Design Controls and Criteria (I)

Key Ref: AASHTO's Green Book

DESIGN CONTROL AND CRITERIA

- Criteria to optimize or improve design of the various highway and street functional classes
- Key characteristics of:
  - Vehicles
  - Pedestrians
  - Traffic

DESIGN CONTROL AND CRITERIA

1. DESIGN VEHICLES
2. DRIVER PERFORMANCE AND HUMAN FACTORS
3. TRAFFIC CHARACTERISTICS
4. HIGHWAY CAPACITY
5. ACCESS CONTROL AND ACCESS MANAGEMENT
6. PEDESTRIAN FACILITIES
7. BICYCLE FACILITIES

1. DESIGN VEHICLES

- Key controls in geometric highway design are the physical characteristics and the proportions of vehicles of various sizes using the highway.
- It is important to:
  - examine all vehicle types
  - establish general class groupings
  - select vehicles of representative sizes within each class for design use

What are Design Vehicles?

- Design Vehicles are the selected vehicles that are used to establish highway design controls for accommodating designated vehicle classes.
  - representative weight, dimensions, and operating characteristics
- For purposes of geometric design, each design vehicle has larger physical dimensions and a larger minimum turning radius than most vehicles in its class.

General classes of design vehicles

Four general classes of design vehicles have been established:

1. Passenger cars

   Passenger cars of all sizes, sport/utility vehicles, minivans, vans, and pick-up trucks

2. Buses

   Intercity (motor coaches), city transit, school, and articulated buses.

3. Trucks

   Single-unit trucks, truck tractor-semitrailer combinations, and truck tractors with semitrailers in combination with full trailers.

4. Recreational vehicles

   Motor homes, cars with camper trailers, cars with boat trailers, motor homes with boat trailers, and motor homes pulling cars.

NOTE: In addition, the bicycle should also be considered as a design vehicle where bicycle use is allowed on a highway.

General guide for selection for a design vehicle

- In the design of any highway facility, the designer should consider:
  - the largest design vehicle that is likely to use that facility
  - considerable frequency of such vehicle
  - design vehicle with special characteristics appropriate to a particular location in determining the design of such critical features as:
    - radii at intersections
    - radii of turning roadways

General guide for selection for a design vehicle

- A passenger car may be selected when the main traffic generator is a parking lot or series of parking lots.
- A two-axle single-unit truck may be used for intersection design of residential streets and park roads.
- A three-axle single-unit truck may be used for the design of collector streets and other facilities where larger single-unit trucks are likely.
- A city transit bus may be used in the design of state highway intersections with city streets that are designated bus routes and that have relatively few large trucks using them.

