

10 Analyzing Alternatives

10.1 Purpose

The project alternatives should be developed and their effectiveness analyzed consistent with the goals and evaluation criteria selected for the project, and to specifically address deficiencies identified through the Existing and No-Build System analysis. This chapter presents the process for conducting the transportation analysis of Build Alternatives. Topics covered include:

- Highway Design Manual Guidelines
- Screening Preliminary Alternatives
- Identifying Limitations to Design Concepts
- Documentation of Screening Process
- Evaluating Build Alternatives

10.2 Highway Design Manual Guidelines

The performance measures applied to flag deficiencies in the Existing or No-Build system, as described in Chapter 2, provide a basis for requiring improvements. However, when defining the scope and nature of improvements, these indicators are not sufficient. The project design guidelines identified in the *Highway Design Manual* should also be applied to measure acceptability of performance for the horizon forecast year. Refer to Chapter 2 for more detail.

The HDM has different design guidelines for different roadways and the expectation is that the guidelines will be followed. In some cases, however, the costs and impacts associated with a preferred improvement project are too great to fully comply with HDM guidelines, and an exception to the design must be submitted and approved. Design exceptions are not intended as a commonplace occurrence, are not necessarily a quick process and should not be relied on prior to approval. Design exceptions may be needed for planning studies. Corridor studies are usually not developed at a level of detail that involves design exceptions. Transportation Growth Management (TGM) funded projects and refinement plans may have enough detail and information that would support design exception requests. As with normal project development projects, complete background information and sufficient justification as to why the guideline was unable to be met must be provided or be available to initiate the design exception process.

For a project that may be constructed within five years, the planner or project leader in charge of the planning project should contact the Region Technical Services Resource Manager (TSRM) to assist in putting together the design exception request. The design exception request should be processed in the same manner as a project development design exception, which is listed in Section 13.3 of the HDM. For projects that may be constructed within five to ten years, the design exceptions should be identified and the TSRM or the Roadway Engineering Manager should give an indication that a design exception is warranted and would probably be approved.

10.3 Screening Preliminary Alternatives

Alternatives for facilities should be developed, assessed and evaluated relative to the matrix of performance measures selected for this study. Depending on the scope and complexity of the study, it may be appropriate to have a tiered screening process. This process would begin with a screening process that allows for a large range of potential alternatives to be defined (typically through a workshop or open house process). This enables many stakeholders to express any outstanding concerns and potential solutions at a sketch or concept level format. These initial sketch alternatives are then filtered to just a few alternatives through the first screening process. These alternatives would then be advanced to the next level in order to select the best candidates for the purposes of alternative performance evaluations.

Projects that have an up-to-date travel demand model representation of the study area could use this tool to rapidly perform initial assessments of system performance without the need for detailed analytical calculations required for the full performance measures evaluation. These initial assessments typically focus on more general performance indicators, such as v/c ratios on arterials and highways, v/c ratios across screenlines, or approach volumes at major intersections and junctions. These findings can be useful for quickly assessing the general feasibility of a preliminary improvement concept, and provide a basis for eliminating or further refining an initial concept.

10.3.1 Coordination with Stakeholders

The development of potential improvement alternatives should be done in cooperation with any groups within ODOT or other agencies that will be involved in the design, implementation, construction, maintenance, or operations of the facilities. The district and regional units within ODOT that may be contacted during this process are listed in Chapter 2.

ODOT Engineers

Typically, the highway design and traffic operations engineers within ODOT have a key role in assisting the review and confirmation of the selected alternatives. The district or regional staff that would be responsible for the design and implementation of the selected alternative should be included in the concept development, performance assessment and suggested for further refinements.

Local Agencies

The local authorities for affected roadways, other than the state, should be included in the selection and review of alternatives. Typically this includes local cities, counties, or regional metropolitan planning organizations.

ODOT Rail Division

The Rail Division, which is based in Salem, has jurisdiction over railroad crossings and traffic control devices used within crossing areas. They also have exclusive legal authority over public grade crossings and provide coordination with the railroads for affected private rail crossings. The Rail Division should be contacted any time a project will have an impact directly to or within 500 feet of a railroad or rail crossing.

