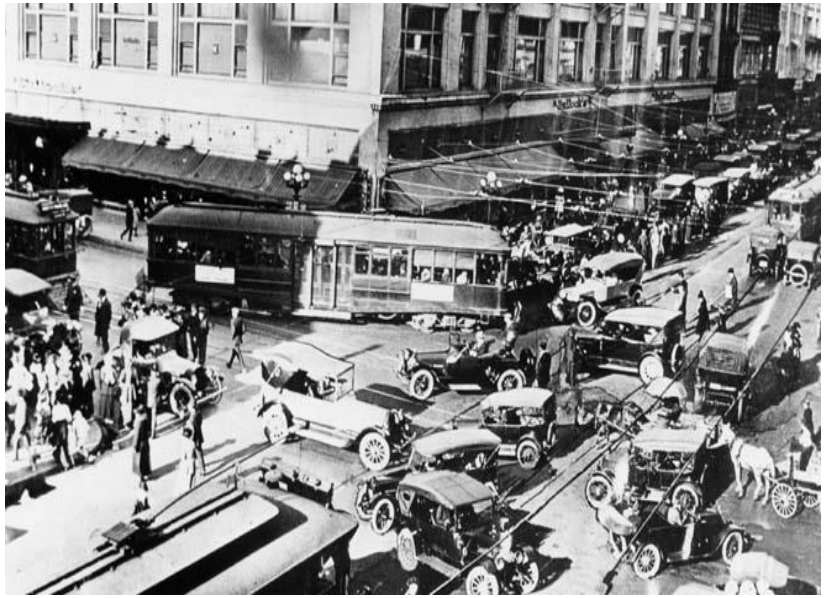
Capacity & Level of Service

مفهوم السعة ومستوى الخدمة




Singapore
Changi Airport


T516次 07：31开
石家庄——北京西
12号车在列车北端，1号车在南端
沿途停靠：
www.Gakei.com (2004/08/22)



Purpose of the HCM

- "To provide transportation practitioners and researchers with a consistent system of techniques for the evaluation of the quality of service on highway and street facilities."
- "HCM does not set policies regarding a desirable or appropriate quality of service…"

Issues of traffic capacity analysis

Highway Capacity Manual (HCM)

- **1950 HCM by the Bureau of Public Roads**
- **1965 HCM by the TRB**
- **1985 HCM by the TRB (Highway Capacity Software published)**
- **1994 updates to 1985 HCM**
- **1997 updates to 1994 HCM**
- **2000 HCM is available**

Design Level of Service (LOS)

	Type of Area and Appropriate Level of Service			
Highway Type	**Rural Level**	**Rural Rolling**	**Rural Mountainous**	**Urban and Suburban**
Freeway	B	B	C	C
Arterial	B	B	C	C
Collector	C	C	D	D
Local	D	D	D	D

Source: Adapted from the AASHTO Green Book

Issues of traffic capacity analysis

- How much traffic a given facility can accommodate?
- Under what operating conditions can it accommodate that much traffic?

Highway Capacity Manual (HCM)

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Transportation Facilities

- Uninterrupted-flow facilities
  - no fixed elements external to the traffic stream to interrupt flow
  - Freeways, multilane hwy, two-land hwy
- Interrupted-flow facilities
  - have controlled and uncontrolled access points that can interrupt flow
  - (un)signalized intersections, urban streets
- Performance?

Capacity Analysis

- Procedures for estimating the traffic-carrying ability of segments or points of a facility over a range of defined operational conditions
- Purposes
  - Assessing facility performance
  - Planning and designing improved facilities

Issues of traffic capacity analysis

- How much traffic a given facility can accommodate?
- Under what operating conditions can it accommodate that much traffic?

