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SAFE MOBILITY IN EGYPT

Road Safety School

**Safe Mobility in Egypt & Road Safety School-UK**

# Intelligent Transportation Systems (ITS)


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# About the Instructor

- **د. يارة إسماعيل علي بسيوني**
- حاصل على دكتوراه هندسة النقل – نظم نقل ذكية ٢٠١٨
- أستاذ مساعد في هندسة النقل والمرور في عدد من الجامعات المصرية
- مهندس محترف أول في مكتب طلعت وإمام للاستشارات الهندسية
- مؤلف ومراجع للعديد من الأبحاث في أشهر مجلات نظم النقل الذكية العالمية
- **مؤسس التنقل الآمن في مصر – Safe Mobility in Egypt**

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# About Road Safety School-UK & Safe Mobility in Egypt

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# للحصول على الشهادة

- للحصول على الشهادة، يشترط الالتزام الكامل بالمتطلبات التالية:
  - إتمام التسجيل الرسمي في المنصة باستخدام بيانات صحيحة.حضور جميع المحاضرات، مع السماح بالغياب عن محاضرة واحدة كحد أقصى فقط.
  - استكمال مشاهدة جميع المحتويات التعليمية المعتمدة داخل المنصة.حل جميع الأسئلة والاختبارات والواجبات المطلوبة دون استثناء.
  - تحقيق مستوى تفاعل فعّال من خلال المشاركة في النقاشات والتعليقات والأنشطة الاجتماعية داخل المنصة.
  - الالتزام التام بالمواعيد النهائية المحددة لتسليم كافة الأنشطة والمهام.

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# Contents

1. Introduction to ITS
2. ITS Applications & Data Science
3. Benefit & Cost Analysis for ITS Applications

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# Background

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# Monthly Traffic Variation

AADT: Annual Average Daily Traffic

Traffic over a year

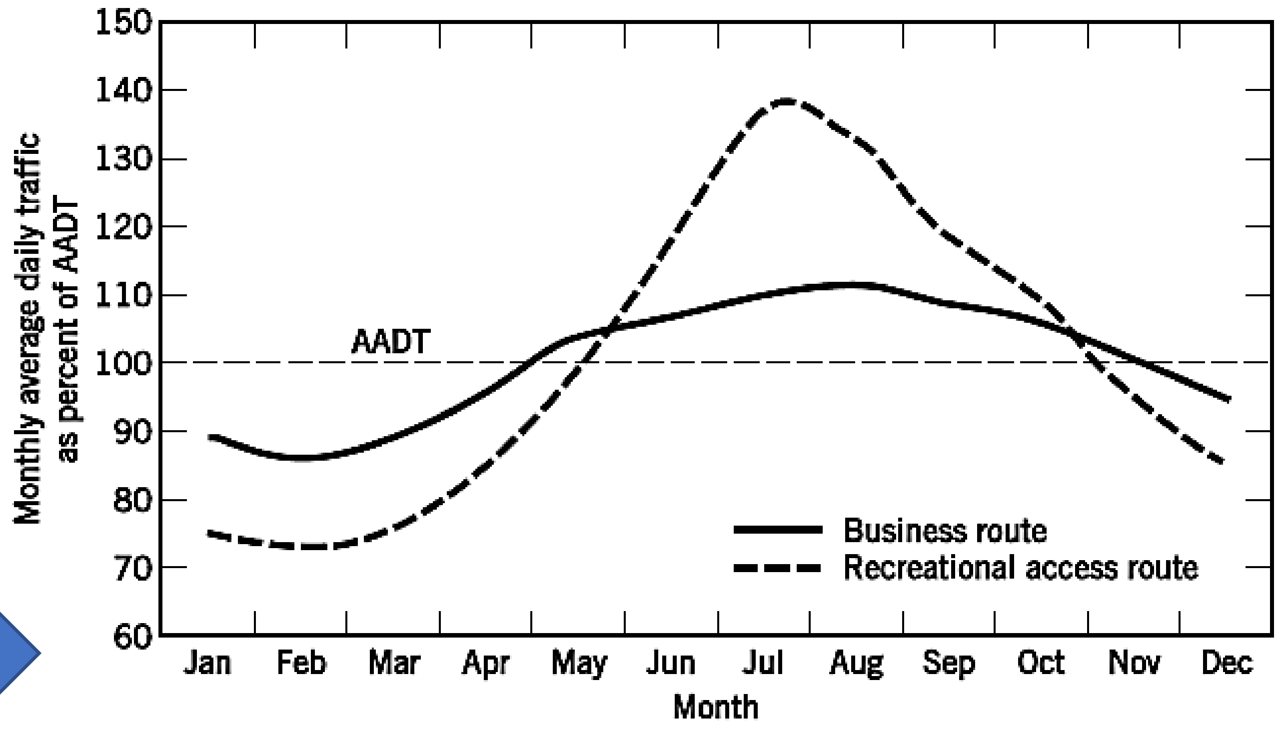


**Figure 6.7** Example of monthly traffic volume variations for business and recreational access routes.

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# Hourly & Daily Traffic variations

Traffic over 24 hours

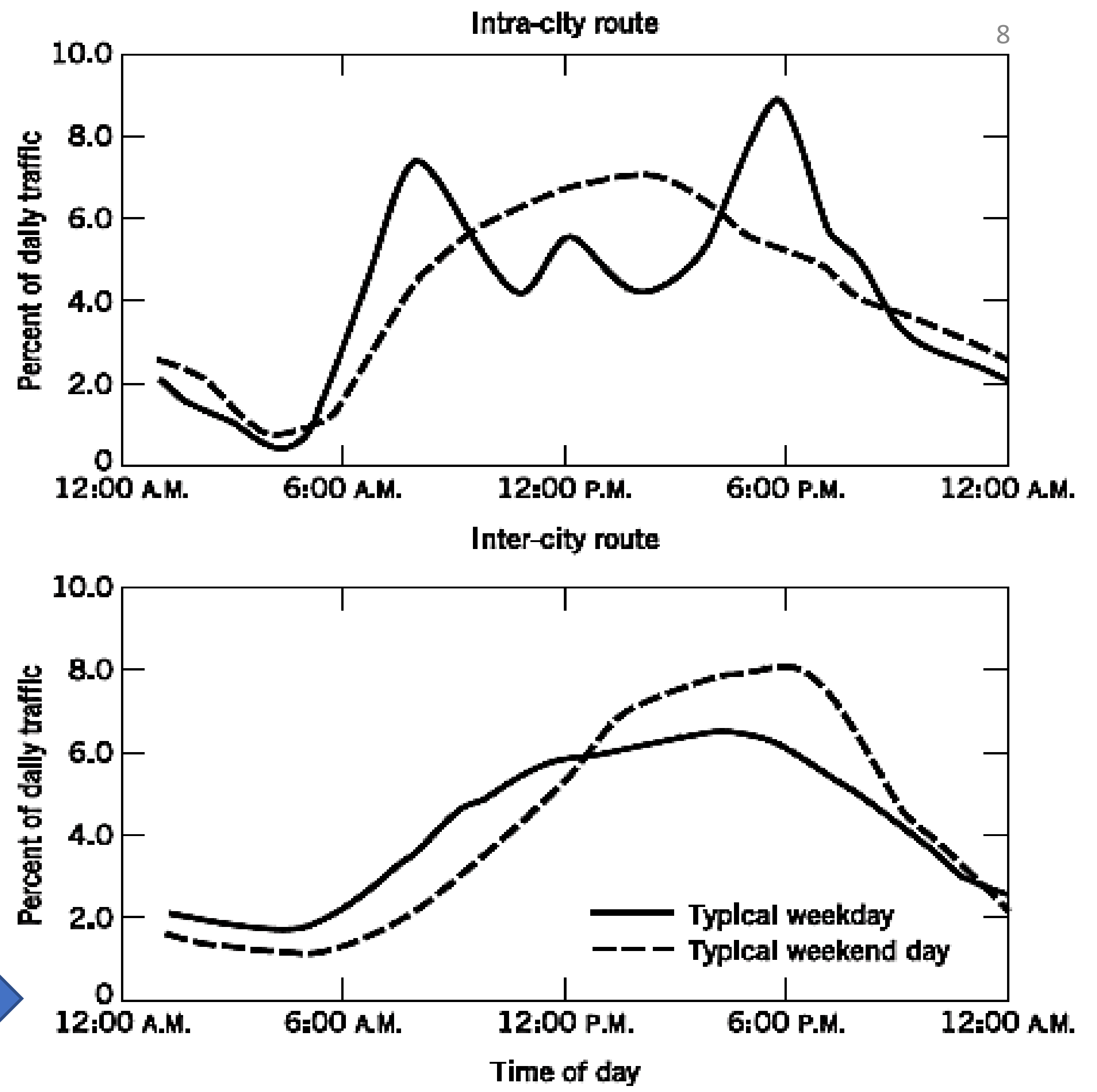


Figure 6.6 Examples of hourly and daily traffic variations for intra-city and inter-city routes.

