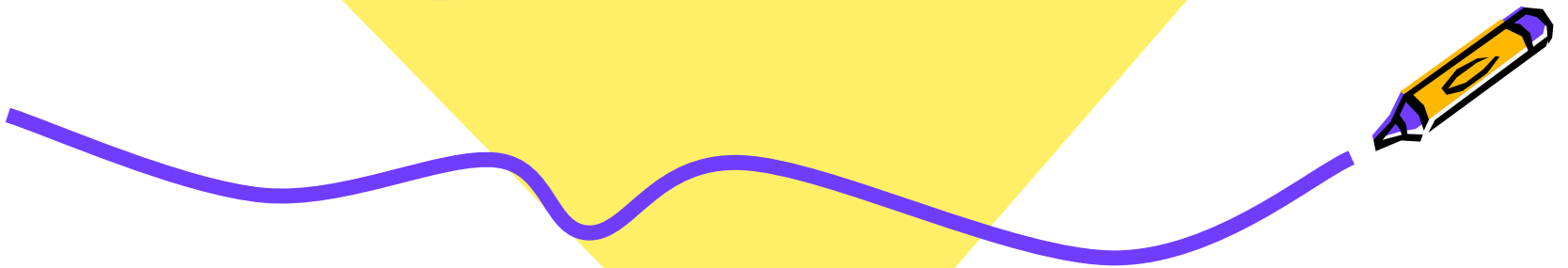




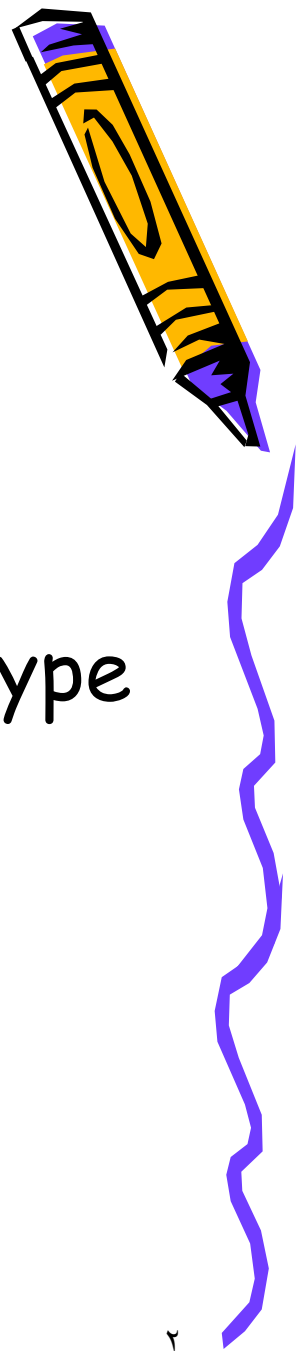
INTERCHANGE SELECTION

CE 550 SPRING 2007

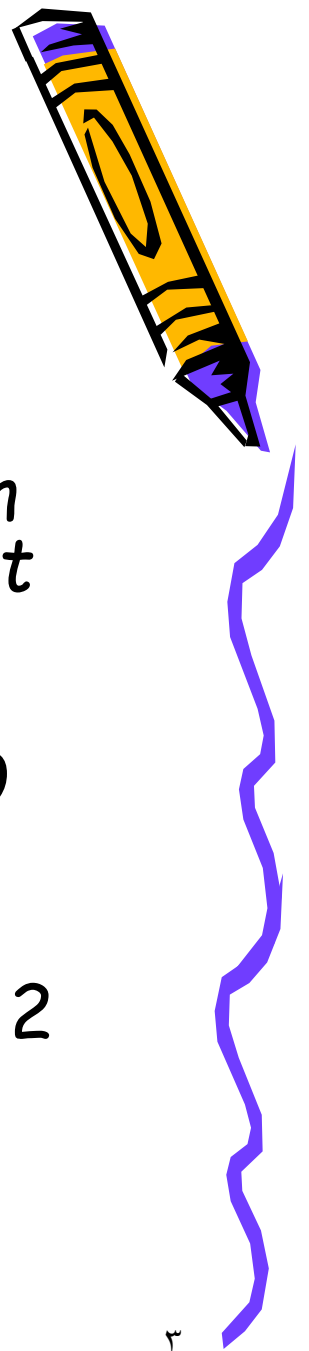


OBJECTIVE

- Identify types of interchange by function and geometry
- Learn process for optimizing the type of interchange for a specific site



Just what is an interchange?

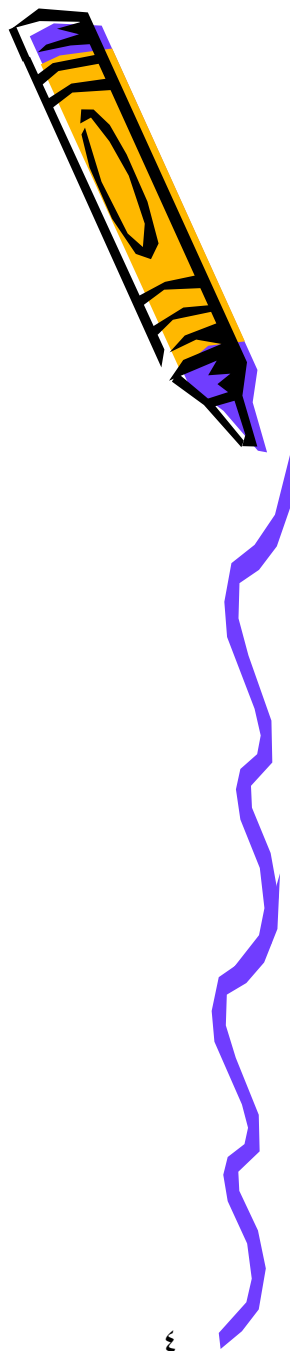


- *An interchange is a system of interconnecting roadways in conjunction with one or more grade separations that provides for the movement of traffic between two or more roadways or highways on different levels. (AASHTO "Green Book" 2001)*
- Basically it is a grade-separated intersection, with connections between 2 or more roads

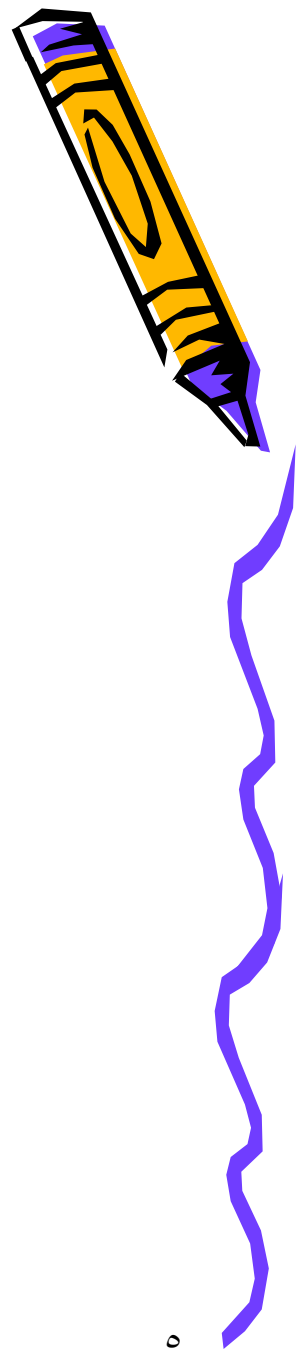


But first, two categories...

- Service interchange - freeway to surface street
- System interchange - freeway to freeway



What's on the Interchange menu?



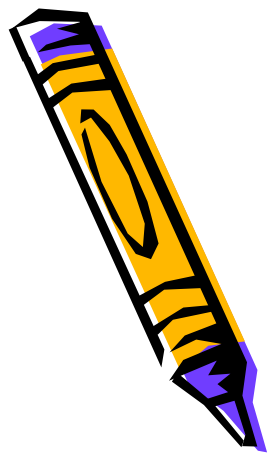
- Diamond
- Single-point urban interchange
- Partial cloverleaf
- Full cloverleaf
- Trumpet
- Directional



Your Basic Diamond



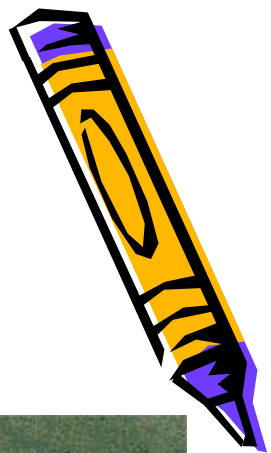
Classic diamond.



Your Basic Diamond

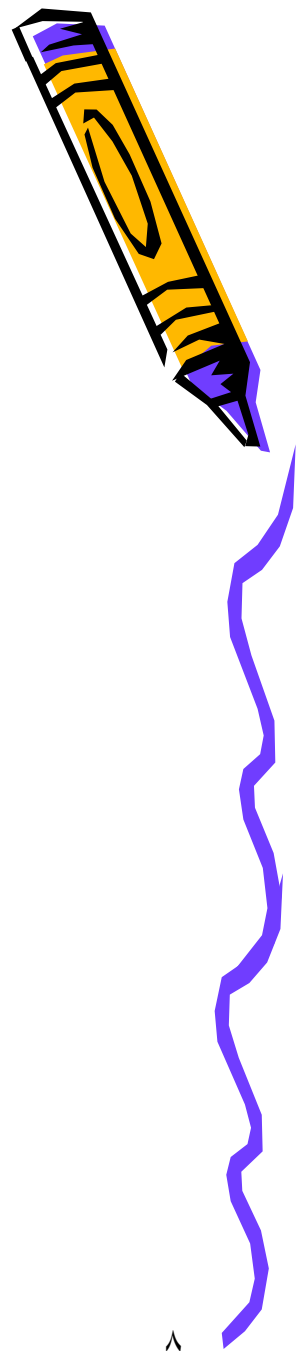


Source: Empire State Roads.com



When to use

- Service interchange only (why?)
- Mostly rural locations
- Low volumes



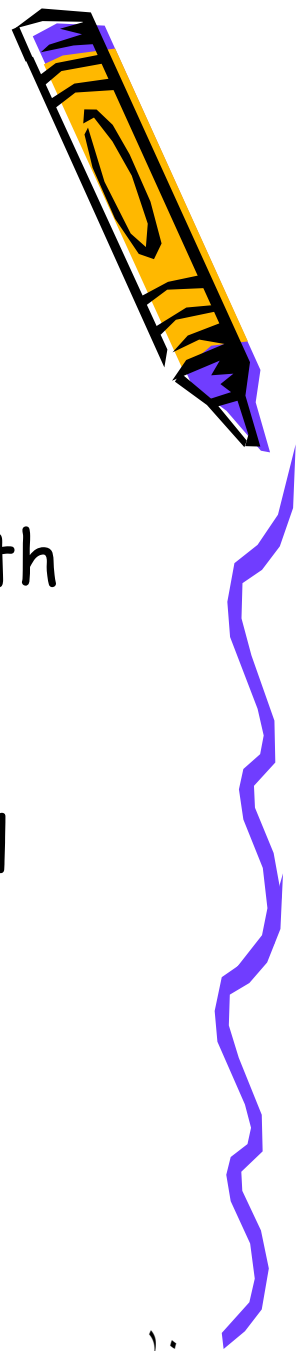
Is a diamond anyone's best friend?



- Plusses:
 - Lower ROW needs than most
 - Excellent in low volume situations, especially where volumes not expected to increase
 - Low cost
 - Most common (overall, 79%)



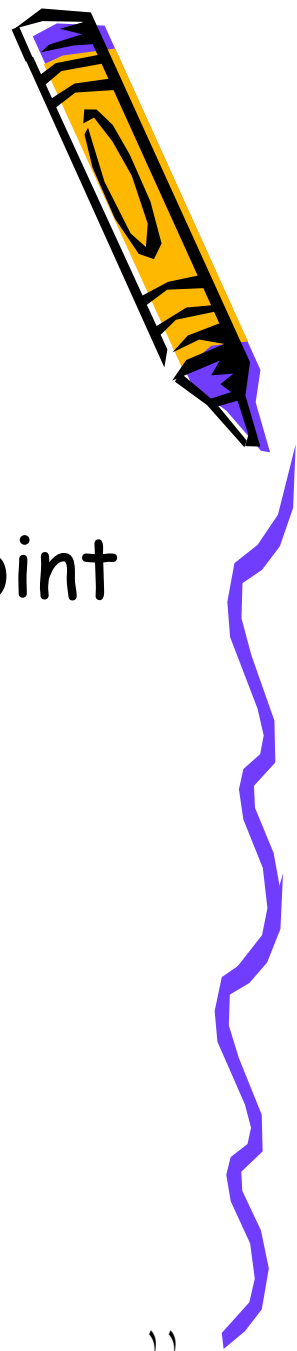
Is a diamond anyone's best friend?



- Minuses:
 - Two ramp termini may be problem with high volume side roads
 - May require signalization at ramps; delay issues due to signals on arterial side road
 - High exiting volumes may require excessively long ramps



Diamond Variants



- Half diamond
- Tight urban diamond (aka single-point urban interchange)
- Diamond with roundabout



Diamond Variants



Half-diamond, West Des Moines IA

Source: Google Earth

Diamond Variants

Proposed grade change I-135 at 1st Street



Proposed Intersection - Traffic Signal

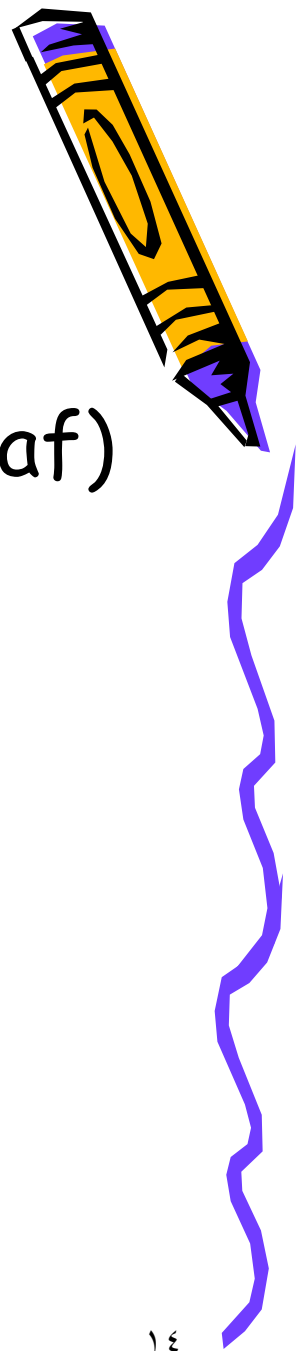


Proposed Intersection - Roundabout Alternate



Source: Center for
Transportation
Research & Training
(KSU)

When is a diamond not a diamond?