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- 1997 updates to 1994 HCM
- 2000 HCM is available

Introduction

- **Uninterrupted Flow** – freeway section without on- and off- ramps (good example)

- interrupted – Signalized intersection, rail - transit
- Flow Unit veh/h

- Level Of Service (LOS) A - F

Capacity

"The *maximum hourly rate* at which persons or vehicles can be reasonably *expected to traverse* a *point or uniform segment* of a lane or roadway during a *given time period* under prevailing roadway, traffic, and roadway conditions"

– *The Highway Capacity Manual -*

السعة* Capacity

هي المعدل الساعي الأعظمي للعربات أو الأشخاص الذي يمكن أن يجتاز نقطة أو مقطع طرقي بشكل معقول خلال زمن محدد ضمن الظروف المسيطرة والتي تشمل الظروف الطرقية، المرورية وظروف التحكم بالحركة.

The Highway Capacity Manual *

مفاهيم مرتبطة بالسعة

- ترتبط السعة بالظروف المسيطرة،
- تحدد من أجل نقطة أو مقطع محدد من الطريق،
- تعرف كمعدل المرور الأعظمي الذي يمكن تخديمه من قبل المنشأة المدروسة،
- تحدد كـ عربة/ساعة أو شخص/ساعة حسب المنشأة والهدف من التحليل،

Capacity concept

يتم التحليل عادة من أجل
(worst) 15-min period.

Capacity as defined by HCM:

"*the maximum **hourly rate** at which persons or vehicles can **be reasonably expected** to traverse **a point or uniform segment** of a lane or roadway **during a given time period** **under prevailing conditions**.*"

- **Traffic** مرورية
- **Roadway**طرقية
- **Control** تحكم

Some regularity expected (capacity is not a fixed value)

Sometimes using persons makes more sense, like transit

من أجل ظروف مسيطرة مختلفة تكون قيم السعة مختلفة أيضاً

Capacity values for ideal conditions

Most capacity analysis models include the determination of capacity under ideal roadway, traffic, and control conditions, that is, after having taken into account adjustments for prevailing conditions.

Freeway, uninterrupted flow	12-ft lane width, 6-ft lateral clearance (right side, 2 ft on left side), all vehicles are passenger cars, familiar drivers, level grade, no heavy vehicles, free-flow speeds (70 mph for urban, 75 mph for rural; if you have a speed limit, it's a different matter. Capacity used is usually *average per lane* (e.g. 2400 pcphpl in one direction)

Prevailing condition types

Geometric conditions	Horizontal & vertical alignment, lane width and lateral clearance, grades
Traffic conditions	Directional distribution, lane distribution, heavy vehicles in the traffic stream, turning movements
Control factors	Speed limits, lane use controls, traffic signals, STOP and YIELD signs

Capacity values for ideal conditions

Most capacity analysis models include the determination of capacity under ideal roadway, traffic, and control conditions.

- Multilane uninterrupted flow
- Two-lane highways
- Interrupted flow

تطبيقات مفاهيم السعة

الدقة		
	منخفضة	تستخدم في دراسات تخطيط النقل لتقييم مدى كفاية شبكات الطرق القائمة (تقدر حجوم المرور ومستوى الخدمة المراد تحقيقه ومن ثم عدد حارات المرور المطلوبة) Used in transportation planning studies to assess the adequacy or sufficiency of existing highway networks (Traffic volumes are estimates; define targeted LOS first then find the number of lanes)
	متوسطة	تستخدم في التصميم وفي اختيار نوع الطريق وتحديد متطلبات الأبعاد (تقدر حجوم المرور ومستوى الخدمة المراد تحقيقه ومن ثم عدد حارات المرور المطلوبة) Used as a design control in the selection of highway type and in determining dimensional needs (Traffic volumes are estimates; define targeted LOS first then find the number of lanes)
	عالية	تستخدم في التحليل العملياتي (تحليل الوضع الراهن) بناء على معطيات هندسية وحجوم مرورية وطريقة التحكم بالحركة، ومن ثم وضع مقترحات لتحسين استثمار المنشأة Used in traffic operational analyses: a) Analysis of existing conditions, b) Estimation of operational improvements (For this analysis volume, geometry and control data exist)

Level of service مستوى الخدمة

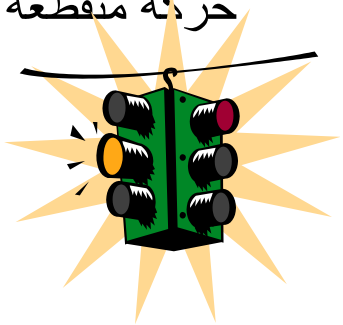
"A *level of service* is a letter designation that describes a range of operating conditions on a particular type of facility."

