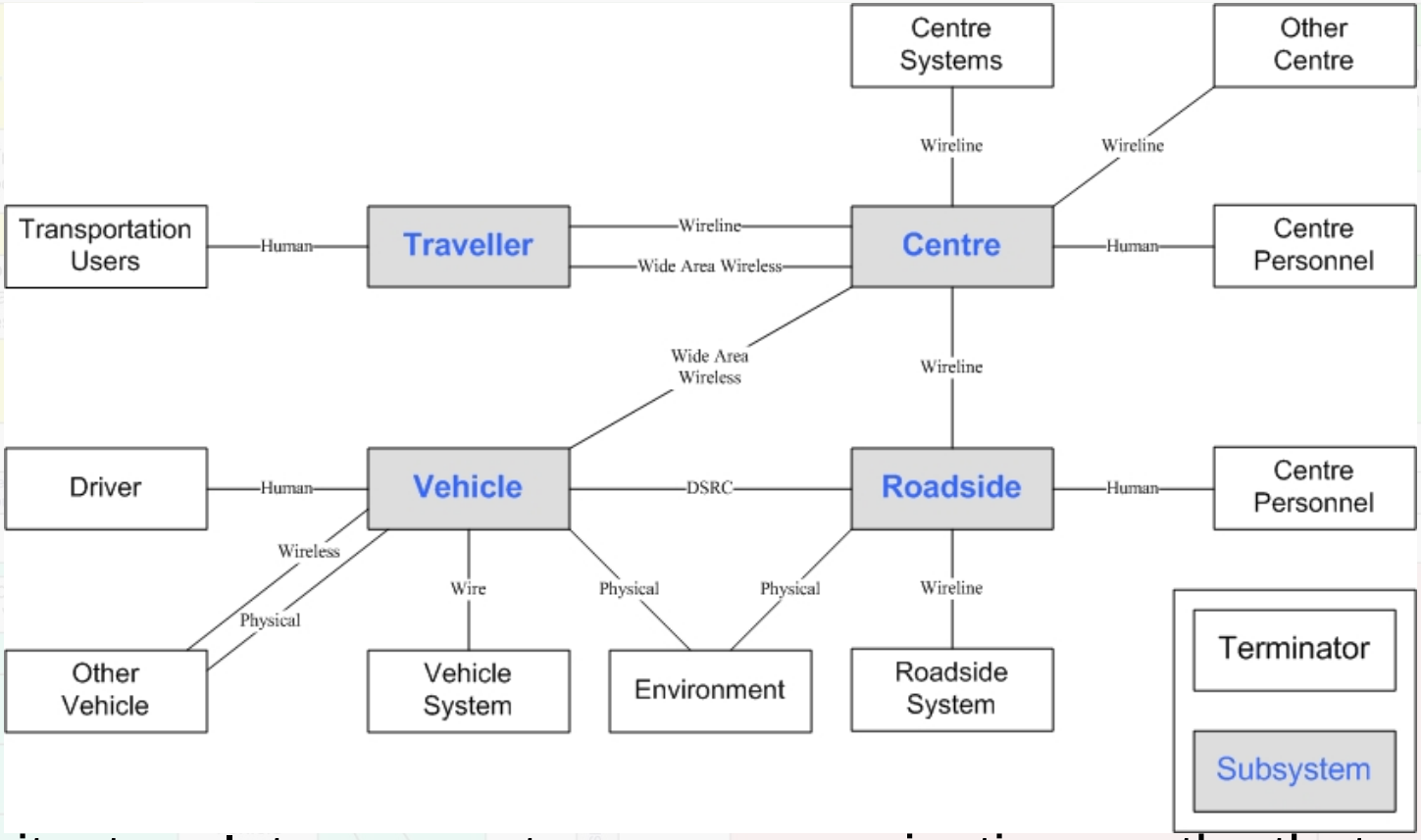


Top Level Architecture Flow Diagram.



- This is the type of information that is exchanged between the four classes of subsystems and the associated terminators

Physical Architecture Interconnects



- Architecture Interconnects are communications paths that carry information between subsystems and terminators in the Physical Architecture.