- Intra-city: within a city
- Inter-city: between two or more cities

# Illustration of freeway LOS (A to F)


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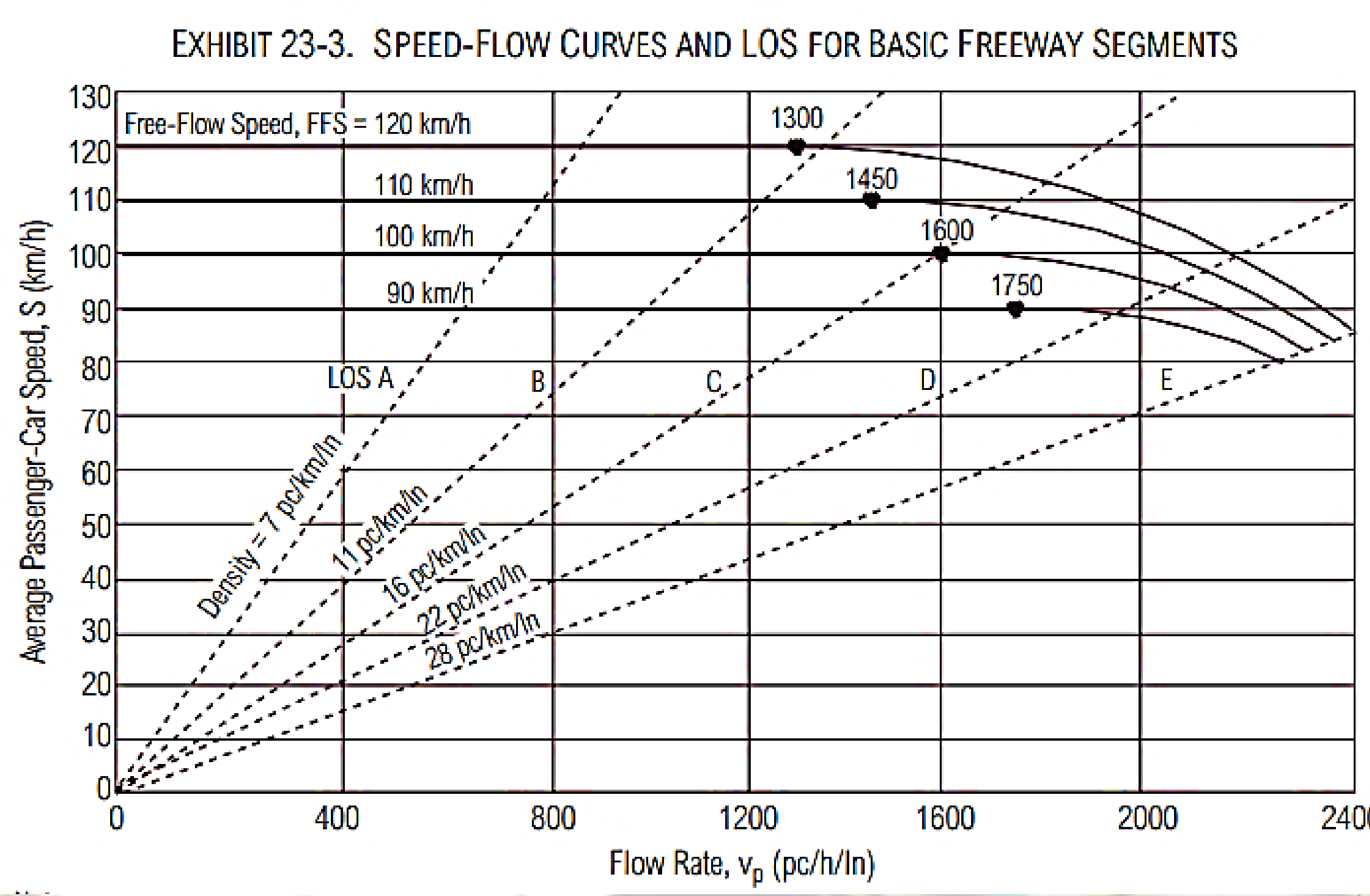
# Level of Service LOS on Basic Freeways

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# Exercise

- If k = 28 vplpkm:
  - Gap = ?

  Gap = (1000/29) – 5 = 29.5 m, (5 m is standard length of vehicle)

- If q = 3000 vplphr & V = 40 vph:
  - Gap = ?

  k = q/V = 3000/40 = 75 vplpkm

  Gap = (1000/76) – 5 = 8.2 m, (5 m is standard length of vehicle)

# Questions

1. Level of Service (LOS) A, has ...

a. highest density

b. lowest speed

c. highest speed

d. highest flow

e. **<u>lowest density & highest speed</u>**

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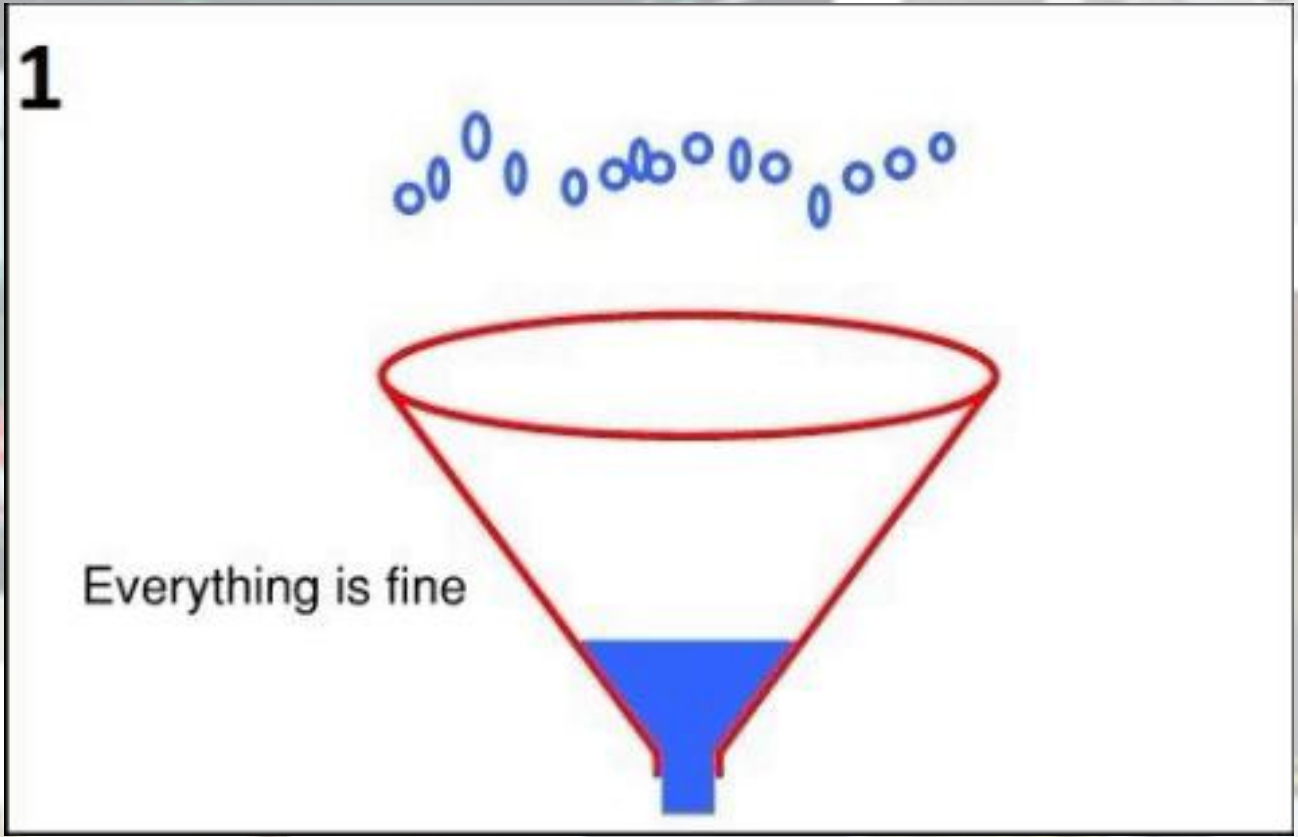
# Basic Idea … Sketch



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# I. Introduction to ITS

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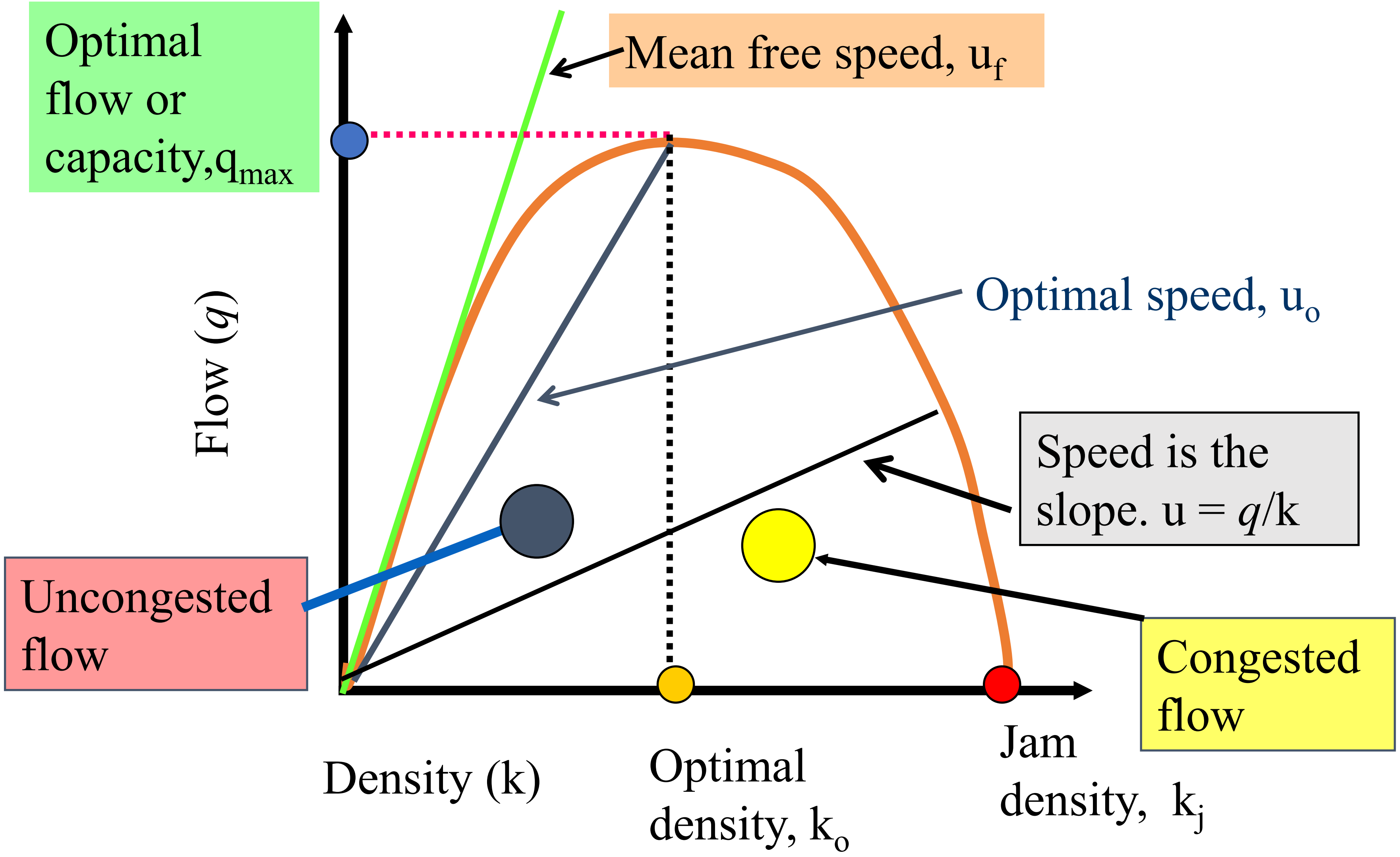
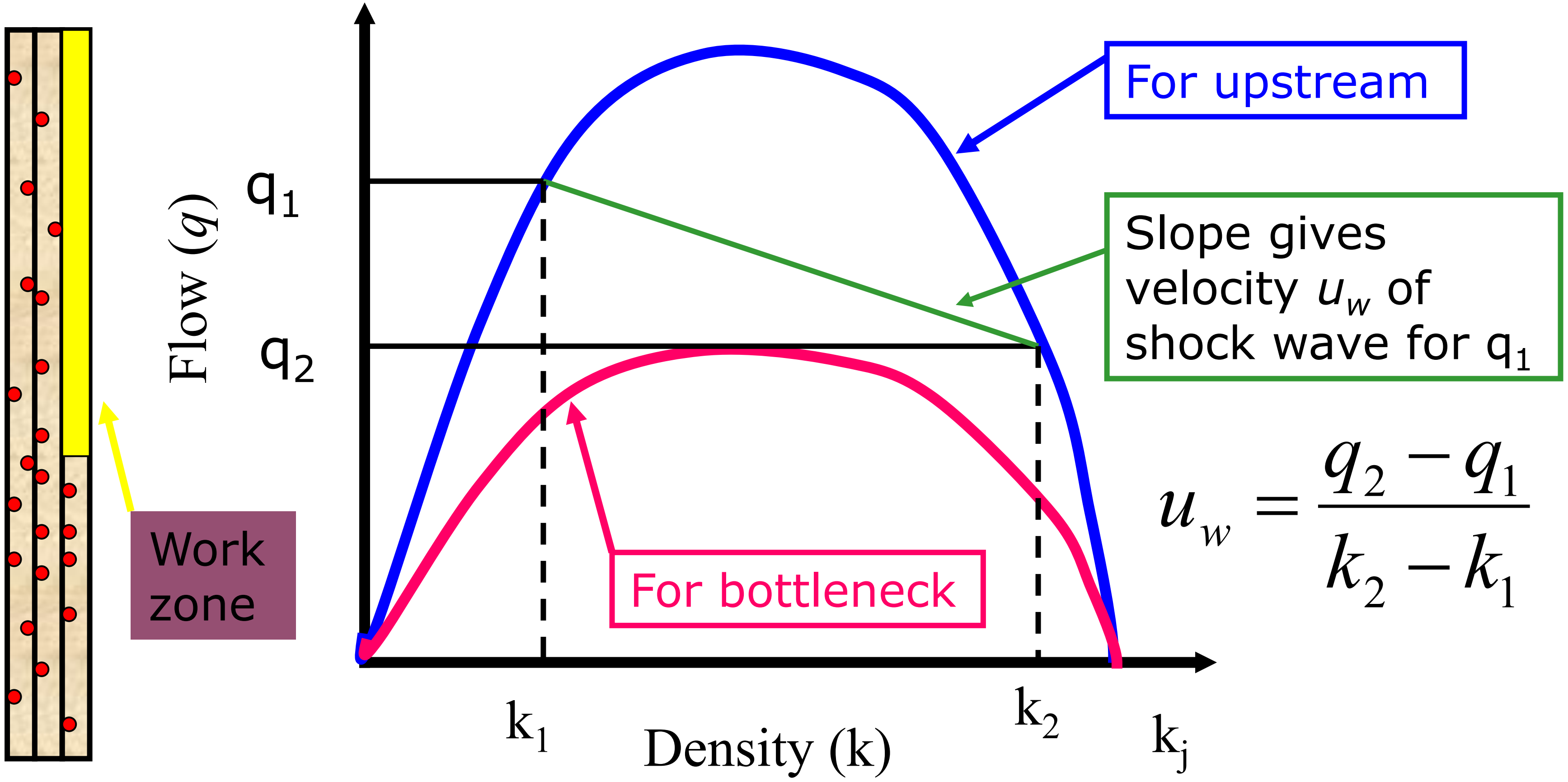
# Questions?