مستوى الخدمة هو المقياس النوعي لظروف حركة المرور ضمن منشأة محددة

LOS A (best) ⇒ LOS F (worst or system breakdown)

A	Free flow **(جريان حر)** **حركة حرة**
B	Reasonably free flow **جريان حر تقريباً**
C	Stable flow **جريان مستقر**
D	Approaching unstable flow **جريان غير مستقر تقريباً**
E	Unstable flow **جريان غير مستقر**
F	Forced flow **حركة قسرية**

MOE in 2000 HCM

حركة مستمرة 	Fwy: Basic sections	Density (pc/km/ln)
	Fwy: Weaving areas	Density (pc/km/ln)
	Fwy: Ramp junctions	Density (pc/km/ln)
	Multilane highways	Density (pc/km/ln)
	Two-lane highways طرق بحارتين باتجاهين	Percent-time spent following Average upgrade speed
Interrupted حركة متقطعة 	Signalized intersections تقاطعات بإشارات ضوئية	Approach delay (sec/veh)
	Unsignalized intersections تقاطعات بدون إشارات ضوئية	Average total delay (sec/veh)
	Arterials الشريانات	Average travel speed
	Transit النقل الجماعي	Load factor (pers/seat)
	المشاة	Space (sq m/ped)

Performance measures

Transportation Mode	Transportation Facility	Performance Measures
Transit	**Signalized Intersections**	**Control delay (sec/veh)**
	Urban streets	**Average travel speed (miles/hr)**
	Transit	**Service frequency (veh/day)**
		Service headway (minutes)
		Passengers/seat

Performance measures

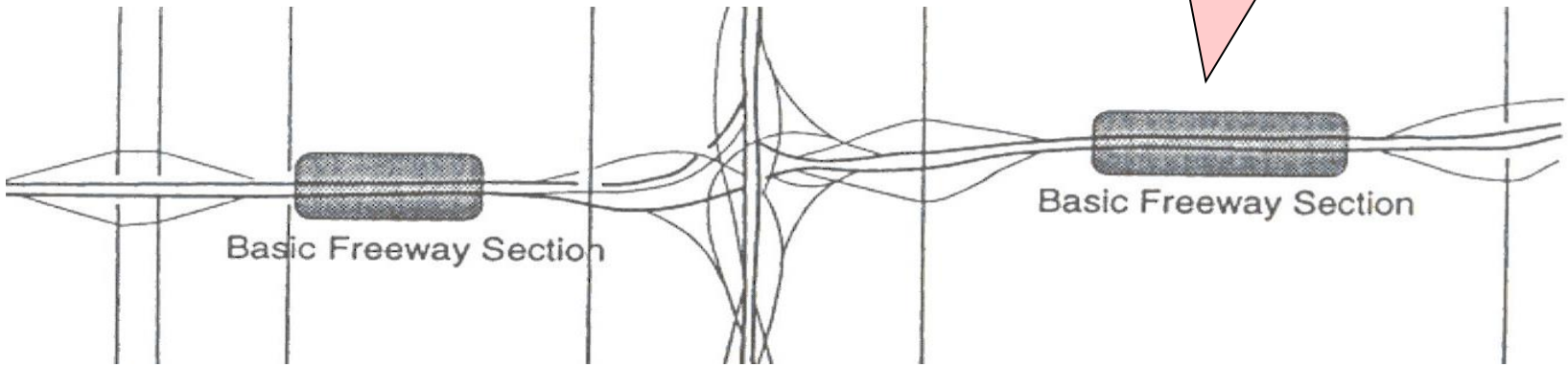
Transportation Mode	Transportation Facility	Performance Measures
Bicycles	Bike paths	Frequency of conflicting events (events/hr)
Pedestrians	Pedestrian facilities	Space (sq ft/pedestrian)
Air	Runways	Delay or aircraft waiting time