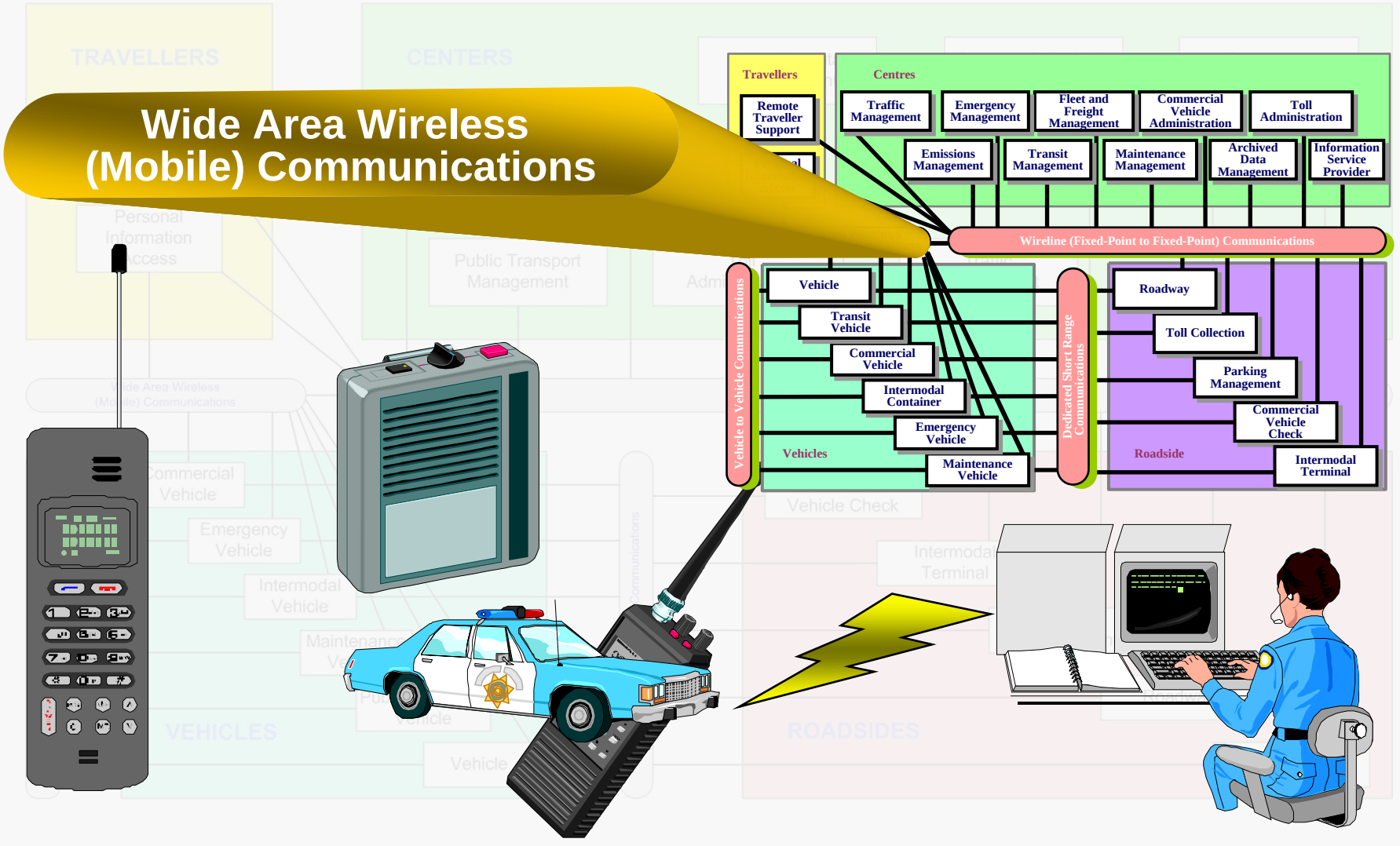
The Development of ITS System Architecture

Physical Architecture Interconnects

Architecture Interconnects

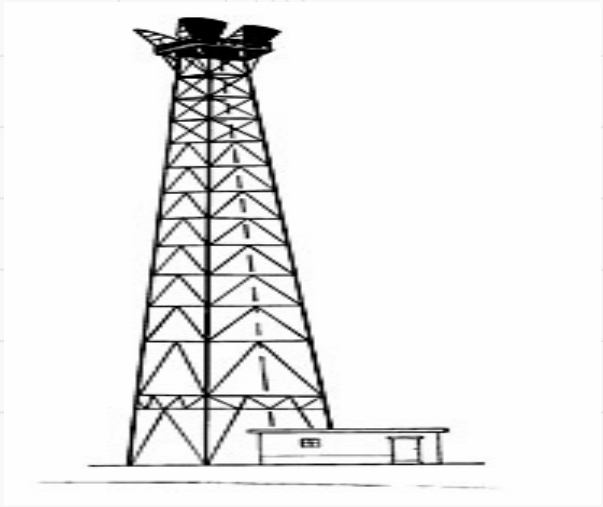
- Identify and classify connectivity between Subsystems
- Underlying definitions in the communications document
- “Communications Highways” between Subsystems
  - Four types of interfaces