Table 2-1 Design Vehicle Dimensions

Design Vehicle Type	Symbol	Dimensions (m)											
		Overall			Overhang								
		Height	Width	Length	Front	Rear	WB_1	WB_2	S	T	WB_3	WB_4	Typical Kingpin to Center of Rear Tandem Axle
Passenger Car	P	1.30	2.13	5. 79	0.91	1.52	3. 35	—	—	—	—	—	—
Single-Unit Truck	SU-9	3.35–4.11	2.44	9. 14	1.22	1.83	6.10	—	—	—	—	—	—
Single-Unit Truck (three-axle)	SU-12	3.35–4.11	2.44	12.04	1.22	3.20	7.62	—	—	—	—	—	—
Buses													
Intercity Bus (Motor Coaches)	BUS-12	3.66	2.59	12.36	1.93	2.73[a]	7.70	—	—	—	—	—	—
	BUS-14	3.66	2.59	13.86	1.89	2.73[b]	8.69	—	—	—	—	—	—
City Transit Bus	CITY-BUS	3.20	2.59	12.19	2.13	2.44	7.62	—	—	—	—	—	—
Conventional School Bus (65 pass.)	S-BUS 11	3.20	2.44	10.91	0.79	3.66	6.49	—	—	—	—	—	—
Large School Bus (84 pass.)	S-BUS 12	3.20	2.44	12.19	2.13	3.96	6.10	—	—	—	—	—	—
Articulated Bus	A-BUS	3.35	2.59	18.29	2.62	3.05	6.71	5.91	1. 89[b]	4.02[b]	—	—	—
Combination Trucks													
Intermediate Semitrailer	WB-12	4.11	2.44	13.87	0.91	1.37[a]	3.81	7.77	—	—	—	—	7.77
Interstate Semitrailer	WB-19*	4.11	2.59	21.03	1.22	1.37[a]	5.94	12.50	—	—	—	—	12.50
Interstate Semitrailer	WB-20**	4.11	2.59	22.40	1.22	1.37[a]	5.94	13.87	—	—	—	—	13.87
"Double-Bottom" Semitrailer/Trailer	WB-20D	4.11	2.59	22.04	0.71	0.91	3.35	7.01	0.91[c]	2.13[c]	6.86	—	7.01
Rocky Mountain Double-Semitrailer/Trailer	WB-28D	4.11	2.59	29.67	0.71	0.91	5.33	12.19	1.37	2.13	6.86	—	12.34
Triple-Semitrailer/Trailers	WB-30T	4.11	2.59	31.94	0.71	0.91	3.35	6.86	0.91[d]	2.13[d]	6.86	6.86	7.01
Turnpike Double-Semitrailer/Trailer	WB-33D*	4.11	2.59	34.75	0.71	1.37[a]	3.72	12.19	1.37[e]	3.05[e]	12.19	—	12.34
Recreational Vehicles													
Motor Home	MH	3.66	2.44	9.14	1.22	1.83	6.10	—	—	—	—	—	—
Car and Camper Trailer	P/T	3.05	2.44	14.84	0.91	3.66	3.35	—	1.52	5.39	—	—	—
Car and Boat Trailer	P/B	—	2.44	12.80	0.91	2.44	3.35	—	1.52	4.57	—	—	—
Motor Home and Boat Trailer	MH/B	3.66	2.44	16.15	1.22	2.44	6.10	—	1.83	4.57	—	—	—

Table 2-2a Min Turning Radii of Design Vehicles (SI Units)

Design Vehicle Type	Passenger Car	Single-Unit Truck	Single-Unit Truck (Three Axle)	Intercity Bus (Motor Coach)		City Transit Bus	Conventional School Bus (65 pass.)	Large[a] School Bus (84 pass.)	Articulated Bus	Intermediate Semitrailer
Symbol	P	SU-9	SU-12	BUS-12	BUS-14	CITY-BUS	S-BUS11	S-BUS12	A-BUS	WB-12
Minimum Design Turning Radius (m)	7.26	12. 73	15.60	12.70	13.40	12.80	11.75	11.92	12.00	12.16
Centerline[b] Turning Radius (CTR) (m)	6.40	11.58	14.46	11.53	12.25	11.52	10.64	10.79	10.82	10.97
Minimum Inside Radius (m)	4.39	8.64	11.09	7.41	7.54	7.45	7.25	7.71	6.49	5.88
Design Vehicle Type	**Interstate Semitrailer**		**"Double Bottom" Combination**	**Rocky Mtn Double**	**Triple Semitrailer/trailers**	**Turnpike Double Semitrailer/trailer**	**Motor Home**	**Car and Camper Trailer**	**Car and Boat Trailer**	**Motor Home and Boat Trailer**
Symbol	WB-19*	WB-20**	WB-20D	WB-28D	WB-30T	WB-33D*	MH	P/T	P/B	MH/B
Minimum Design Turning Radius (m)	13. 66	13. 66	13.67	24.98	13.67	18.25	12.11	10.03	7.26	15.19
Centerline[b] Turning Radius (CTR) (m)	12.50	12.50	12.47	23.77	12.47	17.04	10.97	9.14	6.40	14.02
Minimum Inside Radius (m)	2.25	0.59	5.83	16.94	2.96	4.19	7.92	5.58	2.44	10.67