# Fundamental diagram of traffic flow (flow vs. density)



# Fundamental diagram of traffic flow and shock wave




$$u_w = \frac{q_2 - q_1}{k_2 - k_1}$$

**Queue forms upstream of the bottleneck. So we use the diagram of the upstream section**

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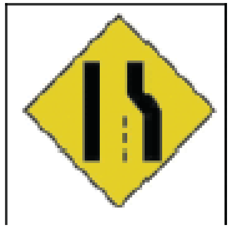
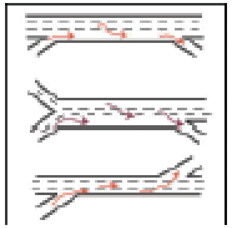
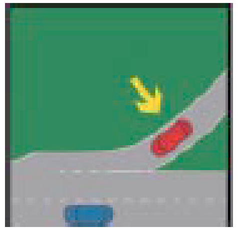
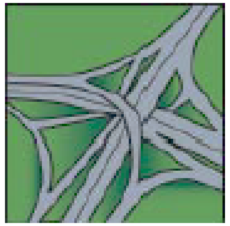
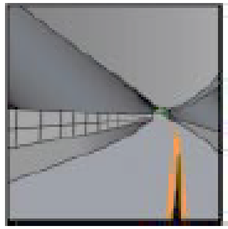
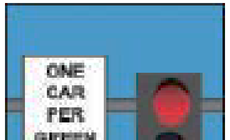
# Common Locations for Localized Bottlenecks

| Location | Symbol | Description |
|---|---|---|
| Lane Drops |  | Bottlenecks can occur at lane drops, particularly midsegment where one or more traffic lanes ends or at a low-volume exit ramp. They might occur at jurisdictional boundaries, just outside the metropolitan area, or at the project limits of the last megaproject. Ideally, lane drops should be located at exit ramps where there is a sufficient volume of exiting traffic. |
| Weaving Areas |  | Bottlenecks can occur at weaving areas, where traffic must merge across one or more lanes to access entry or exit ramps or enter the freeway main lanes. Bottleneck conditions are exacerbated by complex or insufficient weaving design and distance. |
| Freeway On-Ramps |  | Bottlenecks can occur at freeway on-ramps, where traffic from local streets or frontage roads merges onto a freeway. Bottleneck conditions are worsened on freeway on-ramps without auxiliary lanes, short acceleration ramps, where there are multiple on-ramps in close proximity and when peak volumes are high or large platoons of vehicles enter at the same time. |
| Freeway Exit Ramps |  | Freeway exit ramps, which are diverging areas where traffic leaves a freeway, can cause localized congestion. Bottlenecks are exacerbated on freeway exit ramps that have a short ramp length, traffic signal deficiencies at the ramp terminal intersection, or other conditions (e.g., insufficient storage length) that may cause ramp queues to back up onto freeway main lanes. Bottlenecks could also occur when a freeway exit ramp shares an auxiliary lane with an upstream on-ramp, particularly when there are large volumes of entering and exiting traffic. |

# Common Locations for Localized Bottlenecks

| | | |
|---|---|---|
| Freeway-to-Freeway Interchanges |  | Freeway-to-freeway interchanges, which are special cases on on-ramps where flow from one freeway is directed to another. These are typically the most severe form of physical bottlenecks because of the high traffic volumes involved. |
| Changes in Highway Alignment |  | Changes in highway alignment, which occur at sharp curves and hills and cause drivers to slow down either because of safety concerns or because their vehicles cannot maintain speed on upgrades. Another example of this type of bottleneck is in work zones where lanes may be shifted or narrowed during construction. |
| Tunnels/ Underpasses |  | Bottlenecks can occur at low-clearance structures, such as tunnels and underpasses. Drivers slow to use extra caution, or to use overload bypass routes. Even sufficiently tall clearances could cause bottlenecks if an optical illusion causes a structure to appear lower than it really is, causing drivers to slow down. |
| Narrow Lanes/Lack of Shoulders |  | Bottlenecks can be caused by either narrow lanes or narrow or a lack of roadway shoulders. This is particularly true in locations with high volumes of oversize vehicles and large trucks. |
| Traffic Control Devices |  | Bottlenecks can be caused by traffic control devices that are necessary to manage overall system operations. Traffic signals, freeway ramp meters, and tollbooths can all contribute to disruptions in traffic flow. |

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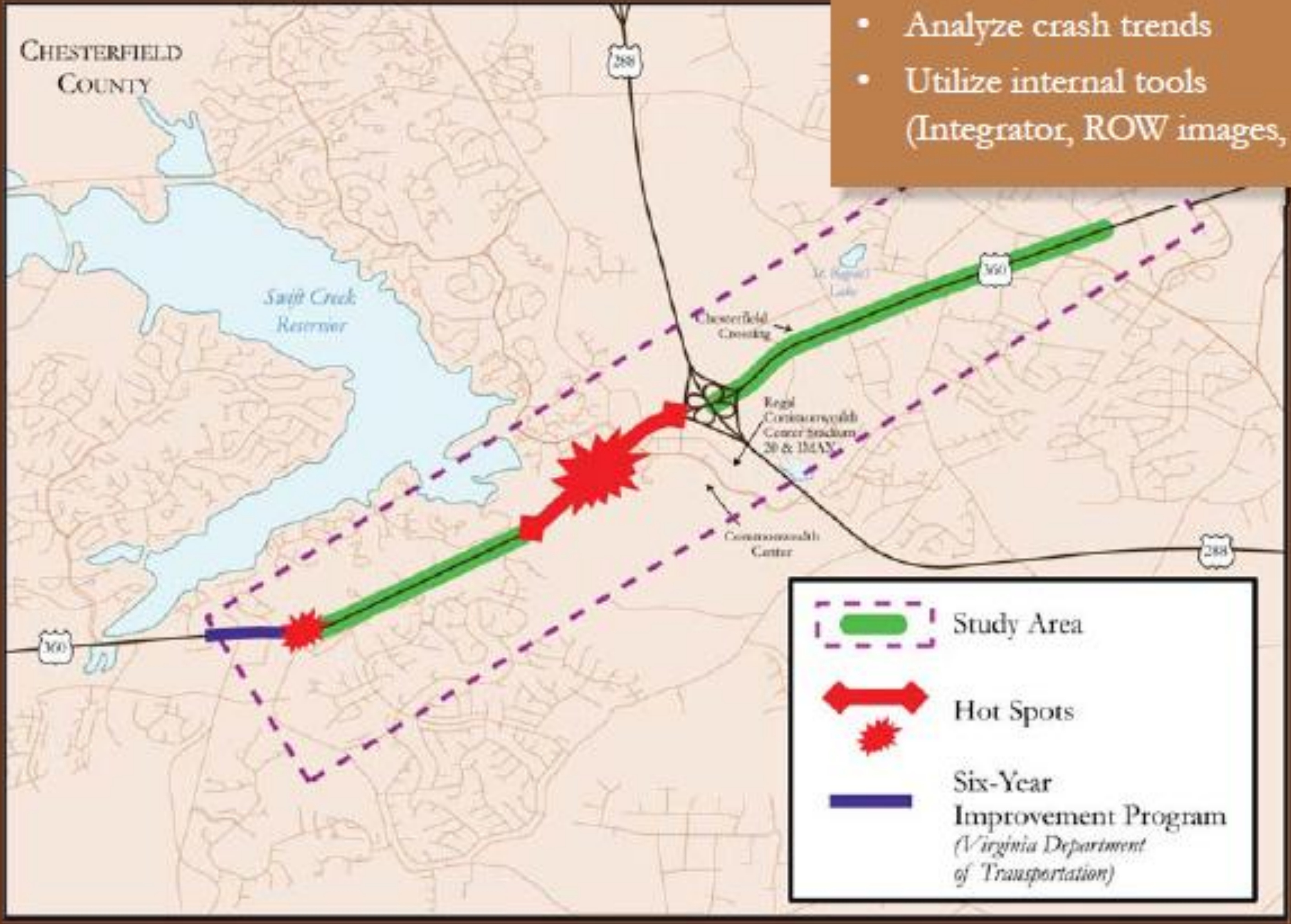
# Identifying Study Locations