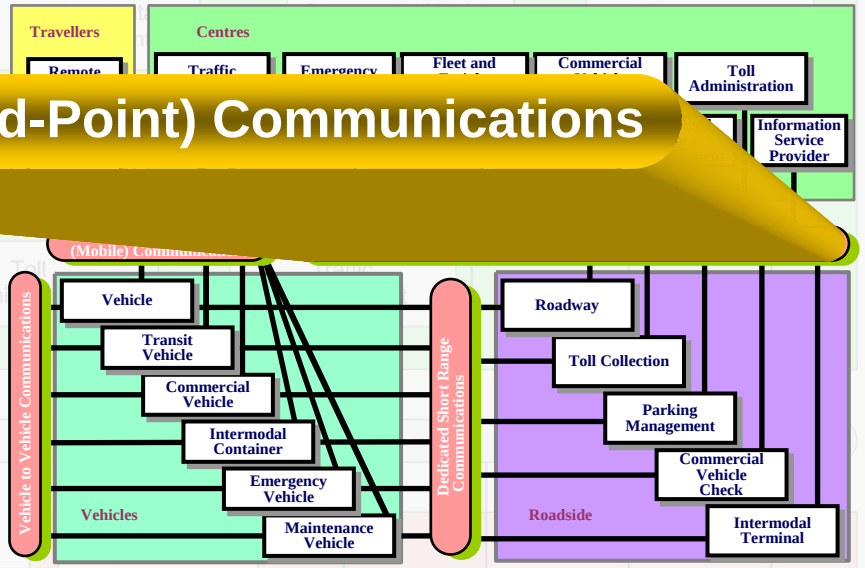
Wide Area Wireless- (Mobile) Communications

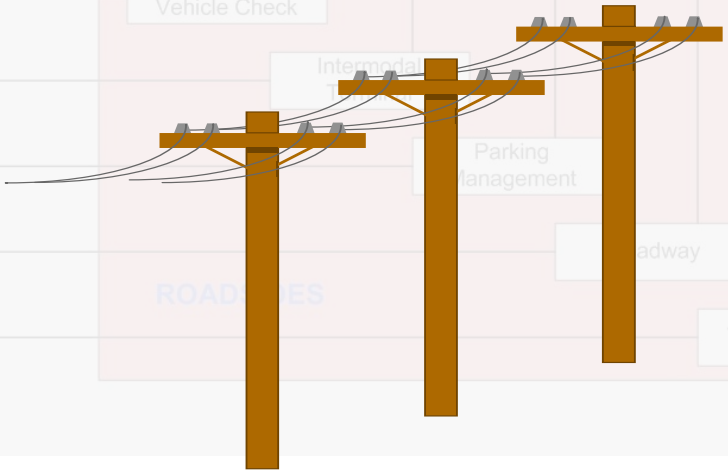


Wireline (Fixed-Point to Fixed-Point) Communications

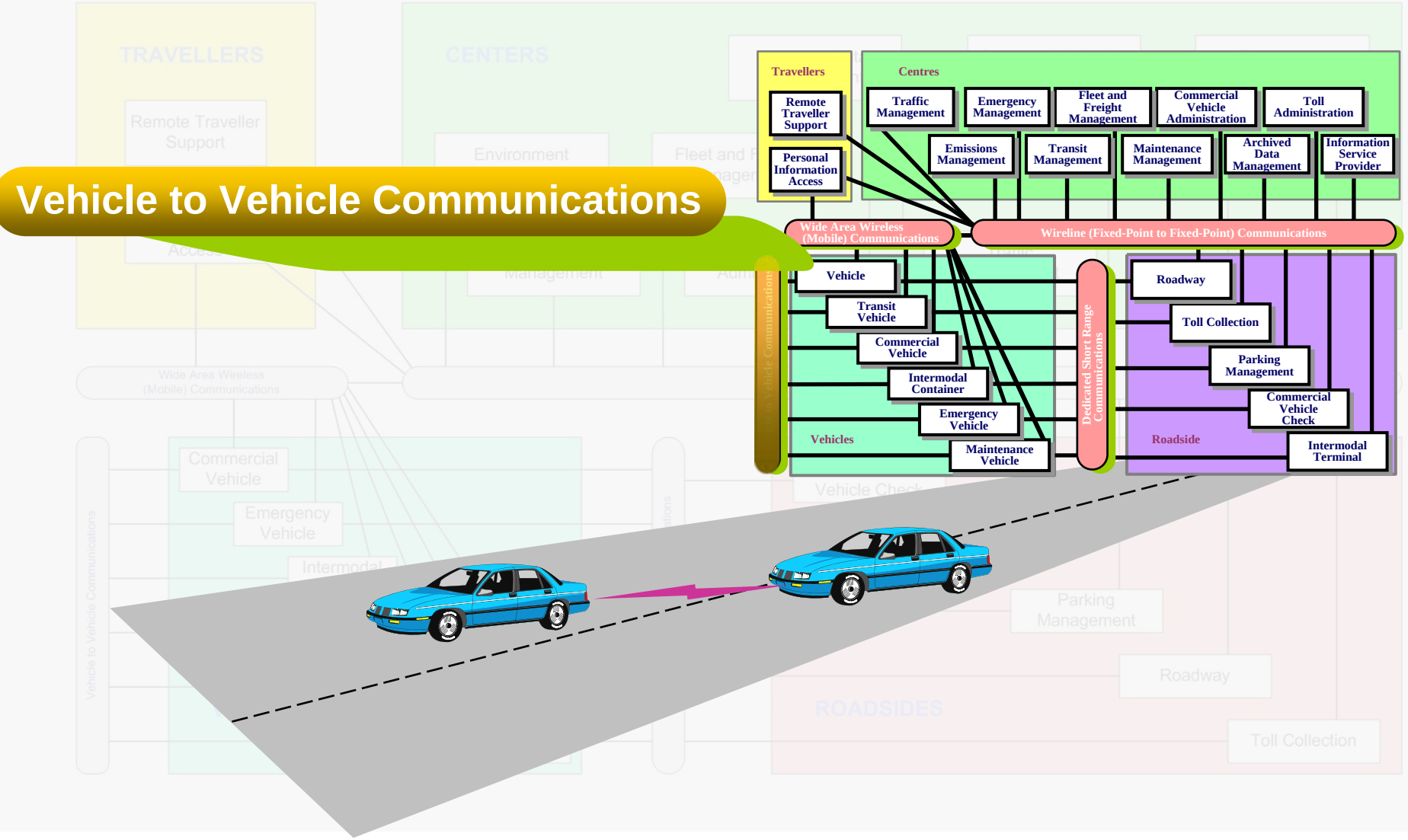
Wireline (Fixed-Point to Fixed-Point) Communications