10.3.2 Potential Facility Solutions

The range of potential facility improvements and associated system solutions that can be recommended to address existing or future performance deficiencies include the following categories:

- TDM
- Access Control and Local Circulation Improvements
- Transportation System Management (TSM)
- Capacity Increases
- Intersection Control Improvements
- Interchanges

In general, the analyst should first consider the least impact to existing development, natural systems and cost, then progress towards improvements that have potentially larger investments and associated impacts until the identified need is resolved.

Travel Demand Management

The initial assessment for the project area should consider solutions that do not require physical improvements to the transportation system. Travel demand management generally includes the following types of programs and services that can marginally reduce the estimated travel demand where these types of programs are not in place. In general, these types of programs are most suitable for urban areas where commute traffic represents a significant component of the study period flows. In general, they include:

- Carpooling/Ridesharing
- Shuttle Service/Transit Service Expansion
- Transit Fare Subsidies
- Flextime/Compressed Work Week
- Bike Parking/On-Site Lockers and Showers
- Telecommuting

The effectiveness of these types of programs can be estimated based on surveys conducted for the Employee Commute Options Rule compliance. Typically, these measures can reduce commute travel demand for a given activity center by 1 to 10 percent or more, if the management takes aggressive measures. For more details, refer to the 1996 study²² that assessed the marginal reduction in traffic generation associated with various TDM options.

Potential Land Use or Regulatory Changes

In addition, other planning actions taken by the local jurisdiction may have substantial effects on the initial horizon year forecasts that would reduce the future demand and partially (or fully) mitigate the identified need. These actions could include:

- Re-zoning land to allow less intense transportation uses.
- Restricting the intensity allowed within the current zoning by imposing trip caps that are regulated by local ordinance.
- Supporting mixed use development that minimizes trips onto the roadway system.

These actions require coordination with local agencies that are responsible for land use review and approval, and it may require a separate review and approval process to be implemented.

Access Control and Local Circulation Improvements

State facilities should be reviewed to compare background access provisions on state highways against the adopted standards as presented in OAR 734-51. Consolidating (or eliminating) existing vehicular access can substantially improve travel speeds and reduce vehicle conflicts along the highway. Typically, this would require coordination with affected property owners and implementation of necessary permits and easements to effect an alternative local circulation plan. This approach is most effective on a site that is making development application and has substandard existing access spacing provisions.

In addition, the local agency could implement alternative local circulation plans that reduce the volume of traffic using the highway and shifts a portion of the local vehicle trips onto local roadway facilities. This can be accomplished through connecting circulation routes within adjoining uses across parking lots, or via alleys, frontage roads and backage roads.

²² *Guidance for Estimating Trip Reductions From Commute Options*, Oregon Department of Environmental Quality, August 1996.

Transportation System Management

Substandard performance at highway intersections can be addressed by adding capacity to critical movements or upgrading the traffic control schemes to serve higher demand levels. These type of improvements are also discussed further in Chapter 7. The progression of potential solutions includes:

- ***Reconfiguring Lanes:*** This involves revising existing lane designations. An example would be revising a two lane approach, where you have a shared left/through lane and an exclusive right turn lane into an exclusive left turn lane and a shared through/right lane. This may or may not involve phasing changes at a signalized intersection.
- ***Signal Phasing:*** This involves signal phasing changes such as adding a right turn overlap or adding a u-turn.
- ***Added Turn Lane Without Widening:*** An example would be converting available shoulder or parking space for use as a turn lane.

Capacity Increases

Added Turn Lane

Review right and left-turn lane warrants to serve higher peak period demands. A good planning-level threshold is when turning volumes exceed roughly 150 to 200 vehicles per hour, a turn lane should be considered as an option. If the volumes satisfy warrants, review the intersection geometry to determine if improvements are required on the receiving side of the intersection to adequately serve the extra approach lane.

For example, a second left turn lane on one approach will require two lanes exiting the intersection for receiving the turning volumes. Another example that can be less intuitive is when a left turn lane is suggested, the opposite side should also be considered for a turn lane since the cross-section on the receiving side needs to be widened anyway to align the through lanes.

Furthermore, the corridor needs of extra lanes between intersections may necessitate widening of the highway to add travel lanes to reduce merge/diverge and weaving issues between intersections. This is particularly the case in urban areas with closely spaced intersections. The approach and departure lanes at major intersections may dictate the cross-section of the highway between these major junctions.

