Lecture 2.15

2.4 Speed Studies

Spot Speed Survey Methods: Direct Timing

Direct timing is the simplest manual method for measuring spot speed over a measured baseline trap distance (e.g., 30 meters to 50 meters).

An observer uses a stopwatch to measure the elapsed travel time (t) required for a vehicle's front wheels to cross baseline entry and exit lines.

- Base Trap Distance (L): 15 m (urban) to 50 m (rural high-speed highways)
- Spot Speed Formula: $v = (L / t) \times 3.6$ (km/h)
- Parallax Error: Human visual sighting delay at entry and exit lines
- Low capital cost; requires minimal equipment

Spot Speed Measurement using Enoscope (Mirror Box)

The Enoscope (or mirror box) is an L-shaped box containing a 45-degree inclined mirror mounted on a tripod at one end of the speed trap baseline.

When a passing vehicle crosses the far baseline point, the observer sees the vehicle reflection in the mirror, eliminating parallax sighting error.

- Eliminates human parallax sighting errors during timing
- Simple optical device requiring no electric power supply
- Observer stationed opposite Enoscope at middle point of baseline trap
- Inexpensive and highly suitable for diploma student field lab practicals

Radar Speed Gun and Laser Lidar Measurement

Radar speed guns emit high-frequency microwave radio signals towards approaching vehicles, measuring instantaneous speed via the Doppler frequency shift effect.

Laser Lidar speed guns emit narrow infrared light pulses, calculating speed by measuring pulse flight reflections; Lidar isolates individual vehicles in multi-lane traffic.

- Radar Gun: Uses Doppler effect ($f\_shift \propto$ speed); handheld or vehicle-mounted
- Cosine Error: Occurs if radar beam angle relative to vehicle path exceeds 10°
- Laser Lidar: Extremely narrow beam; targets specific vehicles in crowded lanes
- Widely deployed by highway police for automated speed limit enforcement

High-Speed Video Camera & Automated License Plate Recognition

Modern Intelligent Transportation Systems deploy high-speed digital video cameras with Automated License Plate Recognition (ALPR) for automated speed enforcement.

Point-to-Point (P2P) speed camera systems record vehicle timestamps at two distant highway gantries, calculating average sectional speed.

- P2P Average Speed Enforcement: Detects drivers who slow down only near fixed radar guns
- High-definition video cameras capture night license plates using infrared flashes
- Automatic generation of traffic violation challans
- Provides 24/7 continuous speed data collection for traffic monitoring

Speed and Delay Study Objectives & Methods

Speed and Delay studies evaluate the quality of service along a highway corridor by identifying locations, causes, and magnitudes of operational delays.

Data collected identifies traffic bottlenecks, evaluates signal synchronization performance, and calculates travel time savings for highway widening projects.

- Floating Car Method (Moving Observer): Test vehicle floats with traffic stream
- License Plate Method: Matching arrival/departure times across corridor checkpoints
- Interview Method: Surveying drivers at terminal destinations about route delays
- GPS Probe Vehicle Method: Logging continuous GPS speed profiles along routes

Floating Car Method (Moving Observer Method) Review

In the Floating Car method, a test car equipped with observers drives along the test section attempting to float with traffic (overtaking as many vehicles as overtake the test car).

Role	Primary Duties
Observer 1	Logs timestamps at checkpoints and stopped delay times
Observer 2	Counts vehicles met traveling in opposite direction (m)
Observer 3	Counts vehicles overtaking test car (o) & overtaken by test car (p)
Driver	Attempts to "float" by balancing overtakes ($n_y = o - p \approx 0$)

Yields stream volume (q) and average journey time ($\bar{t}$) per section.

Causes of Traffic Delays (Fixed vs Operational)

Traffic delays are categorized into Fixed Delays and Operational Delays depending on their primary source.

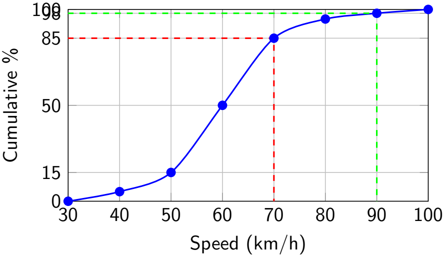
Distinguishing delay causes enables engineers to apply target solutions—such as signal retiming for fixed delays or lane widening for operational delays.

Delay Category	**Characteristics**	**Common Examples**
Fixed Delays	Independent of volume	Traffic signals, stop signs, rail crossings
Operational Delays	Vehicle interaction	High density, turning maneuvers
Curb Friction	Roadside activity	Double parking, bus stops, stalls
Geometric Delays	Physical constraints	Sharp curves, narrow bridges, grades

Cumulative Speed Distribution Frequency Curves

Spot speed data collected in the field is grouped into speed intervals (e.g., 40-45 km/h, 45-50 km/h) to construct frequency distribution histograms.

Plotting cumulative percentage against upper speed class limits yields an S-shaped Cumulative Speed Distribution Curve.



Speed Distribution Frequency Histogram & Pace

A Frequency Histogram plots the percentage of vehicles observed in each speed class against speed intervals.

The peak of the frequency curve represents the Modal Speed, while the 10 km/h band containing the maximum number of vehicles defines the Pace.

- Modal Speed: Speed value corresponding to the peak frequency interval
- 10 km/h Pace: Standard 10 km/h range containing highest vehicle percentage
- Percent Vehicles in Pace: Indicates speed uniformity (aim for ¿70%)
- Skewed distributions reveal speed distortion caused by slow heavy vehicles or enforcement

Applications of Speed Data in Traffic Management & Safety

Speed data directly guides decisions across highway design, traffic regulation, accident analysis, and environmental modeling.

Proper application of speed metrics improves road safety, optimizes fuel consumption, and reduces vehicular emissions.

- Setting regulatory maximum and minimum speed limits
- Designing geometric sight distances (SSD, OSD) and curve superelevation
- Synchronizing traffic signals along progressive green wave corridors
- Evaluating speed reduction interventions (speed humps, rumble strips, chicanes)
- Calibrating traffic simulation software models (VISSIM, AIMSUN)

Summary & Key Takeaways

Spot speed instruments include Enoscopes, Radar guns, Laser Lidar, and P2P video cameras.

Cumulative speed curves provide the 98th, 85th, 50th, and 15th percentile speeds essential for geometric design and traffic regulation.

- Enoscope eliminates parallax error; Radar/Lidar measures instantaneous spot speed
- Floating car method measures corridor speed and operational delays
- Cumulative S-curve yields 98th (Design), 85th (Limit), and 15th (Minimum) percentiles
- 10 km/h Pace and Modal Speed evaluate traffic stream speed uniformity