## Step 7 – Refine High-Priority Corridors

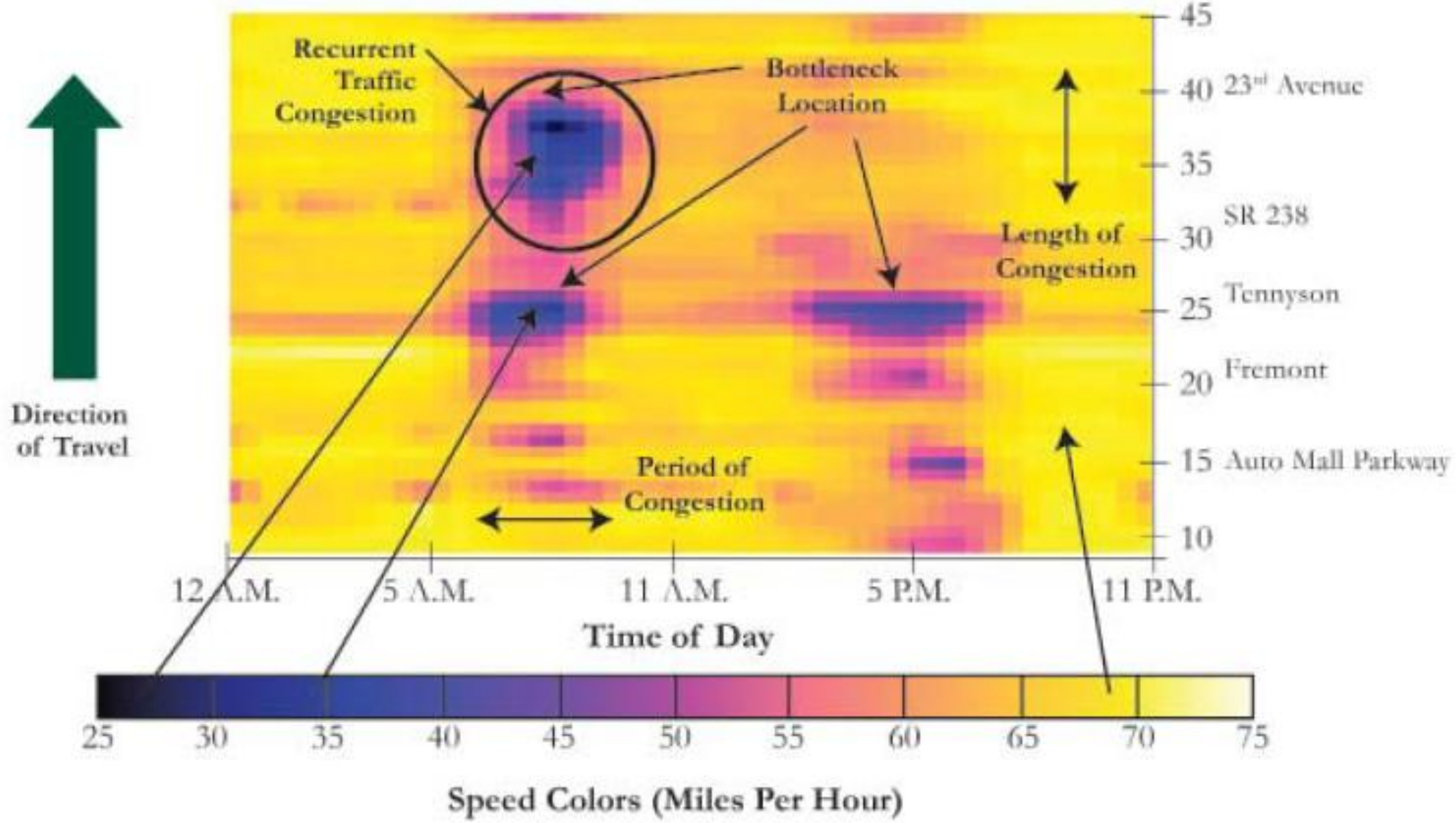
### Identify Safety and Congestion Hot Spots

- Conduct preliminary safety and congestion assessment
- Field inspection
- Analyze crash trends
- Utilize internal tools
(Integrator, ROW images, 1/4 mile crash densities, etc.)

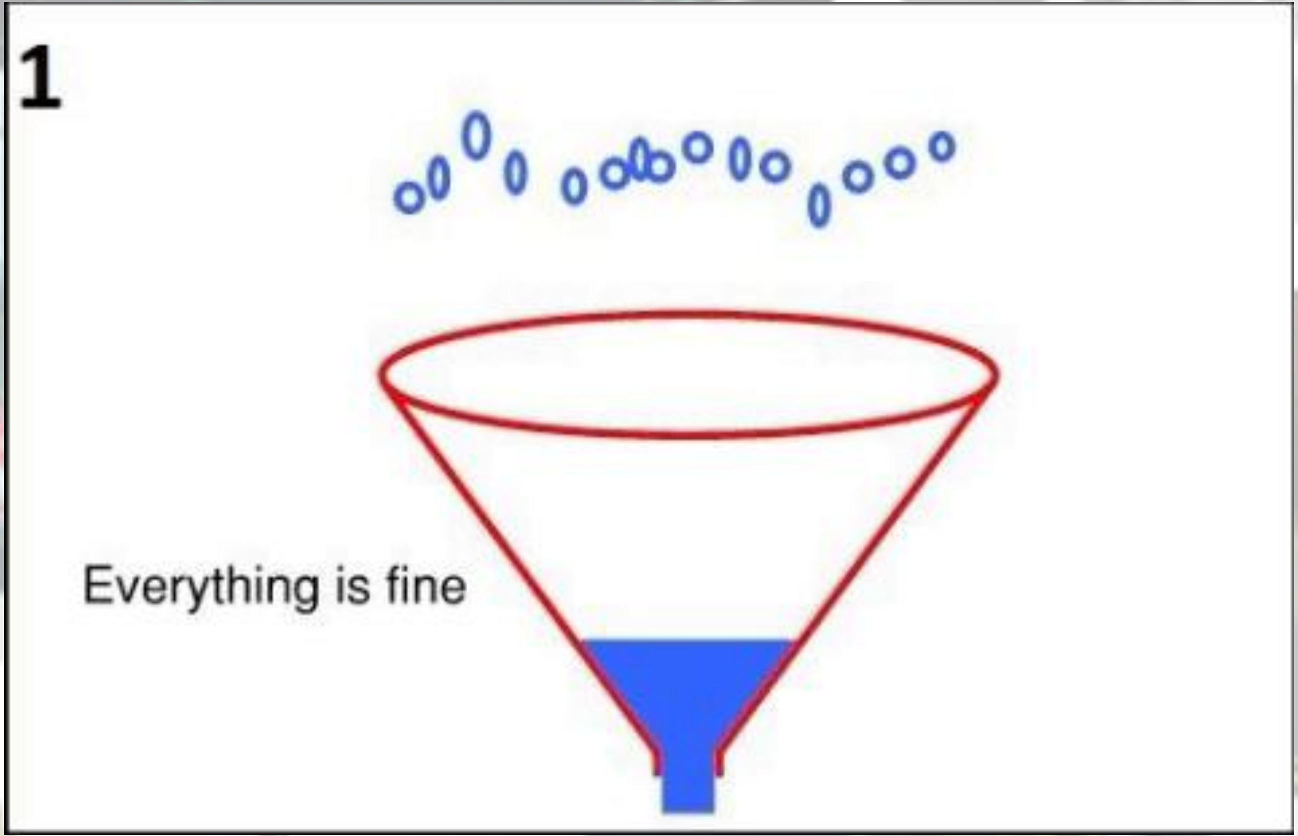


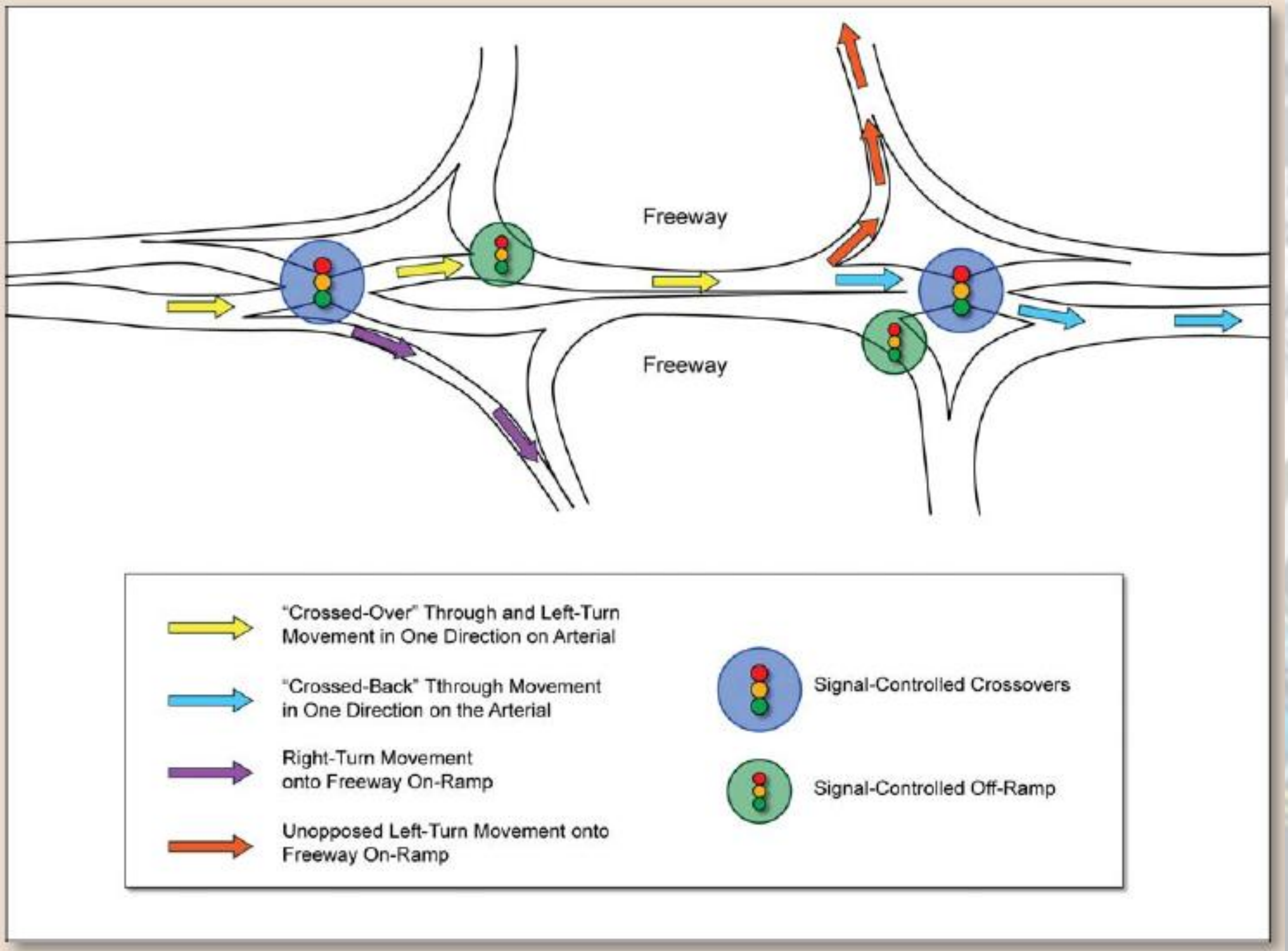
# Exhibit 6. Using Freeway Detector for Bottleneck Analysis

## Northbound I-880
## Average Speed (Miles per Hour)
## 10/1/04-10/31/04, Tuesday-Thursday




# Basic Idea … Sketch





Freeway
Freeway
"Crossed-Over" Through and Left-Turn Movement in One Direction on Arterial
"Crossed-Back" Tthrough Movement in One Direction on the Arterial
Right-Turn Movement onto Freeway On-Ramp
Unopposed Left-Turn Movement onto Freeway On-Ramp
Signal-Controlled Crossovers
Signal-Controlled Off-Ramp

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# Questions?