LOS example: freeway basic sections



Basic freeway segments: Segments of the freeway that are outside of the influence area of ramps or weaving areas.

See Exhibit 23-3.



Level of Service: general descriptions

Level of service	General operating conditions
A	Free flow
B	Reasonably free flow
C	Stable flow
D	Approaching unstable flow
E	Unstable flow
F	Forced or breakdown flow

Note: Specific definitions of levels-of-service A through F vary by facility type and are presented in the HCM (**15**).

Exhibit 2-31. General Definitions of Levels of Service

LOS for basic freeway segments

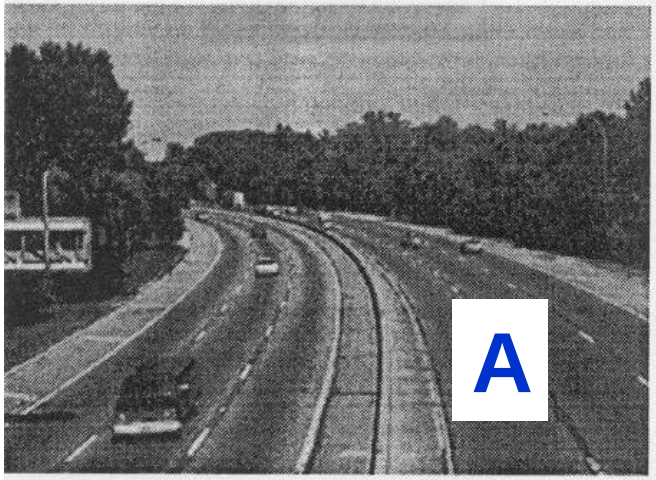


ILLUSTRATION 13-5. LOS A.



ILLUSTRATION 13-7. LOS C.

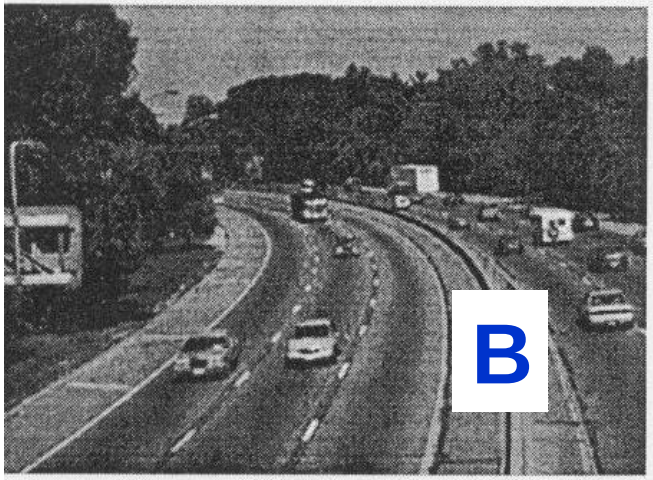


ILLUSTRATION 13-6. LOS B.

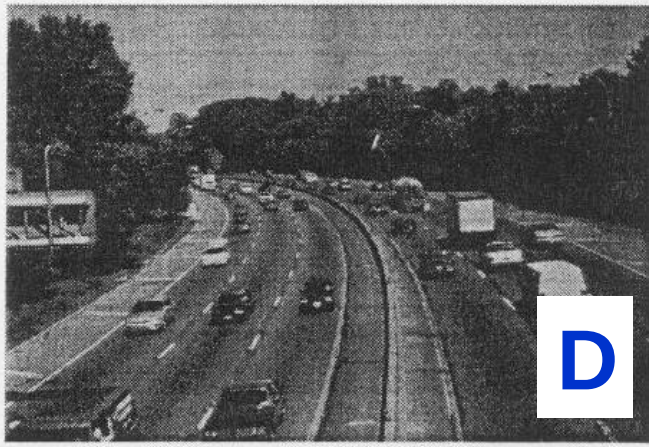


ILLUSTRATION 13-8. LOS D.