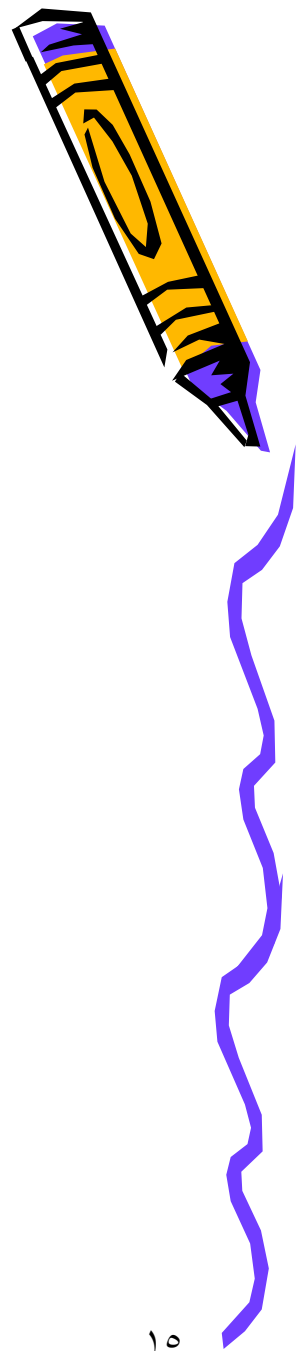


- When it's a parclo (partial cloverleaf)
- A diamond with one to three loops

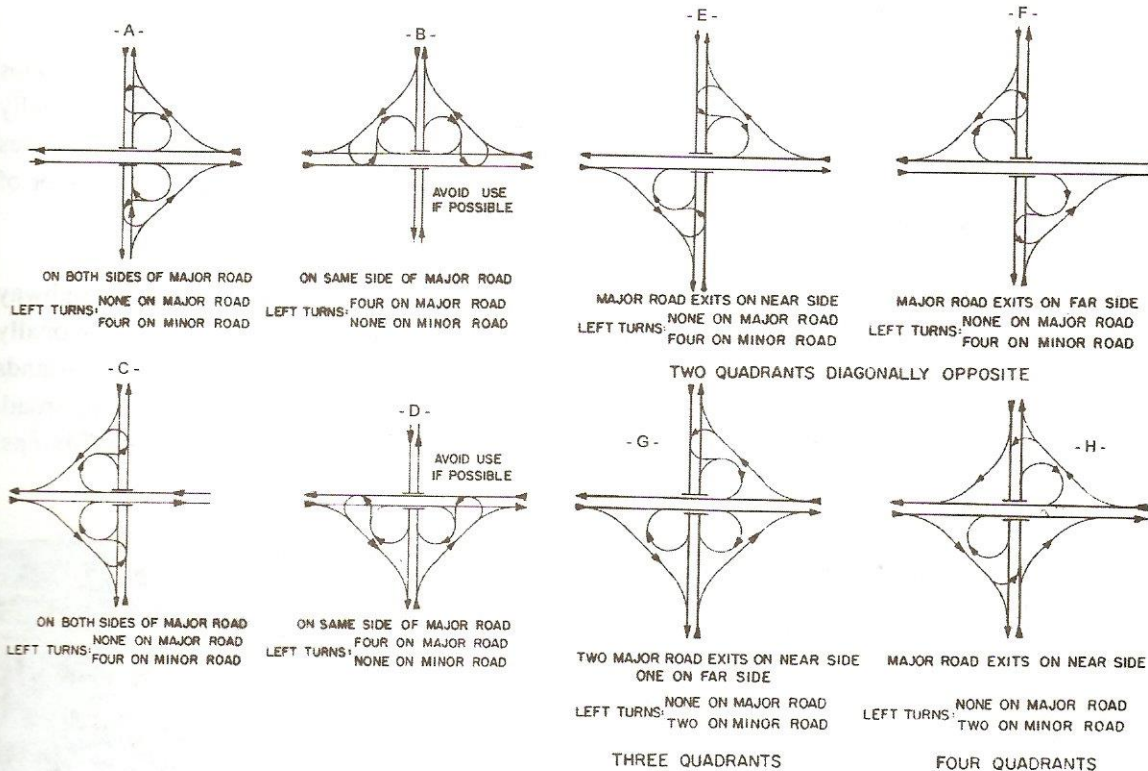


Partial Cloverleaf

- Aka parclo
- Service interchange (7%)
- Higher volumes than diamond
- Variety of arrangements
- Diagonally opposite most common



Parclo Layouts



Source:
AASHTO
"Green
Book"

Exhibit 10-28. Schematic of Partial Cloverleaf Ramp Arrangements, Exit and Entrance Turns

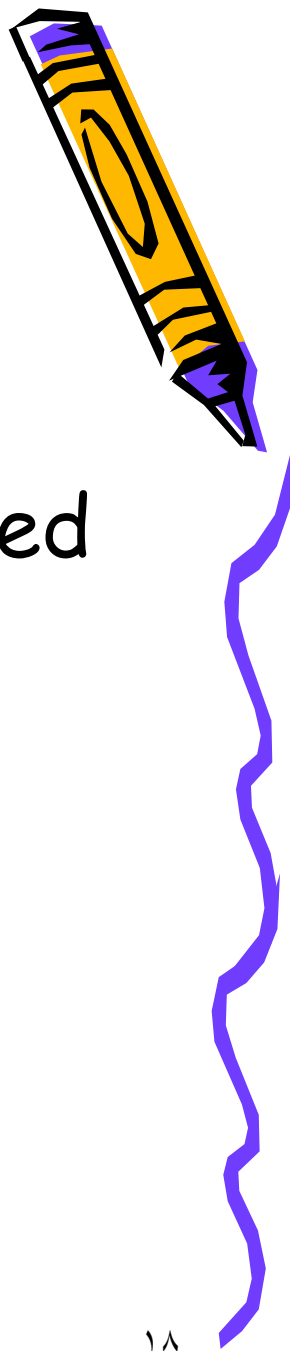
About Parclos

- Use with high turning volumes or side road volumes
- Exit - low-speed loop reinforces need to slow down
- Entrance - low-speed loop increases difficulty of entering high-speed traffic

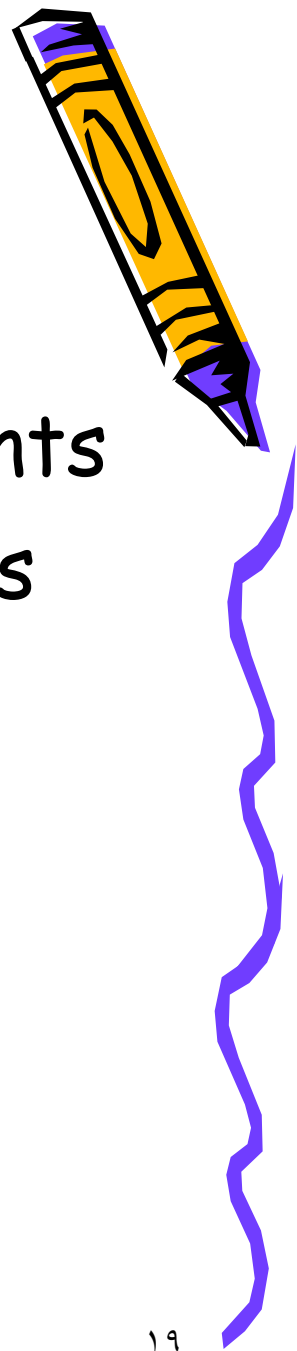


About Parclos

- Site constraints (topography, development, etc) suggest preferred configuration
- Remember driver expectancy and work load
- Loops make for less direct turning movements and longer paths



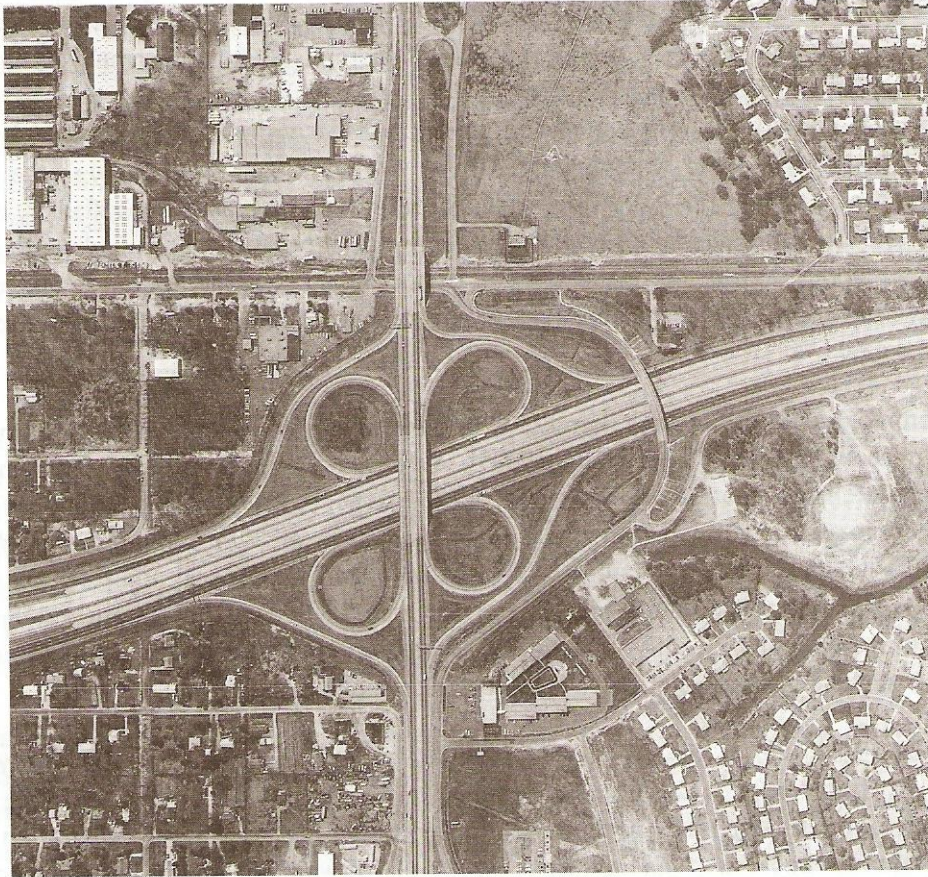
And now, the full Cloverleaf



- Loops and ramps in all four quadrants
- Service interchange (9%) as well as system interchange (29%)
- Higher volumes and speeds



And now, the full Cloverleaf

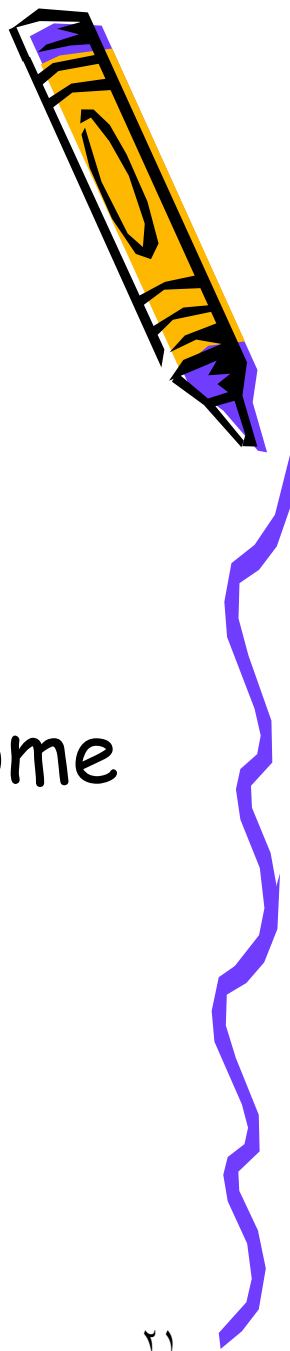


Source: AASHTO
"Green Book"

Exhibit 10-27. Cloverleaf Interchange With Collector-Distributor Roads

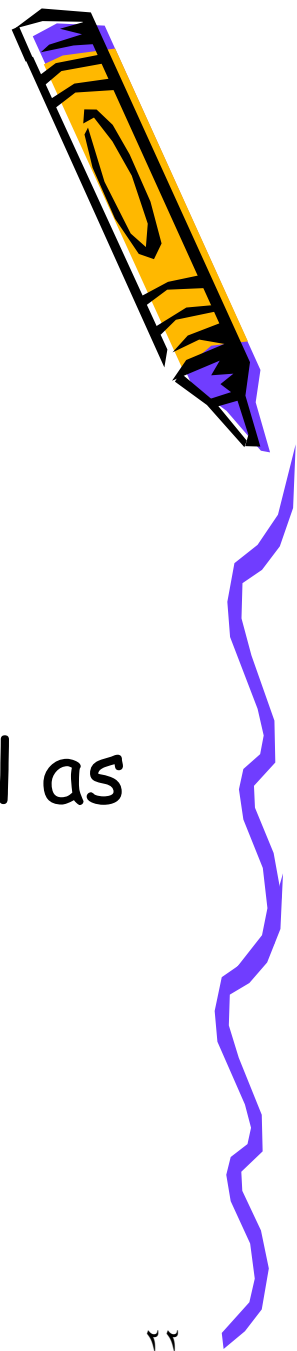
Cloverleaf Issues

- Out of route (long) paths for loop users
- Very land intensive
- Merging and weaving sections become problems when volumes increase
- Multiple exit points - signing and safety problems



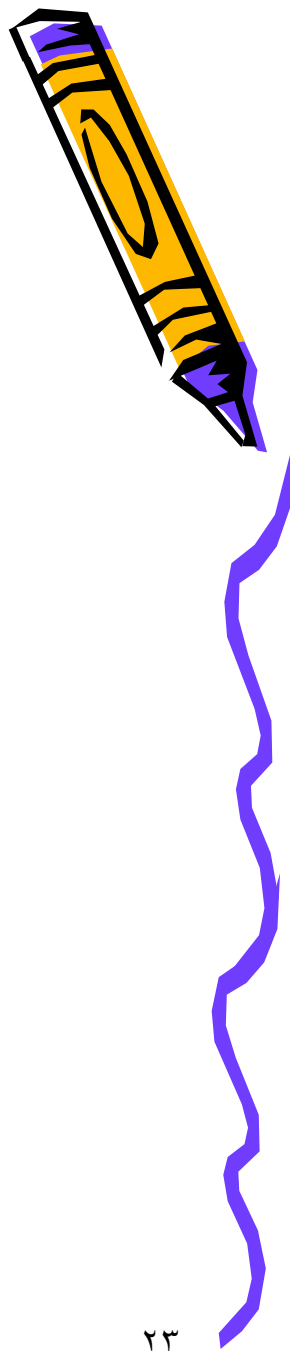
Cloverleaf Issues

- Need constant radius loops (some older ones tightened up at end)
- Need C-D roads to address high-volume weaving and merging as well as multiple exit points