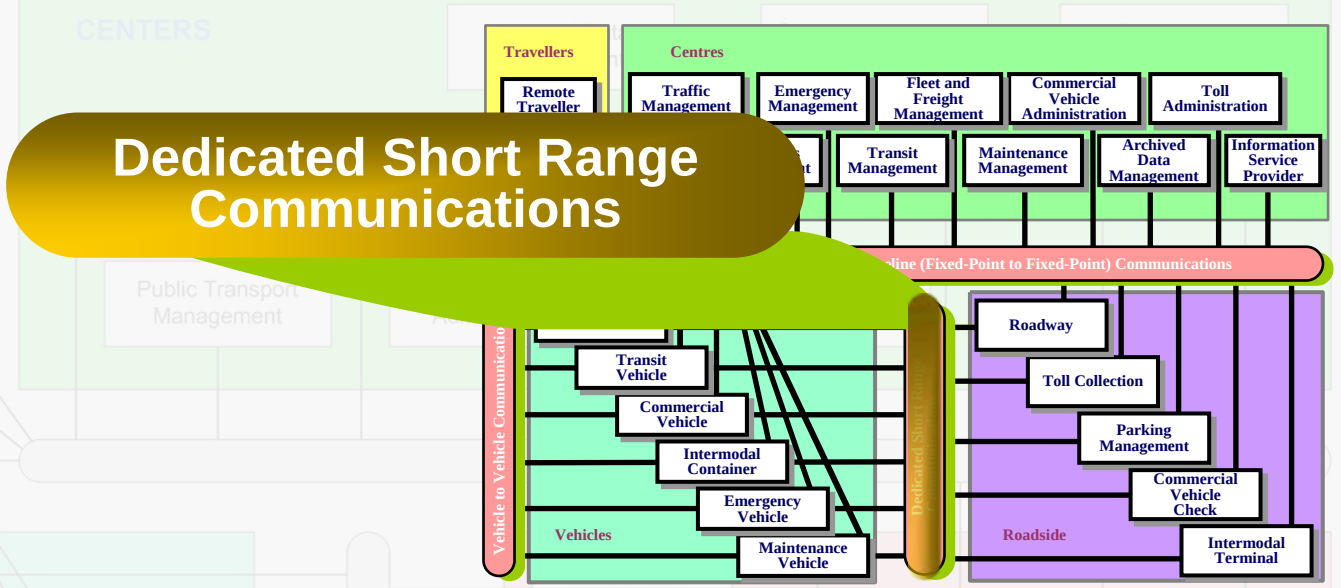
Vehicle to Vehicle Communications



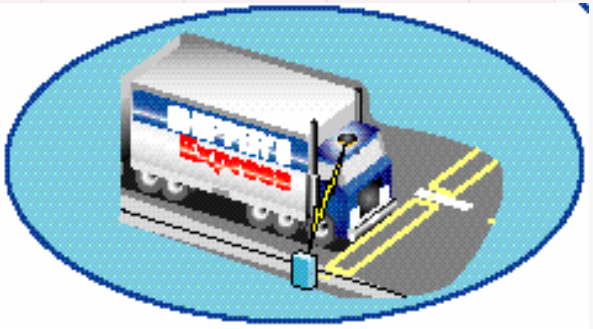
Dedicated Short Range Communications

Examples

- Electronic Toll Collection
- Emergency Vehicle Signal Preemption
- Electronic Commercial Vehicle Check



Electronic Toll Collection



Electronic Commercial Vehicle Check

Architecture Flows

Just as there is a *Functional Hierarchy* (Subsystems to PSpecs), an *Information Hierarchy* exists whose highest level is the Architecture Interconnect.