LOS for basic freeway segments (cont.)

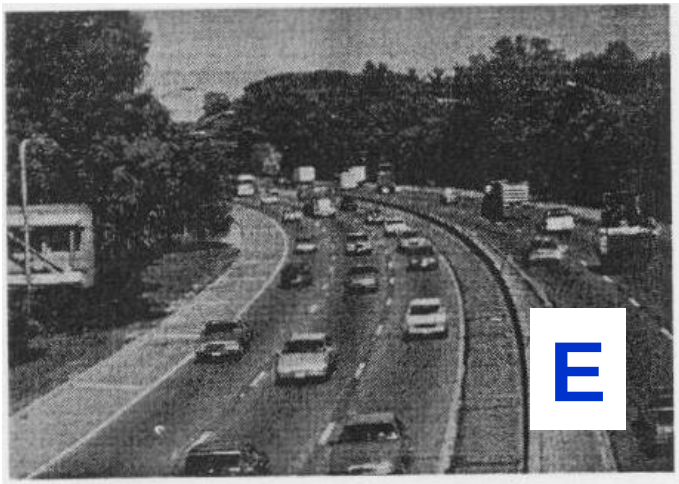


ILLUSTRATION 13-9. LOS E.

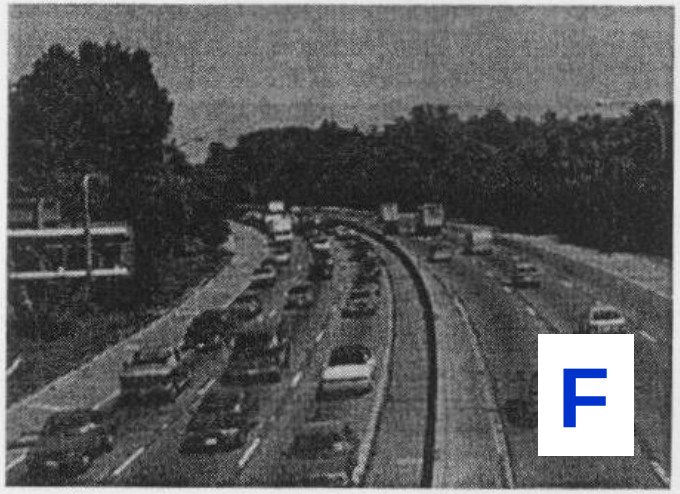
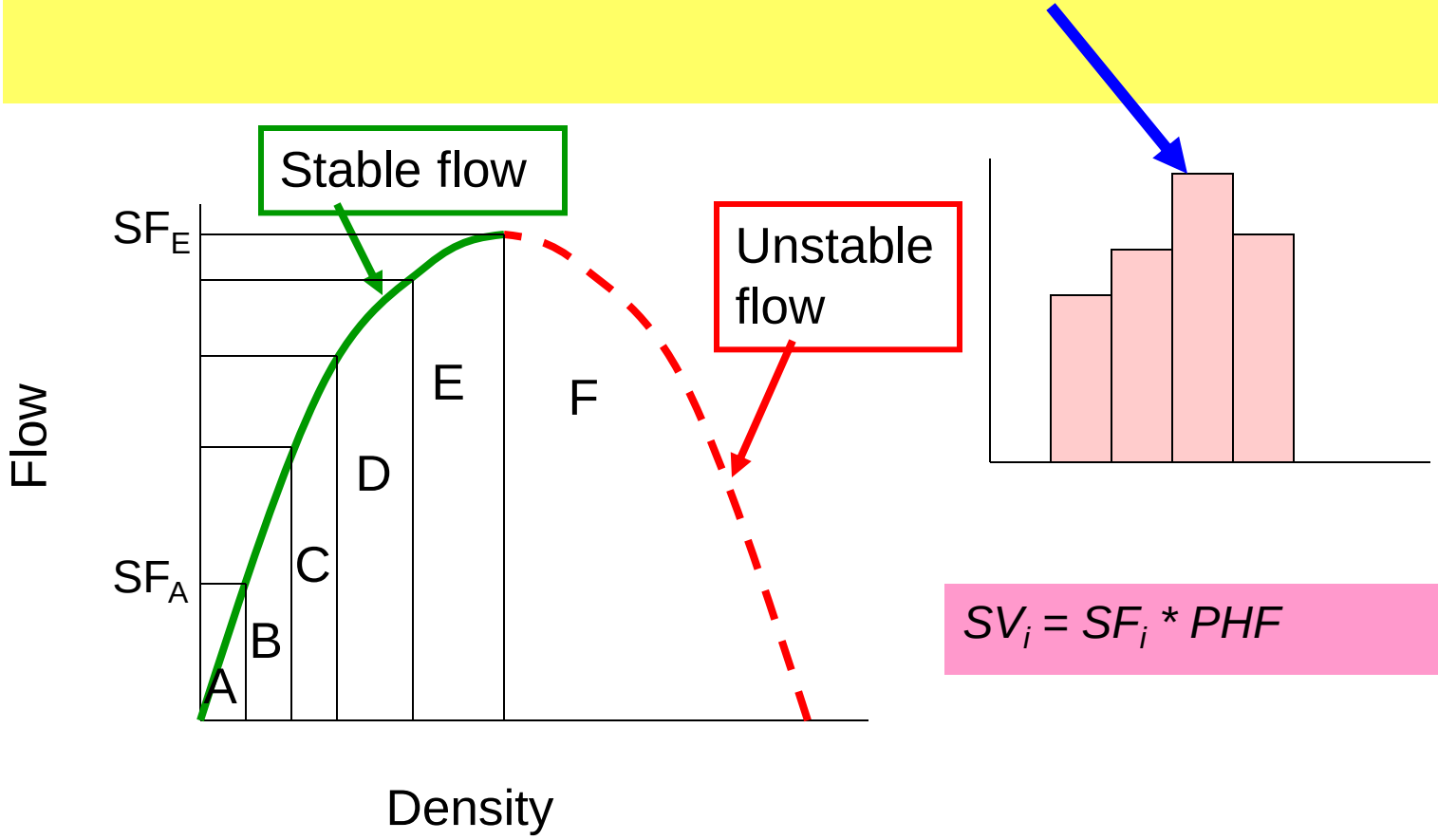


ILLUSTRATION 13-10. LOS F.

Service flow rates vs. service volumes

What is used for analysis is *service flow rate*. The actual number of vehicles that can be served during one peak hour is *service volume*. This reflects the peaking characteristic of traffic flow.



$SV_i = SF_i * PHF$

Design service flow rate vs. design volume

Design volume (DHV, vph)	Hourly volume of traffic estimated to use a certain type of facility during the design year (peak period)
Design service flow rate (vph)	Maximum hour flow rate of traffic that a new facility can serve without the degree of congestion falling below a pre-selected level

$$v_p = v/(PHF \times N \times f_{HV} \times f_p)$$

Acceptable degree of congestion

Rural freeway	Motorists expect high speed smooth traffic always
Urban arterial	Motorists accept few delays because they know there are physical limits for improvements (and budgets)

Balance need (demand) and resources available (supply) to determine the degree of congestion for design.