Trumpets

- Limited ROW
- Low volumes
- Service (1%) or system (3%)
- Limited applicability



Trumpets

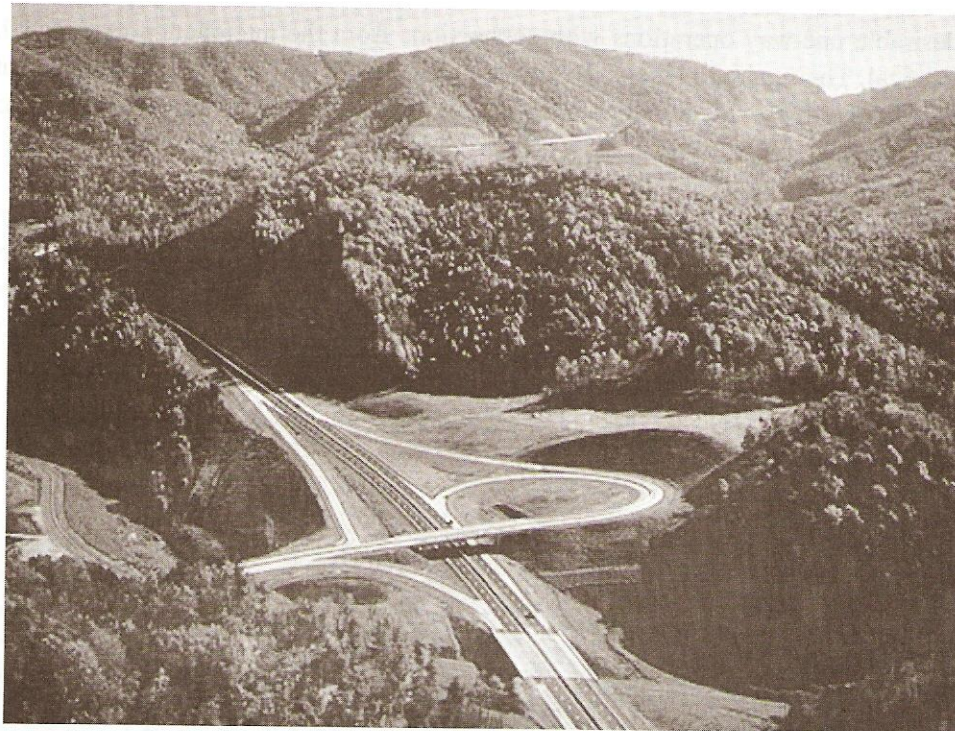
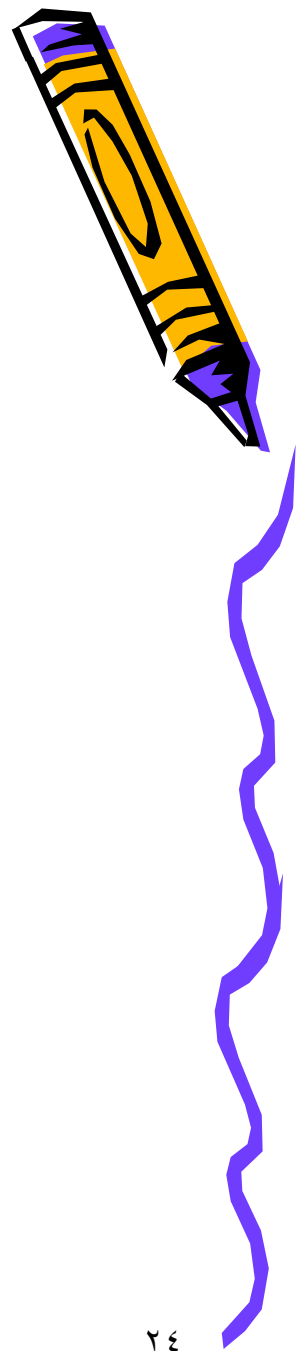
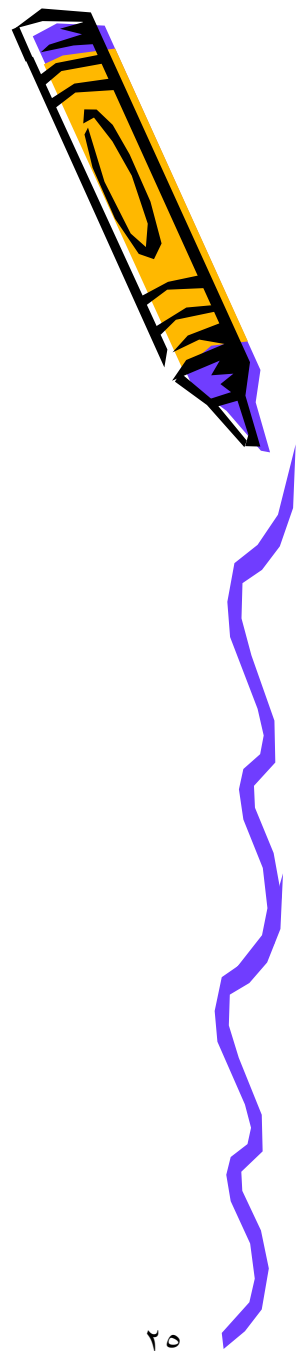


Exhibit 10-14. Trumpet Freeway-to-Freeway Interchange

Source: AASHTO "Green Book"



Single-Point Urban Interchange



- Aka "SPUI"
- Less ROW
- More \$\$
- Signalization benefits
- About 1% of service interchanges



Single-Point Urban Interchange



Source: AASHTO
"Green Book"

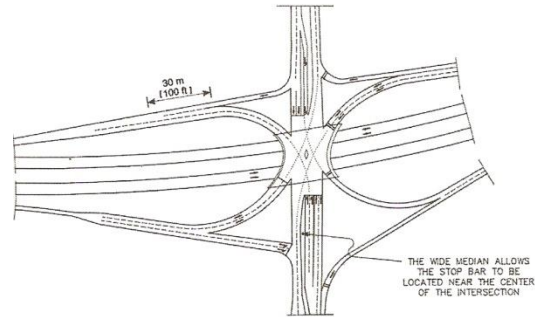


Exhibit 10-22. Underpass Single Point Urban Interchange

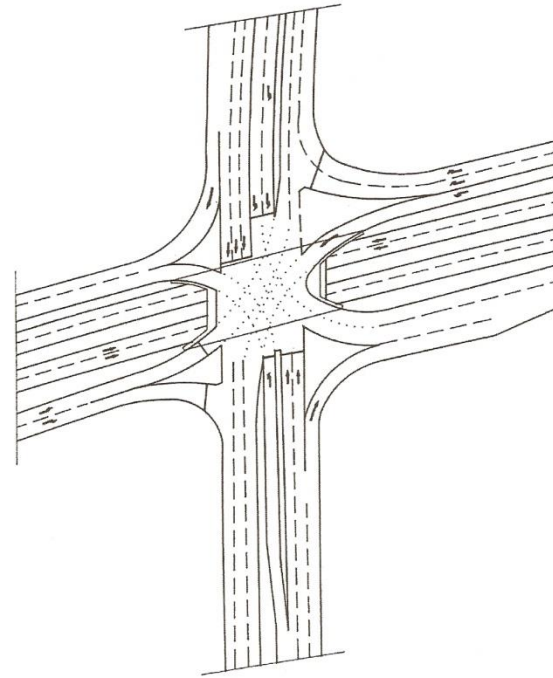
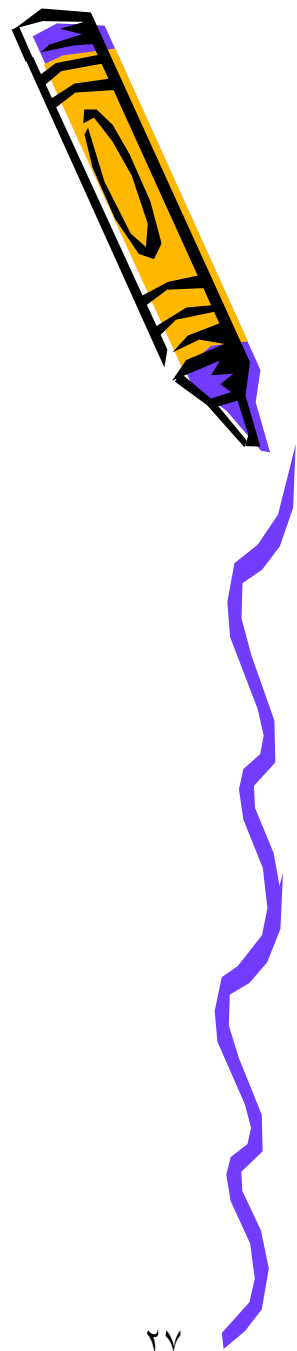


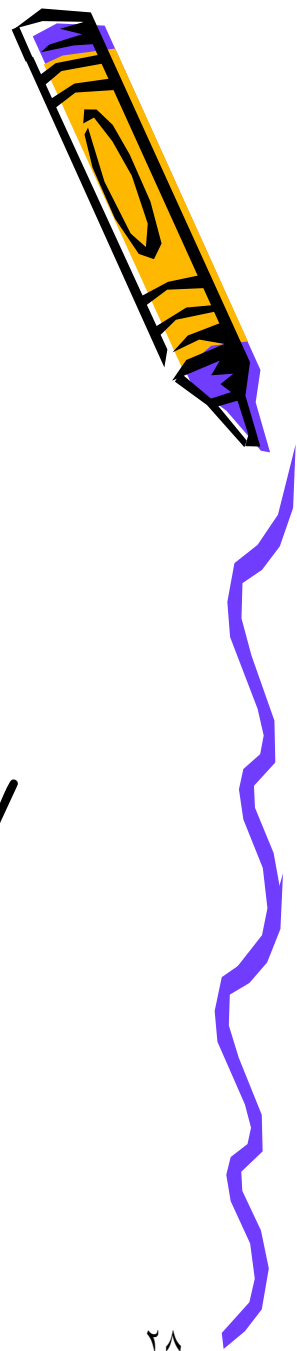
Exhibit 10-23. An SPUI Underpass in Restricted Right-of-Way



Single-Point Urban Interchange



Single-Point Urban Interchange

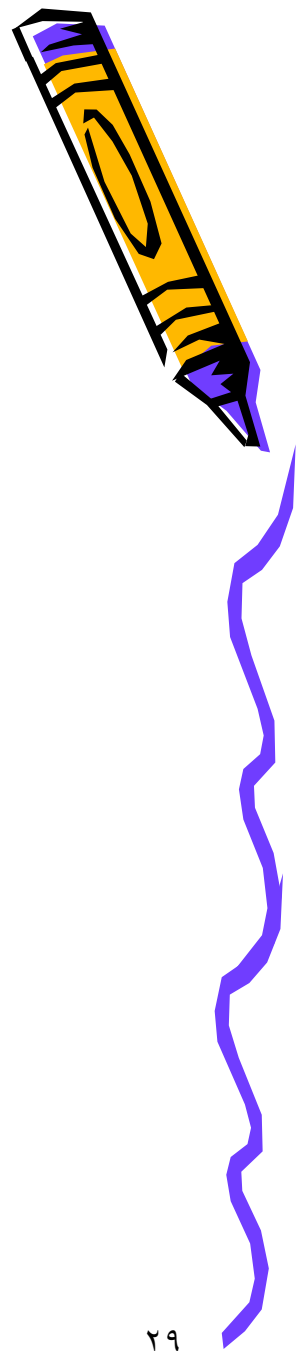


- Usually dual lane ramps (higher volumes)
- Good arterial signal progression
- Somewhat unfamiliar, operationally
- Large skew angles increase costs
- Not pedestrian friendly

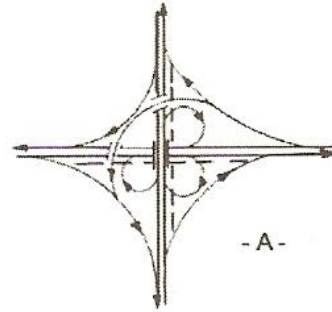


Directional Interchange

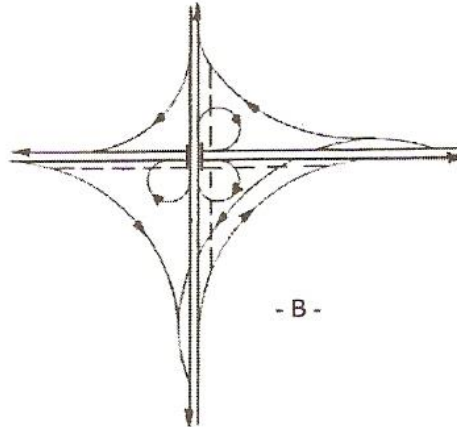
- Direct paths for all (most) movements
- Most expensive
- Land intensive
- System interchanges only (52%)



Directional Interchange



- A -



- B -

NOTE: WEAVING ADJACENT TO THE THROUGH LANES IS
ELIMINATED BY PROVIDING COLLECTOR-
DISTRIBUTOR ROADS AS SHOWN BY DOTTED LINES.

