Traffic Engineering and its Impact on Operation and Safety

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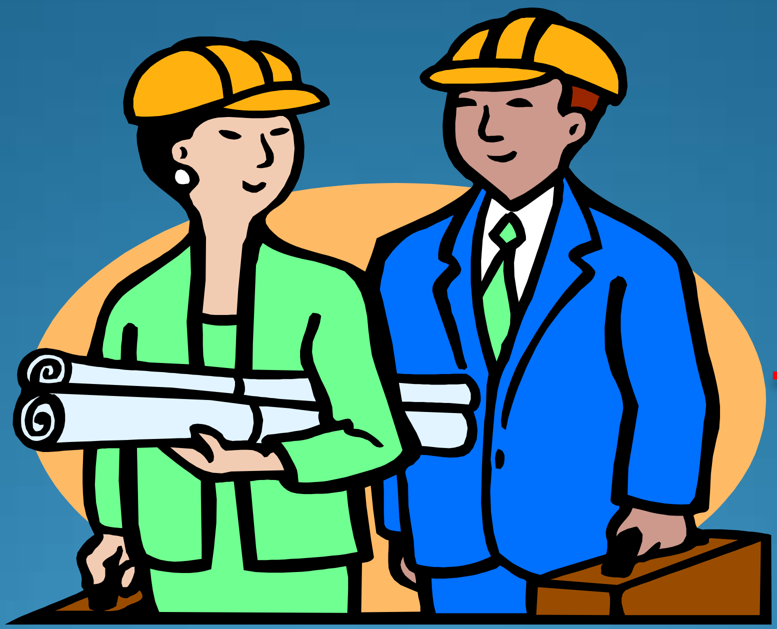
KLEINFELDER
Bright People. Right Solutions.

Engineering is Finding Solutions

Challenge

OR

Need



Solution

Mathematics	Science	Engineering Principles

Transportation Engineering

It is defined as a discipline applying technology and scientific principles to the planning, functional design, operation, and management of facilities for all modes of transportation, including land, rail, water, air, and pipe

Definition of Traffic Engineering

It is the phase of transportation engineering that deals with the planning, geometric design and traffic operations of roads, streets and highways, their networks, terminals, abutting lands, and relationships with other modes of transportation

Basic Concepts and Areas of Emphases

Components of Traffic Stream

Traffic Stream Characteristics

Traffic Studies:

- Data Collection
- Volume Studies
- Accident Studies
- Speed Travel Time and Delay Studies
- Parking, Pedestrian, Bicycle Studies

Urban Street and Highways

Traffic Control

Capacity Analyses

Level of Service Analyses

Management and Operation of Congested Facilities

Components of Traffic System

Road Users & Vehicles

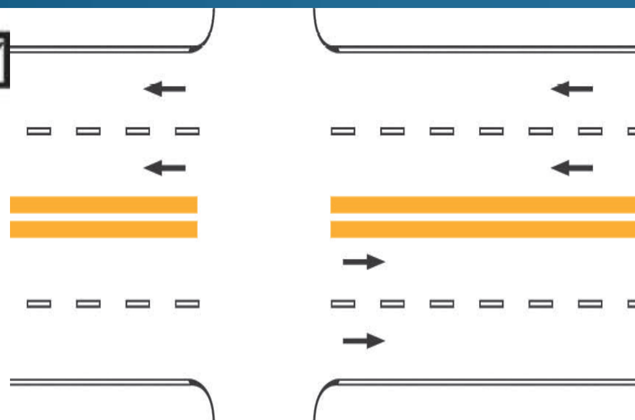




Roadway


EXIT 74 C
33 250
Broad St
EXIT ONLY
RIC Airport
Williamsburg
Va Beach
USE EXIT 75
H
EXIT
74C - WEST

Controls



Human Response Process

Visual Reception

- Visual Acuity

  20/20 vision is a term used to express normal visual acuity (the clarity or sharpness of vision)

- Peripheral Vision

  The ability to see objects and movement outside of the direct line of vision

- Color Vision

  The normal ability to see colors

- Glare Vision & Recovery

  Discomfort in the eye and depression of central vision produced when a bright light enters the field of vision

- Depth Perception

  The ability to perceive spatial relationships, especially distances between objects, in three dimensions.