- Typically a single left or right turn lane can carry about 300 vehicles per hour when intersecting another major cross-section. Higher volumes typically have major vehicle queue spillback and delay issues.
- Typically a dual left or right turning lanes at an intersection can carry up to 500 vehicles per hour. When forecasted volumes exceed this level,

analysis of alternative solutions is needed. Alternative solutions may include improved adjacent accesses, better connecting linkages, interchange and signal phasing adjustments.

- **Triple Left Turn Lanes:** When it starts to become apparent that dual left turn lanes are not sufficient to accommodate volumes, a grade separation should be considered as opposed to triple left turn lanes. Triple left turn lanes require a long run-out length of six-lane highway. ODOT presently has no triple left turn lanes.
- Similarly, when an exclusive right-turn lane volume approaches or exceeds 1,000 vehicles per hour, and is not controlled by a traffic signal, the intersection can be modified to provide an exclusive receiving lane that requires no merging with other movements.
- **Excessive Intersection Size:** When the width of an intersection leg starts to exceed approximately 110 feet curb to curb, further widening results in diminishing returns in terms of additional capacity.

Added Through Lane

The addition of travel lanes on a highway facility may be appropriate to serve forecasted travel demands. As noted in the previous section, within urban areas the cross-section requirements of the highway may be influenced by the approach and departure lane requirements at the major intersections. Outside of urban areas, added through lanes may be needed to serve forecasted long-range growth in nearby communities, or to reduce delays associated with trucks climbing extended grades. The limits of the recommended widening improvements should consider operational performance, study area intersections and the appropriate transition lengths back to the existing highway cross-section.

Intersection Control Improvements

All-Way Stop Controls

If the side street approach to the highway carries roughly the same volume as the highway, an all-way stop control may be appropriate to reduce delays on the minor streets in cases where the existing controls are stop signs on the minor approaches only. However, this solution should consider freight volume levels and any functional designations for priority freight movement on the highway. An all-way stop control is not recommended when freight movement is a priority, since it adds recurring delays on the highway regardless of volume levels.

Roundabouts

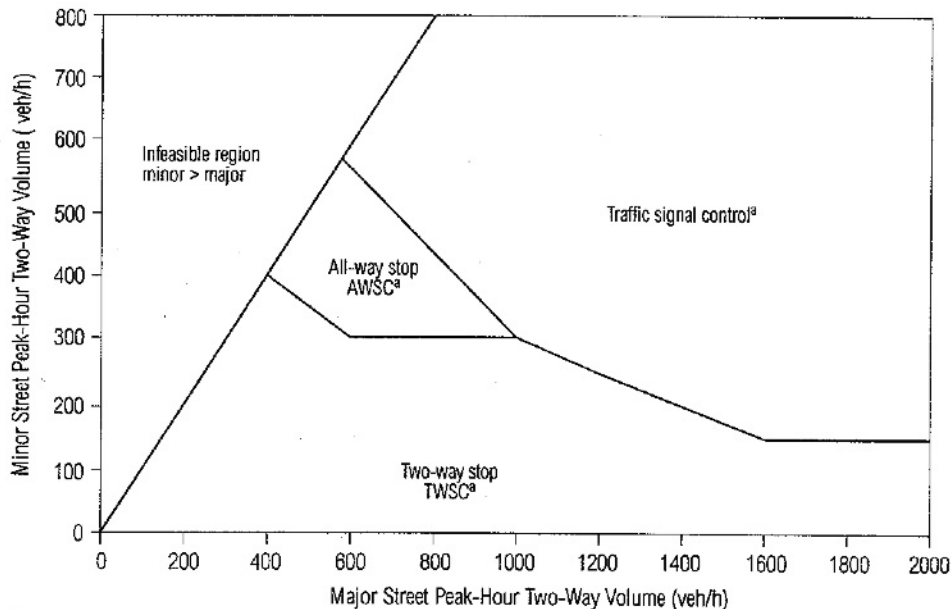
ODOT guidelines for consideration of siting roundabout facilities on state highways are contained in the *Traffic Manual* and the *HDM*. Currently the criteria includes the following:

