Traffic flow and roadway capacity

Austroads (2013/15/17) Guide to Traffic Management (GTM)
Parts 2, 3 and 5

Session objectives

• To provide fundamental understanding of:
  – basic traffic parameters,
  – estimating traffic capacity,
  – levels of service.

• Not discussing unsignalised, signalised intersections, roundabouts or interchanges. Information found in:
  – Part 4A Unsignalised and Signalised Intersections.
  – Part 4B Roundabouts.
  – Part 4C Interchanges.
Why is traffic of interest?

- Provides understanding of the function of a road.
- Assists in planning requirements.
- Required for design:
  - speed modelling,
  - number of lanes,
  - traffic composition,
  - traffic patterns,
  - type of intersection/interchange,
  - pavement.

Roadway capacity

Roadway conditions that affect capacity, level of service and degree of saturation include:
- type of facility and its development environment,
- traffic lane widths,
- shoulder widths and/or lateral clearances,
- design speed,
- horizontal and vertical alignment.

Correction factors for these conditions are given in GTM Part 3.
Vehicle operating speeds affected by

- Vehicle type (motorcycle, passenger or heavy vehicle)
- Geometric road design,
- Street type, cross-section and function, for example more lanes will generally lead to higher speeds,
- Kerb and channel present will generally lead to higher speeds,
- Speed limit,
- Surrounding environment (CBD, residential, commercial etc.),
- Interaction with vulnerable road users (pedestrians, cyclists etc.),
- Footpaths present may lead to slower speeds,
- More objects (utility poles, roadside furniture etc.) will reduce speeds,
- Parked vehicles (vehicles parked on the road will lead to slower speeds),
- Bus stops will reduce speeds,
- Number of entries/exits to the main flow (driveways, intersections with minor roads etc. will lead to lower speeds),
- Traffic flow measures, including intensity, directional distribution, rate of through traffic).

Speed-volume relationship (GTM Part 2, Fig 2.1)
Traffic flows

- Two broad categories of flow:
  - interrupted (typically urban streets)
    - from traffic signals, stop signs, etc.
  - uninterrupted
    - free flow (typically rural roads).

- Distribution of vehicles across road can vary during peak periods.

- Volume in itself not a good measure of quality of flow
  - need speed or density as well to describe it.

Capacity in general

- Performance and capacity influenced by physical conditions, e.g.
  - width (of lane/carriageway),
  - number of lanes,
  - geometry (grade, alignment, sight distance, etc.),
  - traffic management devices (e.g. traffic lights, channelisation etc.),
  - environment (e.g. weather).

- Typical one way lane capacities (mid-block):
  - urban  600 – 1,000 vph (interrupted flows),
  - rural 1,200 – 2,200 vph (uninterrupted flows).
Traffic data sources

• Existing traffic volumes obtained from:
  – traffic counters,
  – detector loops,
  – weigh in-motion (WIM),
  – manual.

• Future traffic volumes obtained from:
  – projected traffic growth,
  – corridor studies,
  – transportation studies.

Traffic composition

Vehicles:
• Cars and Trucks/MCVs:
  – may be different % in peak and non-peak hours,
  – define actual distribution so as to not be over-conservative,
  – sometimes equate to passenger car equivalents (e.g. LOS).
• HOVs (high occupancy vehicles).
• Motorcycles.
• Bicycles.
• Public transport
Design period/life

\[ Vol_2 = Vol_1 \times (1 + p)^n \]

where:
- \( Vol_2 \) = traffic volume at the end of the design period (design traffic volume).
- \( Vol_1 \) = traffic volume at the start of the design period (from traffic counts).
- \( p \) = growth rate (percent /100)
- \( n \) = design period/life (years)

Normal prediction period is 10 – 30 years depending on road function.

Traffic parameters

- **ADT** = Average Daily Traffic.
- **AADT** = Annual Average Daily Traffic.
- **HHV** = Highest Hourly Volume
  (can be based on 8–12% of AADT/2).
- **Design Hour Traffic:**
  - 30\(^{th}\) HHV.
  - 90\(^{th}\) percentile hourly volume.
  - Level of Service (LOS) value.
Traffic data - example

Traffic data analysis and reporting system

Traffic Analysts and Reporting System
PERMANENT SITE REPORT

<table>
<thead>
<tr>
<th>District</th>
<th>3 SOUTHERN DISTRICT (MR)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Site</td>
<td>188 TOOWOOMBA - DALBY</td>
</tr>
<tr>
<td>Site Stream</td>
<td>All Site Streams</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Year</th>
<th>AADT</th>
</tr>
</thead>
<tbody>
<tr>
<td>1999</td>
<td>9,686</td>
</tr>
</tbody>
</table>

Growth last year: 6.60%
Growth last 5 yrs: 4.90%
Growth last 10 yrs: 2.18%

Average Week Day: 10.593
Average Weekend Day: 8.057

Level of service

Qualitative measure describing operational conditions within a traffic stream, and their perceptions by motorists (GTM Part 3 Chpt. 3):

- speed and travel time,
- freedom to manoeuvre,
- traffic interruptions,
- comfort, convenience and safety,
- use to assess:
  - existing and new projects,
  - construction/long or short-term roadworks,
- not applicable for interrupted flow.
**Level of service - A**

Free flow with high desired speeds and low flows (<700 veh/h/lane).