Perception Reaction Process

Perception

Driver sees a control device or an object on the road

Identification

Driver identifies the object on the road

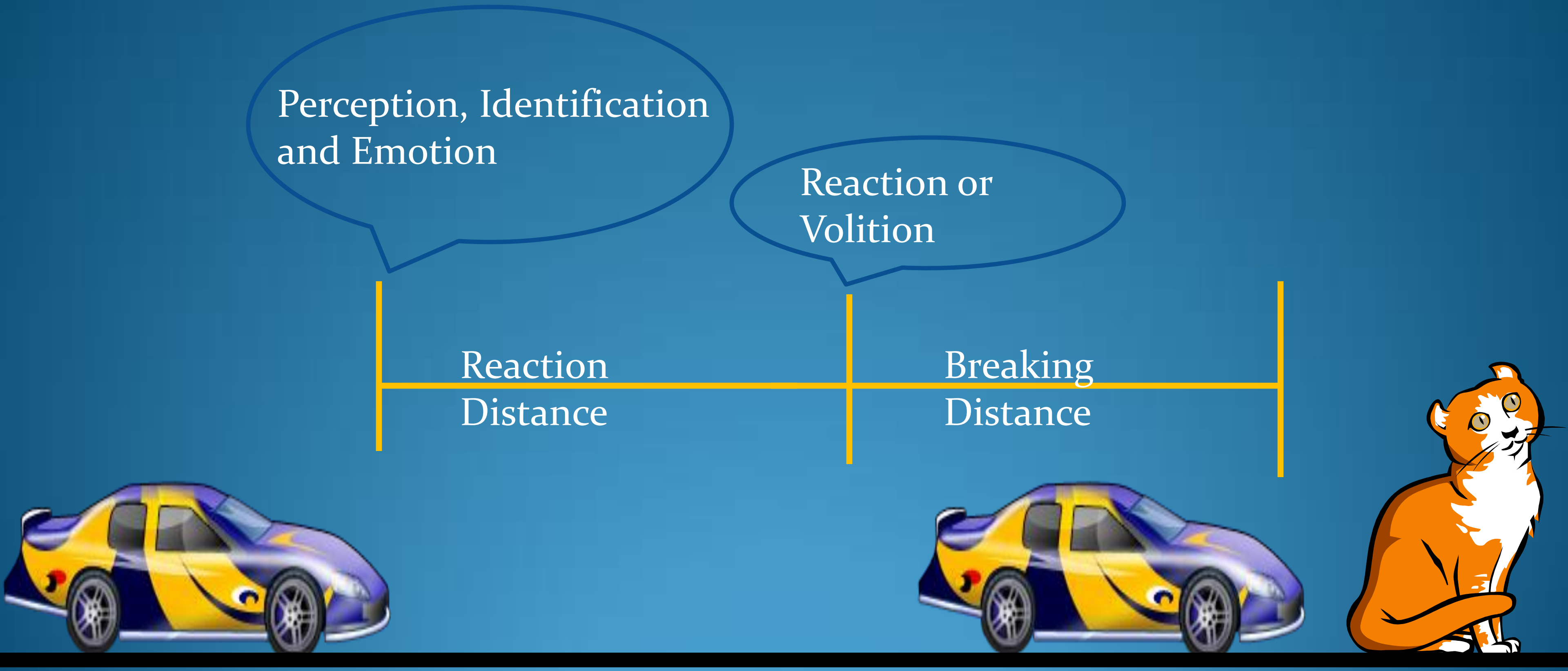
Emotion

Driver decides what action to take

Reaction or Volition

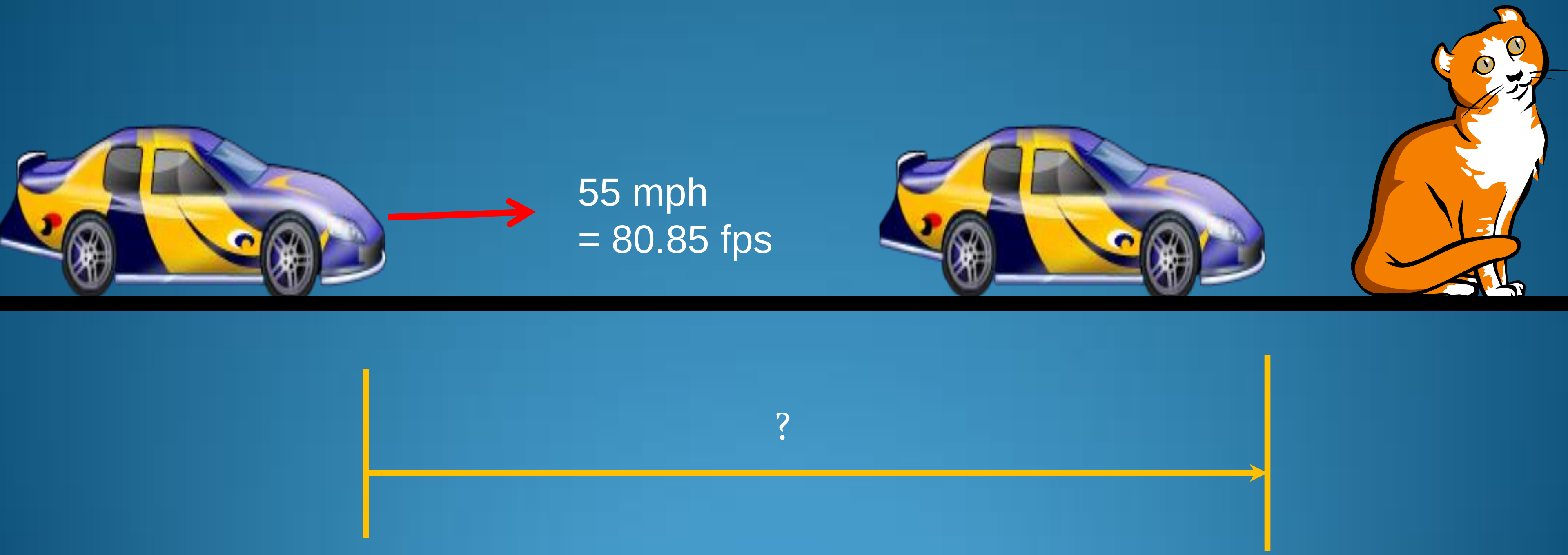
Driver execute the decided action

Reaction and Braking Distance



An Example

Perception, Identification and Emotion time + Reaction or Volition time = 2.5 seconds



Simple Distance formula: D = V * t D = 80.85 * 2.5 → 202.1 feet

Safety Facts

National Highway Traffic Safety Administration (NHTSA)

Fatality Analysis Reporting System (FARS)

2011National Crash Records

Fatal crashes	29,757		
Drivers	16,430	Passengers	5,953
Motorcyclist	4,612	Pedestrian	4,432
Pedal cyclists	677		

Comparison

National Fatalities per 100 million vehicle miles of travel (RMVM)= 1.10 in 2011

down from 1.73 in 1994

Texas RMVM = 1.29 as compared to National RMVM of 1.11 for 2010

Fatal crashes	3,016
Drivers + Passengers	1,980
Motorcyclist	471
Pedestrian	421

An Example of Accident Rate Calculation

It is observed that 20 traffic accidents occurred on a 18.5 mile long section of a highway in one year. The ADT on the section was 7,500 vehicles

a) Determine the rate of total accident per 100 million vehicle-miles

b) Determine the rate of fatal accident per 100 million vehicle-miles, if 3% of the accidents were fatal

a) $\mathrm{RMVMt} = \frac{N*100,000,000}{SL*ADT*365}$ $\mathrm{RMVMt} = \frac{20*100,000,000}{18.5*7,500*365} = 3.95$

b) RMVMf = 3.95 * 0.03 = 0.12

Probable Accident Causes for Different Type of Accidents

Accident Pattern	Probable Cause
Left-turn head on collision	▪ Large volume of left turns ▪ Restricted sight distance ▪ Too Short amber phase ▪ Absence of special left-turning phase ▪ Excessive speed on approaches
Right-angle collisions at signalized intersections	○ Restricted sight distance ○ Excessive speed on approaches ○ Poor visibility of signals ○ Inadequate signal timing ○ Inadequate advance intersection warning signs ○ Inadequate roadway lighting ○ Large total intersection volume