Exhibit 10-31. Semidirect Interchanges With Weaving

Directional Interchange

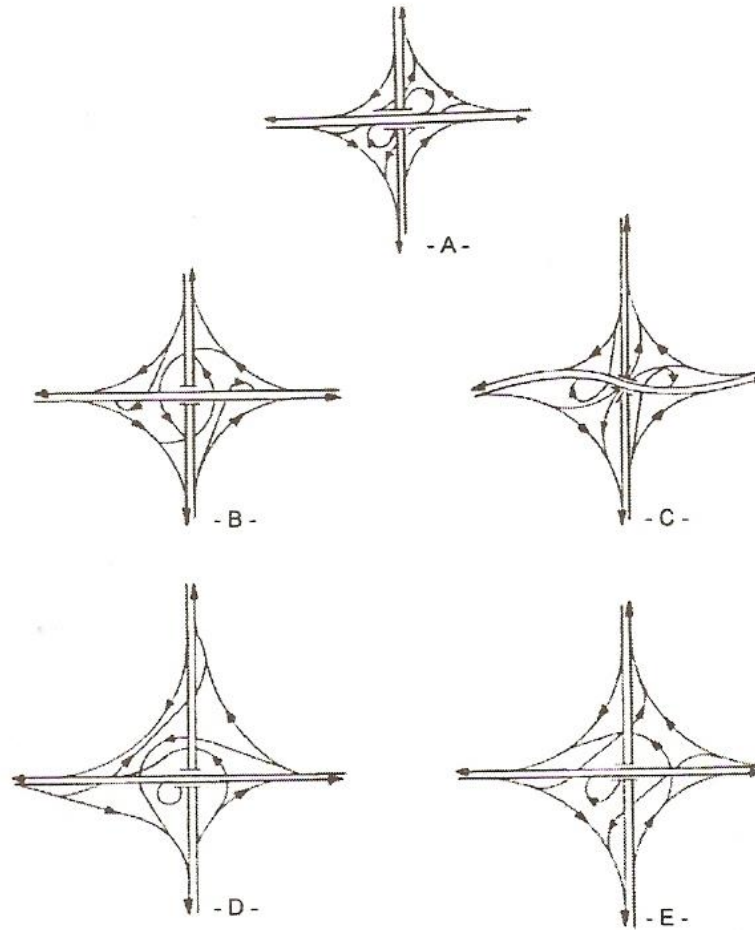


Exhibit 10-32. Semidirect Interchanges With No Weaving

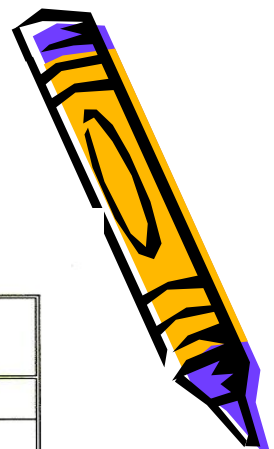
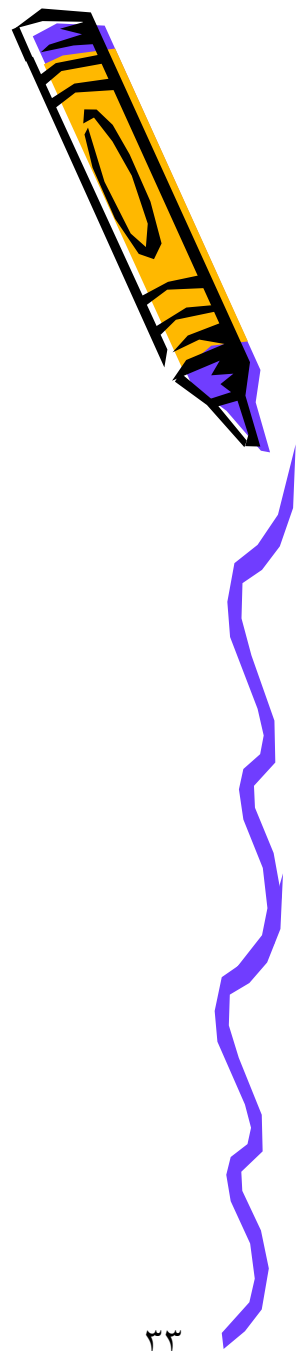


Table 1. Summary of Interchange Characteristics

Interchange Type	Right of Way Required	Capacity	Cost	Notes
Diamond	Low	Low	Low	Simplest interchange
SPUI	Low	Moderate	Low-Moderate	Designed for urban use, problems accommodating pedestrians
Partial Cloverleaf	Moderate	Moderate	Moderate	Loops should be arranged to serve largest left turning movements
Full Cloverleaf	High	Moderate	High	Weaving areas are safety and capacity concerns
Trumpet	Moderate-High	Moderate	Moderate-High	Should be used when 3 legs are present
Directional	Very High	High	Very High	Preferred interchange for freeway to freeway connections

Source: Virginia Transportation
Research Council (1999)





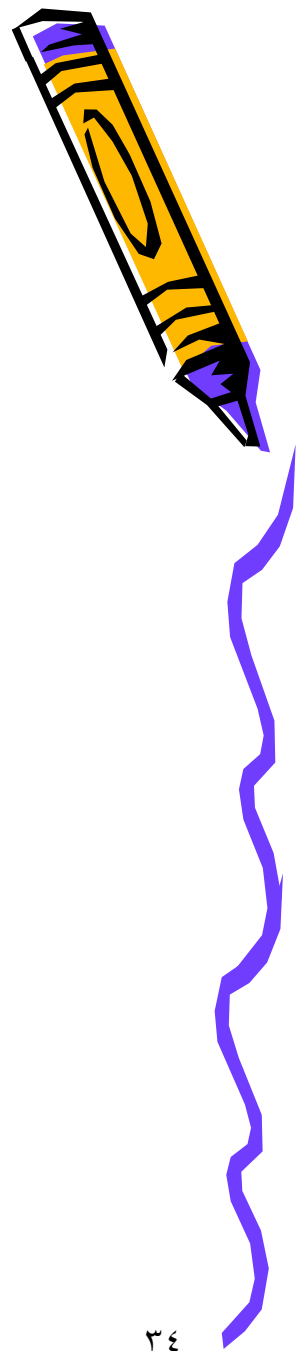
The Proper Interchange...

- Selection is very site specific
- Requires considerable experience
- A lot of things to consider



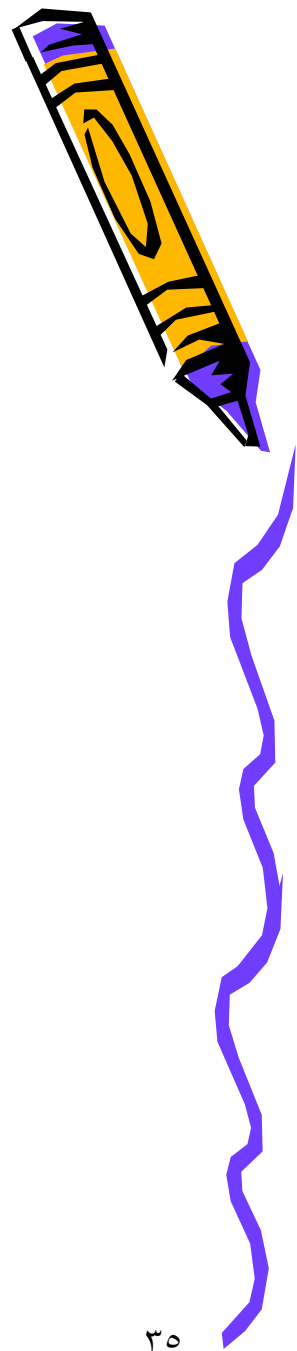
The Process

- Basics
- Data collection
- Evaluation and analysis
- Two general conditions



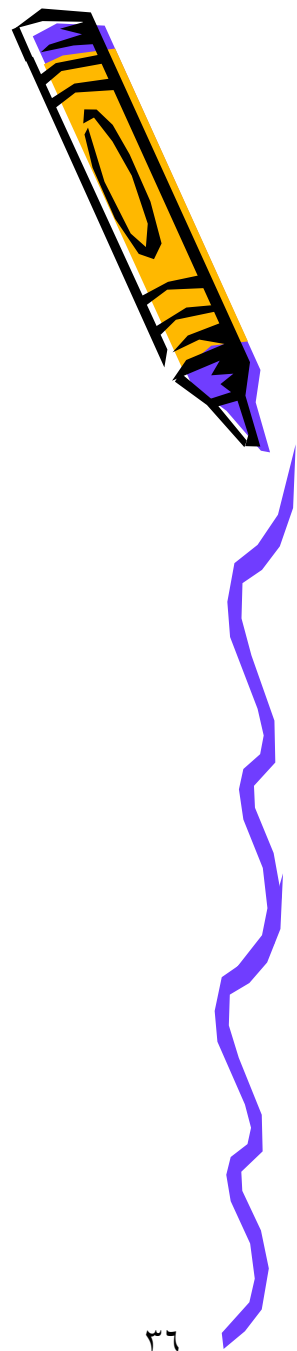
The Process - Basics

- New or existing
- Number of legs
- Functional class of all roadways
- General environment



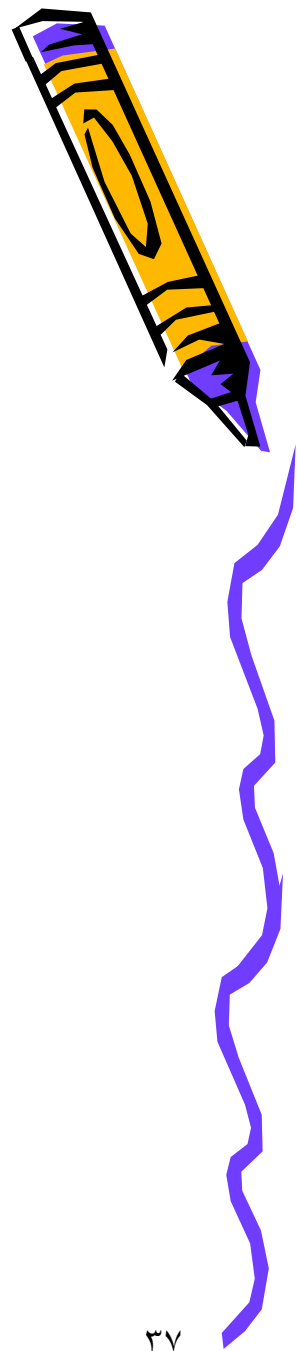
The Process - Data Collection

- ADT (and traffic projections if available)
- Crash history
- Land uses
- Design criteria
- Community impact data



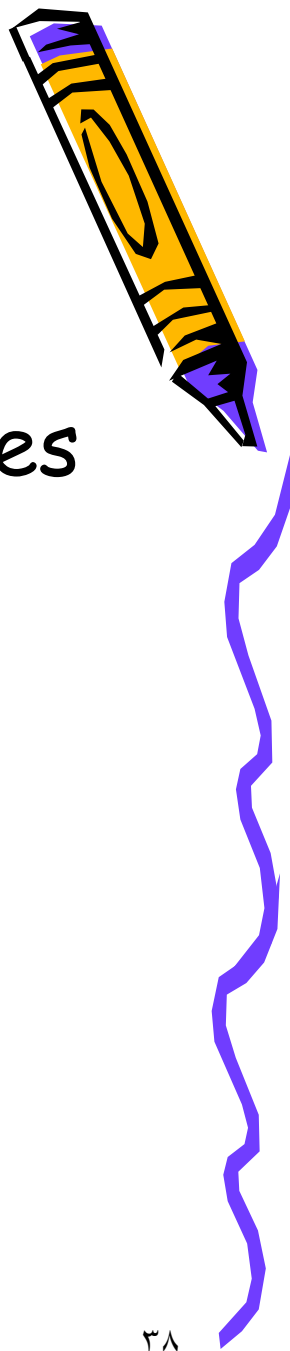
ADT

- Projections from planning agency's model
- Applying historic growth data to current ADT
- Traffic impact analyses data
- Traffic composition (esp. trucks & buses)
- Pedestrian and bicycle needs



Traffic Forecasting

- Procedure varies with circumstances



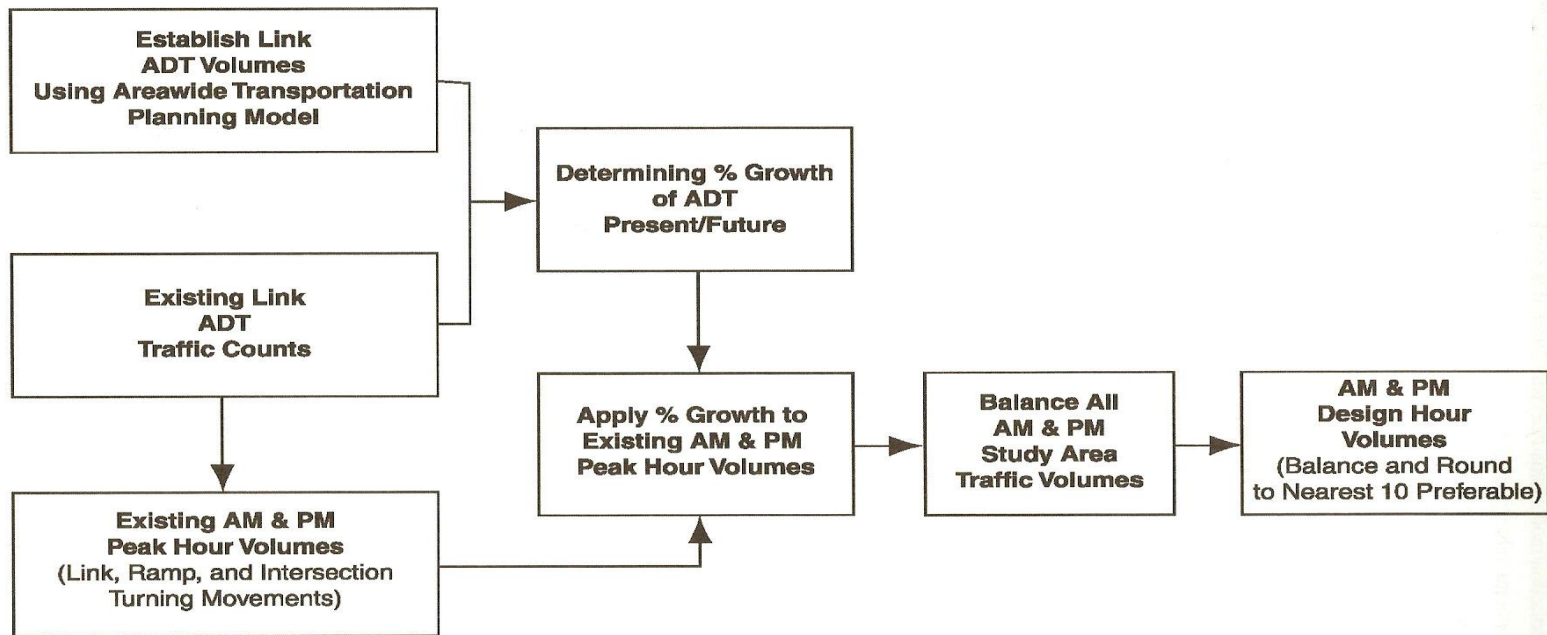


Figure 4–5. Traffic Forecast Procedure for Existing Interchange in a Developed Urban Area.
Source: Joel P. Leisch.