Targeted LOS

Functional class	Appropriate level of service for specified combinations of area and terrain type			
	Rural level	Rural rolling	Rural mountainous	Urban and suburban
Freeway	B	B	C	C
Arterial	B	B	C	C
Collector	C	C	D	D
Local	D	D	D	D

Exhibit 2-32. Guidelines for Selection of Design Levels of Service

Two-lane Highways

- Unique among uninterrupted flow facilities
- Passing takes place in the opposing lane, traffic in one direction affects traffic in the other
- Thus, for two-lane rural highways, capacity is expressed in terms of total two-directional flow.



Two-lane Highways (cont')

- Ideal conditions for two-lane rural highways are
  - Design speed ≥ 60 mph
  - 12-foot lane widths
  - 6-foot minimum clear shoulders at the roadside
  - level terrain
  - No "NO PASSING" zones
  - 50/50 directional split of traffic
  - All passenger cars in the traffic stream

Two-lane Highways (cont')

- Under these conditions, a two-lane rural highway has a capacity of 2800 pcph in both directions.
- Note that there are more ideal conditions specified than for multilane highways.

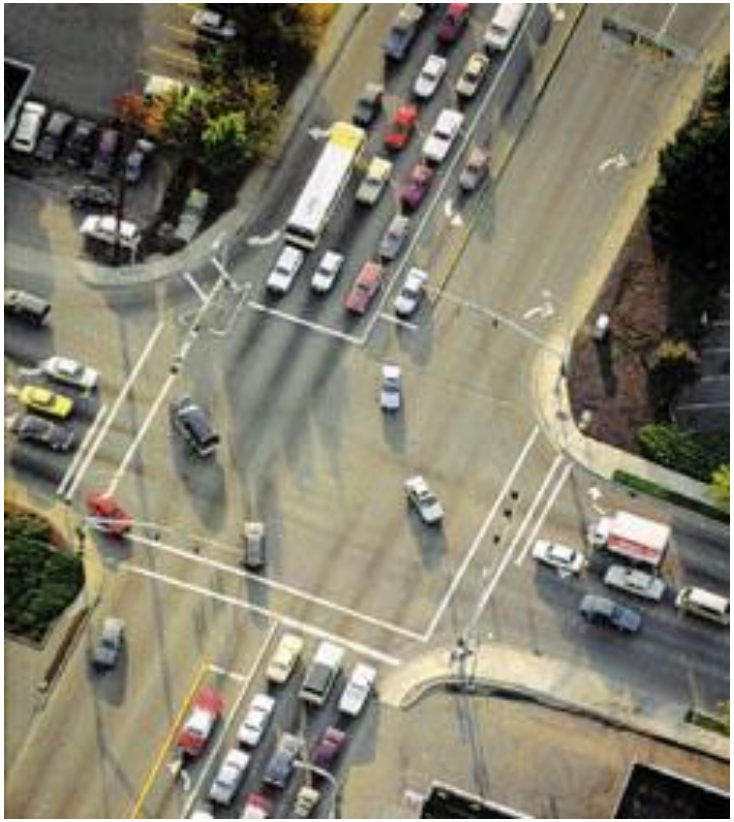
Highways : Interrupted Flow

- Urban areas
- At grade intersection
- Reduce conflict by separating them

Interrupted Flow

- Signalized intersections represent the most severe capacity restrictions, as it is only for those that full capacity values can be specified.
- The saturation flow rate at signalized intersections under ideal conditions is 1900 pcphgpl – passenger cars per hour of green per lane.

Interrupted Flow (cont')





Interrupted Flow (cont')

- The ideal conditions at a signalized intersection approach are:
  - 12-foot lane widths
  - Level approach grade
  - All passenger cars in the traffic stream
  - No left-or right-turning vehicles in the traffic stream
  - No parking adjacent to a travel lane within 250 ft of the stop line
  - Intersection located in a non-CBD area