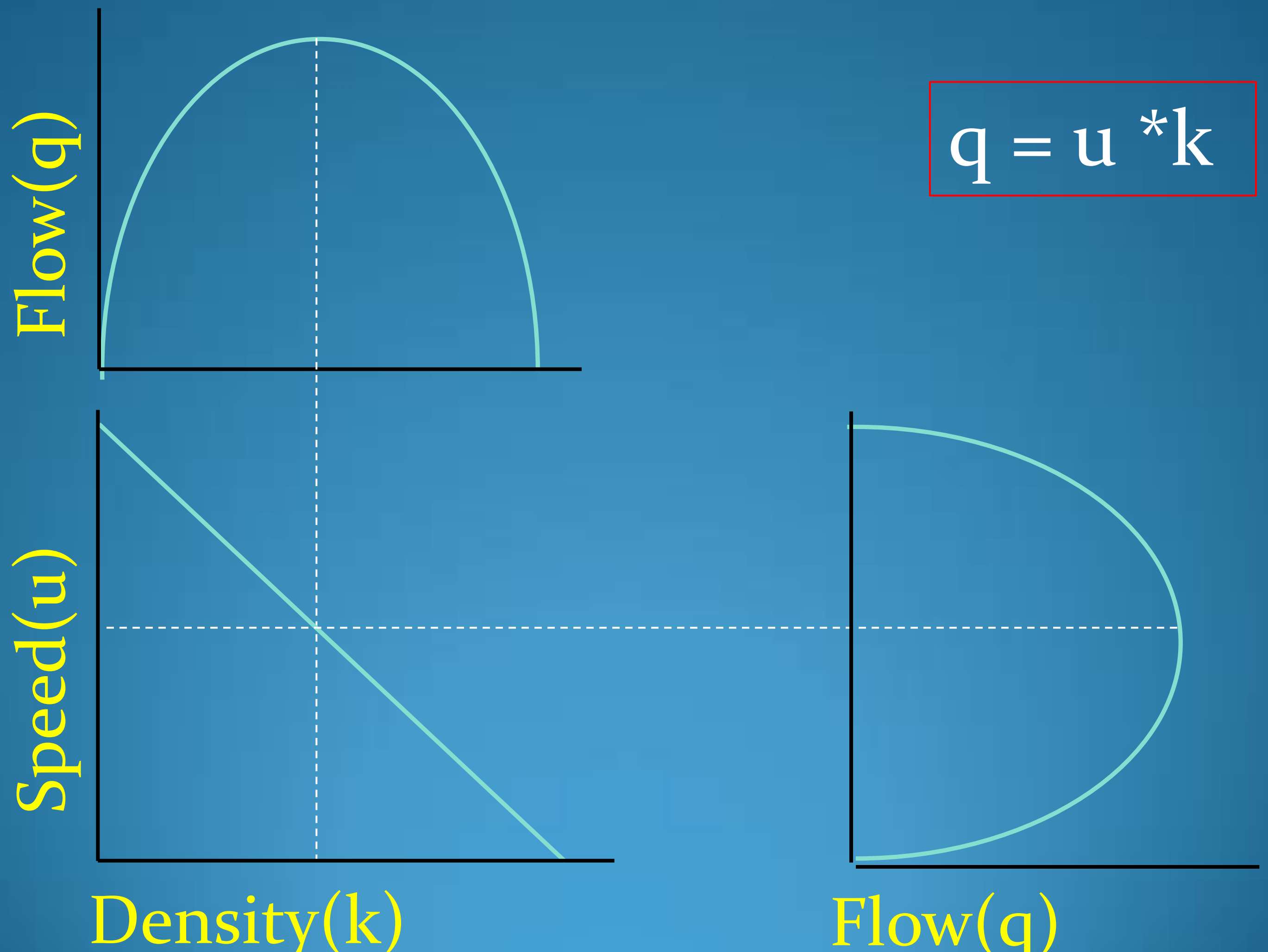
Probable Accident Causes for Different Type of Accidents