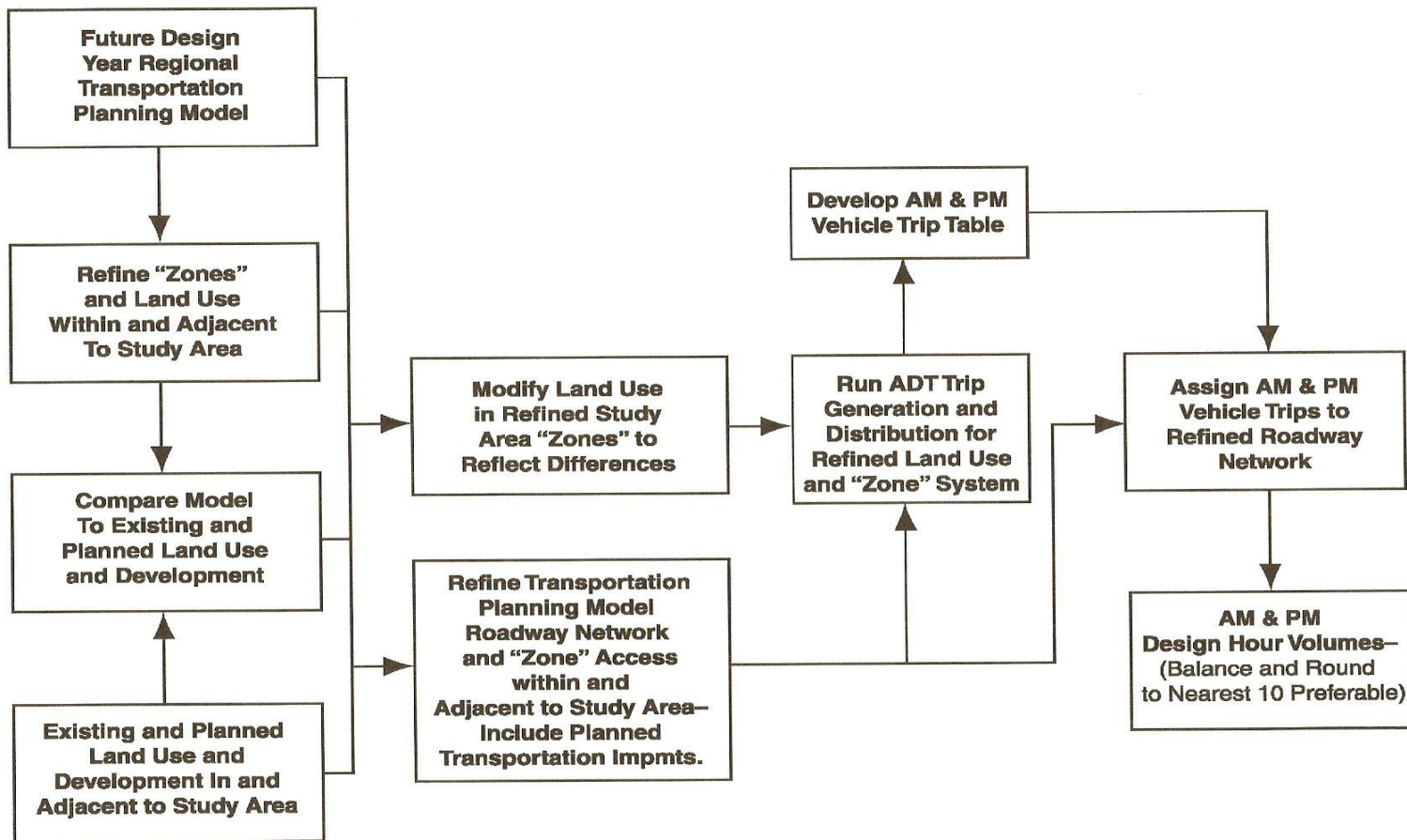


Figure 4-6. Traffic Forecast Procedure for Proposed Interchange in a Developing Suburban Area.
Source: Joel P. Leisch.

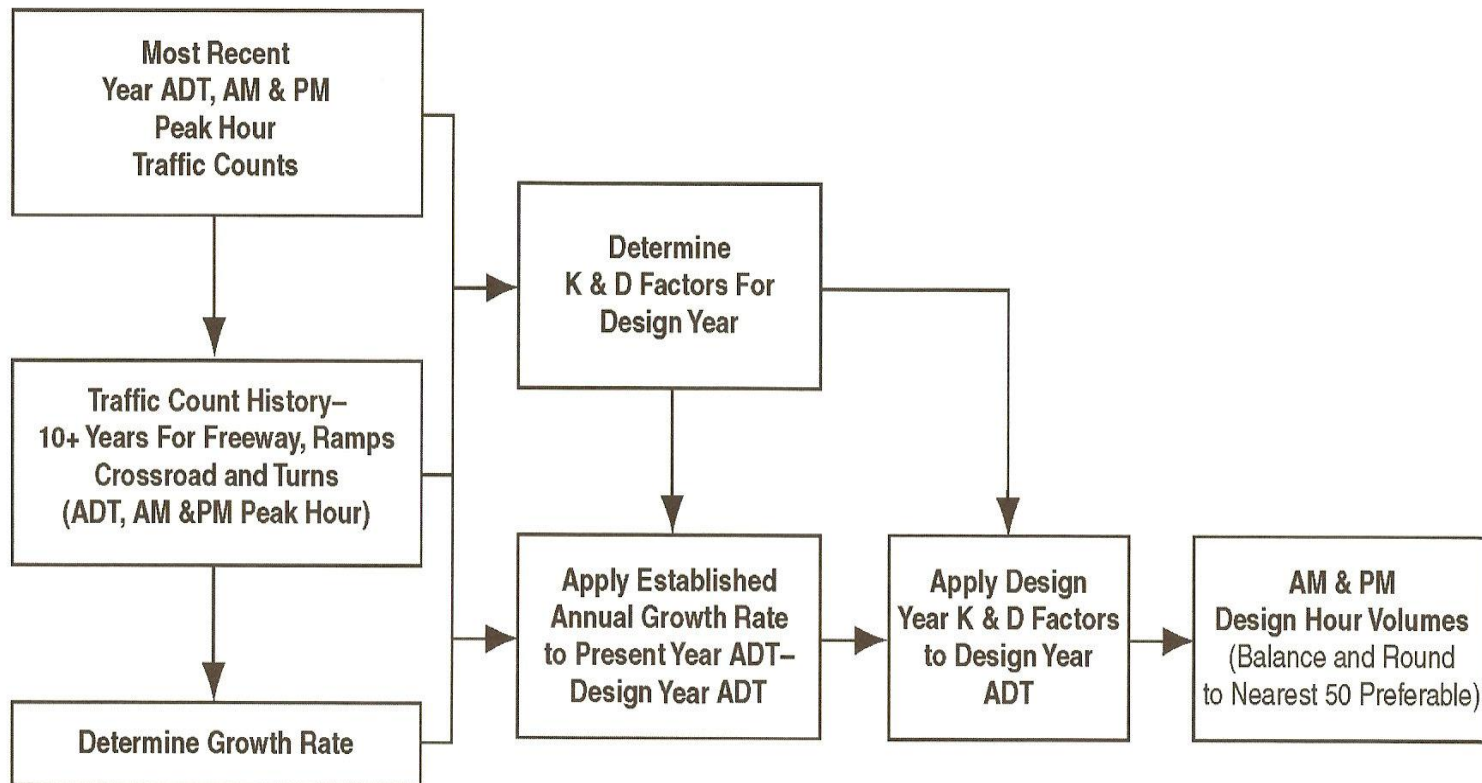
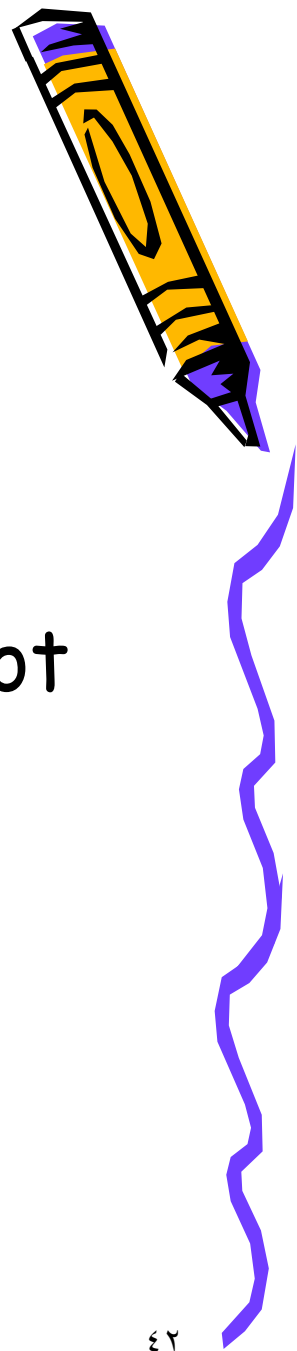


Figure 4-7. Traffic Forecast Procedure for Existing Interchange in a Rural Area.

Source: Joel P. Leisch.

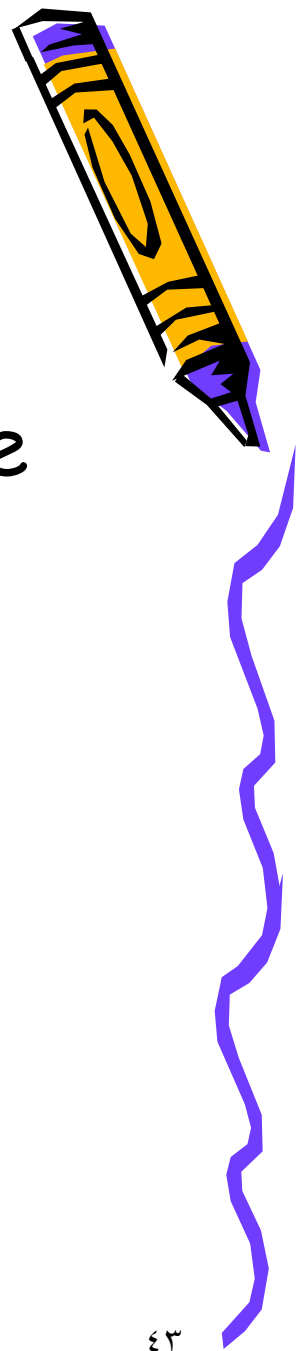
Crash History

- Primarily on existing facilities
- Data for both roadways
- Five years minimum for projects not related to crash problems
- As many years as possible for projects aimed at solving crash problems



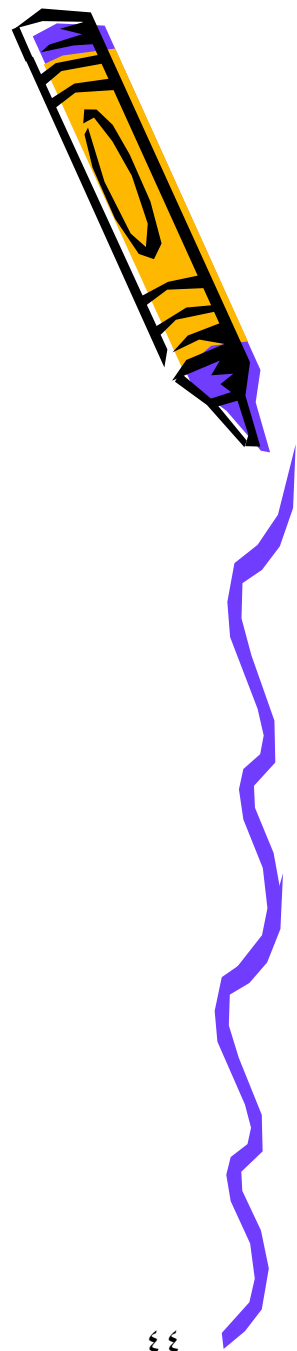
Land Uses

- Existing and proposed in immediate area
- Changes expected by jurisdiction (city?) not in MPO model
- If new interchange consider likelihood of added growth



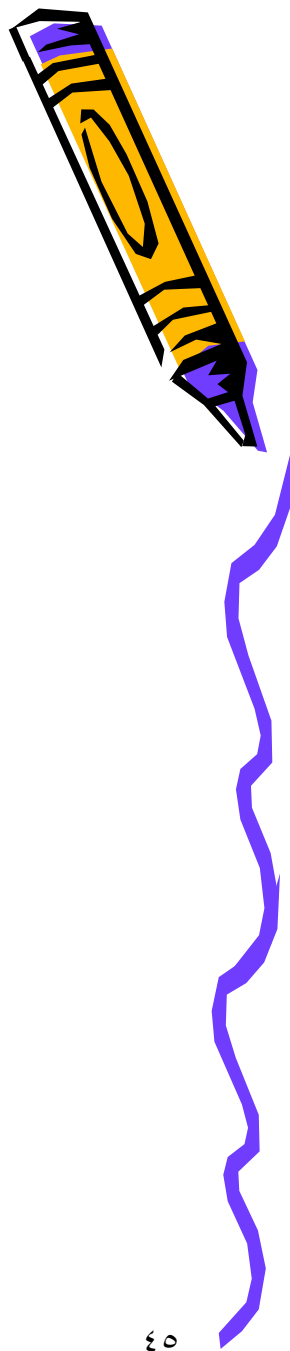
Design Criteria

- Level-of-service
- Design speed
- Superelevation
- Lane widths, especially for ramps
- Ramp geometry



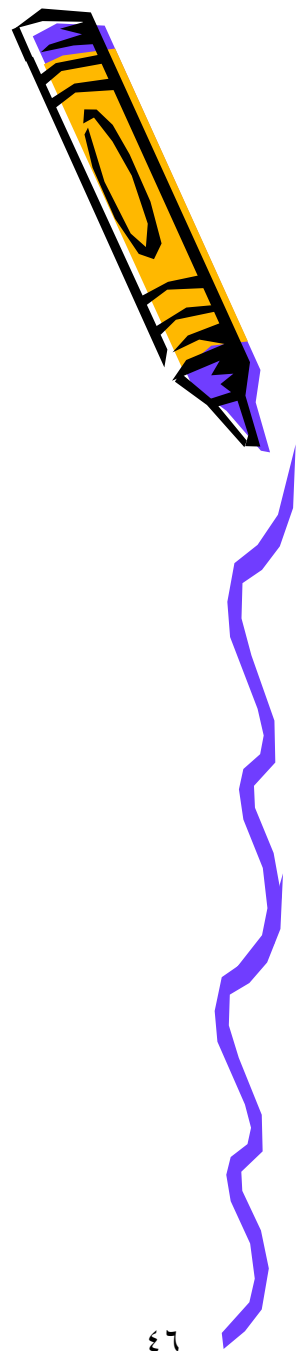
Community Impacts

- Amount of right-of-way available
- Number and approximate value of homes in proximity
- Public buildings and facilities affected
- Access to adjacent properties
- Wetlands



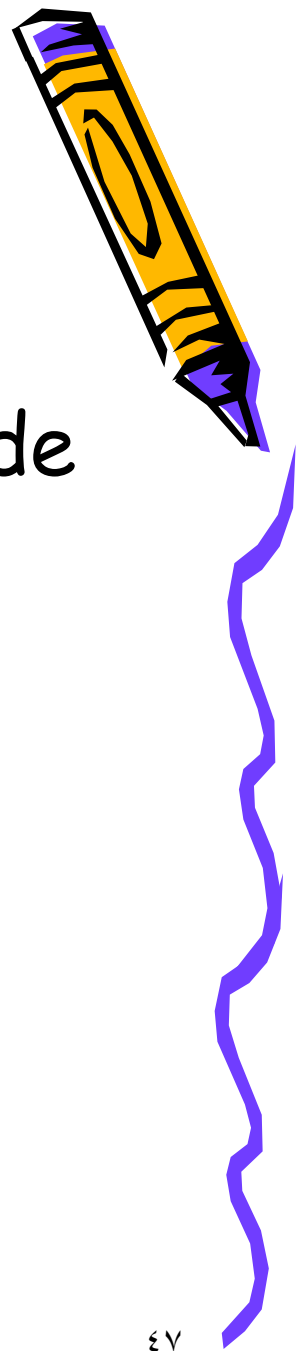
Others

- Soils information
- Other improvements programmed
- Interchange spacing
- ITS strategies