Level of Service

- Level A
- Level B
- Level C
- Level D
- Level E
- Level F

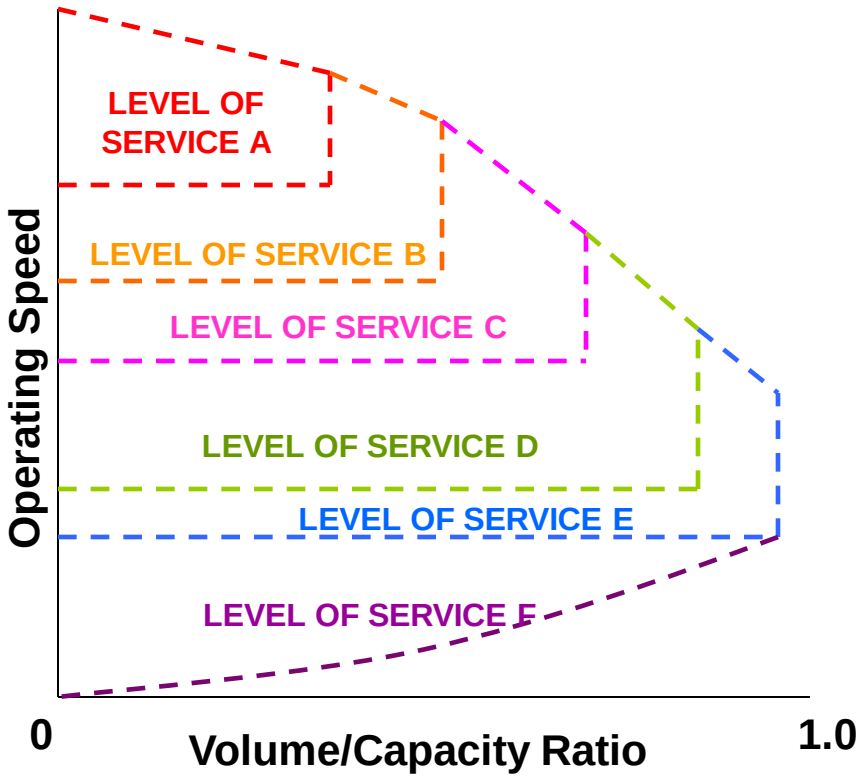
The *v/c* Ratio

- v/c = rate of flow / capacity
- This ratio is often used as a measure of the sufficiency of existing or proposed capacity.
- In concept, a ratio greater than 1.00 can exist where a forecast demand flow rate is used to compare to an existing or estimated capacity.

Highways: Uninterrupted Flow

Level of Service

- Level-of-service A
- Level-of-service B
- Level-of-service C
- Level-of-service D
- Level-of-service E
- Level-of-service F



Level-of-Service

Level-of-service A

- Free-flow operations
- Free-flow speeds prevail
- Vehicles are almost completely unimpeded in their ability to maneuver within the traffic stream.



Level-of-Service



Traffic on Sukhumvit Rd.

Level-of-service B

- Reasonably free flow
- Free-flow speeds are maintained
- The ability to maneuver within the traffic stream in only slightly restricted
- Highly general level of physical and psychological comfort provided to drivers

Level-of-Service

Level-of-service C

- Providing for flow with speeds at or near the free-flow speed of the freeway
- Minor incidents may still be absorbed
- The local deterioration in service will be substantial.
- Queues may be expected to form behind any significant blockage.



Level-of-Service

Level-of-service D

- The level in which speeds can begin to decline slightly with increasing flows and density begins to increase somewhat more quickly.
- Even minor incidents can be expected to create queuing.
- The traffic stream has little space to absorb disruptions.



Level-of-Service





Level-of-service E

- Operation at capacity
- Volatile operations
- Virtually no usable gaps and extremely limited maneuverability in the traffic system
- The traffic stream has no ability to dissipate even the most minor disruptions
- Any incident can be expected to produce a serious breakdown with extensive queuing
- Poor level of physical and psychological comfort afforded the driver

Level-of-Service

Level-of-service F

- Breakdowns in vehicular flow
- Such conditions generally exist within queues forming behind breakdown points.





The End