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## Question

## How does traffic around a football stadium differ between a match day and a non-match day?

# Case Study

Identify pain points and bottlenecks. Based on event and traffic management initiatives, you can develop clear traffic guidelines, including suggestions for alternative access routes, load balancing across multiple parking lots and incentives for varying arrival times.

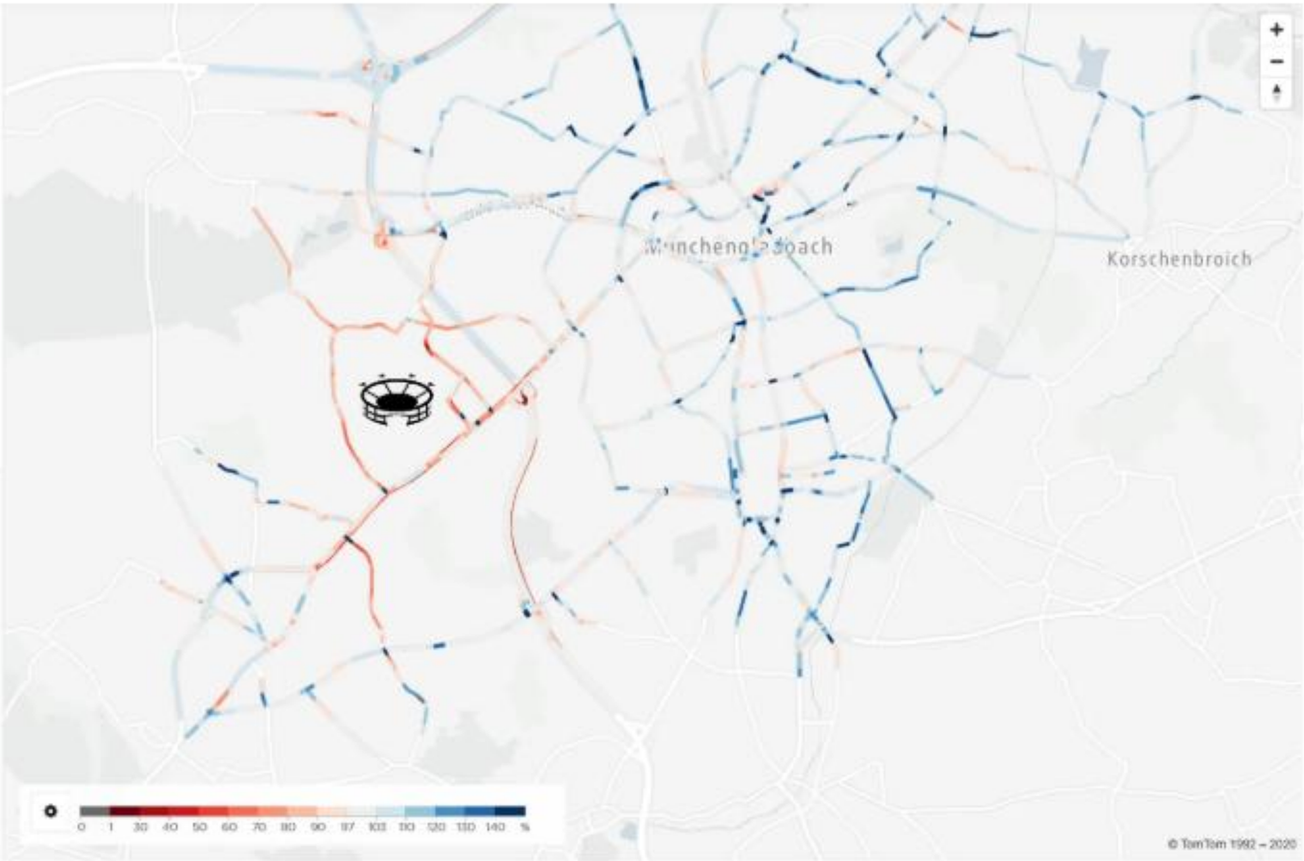


*Figure 6: Average speed comparison around the stadium*

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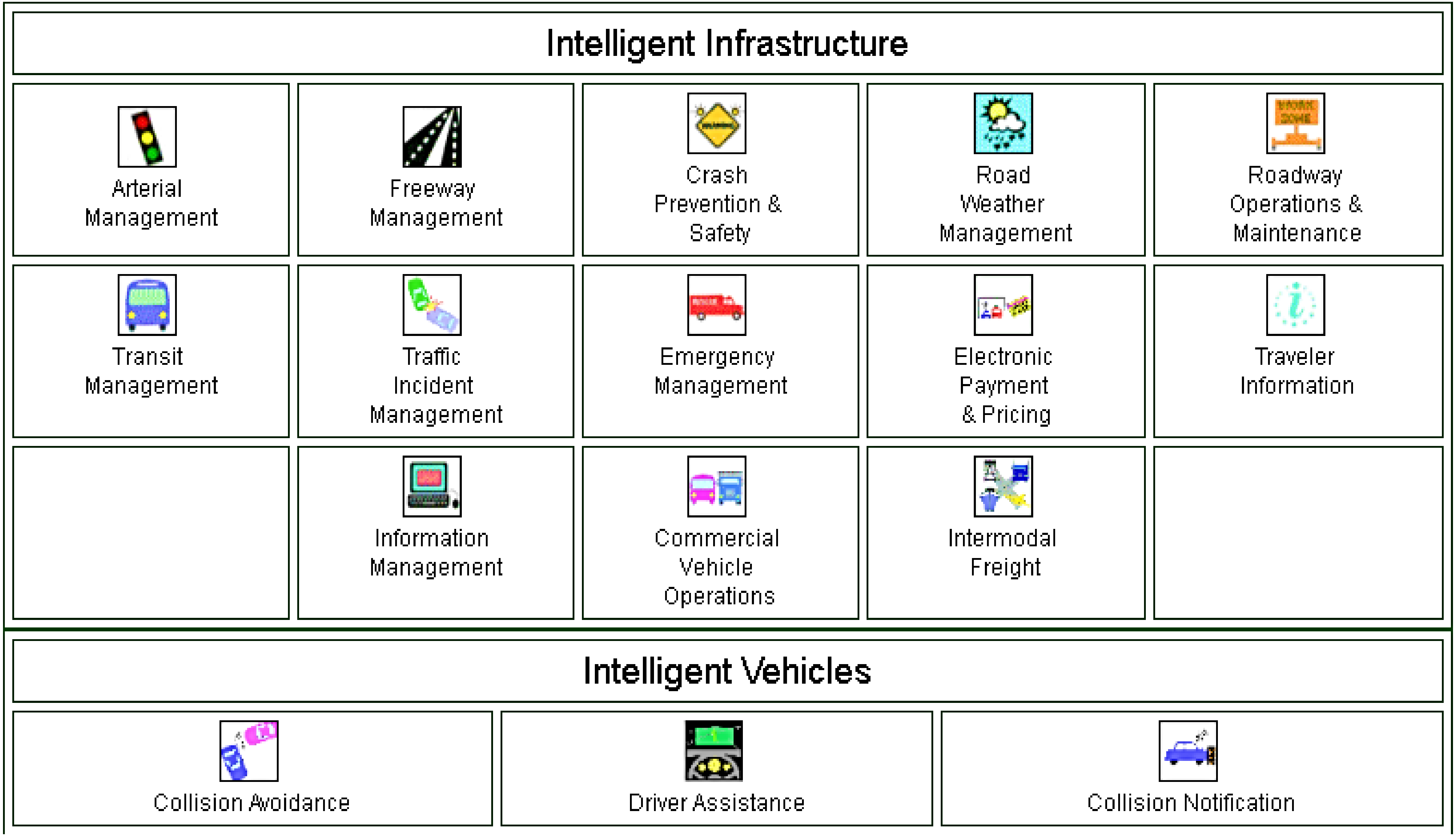
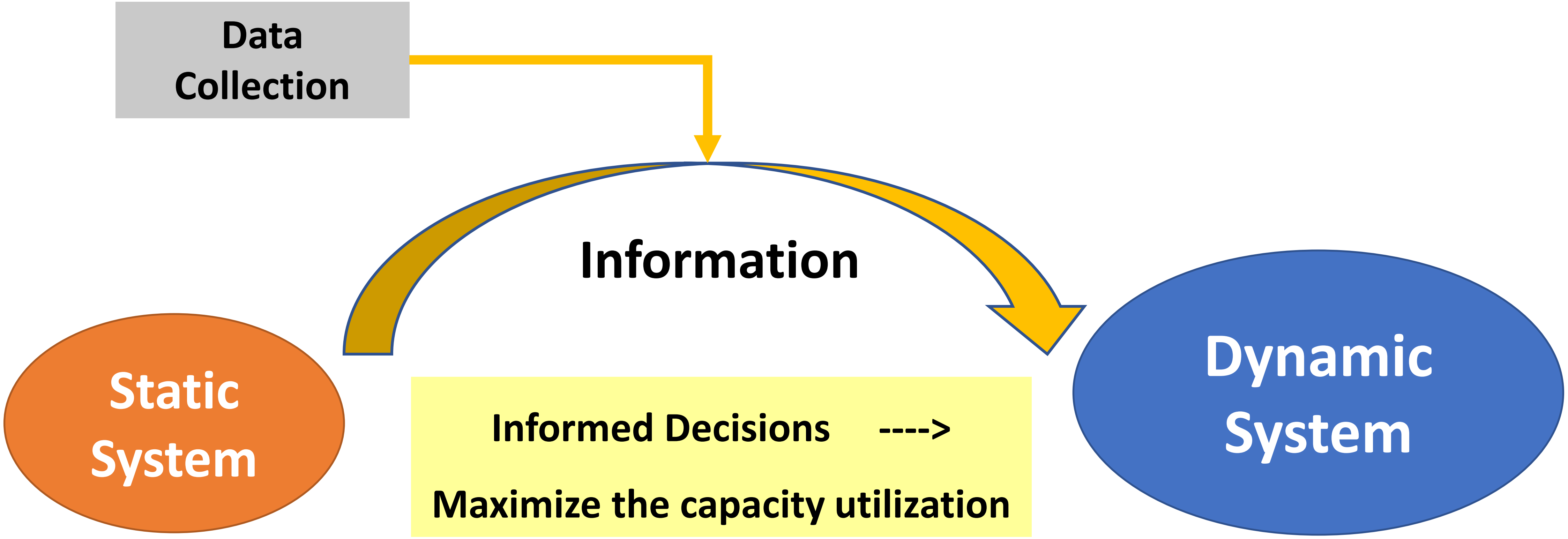
# II. ITS Applications & Data Science


