Lecture 2.12

2.1 Types and Need for Traffic Studies

Planning and Framework for Traffic Data Collection

Successful field surveys require structured planning, including defining study objectives, selecting appropriate sample sizes, training personnel, and ensuring field safety.

Engineers prepare detailed work plans specifying survey station locations, equipment calibration protocols, and weather contingency procedures.

- Defining precise spatial and temporal survey boundaries
- Selecting appropriate counting intervals (5-min, 15-min, 1-hour)
- Safety protocols for field survey crews working on active carriageways
- Pre-survey pilot testing of equipment and tally sheets

Manual vs Automated Data Collection Methods

Traffic data collection methods are divided into manual observational techniques and automated sensor-based technologies.

Selecting between manual and automated methods involves evaluating accuracy requirements, survey duration, labor availability, and budget constraints.

Feature	Manual Methods	Automated Methods
Cost	Low initial cost	Higher equipment capital cost
Duration	Short-duration (peak hours)	Continuous 24/7 operation
Limitations	Human fatigue, weather dependent	Higher cost, subject to power loss
Best For	Complex vehicle classification	Long-term AADT monitoring

Pneumatic Tube Counters and Inductive Loop Detectors

Pneumatic tube counters compress air pulses when vehicle tires cross flexible rubber tubes laid across the roadway, recording axle counts.

Inductive loop detectors embedded in the road pavement detect changes in magnetic inductance caused by metallic vehicle bodies passing overhead.

- Pneumatic Tubes: Portable, temporary installation; divides axle count by 2 (can miscount multi-axle trucks)
- Inductive Loops: Permanent installation, highly accurate for volume and occupancy measurement
- Loop configuration: Quadrupole or dual-loop systems measure vehicle speed and length
- Subject to damage during asphalt resurfacing operations

Radar, Lidar, and Ultrasonic Sensors in Traffic Data

Non-intrusive sensor technologies collect traffic data overhead or from roadside poles without physically cutting into the road pavement.

Technology	Mechanism	Key Capability
Radar	Emits radio waves	Highly accurate spot speed and volume tracking
Lidar	Light Detection & Ranging	High-precision 3D profiling for classification
Ultrasonic	Emits high-frequency sound	Detects vehicle presence in specific lanes

Non-intrusive setup eliminates traffic disruption during sensor installation and maintenance.

Video Image Processing and Computer Vision

Video Image Processing Systems (VIPS) use digital cameras coupled with computer vision AI algorithms to analyze traffic streams in real time.

VIPS can simultaneously perform multi-lane vehicle counting, classification, speed detection, queue measurement, and incident detection.

- Real-time video analytics replacing multiple physical point sensors
- Automatic vehicle classification (2-wheelers, cars, buses, heavy trucks)
- Detects wrong-way driving, stopped vehicles, and queue lengths
- Performance degraded by severe lens glare, fog, heavy rain, or night shadows

GPS Probe Vehicle Data and Mobile Location Data

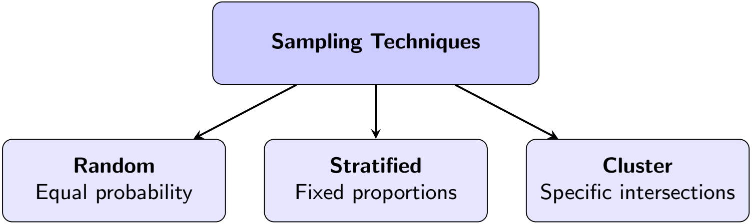
Probe vehicle techniques utilize floating vehicles equipped with GPS transponders or mobile location data from smartphones to track traffic flow speeds.

Aggregating probe vehicle GPS traces yields continuous, network-wide travel time metrics without installing fixed physical sensors.

- Provides real-time average travel speed across entire city road networks
- Powers commercial navigation maps and dynamic routing apps
- Enables historical bottleneck identification and travel time variability analysis
- Requires privacy protection anonymization protocols for location tracks

Sampling Techniques in Traffic Engineering Surveys

Because counting or interviewing 100% of vehicles is impractical, traffic surveys rely on rigorous statistical sampling techniques.



Important: Engineers must avoid sample bias (e.g., over-sampling the fast lane or specific peak windows).

Sample Size Determination and Statistical Reliability

Determining the minimum required sample size ensures survey results fall within acceptable confidence intervals (e.g., 95% confidence level).

Sample size depends on speed variance, desired level of precision, and standard deviation of traffic variables.

- Formula for Spot Speed Sample Size: $N = (S \times Z/E)^2$
- N = Minimum sample size; S = Standard deviation of speeds (km/h)
- Z = Standard normal statistic (1.96 for 95% confidence)
- E = Permissible error tolerance (e.g., $\pm$1.5 km/h)
- Higher variance in traffic speeds mandates larger sample sizes

Data Cleaning, Processing, and Quality Control

Raw traffic survey data collected in the field contains errors, missing records, double counts, and equipment anomalies.

Rigorous quality control protocols filter outliers and normalize data before populating engineering databases.

- Outlier Filtering: Removing unrealistic speeds (e.g., 200 km/h errors)
- Data Imputation: Estimating missing periods using daily variation curves
- Logical Checks: Ensuring sum of lane volumes equals total approach volume
- Database Storage: Structuring time-series traffic data for GIS analysis

Integration of GIS and Remote Sensing in Traffic Analysis

Geographic Information Systems (GIS) provide a powerful spatial framework for visualizing, analyzing, and mapping traffic survey data.

Combining traffic volume, speed, and crash layers in GIS enables dynamic spatial query and corridor performance mapping.

- Mapping traffic volume densities across road networks
- Spatial overlay of accident locations with road geometric attributes
- Remote Sensing drone imagery for parking accumulation and queue length mapping
- Interactive dashboard reporting for municipal traffic managers

Summary & Key Takeaways

Modern traffic studies combine physical sensors, computer vision, GPS probe data, and statistical sampling to gather high-precision traffic data.

Understanding sensor principles, sampling equations, and GIS integration prepares diploma engineers for modern digital traffic management.

- Intrusive sensors (loops, tubes) vs Non-intrusive sensors (radar, Lidar, video)
- Video AI processing provides comprehensive real-time multi-modal traffic data
- Sample size $N = (S \times Z/E)^2$ ensures statistical reliability at 95% confidence
- GIS integration enables spatial visualization of volume, speed, and safety layers