Figure 2-1. Minimum Turning Path for Passenger Car (P) Design Vehicle

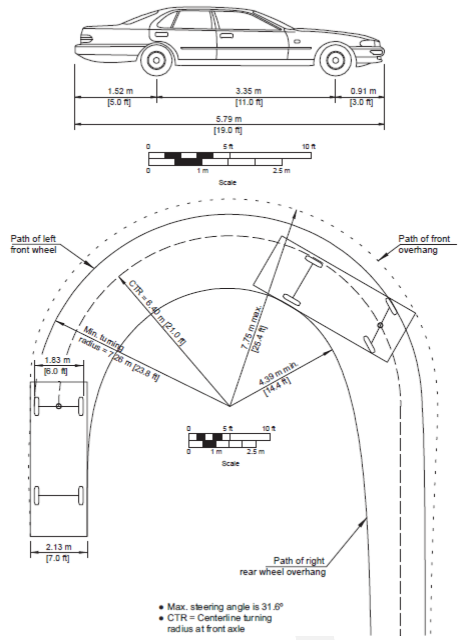


Figure 2-2. Minimum Turning Path for Single-Unit Truck (SU-9 [SU-30]) Design Vehicle

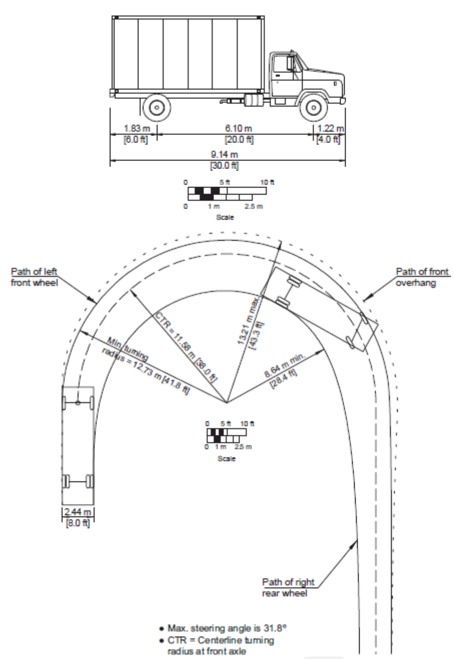


Figure 2-3. Minimum Turning Path for Single-Unit Truck (SU-12 [SU-40]) Design Vehicle

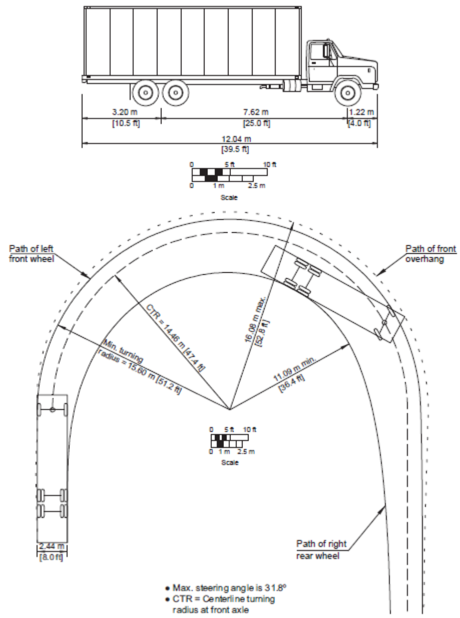
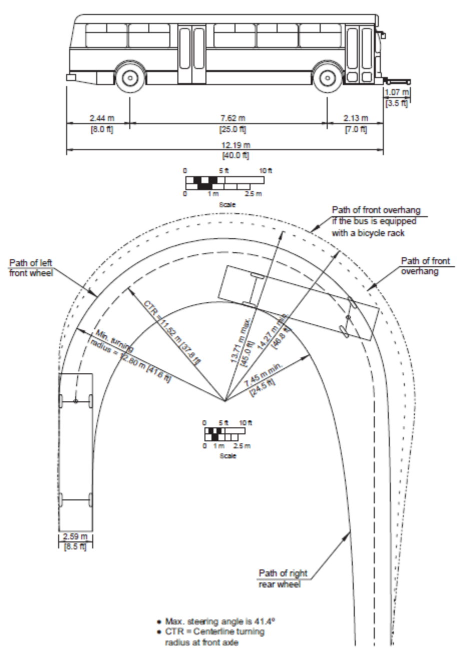