Intelligent Infrastructure
Arterial Management
Freeway Management
Crash Prevention & Safety
Road Weather Management
Roadway Operations & Maintenance
Transit Management
Traffic Incident Management
Emergency Management
Electronic Payment & Pricing
Traveler Information
Information Management
Commercial Vehicle Operations
Intermodal Freight
Intelligent Vehicles
Collision Avoidance
Driver Assistance
Collision Notification

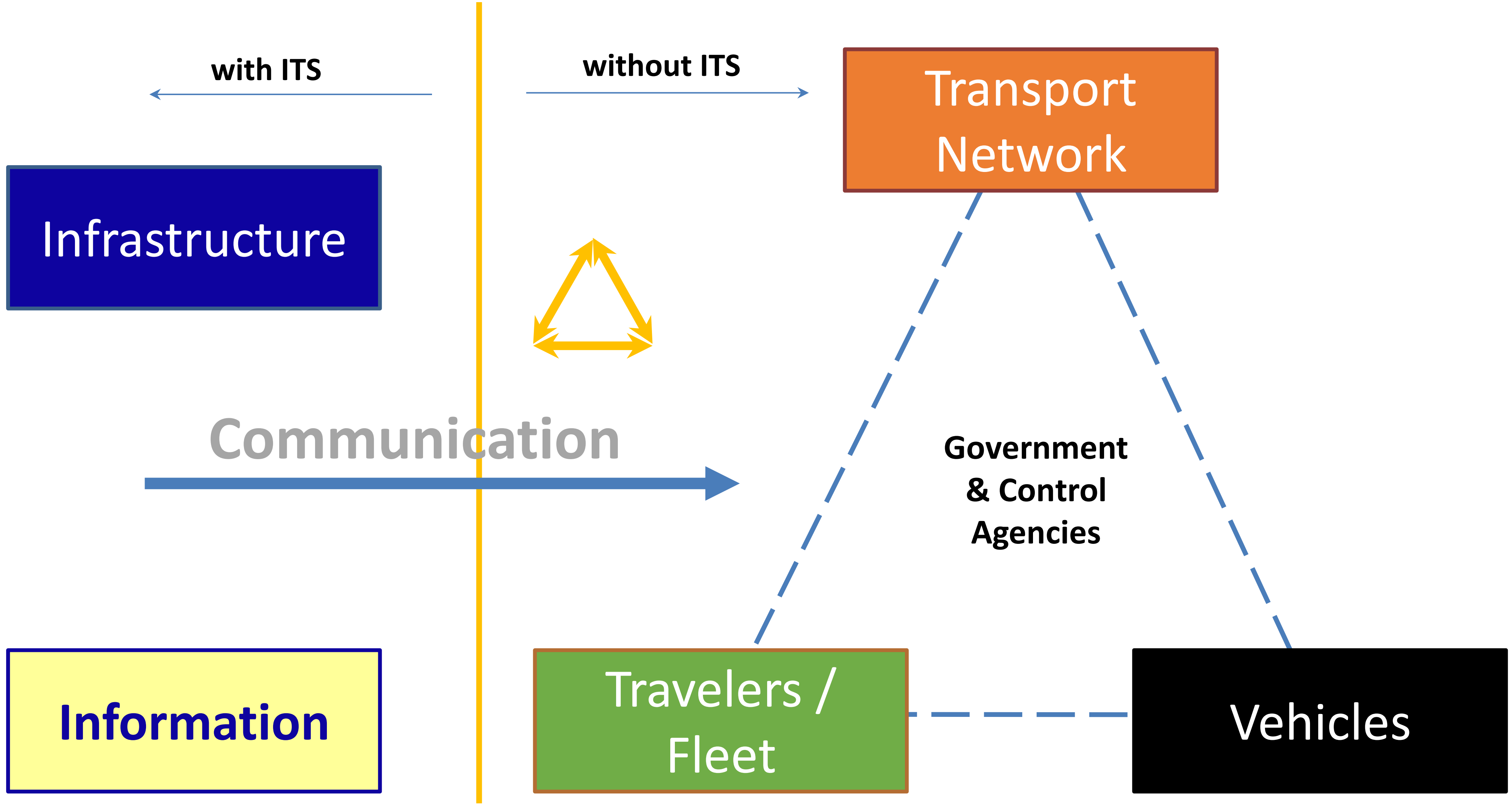
# Impact of ITS on the Transport System

- Converts the **Static** Control Systems into **Dynamic** Control Systems



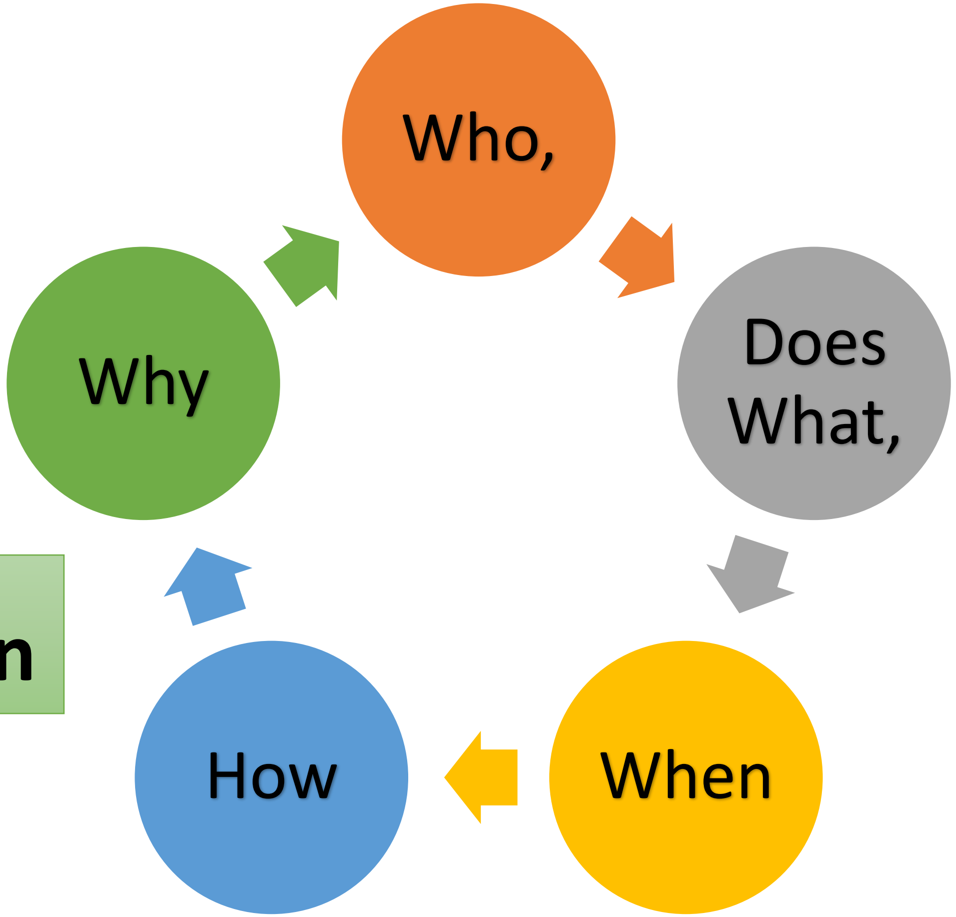

Intelligent
System
Transportation

# What is an ITS System ?



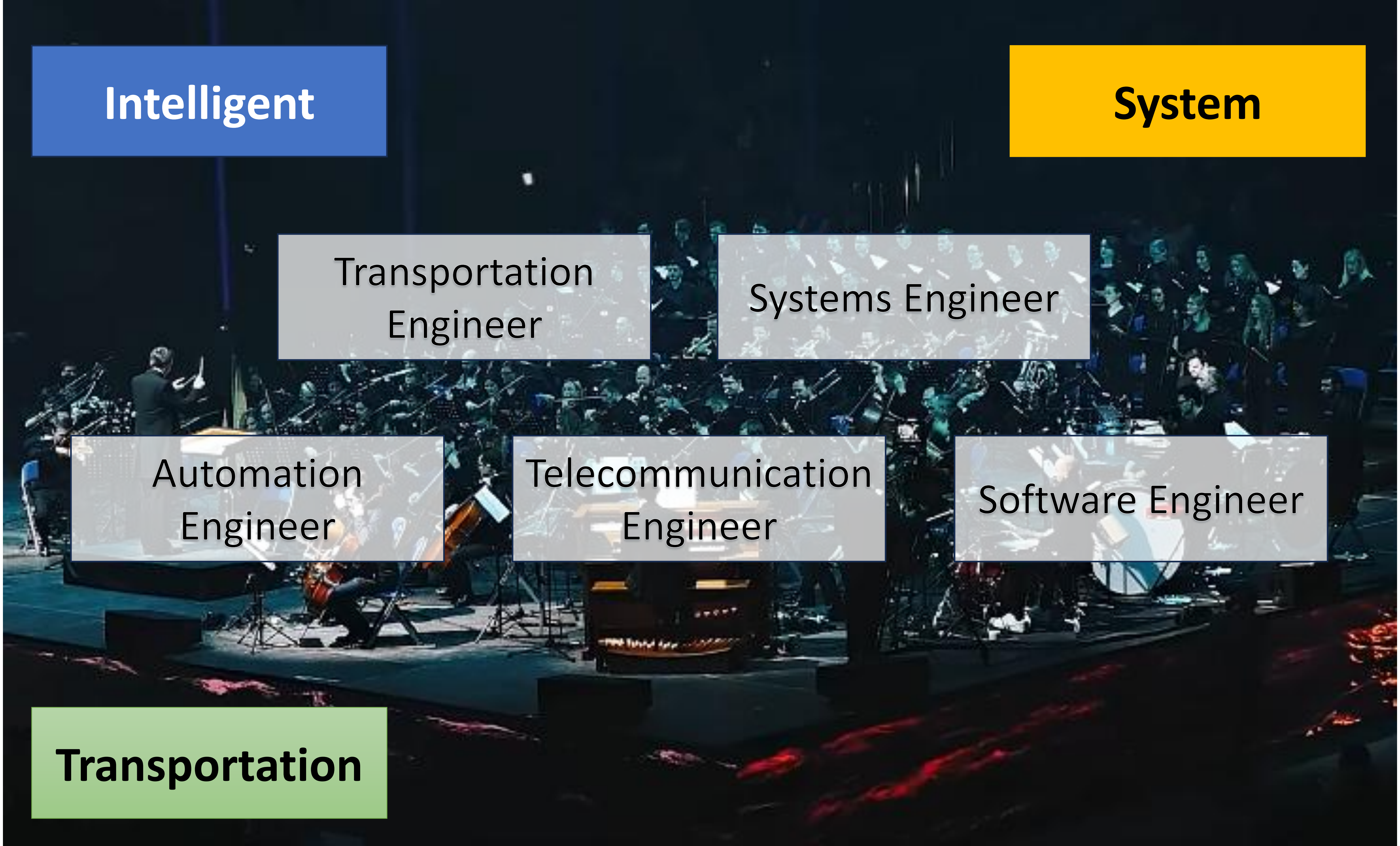
# Application in ITS

**Intelligent**




**Transportation**

**System**



Intelligent

System

Transportation Engineer

Systems Engineer

Automation Engineer

Telecommunication Engineer

Software Engineer

Transportation

# When to think about ITS

- **Solve** an existing traffic problem: congestion, reliability, … etc
- **Improve** traffic services
- **Operate** the traffic system more reliably and more effectively
- **Store** and evaluate archived **data** collected from the operating system