But what are the Architecture Interconnects comprised of?

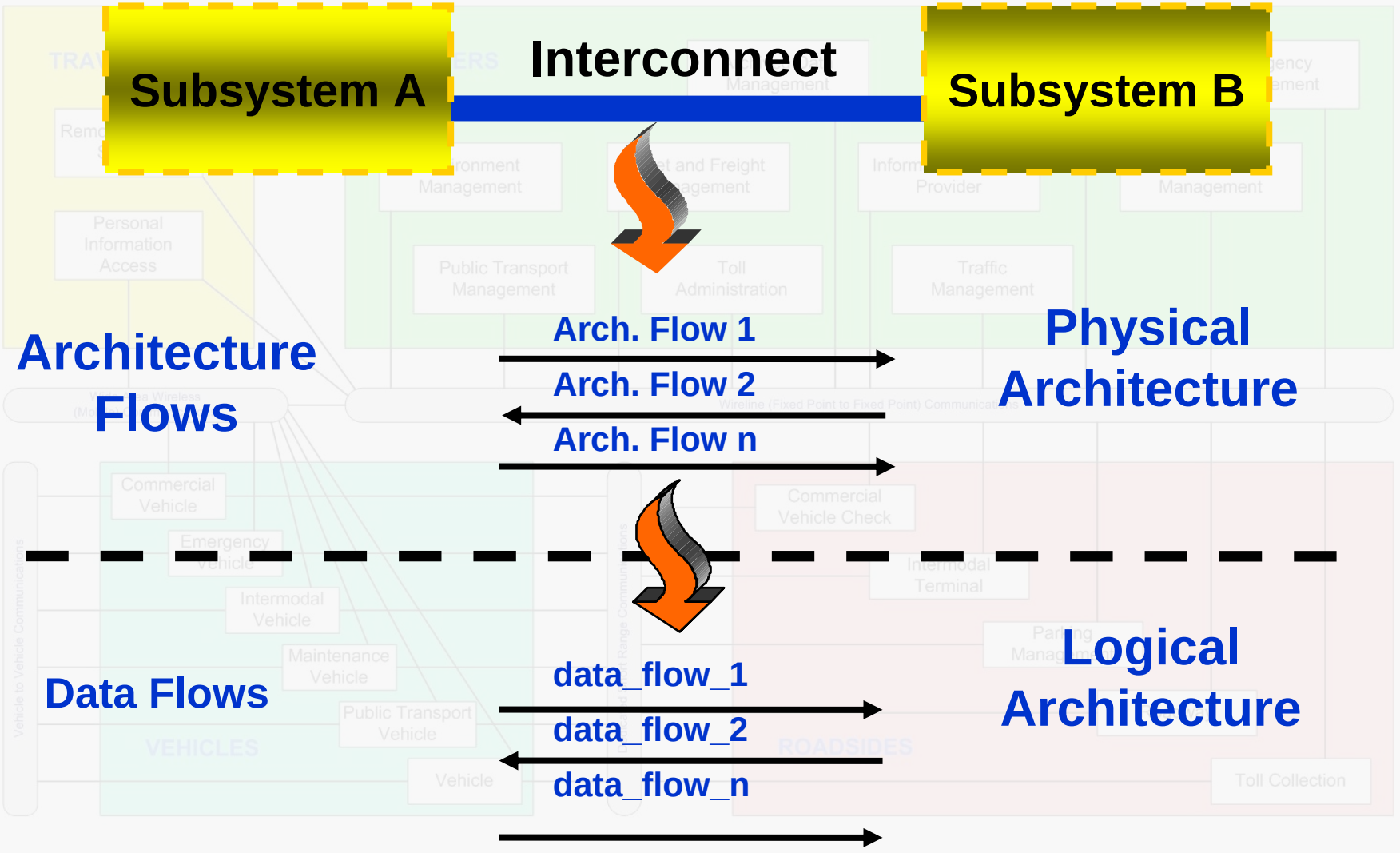
Architecture Flows

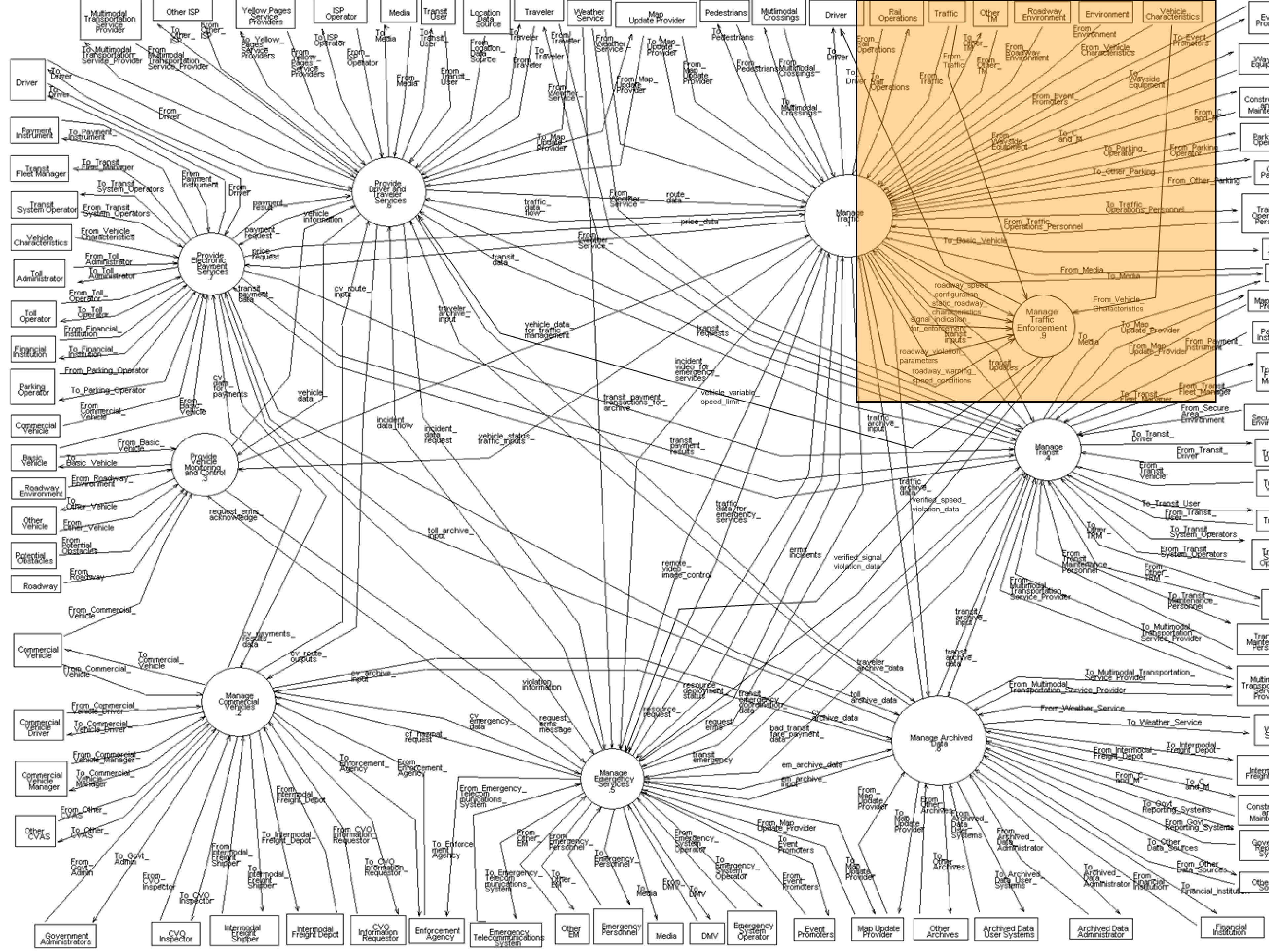
Interconnects Consist of Architecture Flows

- Architecture Flows
  - Identify flow of data between Subsystems
  - Supporting definitions in the Logical Architecture
  - Associated Architecture Interconnects characterize the communications requirements