Figure 2-6. Minimum Turning Path for City Transit Bus (CITY-BUS) Design Vehicle



Vehicle Performance

- Acceleration and deceleration rates of vehicles are often critical parameters in determining highway design.
- These rates often govern the dimensions of such design features as intersections, freeway ramps, climbing or passing lanes, and turnout bays for buses.

Vehicle Performance

- From Figures 2-24, it is evident that relatively rapid accelerations and decelerations are possible, although they may be uncomfortable for the vehicle's passengers.
- The data are not meant to depict average performance for specific vehicle classes but rather lower performance vehicles suitable for design application, such as a low-powered (compact) car and a loaded truck or bus.
- The data used may become outdated with passage of time due to advancements in vehicle designs and performance.

Figure 2-24. Acceleration of Passenger Cars, Level Condions

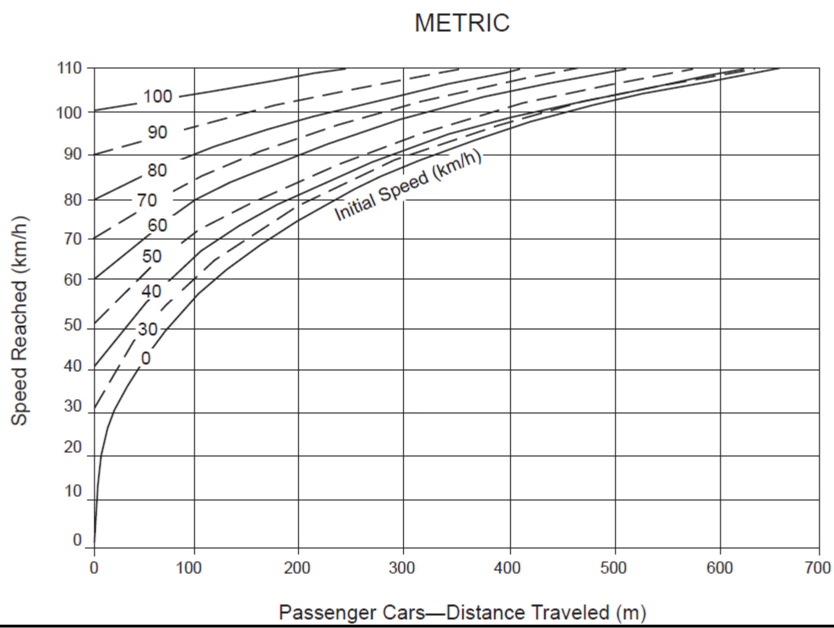


Figure 2-24. Acceleration of Passenger Cars, Level Condions

What will be the speed if a passenger car travelling at a speed of 40mph, accelerates for a distance of 350 ft?