# Questions

3. ITS systems offer “informed decisions” to …

   a. Static systems
   b. Dynamic systems
   c. Maximize capacity utilization
   d. Transportation systems
   e. Decision makers

# ATDM

# Active Transportation and Demand Management (ATDM)

- Linking transportation demand management (TDM) and traffic management enhances the ability for transportation stakeholders to address **mobility and reliability** concerns in travelers' decision-making processes and enable users to make informed decisions throughout their trip.

| Active Demand Management | Active Traffic Management | Active Parking Management |
|---|---|---|
| Dynamic Ridesharing | Dynamic Lane Use/Shoulder Control | Dynamically Priced Parking |
| On-Demand Transit | Dynamic Speed Limits | Dynamic Parking Reservation |
| Dynamic Pricing | Queue Warning | Dynamic Way-Finding |
| Predictive Traveler Information | Adaptive Ramp Metering | Dynamic Parking Capacity |

# Questions

4. ATDM systems enhance …

a. traffic management
b. demand management
c. **<u>mobility and reliability</u>**
d. users' decisions
e. any of the above

# Active Transportation and Demand Management (ATDM)

- ATDM is the dynamic management, control, and influence of travel demand, traffic demand, and traffic flow of transportation facilities.


https://ops.fhwa.dot.gov/

# Questions

5. ATDM systems are …

   a. Dynamic systems
   b. control systems
   c. ITS systems
   d. Demand management systems
   e. **all of the above**

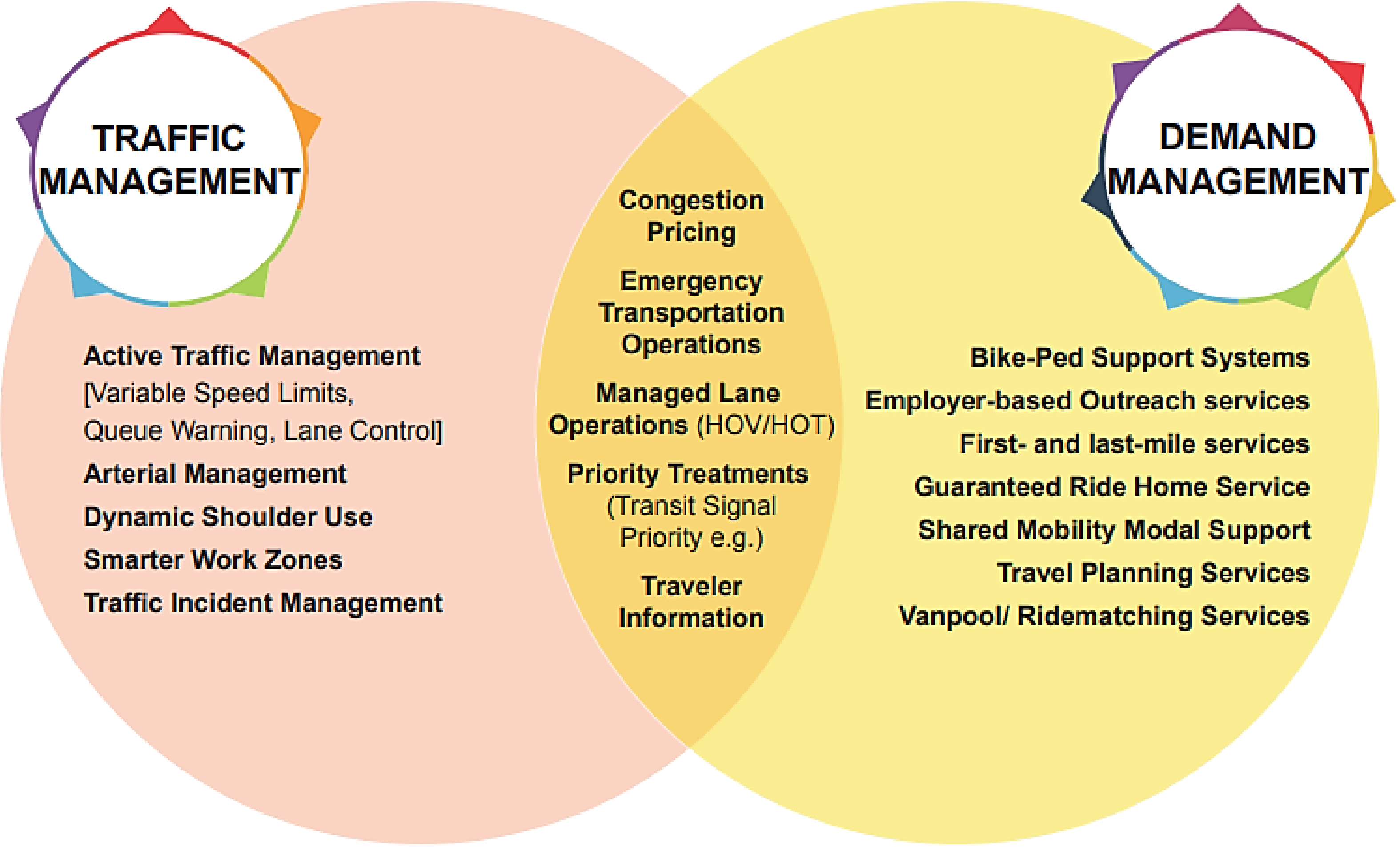



**Figure 2. Illustration. The nexus between traffic management and demand management.**

# Active Traffic Management (ATM) Strategies

- Active Traffic Management (ATM) strategies focus on influencing travel behavior **during a trip** with respect to operations and lane and facility choices.
- ATM is the ability to dynamically manage recurrent and non-recurrent congestion based on prevailing and predicted traffic conditions.
- Focusing on trip reliability, ATM maximizes the effectiveness and efficiency of the facility, while also increasing safety and throughput by using integrated systems with new and automated technologies.
  - Adaptive Ramp Metering (ARM)
  - Adaptive Traffic Signal Control (ATSC)
  - Dynamic Junction Control (DJC)
  - Dynamic Lane Assignment (DLA)
  - Dynamic Lane Reversal (DLR)
  - Dynamic Merge Control (DMC)
  - Dynamic Shoulder Lanes (DShL)
  - Dynamic Speed Limits (DSpL)
  - Queue Warning (QW)
  - Transit Signal Priority (TSP)

# Active Traffic Management (ATM)

- Active traffic management (ATM) is the ability to dynamically manage recurrent and non-recurrent congestion based on prevailing and predicted traffic conditions. Focusing on trip reliability, it maximizes the effectiveness and efficiency of the facility.
- ATM approaches seek to increase throughput and safety through the use of integrated systems with new technology, including the automation of dynamic deployment to optimize performance quickly and without delay that occurs when operators must deploy operational strategies manually.
- ATM includes dynamic routing, dynamic junction control, adaptive signal control, and transit signal priority.

# Active Traffic Management (ATM)

- Dynamic lane use/shoulder control: the dynamic opening of a shoulder lane to traffic or dynamic closure of travel lanes on a temporary basis in response to increasing congestion or incidents.
- Dynamic speed limits: the dynamic change in speed limits based on road, traffic, and weather conditions.
- Queue warning: the dynamic display of warning signs to alert drivers that congestion and queues are ahead.
- Adaptive ramp metering: the dynamic adjustment of traffic signals at ramp entrances to proactively manage vehicle flow from local-access roads.
- Dynamic rerouting: the dynamic provision of alternate route information in response to increasing congestion at bottlenecks/incidents.
- Dynamic junction control: the provision of lane access based on highway traffic present and merging/diverging traffic to give priority to the facility higher volume to minimize the impact of the merging/diverging movement.
- Adaptive traffic signal control: the optimization of signal timing plans based on prevailing conditions to increase throughput along an arterial.

# Questions

## 6. ATM systems manage …

a. throughput
b. dynamic systems
c. **recurrent and non-recurrent congestion**
d. Demand management systems
e. all of the above

# Benefits of ATM

- A **decrease in primary incidents** by alerting drivers to congested conditions and promoting more uniform speeds;
- A **decrease in secondary incidents** by alerting drivers to the presence of queues or incidents and proactively managing traffic in and around incidents;
- **Increased throughput** by reducing the delay associated with the number of primary and secondary incidents reducing speed differential in traffic flow, and reducing the shockwave effects of excessive breaking.
- **Increased overall capacity** by adding shoulder use during congested periods when it is needed most;
- Overall **improvement in speed uniformity** during congested periods; and
- **Increased trip reliability** by increasing capacity and throughput and reducing incident delay and improving vehicle throughput.

# Identifiers to use ATM Strategies

- High traffic volumes;
- Changes in prevailing conditions;
- A high prevalence of crashes;
- Capacity bottlenecks;
- Adverse weather;
- Adverse environmental impacts;
- Variability in trip reliability;
- Construction impacts;
- Financial constraints and priorities; and,
- Limitation in capacity expansion.