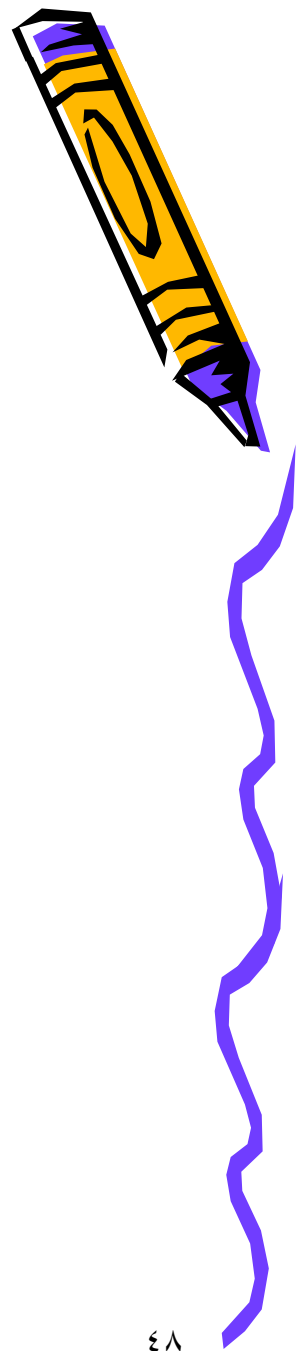
Basic Design Criteria

- All exits and entrances on right side
- Single exit per interchange
- Proper ramp spacing
- Lane balance and basic number of lanes



Selection Process Flow Charts

- Service interchanges
- System interchanges



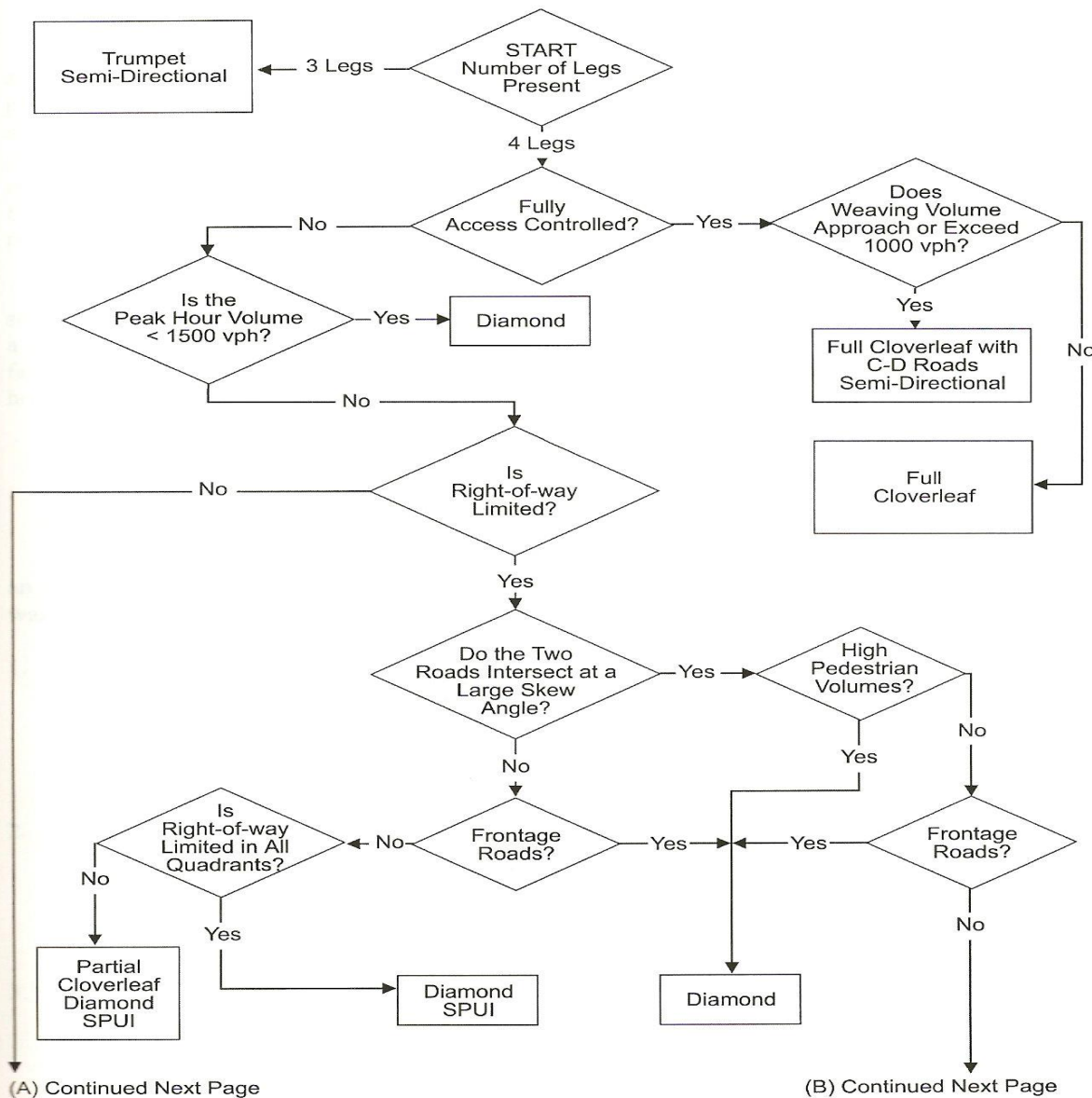
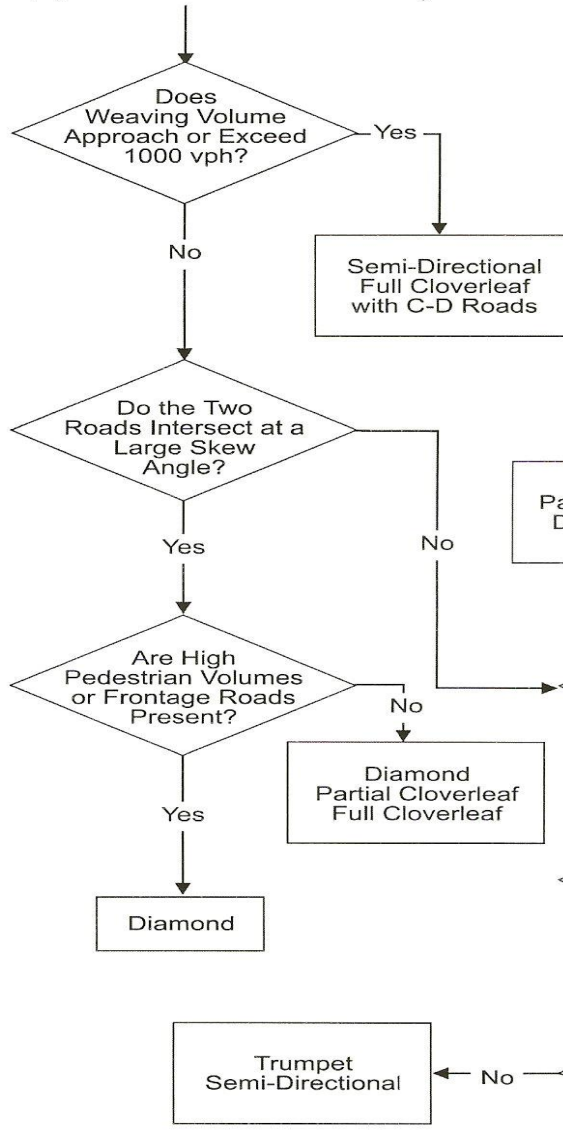


Figure 35. Service Interchanges (Major Road to Lesser Facility)

Source:
Virginia
Transportation
Research
Council

(A) Continued From Previous Page



(B) Continued From Previous Page

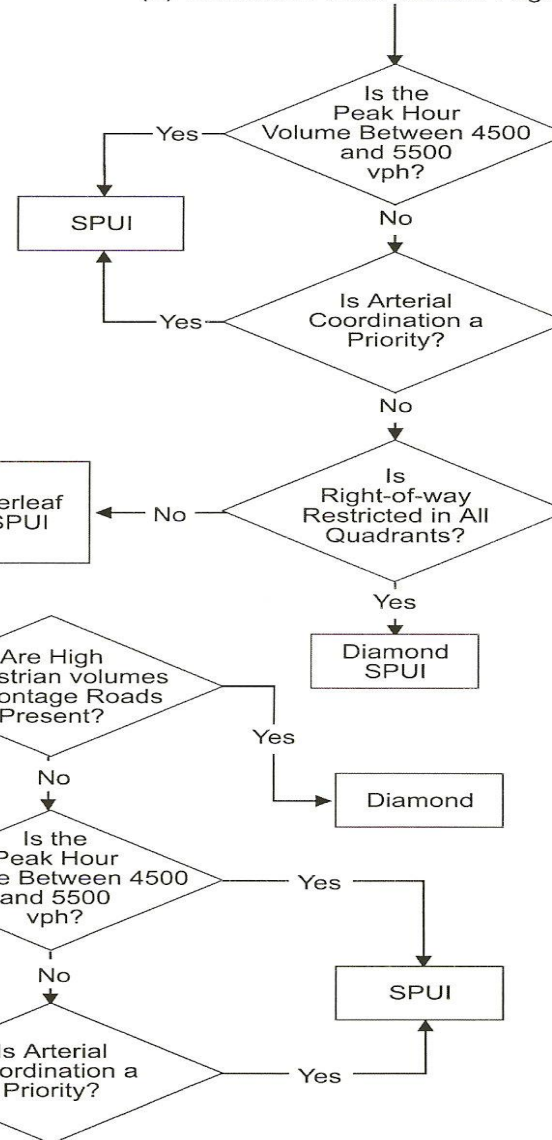


Figure 35. Service Interchanges (Major Road to Lesser Facility) (Continued)

Source:
Virginia
Transportation
Research
Council

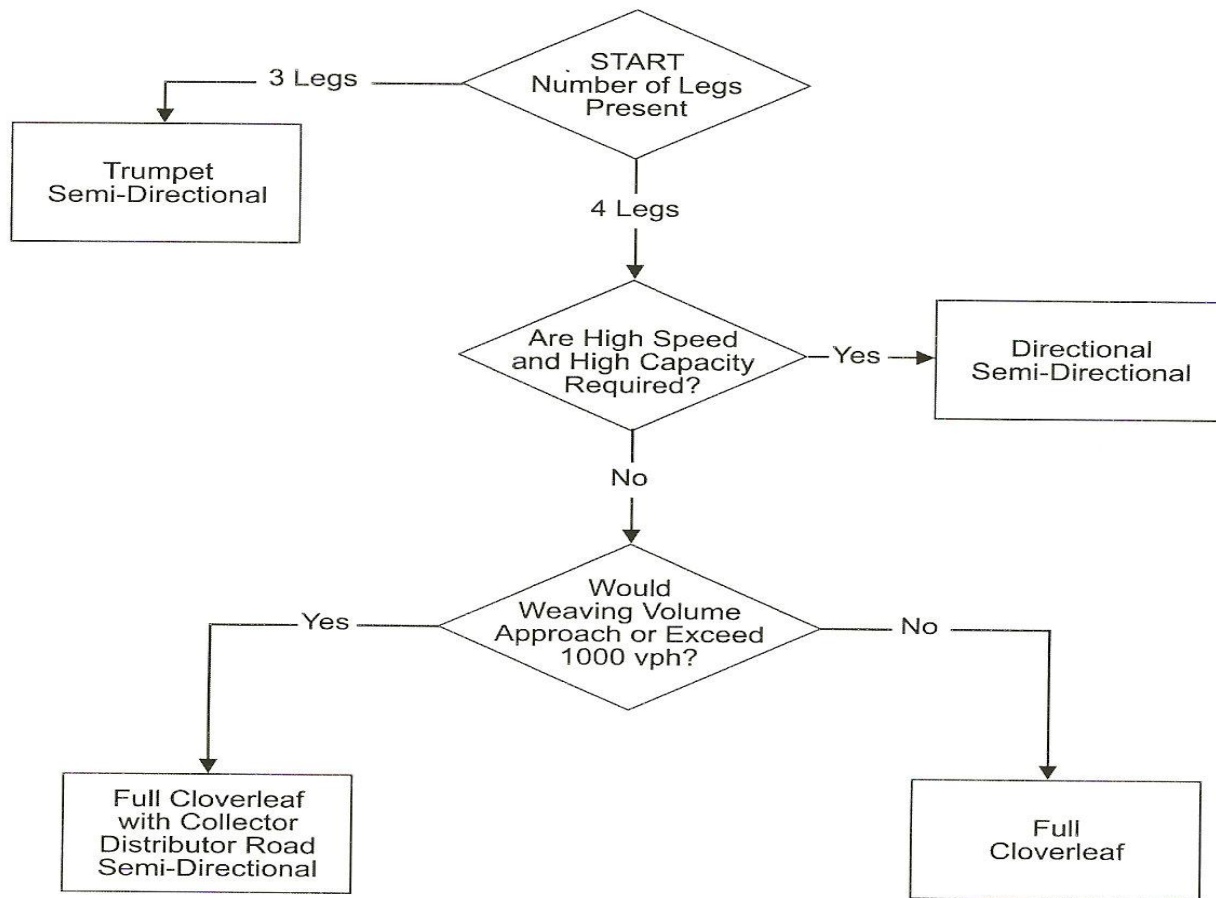
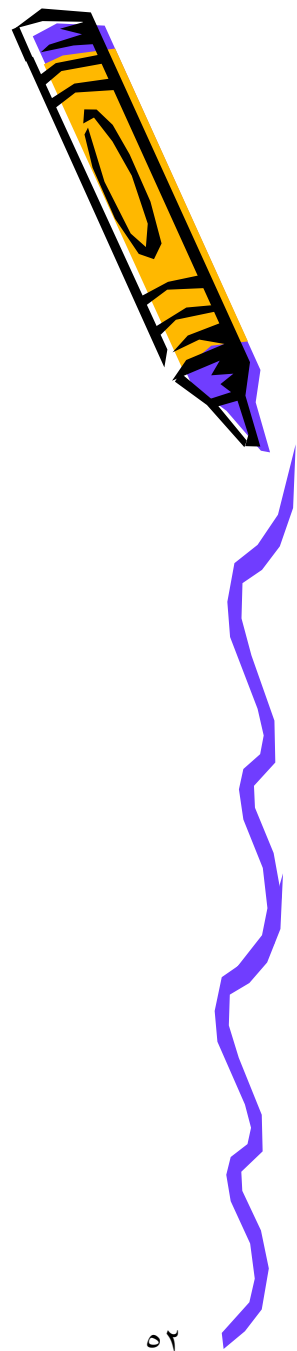