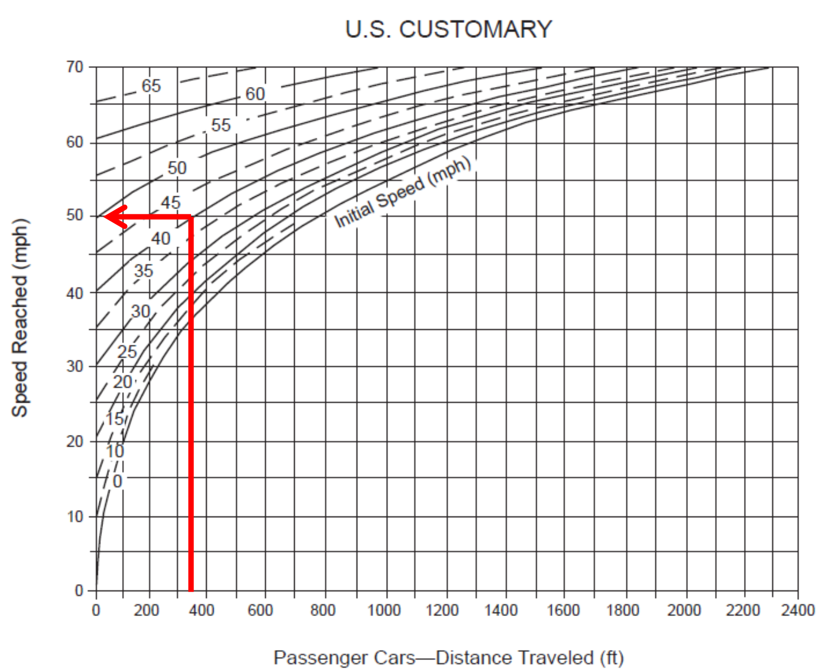


Figure 2-25. Deceleration Distances for Passenger Vehicles Approaching Intersections

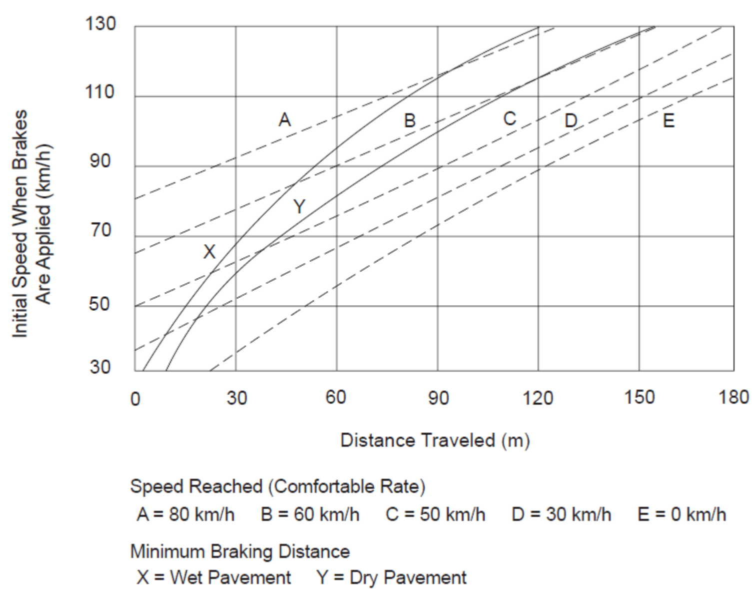
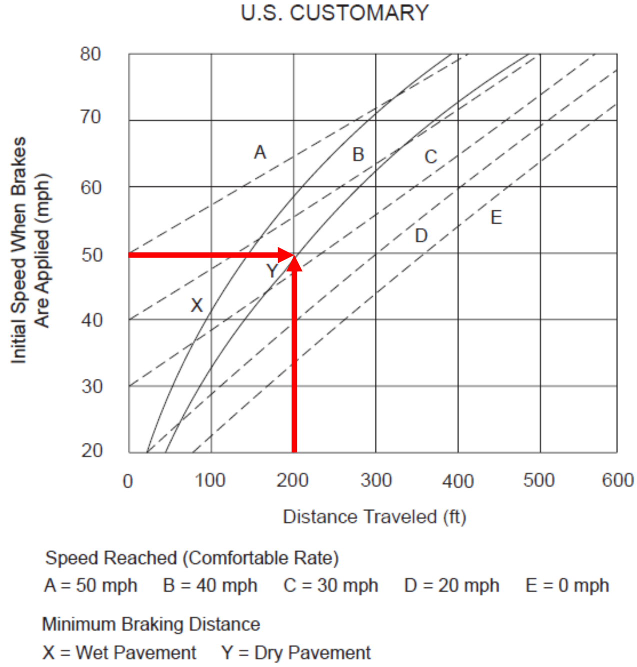


Figure 2-25. Deceleration Distances for Passenger Vehicles Approaching Intersections

From speed reached (50mph), what distance vehicle will need to travel to decelerates comfortably to 30mph?