# Questions

7. It is advised to use ATM systems at …. conditions

   a. limited capacity expansion
   b. adverse weather
   c. high traffic volumes
   d. construction impacts
   e. **<u>all of the above</u>**

# Potential measures to evaluate system performance and ATDM deployments

| | | |
|---|---|---|
| • Average Travel Time | • Travel Delay | • Bike/Ped Accessibility |
| • Travel Time Reliability | • Non-Recurring Delay | • Transit Use |
| • Travel Time Buffer Index | • Average System Speed | • Transit vs Auto Travel Time |
| • Travel Time $x^{th}$ Percentile | • Incident Info. Dissemination | • Transit On-Time Performance |
| • Planning Time Index | • Incident Severity | • Mode Share |
| • Vehicle Miles Traveled | • Incident Clearance Time | • Parking Occupancy |
| • Congestion Level | • Road Weather Clearance Time | • Number of Citations |
| • Traffic Density | • Queue Length | • Customer Satisfaction |
| • Traffic Volume | • Occupancy | • Reduced Trips |

# Questions

8. Potential measures to evaluate system performance and ATDM deployments include ….

   a. travel time
   b. travel delay
   c. queue length
   d. vehicle miles travelled
   e. **all of the above**

# Active Traffic Management (ATM) in USA

# Information

**Data Collection ---> Processing ---> Analysis ---> Information**

**Daily**

- Speed
- Flow
- Travel Time
- Weight
- Departure Time
- Trip Duration
- Accidents

**Hourly**

- Speed
- Flow
- Travel Time
- Weight
- Departure Time
- Trip Duration
- Accidents

**Real-time**

- **Speed**
- **Flow**
- **Travel Time**
- **Weight**
- **Departure Time**
- **Trip Duration**
- **Accidents**

**Predictions**

- **Predicted Speed**
- **Predicted Flow**
- **Expected Time of Arrival**
- **Alternative Routes**
- **En-route Information**

# Information
## Information Systems

Data Collection ---> Processing ---> Analysis ---> Information

Software Packages

Experts; Scientists
& Engineers

Processing Units

Algorithms

# Before Implementing ITS

- Nation-wide Vision
- ITS Architecture
- Feasibility Studies … Cost – Benefit Analysis
- ITS Applications should be:
  1. Integrated: major elements of the ITS Taxonomy are linked
  2. Compatible:
  3. Expandable:
  4. Standardized:

# Integration in ITS

- Sharing of information between agencies
  - when arterial traffic data are shared with transit agencies so they can improve service
- Equipment interoperability
  - when emergency vehicles communicate with traffic signals to preempt signal timing to improve incident response
- Coordinate control actions between different agencies
  - when arterial management agencies coordinate signal timing on a corridor

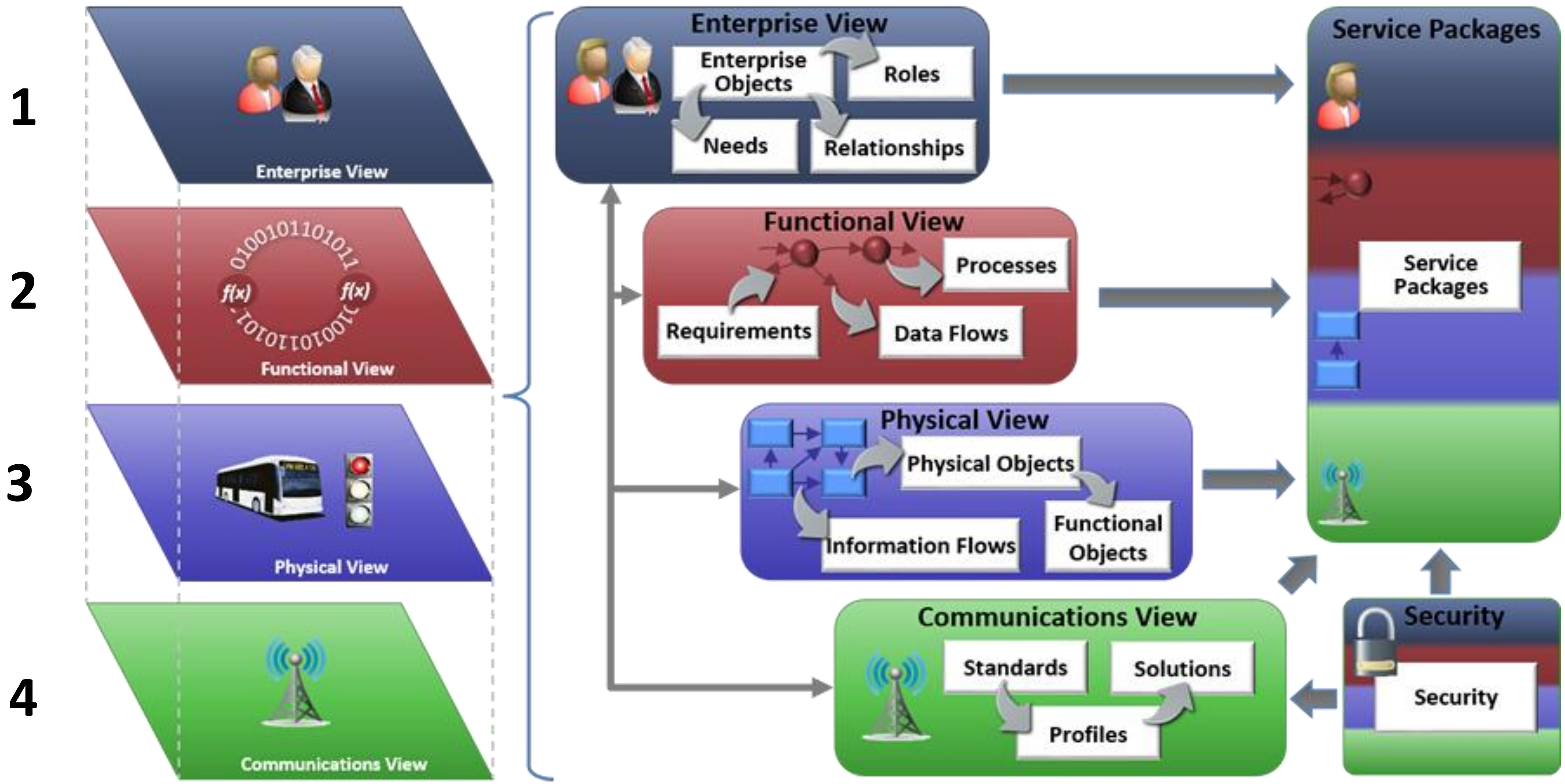
# Standardization in ITS

Regional standards or utilized from other regions. Standards lead to faster and more reliable systems development according to the governmental goals.

- To have a consistent & expectable product behavior
- To improve the interfaces between parts of complex systems
- Help users to expect at least minimum product performance
- Help public agencies and other organizations to cooperate and interact successfully.
- Offer manufacturers and vendors easier entry to markets
- Offer buyers a greater choice of suppliers, at lower risk and lower cost.

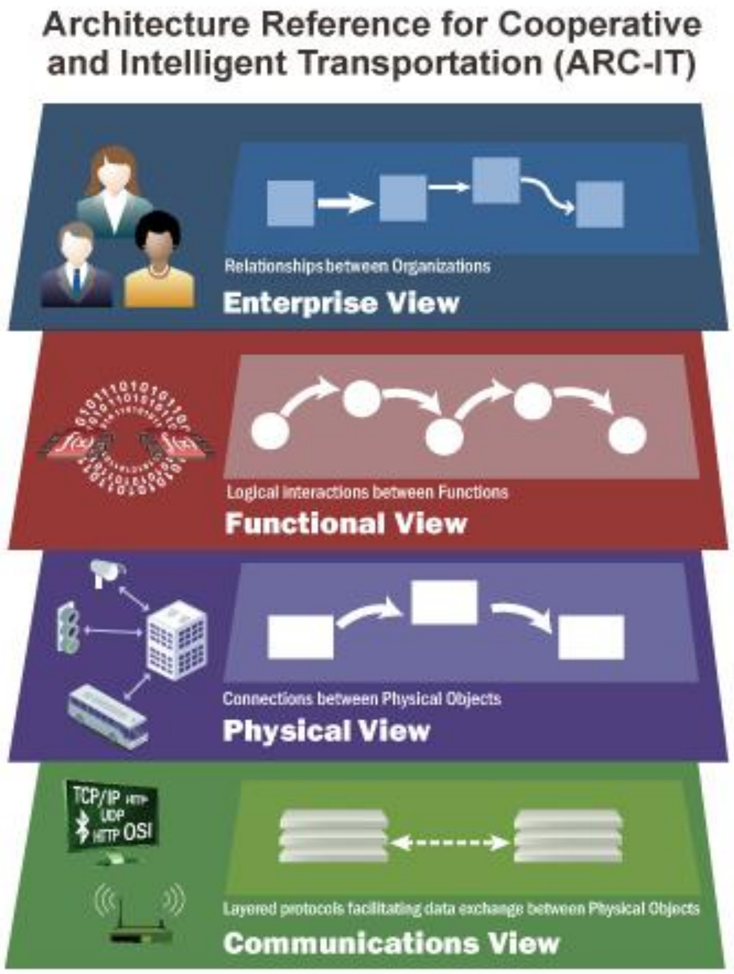
# Architecture

## 4 Types of ITS Architecture:



# Architecture Reference

- The Architecture Reference for Cooperative and Intelligent Transportation (ARC-IT) provides a common framework for planning, defining, and integrating intelligent transportation systems.
- ARC-IT is a reference architecture: it provides common basis for planners and engineers with differing concerns to conceive, design and implement systems using a common language as a basis for delivering ITS, but does not mandate any particular implementation.
- ARC-IT includes artifacts that answer concerns relevant to a large variety of stakeholders, and provides tools intended for transportation planners, regional architects and systems engineers to conceive of and develop regional architectures, and scope and develop projects.



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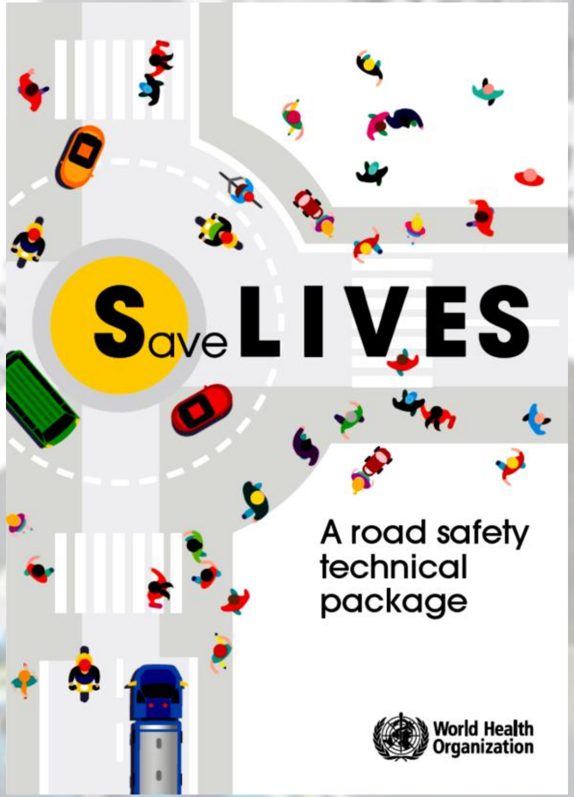
# Questions?

# Thank You!


والعلم لا يعطيك بعضه إلا إذا أعطيته كلك، فإذا أعطيته بعضك لم يعطك شيئاً،
ويظل المرء عالماً ما طلب العلم، فإذا ظن أنه قد علم فقد جهل.