Accident Pattern	Probable Cause
Right-angle collisions at un-signalized intersections	▪ Restricted sight distances ▪ Large total intersection volume ▪ Excessive speed on approaches ▪ Inadequate roadway lighting ▪ Inadequate advance intersection warning signs or signal ▪ Inadequate traffic control devices
Rear-end collisions at un-signalized intersections	o Driver not aware of intersection o Slippery surface o Large number of turning vehicles o Inadequate roadway lighting o Excessive speed on approach o Lack of adequate gaps o Crossing pedestrians

Probable Accident Causes for Different Type of Accidents

Accident Pattern	Probable Cause
Rear-end collisions at signalized intersections	▪ Slippery surface ▪ Large number of turning vehicles ▪ Poor visibility of signals ▪ Inadequate signal timing ▪ Unwarranted signals ▪ Inadequate roadway lighting
Pedestrian vehicle collision	○ Restricted sight distance ○ Inadequate protection for pedestrians ○ School crossing area ○ Inadequate signals ○ Inadequate phasing signal

Traffic –Stream Characteristics
Speed , Flow and Density Relationship



$$q = u * k$$

Performance Measure at Signalized Intersection

Average control delay (d)

$$d = d_1 * (PF) + d_2 + d_3$$

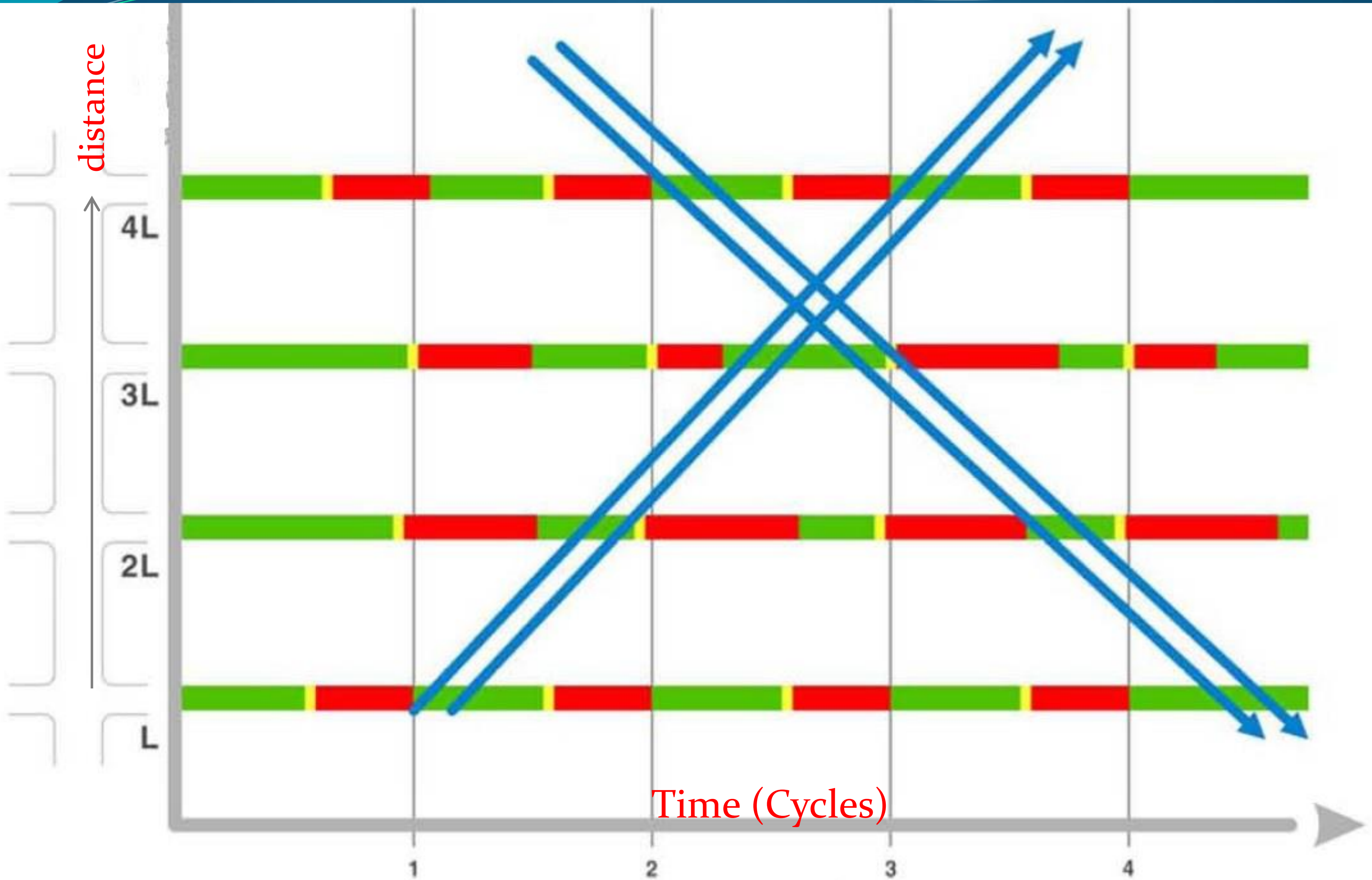
Uniform control delay assuming uniform arrival	Uniform delay progression adjustment factor	Incremental delay	Initial queue delay