Is this correct or not?

Vehicular Pollution

- Pollutants emitted from motor vehicles and their impact on land uses adjacent to highways are factors affecting the highway design process.
- As each vehicle travels along the highway, it emits pollutants into the atmosphere and transmits noise to the surrounding area.
- The highway designer should recognize these impacts and evaluate them in selecting appropriate transportation alternatives.

Vehicular Pollution

Many factors affect the rate of pollutant emission from vehicles, including:

- vehicle mix
- vehicle speed
- ambient air temperature
- vehicle age distribution
- percentage of vehicles operating in a cold mode

Vehicular Pollution

- The quality of noise varies with the number and operating conditions of the vehicles while the directionality and amplitude of the noise vary with highway design features.
- The highway designer should therefore be concerned with how highway location and design influence the vehicle noise perceived by persons residing or working nearby.
- The perceived noise level decreases as the distance to the highway from a residence or workplace increases.

2. DRIVER PERFORMANCE AND HUMAN FACTORS

- Consideration of **driver performance** is **essential** to **proper highway design and operation**. The suitability of a design rests as much on how effectively drivers are able to use the highway as on any other criterion.
- **Compatible highway design** with the capabilities of drivers > Drivers performance is aided.
- **Incompatible highway design** with the capabilities of drivers > The chance for driver errors increase, and crashes or inefficient operation may result.

Driver Performance and Human Factors

- It describes drivers in terms of their performance:
  - ***how they interact with the highway and its information system***
  - ***why they make errors***

Older Drivers and Older Pedestrians

% of Drivers population (in USA) of age 65 and older:

- At the start of the 20th century: ~ 4%
- 2010: ~ 15%
- 2030: ~ 22%

Special Need for Older Drivers

- Older drivers have special needs that should be considered in highway design and traffic control.

Example:

- For every decade after age 25, drivers need twice the brightness at night to receive visual information.
- => by age 75, some drivers may need 32 times the brightness they did at age 25.

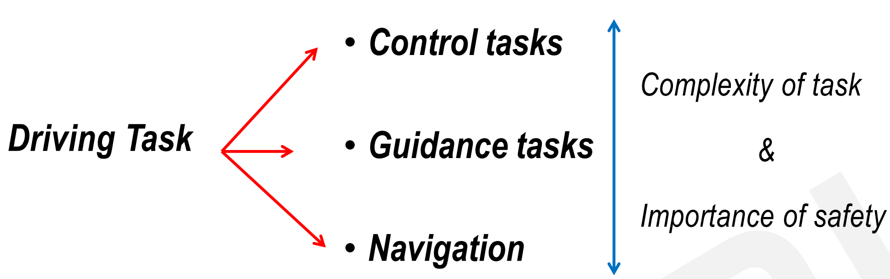
- Older drivers and older pedestrians are a significant and rapidly growing segment of the highway user population with a variety of age-related diminished capabilities.
- Older road users deserve mobility and they should be accommodated in the design of highway facilities to the extent practical.
- Research findings show that enhancements to the highway system to improve its usability for older drivers and pedestrians can also improve the system for all users.
- Thus, designers and engineers should be aware of the capabilities and needs of older road users and consider appropriate measures to aid their performance.

The Driving Task

- The ***driving task*** is complex and demanding.
- This is particularly so when vehicle speeds are high, time pressure bear on the drivers, locations are unfamiliar, and when environmental conditions are adverse.
- Therefore, ***Driver Performance*** is one of the essential components to be considered when designing highways.

Driver Performance

- Driver performance activities fall into three levels:



Levels of Driver Performance

❖*Control tasks* include the driver's interaction with the vehicle and the lateral and longitudinal control of the vehicle through the steering wheel, accelerator, and brake.

❖*Guidance tasks* include the driver's performance of selecting an appropriate and safe path on the highway, as well as driver evaluation of immediate conditions and decisions for control actions relating to lane changes, headways, overtaking, and speed change.