The Development of ITS System Architecture

Hierarchy of Information

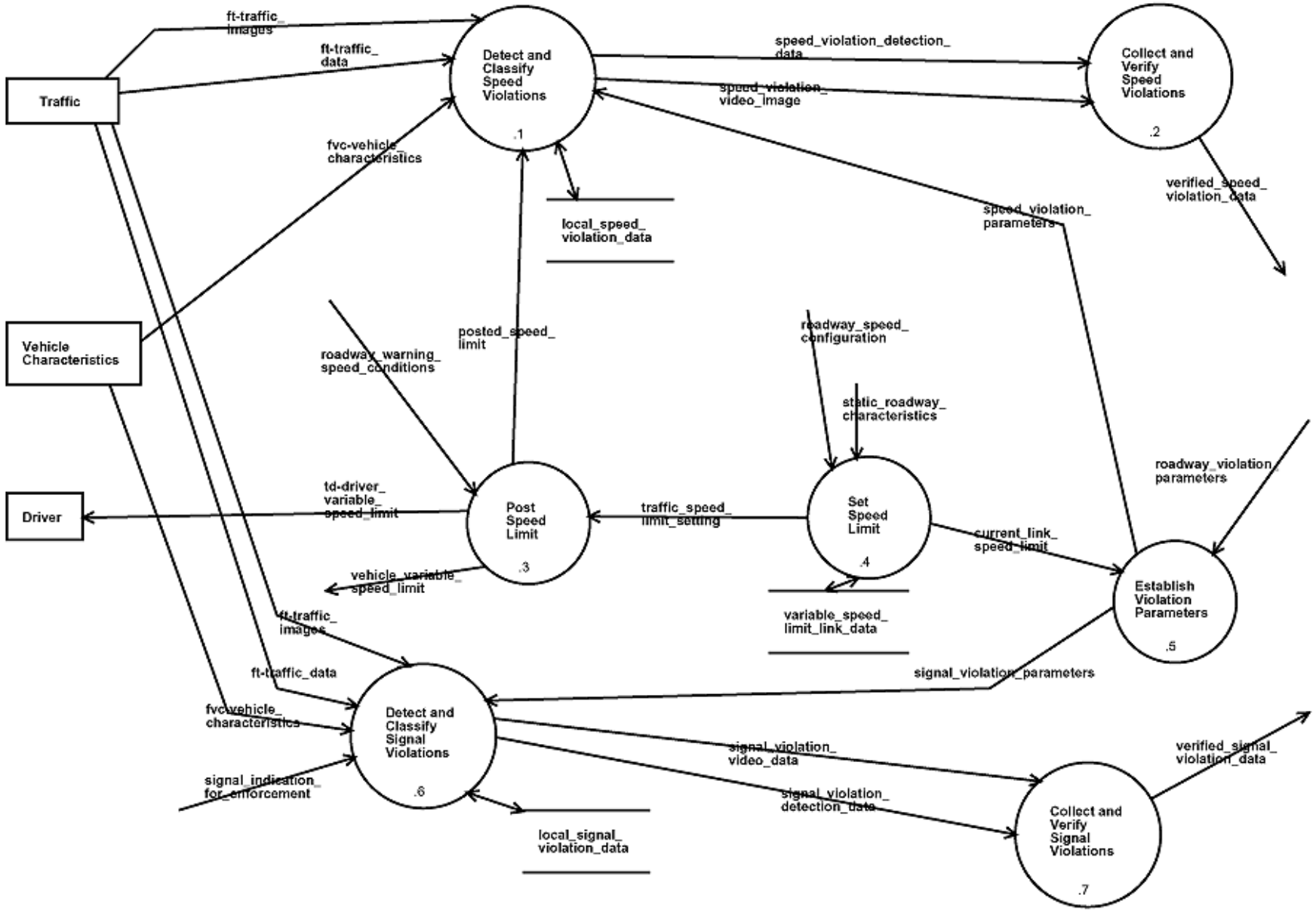




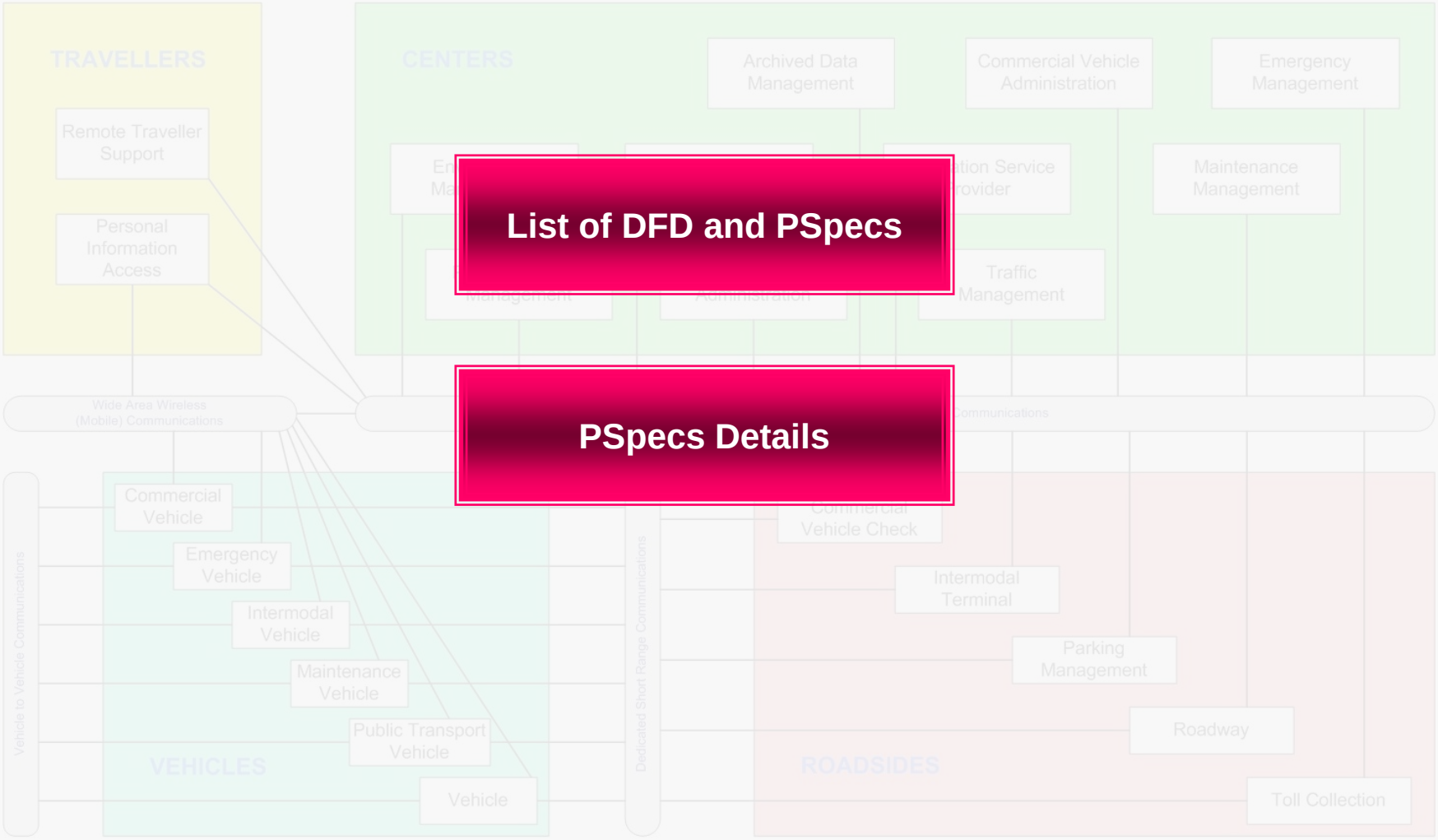
Multimodal Transportation Service Provider
Other ISP
Yellow Pages Service Providers
ISP Operator
Media
Transit User
Location Data Source
Traveler
Weather Service
Map Update Provider
Pedestrians
Multimodal Crossings
Driver
Rail Operations
Traffic
Other TM
Roadway Environment
Environment
Vehicle Characteristics
Driver
Payment Instrument
Transit Fleet Manager
Transit System Operator
Vehicle Characteristics
Toll Administrator
Toll Operator
Financial Institution
Parking Operator
Commercial Vehicle
Basic Vehicle
Roadway Environment
Other Vehicle
Potential Obstacles
Roadway
Commercial Vehicle
Commercial Vehicle Driver
Commercial Vehicle Manager
Other CVAS
Government Administrators
CVO Inspector
Intermodal Freight Shipper
Intermodal Freight Depot
CVO Information Requestor
Enforcement Agency
Emergency Telecommunications System
Other EM
Emergency Personnel
Media
DMV
Emergency System Operator
Event Promoters
Map Update Provider
Other Archives
Archived Data User Systems
Archived Data Administrator
Financial Institution
Provide Driver and Traveler Services .6
Provide Electronic Payment Services .7
Provide Vehicle Monitoring and Control .3
Manage Traffic .1
Manage Traffic Enforcement .9
Manage Transit .4
Manage Commercial Vehicles .2
Manage Emergency Services .5
Manage Archived Data .8

The Development of ITS System Architecture

9- Manage Traffic Enforcement



The Development of ITS System Architecture



Physical Architecture Summary

Physical Architecture:

- Distributes Functions defined in Logical Architecture
- Defines Interfaces between Physical Entities
- Composed of:
  - Subsystems - Physical Entities inside ITS Boundary
  - Terminators - Constitute ITS Boundary

Physical Architecture Summary (2)

Architecture Interconnects:

- Identify and Classify Connectivity between Subsystems and between Subsystems and Terminators
- 4 Types
  - Wireline or " fixed-point"
  - Wide-Area Wireless or "mobile"
  - Dedicated Short Range Communications (DSRC)
  - Vehicle to Vehicle

Architecture Flows:

- Define Flow of Information between Subsystems, and between Subsystems and Terminators

Physical Architecture Summary (3)

Sausage Diagram:

- Communication Links are the "Sausages"