Figure 34. Flow Chart for Preliminary Selection of System Interchanges (Freeway to Freeway)

Source:
Virginia
Transportation
Research
Council

Evaluation and Analysis

- Four broad categories
 - Operations and safety
 - Project costs
 - Constructability and maintenance of traffic
 - Social and environmental impacts



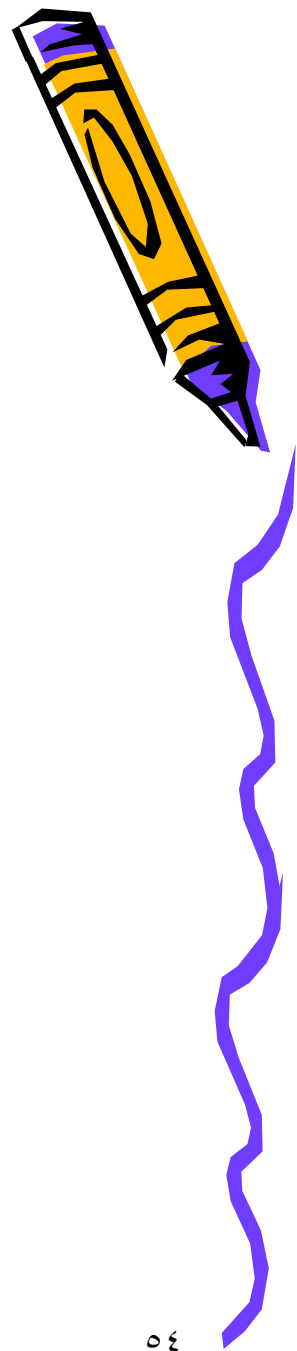
Evaluation and Analysis

- Operations and safety
 - Vehicular and non-motorized safety
 - Level-of-service for projected traffic
 - Flexibility in accommodating future traffic (when projections are exceeded)



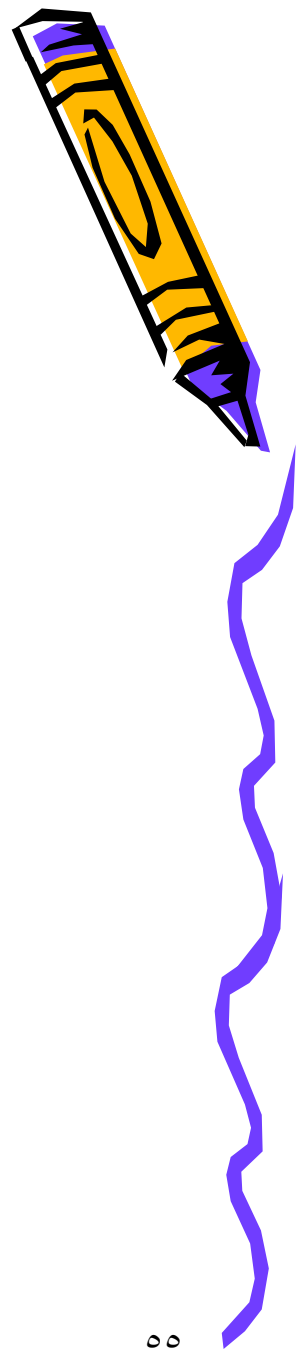
Evaluation and Analysis

- Costs of improvements
 - Right-of-way
 - Construction
 - Impact mitigation (e.g., wetlands)
 - Operations (maintenance)



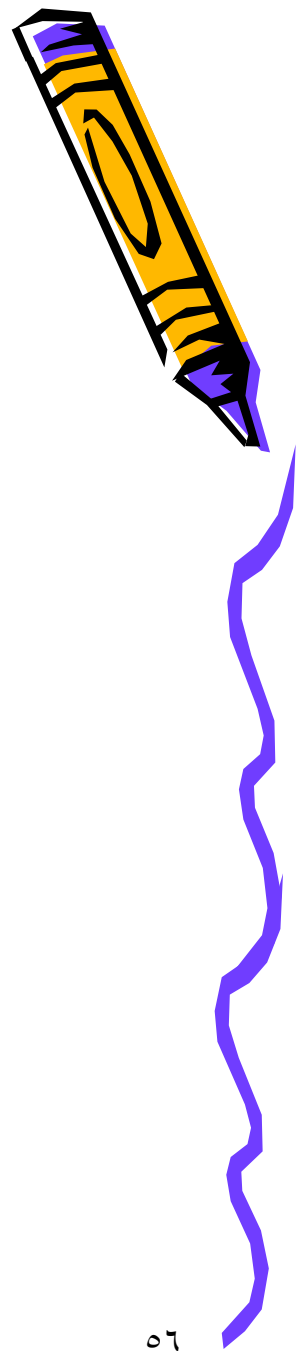
Evaluation and Analysis

- Constructability
- Maintenance of traffic
- Ability to add improvements



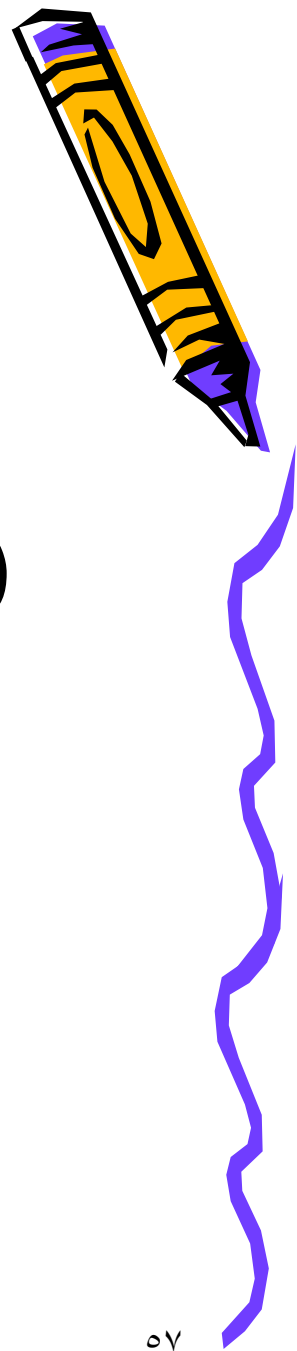
Evaluation and Analysis

- Social and environmental effects
 - Air, noise, water, etc.
 - Economic
 - Land use changes
 - Public transportation



Process - Step 1

- Look at all forms of interchanges
- Screen for suitability (fatal flaws)
- Documentation



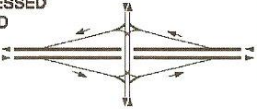
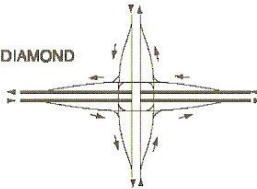
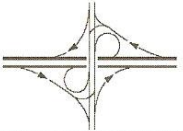
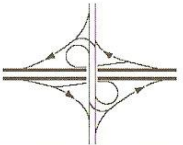
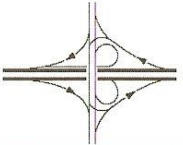
INTERCHANGE FORM	TRAFFIC OPERATIONS	RIGHT-OF-WAY	ENVIRONMENTAL/ SOCIAL IMPACTS	COSTS	CONSIDERATION TIER 2
COMPRESSED DIAMOND 	• Adequate Capacity • Not as efficient as other Diamonds	• Small Amount of ROW– More than other Diamonds	• Environmental – None • Some Access Modification	• Low Cost	NO
SINGLE-POINT DIAMOND 	• Adequate Capacity	• Minimal ROW	• None	• Moderate Cost	YES
TIGHT URBAN DIAMOND 	• Adequate Capacity	• Minimal (+) ROW	• None	• Low Cost	YES
3-LEVEL DIAMOND 	• High Capacity	• Moderate ROW	• Environmental – None • Significant Access Impacts along Arterial	• High Cost	NO
PAR CLO A 	• High Capacity	• Significant ROW	• Environmental – None • Some Access Modification	• Moderate Cost	YES
PAR CLO B 	• High Capacity	• Significant ROW	• Loop in NE Quadrant – Historic Site • Some Access Modification	• Moderate Cost	NO
PAR CLO AB 	• Adequate Capacity	• Significant ROW	• Loop in NE Quadrant – Historic Site • Some Access Modification	• Moderate-High Cost	NO

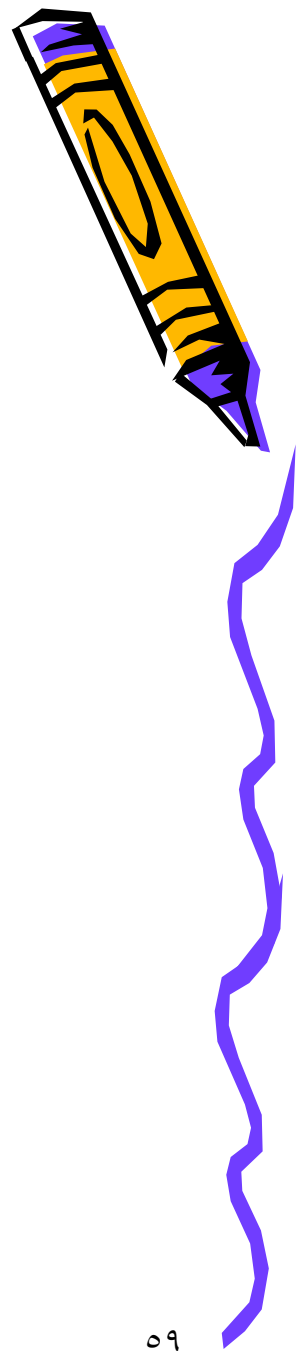
Figure 4–15. Tier 1—Alternatives Screening.

Source: Joel P. Leisch.

Source: Freeway and Interchange
Geometric Design Handbook (ITE)

Process - Step 2

- Develop scaled concepts
 - remaining candidate forms
 - sketch plans
- Evaluate data
- Compare to criteria (matrix?)
- Advance reduced number



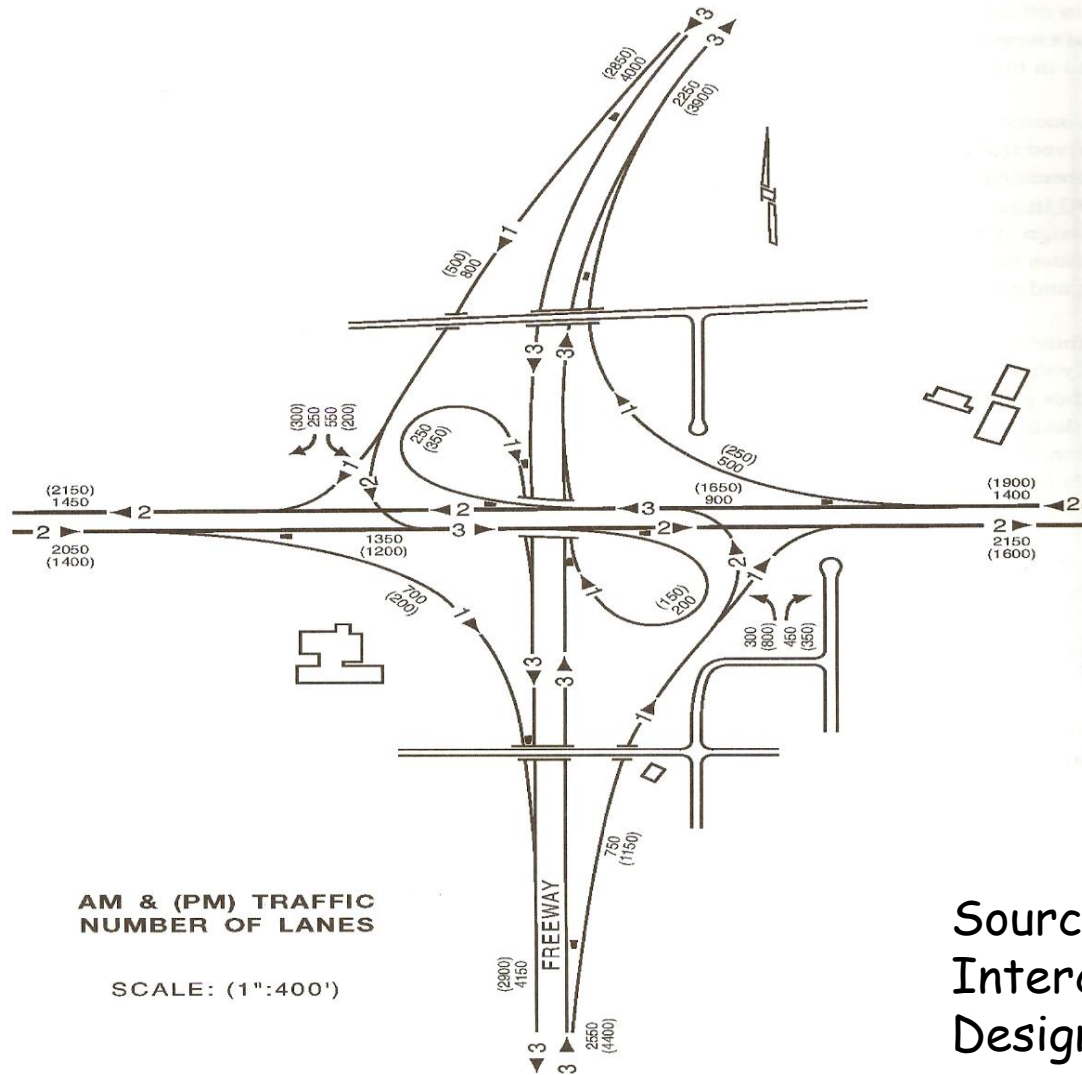


Figure 4-16. CADD Generated Single-Line.
Source: Joel P. Leischy/PBS&J.