- Limit number of legs to 4 maximum.
- Should meet acceptable v/c ratios (capacity of 0.80 v/c generally) for the proposed design life.
- Should have normal circular geometry.
- Should have similar or balanced volumes on all approach legs.
- Preferable to have majority of traffic as commuter and local users.
- Posted speeds should be 35 mph or less.
- Should not have high pedestrian volumes.
- Should not have high volumes of large trucks.
- Should not be located within an interconnected signal system.
- Should not be in locations where exiting vehicles would be interrupted by queues from signals, railroads, drawbridges, ramp meters, or by operational problems created by left turns, accesses, etc.
- Should not be located where grades or topography limit visibility or greatly complicate construction.
- Should be at an intersection of roughly the same functional classification, or no more than one level of difference (arterial to arterial, collector to collector, or arterial to collector, e.g., avoid arterial to local street etc.).

Traffic Signal Controls

The ODOT standard signal warrant analysis is required to justify new signal installations. Issues to be considered include traffic volumes, freight volumes, pedestrian volumes, safety history and spacing relative to existing signal and the accepted standards for the highway facility. A general guideline for the appropriate type of intersection controls is presented in the *HCM*, Exhibit 10-15. A facsimile of that diagram is shown in Figure 10-1. As shown, the two-way vehicle volumes on the minor and major street facilities can be used to quickly determine possible traffic control schemes, ranging from two-way stop controls up to traffic signal controls. It is acknowledged that in some cases a roundabout installation may be an alternative solution to be considered.

Figure 10-1 Intersection Traffic Control Options



Notes

a. Roundabouts may be appropriate within portion of these ranges.

Source: Adapted from *Traffic Control Devices Handbook* (8, pp. 4-18) - peak-direction, 8-h warrants converted to two-way peak-hour volumes assuming ADT equals twice the 8-h volume and peak hour is 10 percent of daily. Two-way volumes assumed to be 150 percent of peak-direction volume.

Interchanges

Interchanges on highways are appropriate on all freeway facilities and most expressway facilities to reduce conflicts and to give priority to through movements on the state facility. ODOT and FHWA policies govern the different levels of interchanges which may be considered depending on whether a facility is an interstate, a non-interstate freeway or an expressway. For example, partial directional interchanges could be considered on expressways, but generally not on interstate freeways, although there may be specific locations where a partial directional interchange would be an appropriate treatment that would need to be approved by FHWA. In addition, some arterial locations may have grade-separated solutions when volume demands exceed the levels that can reasonably be served by an at-grade intersection.

When traffic volumes exceed these levels, or if the functional integrity of the facility requires it, an interchange or grade-separated junction should be considered. This could take the form of an interchange, or it could be a series of overcrossings on parallel routes to reduce the demands on the major arterials to a level that could be served by at-grade facilities.

Grade-separated configurations should be developed to serve the forecasted travel demands consistent with the layout and spacing standards recommended in the *HDM*. Refer to that manual for more specific details that are useful in laying

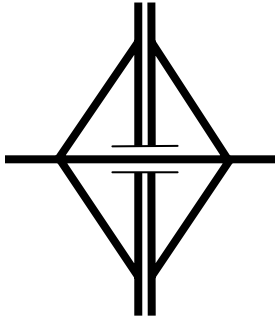
out interchange concepts. The following is a short review of the common elements of an interchange and a discussion of the conventional layout configurations that could be considered during alternative development:

Ramp Types

- ***Jughandle Ramps:*** These ramps are generally used at low-level interchanges, not for freeway connections, and are characterized by low speeds. They may be considered at major private approaches to a state highway. When used for non-interchange at-grade intersections they are termed connections as opposed to ramps.
- ***Diagonal Ramps:*** The carrying capacity of a ramp is determined by the conflicting movements at the ramp terminals. Typically a single lane straight ramp can carry 1,500 to 1,800 vehicles per hour.
- ***Loop Ramps:*** Typically a single lane loop ramp can carry 1,200 to 1,500 vehicles per hour. A loop ramp is appropriate to reduce left turning volumes at ramp terminal intersections. As noted above, when left turning volumes exceed 500 vehicles per hour, the typical at-grade intersection cannot generally accommodate it. For example, if a highway approach to a freeway interchange forecasted 700 left turns in the peak hour onto a freeway on-ramp, in most cases, the v/c ratio at this intersection would exceed guidelines. One solution would be to add a loop ramp so that this traffic demand could turn right at the intersection, in advance of the signal, and loop onto the freeway rather than making a left turn, which requires a major share of the intersection capacity. On-loops are generally preferred over off-loops, because of concerns regarding the speed differential between the off-loop and the mainline, and difficulties encountered on off loops during adverse weather conditions.
- ***Directional Ramps:*** A directional ramp always bends toward the desired direction of travel. These are free-flow non-looping ramps that generally operate at high speeds. A semi-directional ramp exits a road in a direction opposite from the desired direction of travel, but then turns toward the desired direction of travel. Many “flyover ramps” (as in a stack) are semi-directional.