Drivers can travel at their own free speed with little interference.

Volume /capacity (V/C) ratio 0.32*  
(* based on multi-lane highway GTM Part 3 Table 4.4, for free flow 100kmh)

**Level of service - B**

Appropriate to rural roads with moderate design flows (700 – 1,100 veh/h/lane).

Drivers have reasonable freedom to select their speed.

Volume /capacity (V/C) ratio 0.50*  
(* based on multi-lane highway GTM Part 3 Table 4.4 for free flow 100kmh)
Level of service - C

Appropriate to design flows encountered on urban roads (1,100 – 1,575 veh/h/lane).

Drivers are restricted in their freedom to select speed or manoeuvre, but speeds are still at or above optimum speed.

Volume /capacity (V/C) ratio 0.72*

(* based on multi-lane highway GTM Part 3 Table 4.4 for free flow 100kmh)

Level of service - D

Appropriate to flows near tolerable capacity (1,575 – 2,015 veh/h/lane).

Traffic speeds are reduced due to traffic congestion.

Volume /capacity (V/C) ratio 0.92*

(* based on multi-lane highway GTM Part 3 Table 4.4 for free flow 100kmh)
Level of service - E

At or near actual capacity (> 2,015 veh/h/lane).
There may be momentary stoppages.

Volume /capacity (V/C) ratio 1.0*

(* based on multi-lane highway GTM Part 3 Table 4.4 for free flow 100kmh)

Level of service – Main Roads Qld example

<table>
<thead>
<tr>
<th>Road type</th>
<th>Rural</th>
<th>Urban</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Des</td>
<td>Abs</td>
</tr>
<tr>
<td>National Highways</td>
<td>B</td>
<td>C</td>
</tr>
<tr>
<td>(excl. design hour)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Motorways and road performing a motorway function</td>
<td>B</td>
<td>C</td>
</tr>
<tr>
<td>Rural arterial two lane, two way</td>
<td>B</td>
<td>C</td>
</tr>
<tr>
<td>Rural arterial multilane</td>
<td>B</td>
<td>C</td>
</tr>
<tr>
<td>(excl. design hour)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Urban arterial</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Safety - people, drivers and vehicles

- Designers must:
  - understand the road system and the interaction between the parts of the system,
  - understand the relation between design elements and crash rate,
  - ensure that the combination of elements is appropriate to the circumstances,
  - design with the user in mind,
  - reduce or eliminate uncertainty or the unexpected for drivers,
  - take a holistic approach to design.

Road design elements

Designers must:
- The interaction of people, vehicles and road within the surrounding environment
- The level of safety on this system depends on all of the elements.
- Crashes will occur when one or more of these elements is disrupted.
- Must accommodate:
  - both the driver and the vehicle,
  - pedestrians (including those with a disability),
  - bicycles,
  - motorcycles.
- Removing uncertainty will make a design safer.
- The ‘self-explaining’ road provides drivers with some degree of certainty of what to expect.
- The proper combination of design elements is essential to a safe design.
Vehicle characteristics

• Design vehicle:
  – ‘a hypothetical vehicle whose dimensions and operating characteristics are used to establish certain aspects of road and intersection layout and geometry’.

• Types of vehicles:
  – car,
  – Motorcycle,
  – single unit truck,
  – bus,
  – semi-trailer,
  – B-double (BTrain in New Zealand),

Design vehicles

• Design vehicles are used to establish lane widths, sight distance requirements and intersection layout.
• Historically four general classes of vehicles have been selected (based on Australian Design Rules) for design purposes, namely:
  – design prime mover and semi-trailer (19.0 m),
  – design single unit truck/bus (12.5 m),
  – design service vehicle (8.8 m),
  – design car (5.0 m).
• For roads carrying larger vehicles (i.e. B–doubles etc.) refer to Part 4, Table 5.1 for specific vehicle dimensions and requirements.
• For special purpose or over dimensional vehicles permits will be required by the appropriate state road authority.
**Worked example** (estimate LoS for new rural road)

Existing traffic is 5,000 vpd, (AADT) with an Estimated annual rate of 3% (p)

1. Volume in 30 years is:
   \[
   \text{Vol}_{30} = \text{Vol}_0 \times (1 + p)^n
   \]
   \[
   = 5,000 \times (1 + 0.03)^{30}
   \]
   \[
   = 5,000 \times 2.43
   \]
   \[
   = 12,136 \text{ vpd}
   \]

2. Assuming a 10% peak hour flow
   \[
   = 0.1 \times 12,136
   \]
   \[
   = 1,214 \text{ vph (two way)}
   \]

3. Peak hour split 70/30
   \[
   = 0.7 \times 1,214
   \]
   \[
   = 850 \text{ vph (one way)}
   \]

4. Level of Service \(30\) = \(\frac{\text{volume}}{\text{capacity}}\)
   \[
   = \frac{850 \text{ vph}}{2,200 \text{ vph}}
   \]
   \[
   = 0.39
   \]
   (LoS A = <0.32), (LoS B = 0.33 – 0.50)

Level of Service B achieved

**QUESTIONS?**