Source: Freeway and
Interchange Geometric
Design Handbook (ITE)

BASIS: BALANCED
RATING SCALE: 5-10

PLAN ALTERNATIVE		I		II		III	
ITEM	SCALE VALUE	RATING	WEIGHTED VALUE	RATING	WEIGHTED VALUE	RATING	WEIGHTED VALUE
OPERATIONAL (25)							
CAPACITY/LOS	(10)	8	80	8	80	10	100
FLEXIBILITY	(10)	6	60	10	100	10	100
GEOMETRIC ALIGNMENT	(5)	8	40	8	40	10	50
SAFETY (20)							
OPERATIONAL	(15)	7	105	8	120	10	150
ROADSIDE	(5)	9	45	9	45	10	50
COSTS (25)							
CONSTRUCTION	(15)	8	120	10	150	8	120
R-O-W	(10)	10	100	9	90	7	70
IMPLEMENTATION (15)							
STAGING - CONSTRUCTION	(10)	6	60	10	100	9	90
MAINTENANCE OF TRAFFIC	(5)	7	35	9	35	10	50
ENVIRONMENTAL (15)							
TRAFFIC ACCESSIBILITY	(5)	10	50	10	50	8	40
IMPACT ON DEVELOPMENT	(10)	10	100	10	100	7	70
	(100)						
(POSSIBLE: 1000)	TOTAL		795		910		890

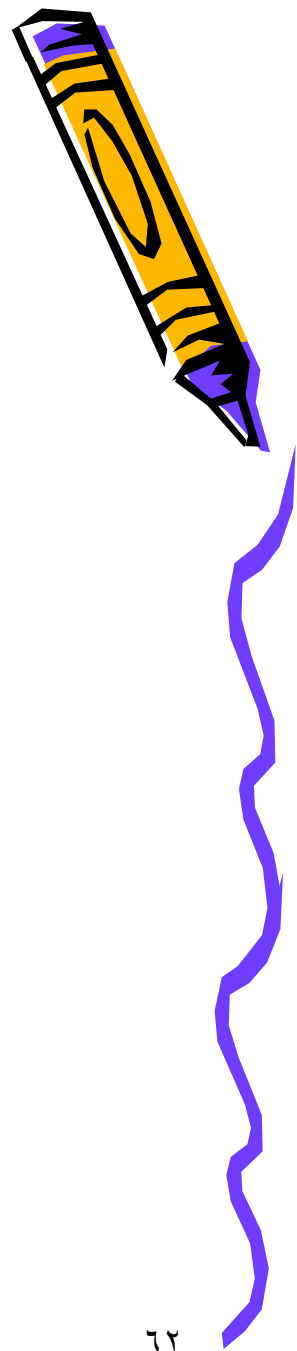
Figure 4-19. Alternatives Ranking (Example).

Source: Jack E. Leisch.

Source: Freeway and Interchange
Geometric Design Handbook (ITE)

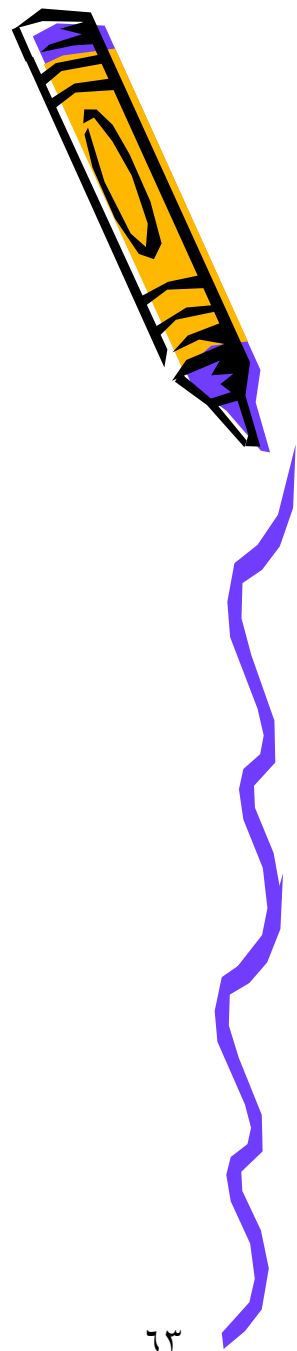
Process - Step 3

- Prepare functional layout plan and profile
- Cross-sections
- Bridge TS&L
- Maintenance of traffic
- Costs (ROW and construction)



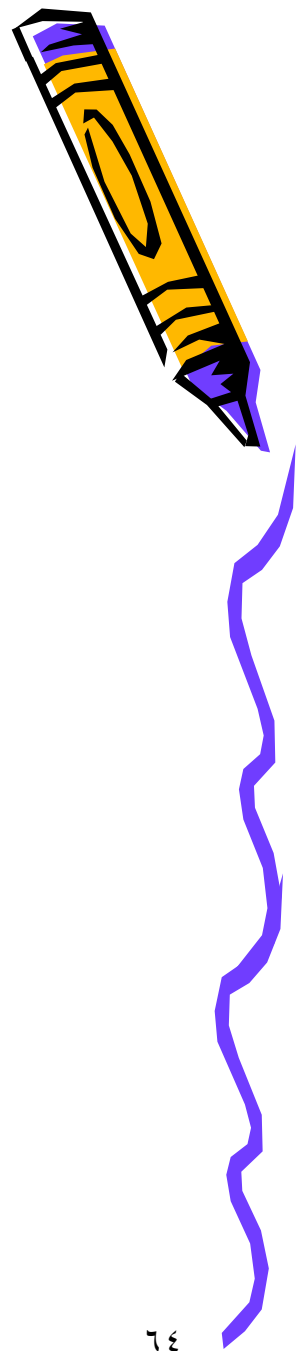
Process - Step 3

- Operational analysis (simulation)
- Evaluation and comparison of alternatives
- Final selection of preferred alternative
- PUBLIC INVOLVEMENT THROUGHOUT!



Documentation

- Design Study Report
- Interchange Justification Report
- Interchange Modification Report



Design Study Report

I. SUMMARY

II. INTRODUCTION

- Study Area and Problem Definition
- Study Goal and Objectives
- Project Approach and Schedule

III. PUBLIC INVOLVEMENT PROGRAM

- Overview of Process
- Public Participants
- Mission Statement
- Communication "Tools"

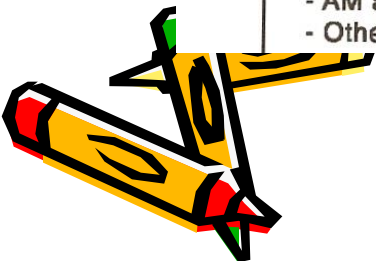
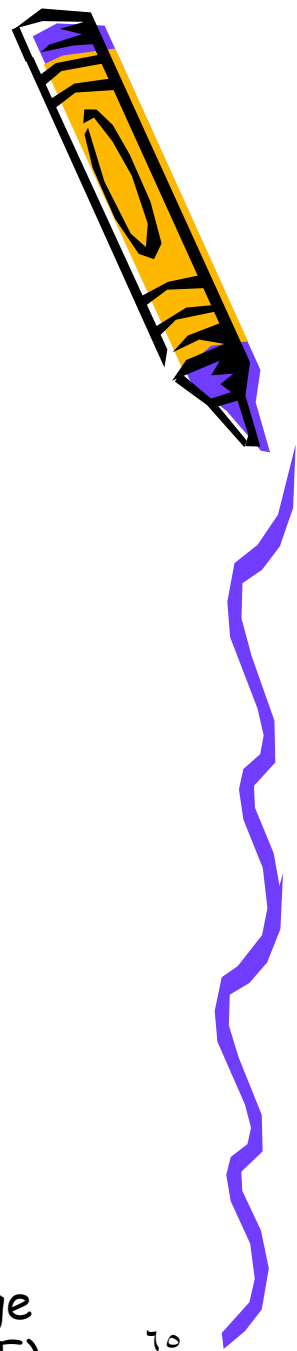
IV. EXISTING CONDITIONS

- Transportation System
- Traffic Volumes, Patterns, and Level of Service
- Accident Experience
- Existing Development and Right-of-Way Constraints
- Environmental Considerations
- Summary and Evaluation of Existing Conditions
- Traffic Model Calibration

V. FORECASTS OF FUTURE TRAVEL

- Growth Projections (Land Use and Development)
- General Projected Travel Growth (ADT)
- AM and PM Design Traffic Projections
- Other Peak Projections

Source: Freeway and Interchange
Geometric Design Handbook (ITE)



Design Study Report

VI. FUTURE SYSTEM DESIGN AND OPERATIONAL CONSIDERATIONS

- Design and Operational Criteria
- HOV and Public Transport Considerations
- ITS Elements
- Basic Lane Requirements

VII. DEVELOPMENT AND EVALUATION OF ALTERNATIVES

- Tier 1 - Alternatives Considered and Screening
- Tier 2 - Alternatives Development and Ranking
- Tier 3 - Alternatives Concept Design and Evaluation

VIII. PREFERRED ALTERNATIVE

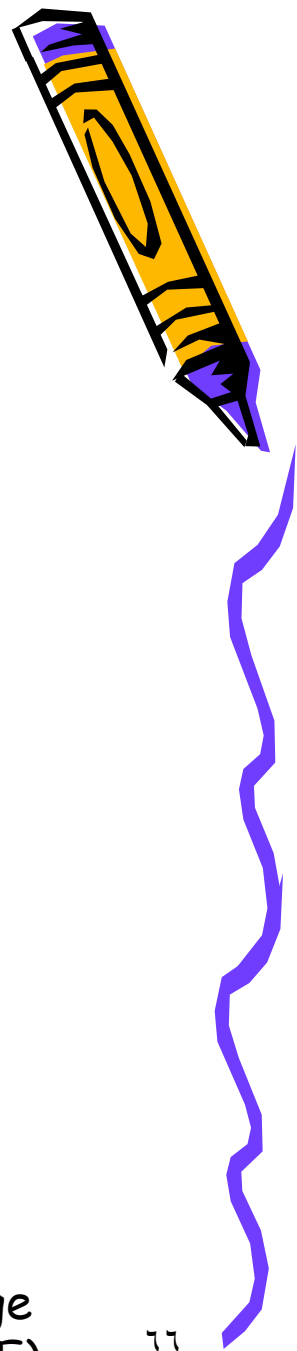
- Description of Preferred Alternative
- Estimated Costs
- Phased Implementation Concept
- Final Operational Analysis - Simulation

IX. SUMMARY AND RECOMMENDATIONS

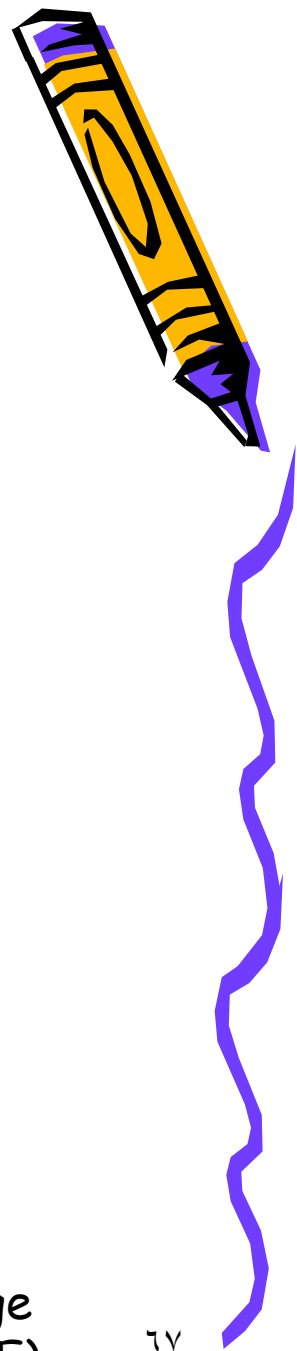
Figure 4-27. Interchange Design Study Report—Example Contents.

Source: PBS&J.

Source: Freeway and Interchange
Geometric Design Handbook (ITE)



Federal Requirements



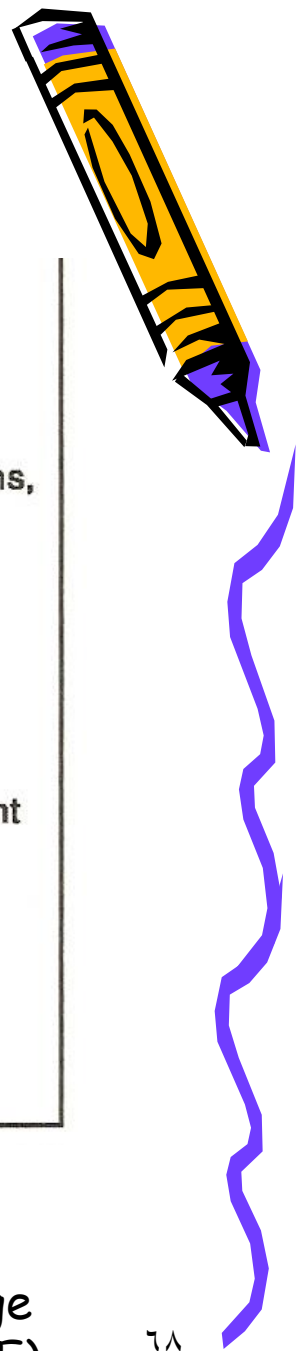
1. The existing interchanges and/or local roads and streets in the corridor can neither provide the necessary access nor be improved to satisfactorily accommodate the design-year traffic demands while at the same time providing the access intended by the proposal.
2. All reasonable alternatives for design options, location and transportation system management type improvements have been assessed and provided for if currently justified, or provisions are included for accommodating such facilities if a future need is identified.
3. The proposed access point does not have a significant adverse impact on the safety and operation of the interstate facility based on an analysis of current and future traffic.
4. The proposed access connects to a public road only and will provide for all traffic movements. Less than “full interchanges” for special purpose access for transit vehicles, for HOVs, or into park and ride lots may be considered on a case-by-case basis.



Source: Freeway and Interchange
Geometric Design Handbook (ITE)

Federal Requirements

5. The proposal considers and is consistent with local and regional land use and transportation plans (i.e. TIP, STIP).
6. In areas where the potential exists for the future multiple interchange additions, all requests for new or revised access are supported by a comprehensive interstate network study with recommendations that address all proposed and desired access within the context of a long-term plan.
7. The request for a new or revised access generated by new or expanded development demonstrates appropriate coordination between the development and related or otherwise required transportation system improvements.
8. The request for a new or revised access contains information relative to the planning requirements and the status of the environmental processing of the proposal.



Source: Freeway and Interchange
Geometric Design Handbook (ITE)

IJR/IMR

1. EXECUTIVE SUMMARY

- "Additional Interchanges to the Interstate System"
- Criteria Discussion and Recommendation

2. INTRODUCTION

- Background
- Study Area Description

3. EXISTING CONDITIONS

- Roadway Description
- Operational Analysis Procedures
- Existing Traffic Counts
- Existing Level of Service

4. FUTURE TRAFFIC AND DISCUSSION OF ALTERNATIVES

- Proposed Roadway Improvements
- Alternates Considered
- Traffic Assignments
- Development of Network Operating Characteristics

5. INTERSTATE ACCESS EVALUATION

- Design Criteria
- Design Concept
- Operational Characteristics
- Right-of-Way
- Estimated Costs
- Procedures Used in Estimating Road User Costs
- Operating Characteristics Analysis Comparison

6. SUMMARY

- Traffic Operations
- Benefit-Cost Ratio

Source: Freeway and
Interchange Geometric
Design Handbook (ITE)

Figure 4-29. Interchange Justification/Modification Report Outline.

Source: PBS&J.

Caveats

- No substitute for experience
- Public involvement throughout
- Often no "right" answer
- Frequently many "wrong" answers