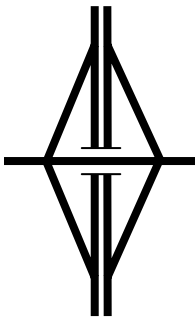
Interchange Types

Figure 10-2 Diamond Interchange



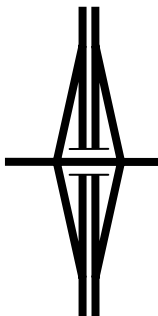
Diamond Interchange: An interchange that has straight ramps in all four quadrants is referred to as a diamond-shaped interchange. The capacity of this facility is typically determined by the operational analysis at the ramp terminals and merge/diverge areas on the mainline. The spacing of the intersections on the crossing street or highway will dictate the available vehicle storage and transition area. A standard diamond interchange has ramp terminal spacing greater than 800 feet. When volume forecasts are high at the terminal intersections, and the spacing is limited, these could be factors that influence the need for an alternative layout concept. An operational analysis of the two ramp terminal intersections, and any nearby intersections that could influence these locations, will be required. Some variations on the diamond interchange include:

Figure 10-3 Compressed Diamond Interchange



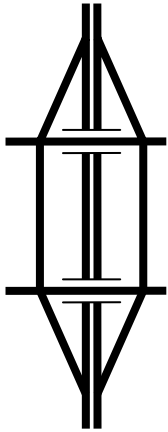
Compressed Diamond Interchange: A typically older interchange design where less than ideal ramp terminal spacing is present, between 400 and 800 feet. Sometimes the two ramp terminals can be operated with a single signal controller. Turn storage is done between the ramp terminals. Queue spillback between the ramp terminals is a common problem.

Figure 10-4 Tight Diamond Interchange



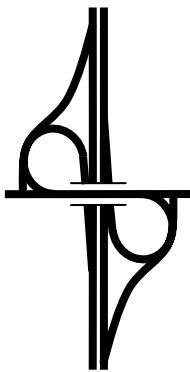
Tight Diamond Interchange: Typically found in urban areas, with ramp terminal spacing less than 400 feet. Usually the two ramp terminals can be operated with a single signal controller. Turn storage is done outside of the ramp terminals.

Figure 10-5 Split Diamond Interchange



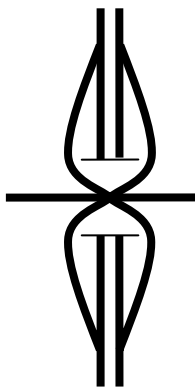
Split Diamond Interchange: Typically found on an urban grid system. Connections between each “half” of the interchange are one-way and are access-controlled.

Figure 10-6 Folded Diamond Interchange



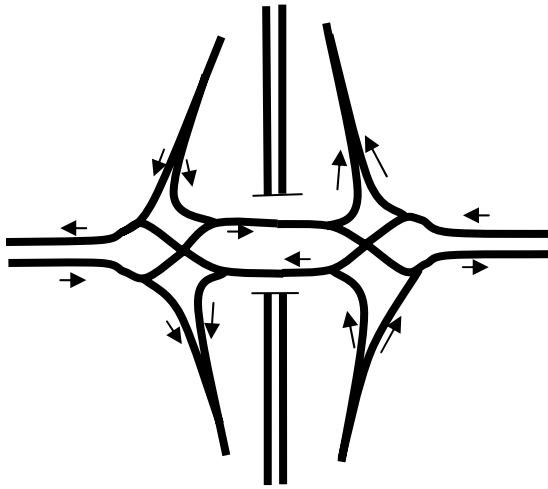
Folded Diamond Interchange: This interchange type “folds” one or two legs of the configuration to minimize impacts in one or two quadrants. Loop ramps can be located where topographical or environmental constraints adjacent to the interchange site do not favor the use of conventional straight ramps, e.g., where a railroad parallels the facility. Loop ramps that are located on the same side of a facility can create weaving sections on the mainline or crossroad that may not be desirable.