Level of Service at Signalized Intersection

Vehicle delay is a method of quantifying level of service considering several intangible, factors, including driver discomfort, frustration, and lost travel time.

Level of Service (LOS)	**Control Delay per vehicle Seconds/vehicle**	**General Description**
A	<10	Free flow
B	>10-20	Stable flow (slight delays)
C	>20-35	Stable flow (acceptable delays)
D	>35-55	Approaching unstable flow
E	>55-80	Unstable flow (intolerable delay)
F	>80	Forced flow (jammed)

Time Space Diagram



Signal Coordination

- The prime benefit is reduction in delays and number of stops
- Benefits are evaluated in terms of a cost function, with the intent to minimize it

$$cost = A * total\ stops + B * (total\ delay) + other\ terms$$

- Maximization of bandwidth window
- Optimization of offset

Goal of Traffic Engineering

Characteristics	Measurement
Safe	Public safety
Rapid	Time value and customer service
Comfortable	Level of service
Convenient	Level of service
Economical	Social cost
Environmentally Sustainable	Clean air, sustainability, and connectivity

Key Information Sources

Texas Criminal and Traffic Law Manual 2011-2012

Manual on Uniform Traffic Control Devices, FHWA

Highway Capacity Manual , 2010

A Policy on the Geometric Design of Highway
and Streets, AASHTO Green Book, 2011

The American Society of Civil Engineers (ASCE)

Institute of Transportation Engineers (ITE)

The Transportation Research Board (TRB)

Traffic Engineer’s Challenge

People DO NOT always act in predictable ways

Like:
Road,
Vehicles (mechanically), and
Traffic Control

System must safely accommodate:

Children, Elderly, and Adults

Healthy and Handicapped

Slow and Speedy

Good drivers and bad drivers

Common Issues for Today's Traffic Engineer

- Growing Urban Traffic Demand Crises
- Rehabilitation and Reconstruction
- Development Impacts
- Growth Impacts
- Safety Programs
- Regional Economic Development

Responsibility and Liability

- Daily safety and dependability of a large number of the public
- Legal advice sought by traffic engineers
- Full command on the traffic laws and regulations in the jurisdiction
- Utmost care and engineering judgment must be practiced in all matters of planning, design, construction, maintenance and operations

Thank you!

UTSA. The University of Texas at San Antonio

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References:

Traffic Engineering, William R. McShane, Roger P. Roess
Prentice Hall, 1990

Traffic and Highway Engineering, Revised Second Edition,
Nicholas J. Garber, Lester A. Hoel,
PWS Publishing, 1996