- ❖Control and guidance errors by drivers contribute directly to crashes.

Levels of Driver Performance

❖*Navigation* includes the driver's execution of a trip, along the course of the highway, using information from maps, guide and information signs, and landmarks.

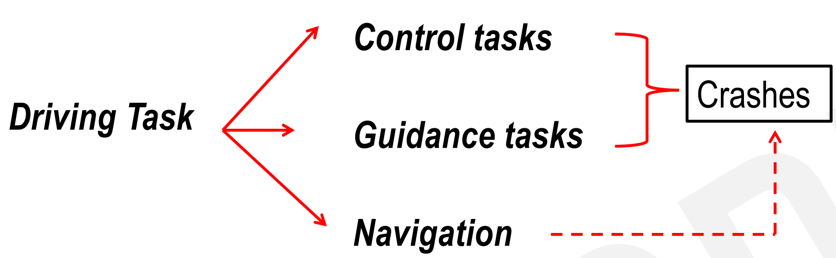
- ❖Navigational errors resulting in delay contribute to inefficient operation and may lead indirectly to crashes.

Driver Errors

- Driving often occurs at high speeds, under time pressure, in unfamiliar locations, and under adverse environmental conditions.
- The driving task may at other times be so simple and undemanding that a driver becomes inattentive.
- ***A key to effective driver performance*** in this broad range of driving situations is ***error-free information handling***.

Driver Errors

- Driver error results from many drivers, vehicle, roadway, and traffic factors.
- For example, deficient or inconsistent designs or information displays may cause confusions.



Driver Errors

- Some driver errors occur because:
  - ***drivers may not always recognize what actions are appropriate in particular roadway traffic situations***
  - ***situations may lead to task overload or inattentiveness***
  - ***deficient or inconsistent designs or information displays may cause confusion.***

- Driver errors may also result from complexity of decisions, profusion of information, or inadequate time to respond

The Guidance Task

- Of the three major components of the driving task, highway design and traffic operations have the greatest effect on guidance.

- An appreciation of the guidance component of the driving task is needed by the highway designer to aid driver performance.

The Guidance Task Activities

a. **Lane Placement and Road Following Decisions**
b. **Car Following Decisions**
c. **Passing Maneuvers Decisions**
d. **Other Guidance Activities**

a. Lane Placement and Road Following Decisions

- Include steering and speed control judgments
- Basic to vehicle guidance
- Drivers use a feedback process to follow alignment and grade within the constraints of road and environmental conditions.
- Obstacle-avoidance decisions are integrated into lane placement and road-following activities.
- Continually performed for following cases:
    - ***Singularly*** ***(when no other traffic is present)***
    - ***Integrated*** ***(when it is shared with other activities)***

b. Car Following Decisions

- Process by which drivers guide their vehicles when following another vehicle.
- More complex than road-following decisions
- Involve speed-control modifications
- Drivers need to constantly modify their speed to maintain safe gaps between vehicles.
- To proceed safely, they have to assess:
  - ***the speed of the lead vehicle***
  - ***the speed and position of other vehicles in the traffic stream***
  - ***continually detect, assess, and respond to changes***

c. Passing Maneuvers Decisions

- The driver decision to initiate, continue, or complete a passing maneuver
- More complex than the decisions involved in lane placement or car following.
- Involve modifications in road and car-following behavior and in speed control.
- Drivers must judge:
  - ***the speed and acceleration potential of their own vehicle***
  - ***the speed of the lead vehicle***
  - ***the speed and rate of closure of the approached vehicle***
  - ***the presence of an acceptable gap in the traffic stream***

d. Other Guidance Activities

- Other guidance activities include:
  - ***merging***
  - ***lane changing***
  - ***avoidance of pedestrians***
  - ***response to traffic control devices***
- These activities also involve complex decisions, judgments, and predictions

The Information System

- Each element that provides information to drivers is part of the information system of the highway.