Figure 10-7 Single Point Urban Interchange



Single Point Urban Interchange (SPUI) also known as Single Point Urban Diamond (SPUD): The SPUI is a relatively recent development that evolved out of the need to limit ROW acquisition in built-up urban areas. SPUIs are a variation of the diamond interchange, which has two ramp terminals with the local arterial. A SPUI combines those two ramp terminal intersections into one larger intersection so that all turning movement to or from the freeway utilize the same intersection. This feature resolves the queue spillback issue that can congest standard diamond intersections, and can be effective in serving high volumes of turning vehicle traffic. SPUI’s need cross-street angles close to 90 degrees. High volume right turns may need to be signalized. SPUI’s have nearly the same ROW costs as tight diamonds and the structure costs are often high.

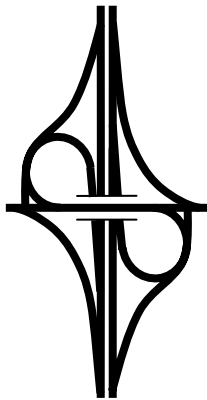
Figure 10-8 Divergent Diamond



Divergent Diamond Interchange:

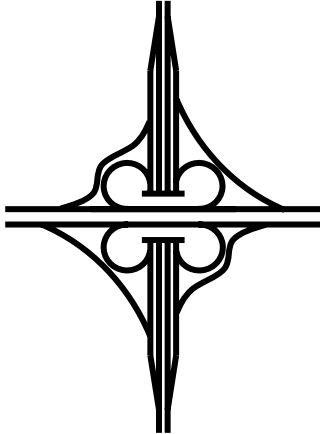
This is a new type of interchange design that has very few installations in the U.S. This form of diamond interchange has the two directions of minor street traffic cross to the opposite side of the roadway under/over structure. This allows for two-phase signal operations since the left turns occur between the two signals in such a way that they do not cross the opposing through movements.

Figure 10-9 Partial Cloverleaf Interchange



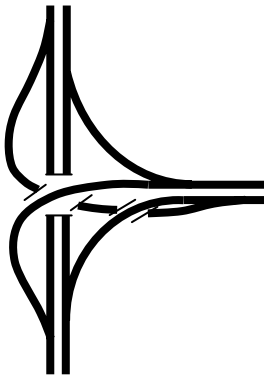
Partial Cloverleaf Interchange: A partial cloverleaf layout combines loop ramps and straight ramps to better serve areas with expected high turning volumes at the ramp terminals. In general, a partial cloverleaf configuration has a higher carrying capacity than a diamond interchange. The preferred configuration is where loop ramps are located in opposite quadrants of the interchange. Loop ramps can also be recommended where topographical or environmental constraints adjacent to the interchange site do not favor the use of conventional straight ramps, e.g., where a railroad parallels the facility. Loop ramps that are located on the same side of a facility can create weaving sections on the mainline that may not be desirable.

Figure 10-10 Full Cloverleaf



Full Cloverleaf: This layout provides loop ramps in all four quadrants of the interchange, requiring a great deal of land area. It is a somewhat outdated design and should typically be used only where loop volumes are low. Loop ramps that are located on the same side of a facility can create weaving sections on the mainline or crossroad that may not be desirable.

Figure 10-11 Directional Interchange



Directional Interchange: This type of interchange is more common in urban areas or at junctions of freeways or expressways with other freeways or expressways. An example would be I-5 at I-205. They are high speed high volume connections with all free flow movements. There are configurations with full or partial trumpet or flyover.

10.4 Identifying Limitations to Design Concepts

The facility design concepts are initially selected based on their ability to meet the needs of future travel demands, but each alternative must further balance those project features against the environmental constraints found at that location. A planning study should provide sufficient preliminary information about a range of environmental and physical constraints that could complicate or preclude a particular solution. Environmental criteria should be established as part of the project's evaluation and selection process. Environmental impacts may be allowed only if there are no other feasible alternatives. The analyst should coordinate with the Environmental Program Manager on these issues.

The typical environmental and physical issues to be considered include the following:

- **Exclusive Farm Use (EFU) Lands:** State regulations are very restrictive about the nature of highway improvements that are allowed within these lands. In general, no facility improvements are allowed that add capacity to serve nearby urban areas. Limited safety improvements are acceptable.
- **Environmentally Sensitive Zones:** Proximity of fish bearing streams, open space, riparian zone, etc., requires substantial setbacks from any improvements. In environmental parlance these are known as "4F" zones, and may include historic sites, parks and other recreational properties, schools and cemeteries.
- **Built Environment:** Existing buildings and structures generally should not be disturbed, unless the owner is a willing seller, and they can be purchased as a part of the improvement project. This requires consideration of historic buildings, schools, hospitals, parks, large developments, low income areas and environmental justice issues.
- **Right of Way:** In general, improvements should be limited to minimize right of way impacts. Acquisition of additional right-of-way adds costs, and may not be feasible in some locations.
- **Alternative Modes:** Depending on the functional designation of the highway facility and the adjoining land development there may be need to service pedestrians and bicycles in all solutions under consideration. Alternative concepts that create adverse conditions for non-auto travel, in these cases, will not be acceptable.

Based on the review of the above issues, the alternatives considered for evaluation may be modified or dismissed if any of these areas have substantial issues. An example case would be where the preferred operational solution for a freeway interchange indicated that a partial cloverleaf layout was superior, but because of proximity to EFU land the available configuration space was too

constrained. The best solution to meet both the performance objectives and the environmental limitations was a tight diamond configuration.

10.5 Documentation of Screening Process

The alternatives analysis for potential improvement projects should be consistent with the established evaluation criteria.

10.5.1 Evaluation Criteria

The screening criteria should be readily assessable, without detailed evaluations. Examples include:

- Meets project goals and objectives.
- Compliance with access spacing standards.
- Consistency with agency design guidelines.
- Avoid potential environmental impacts?
- Does the project impact adjacent private properties?

A screening matrix should be developed and applied to all the sketch level concepts, and those alternatives that clearly do not meet these basic criteria should be dropped from further consideration. Other alternatives should be advanced to the broader assessment of operational performance analysis, project refinement and preliminary cost estimates, as appropriate.

10.5.2 Alternatives No Longer Considered

As the project advances through alternative development to project design, the process that was applied to develop alternatives should be documented to carry forward into an environmental review document. It is important to describe any initial alternatives that were developed and set aside from further consideration (based on the evaluation criteria) for this purpose. These discarded alternatives should be included in the *Alternatives Considered but Dismissed* appendix in the narrative report.

10.6 Evaluating Build Alternatives

A Build Alternative refers to any combination of proposed or potential facility improvements to the current transportation system within the study area. The evaluation of Build Alternatives is compared to the No-Build scenario to quantitatively compare relative performance benefits of the various alternatives.

The alternatives selected for evaluation should be reviewed to determine if new model forecasts (or new manual traffic forecasts) are required to reasonably represent the traffic flow conditions with the proposed improvements. For larger study areas, typically a travel demand model is the best tool for evaluating changes in travel patterns associated with potential system improvements and access management plans. However, in smaller studies these changes can be reasonably represented by making manual re-assignments of travel demand, assuming sufficient background volume and travel pattern data is available.

10.6.1 Analysis of Future Conditions

The future conditions analysis should develop quantitative results sufficient to respond to all the selected performance measures for the study. Performance evaluation criteria typically include one or more of the following indicators. Refer to Chapter 5, 6 and 7 for details on how to make these assessments.

- **Volume-to-Capacity Ratio:** This could apply to individual turning movements, average intersection conditions for all movements, roadway or highway segments, weaving movements and highway merge/diverge operations. This is the primary performance evaluation criterion for ODOT facilities.
- **Level of Service:** Many local jurisdictions use Level of Service ratings in their development code as a performance criteria. Most facility evaluation methods provide both a v/c ratio result and a Level of Service result.
- **95% Queue Length:** Safety and operational impacts associated with the likelihood of a vehicle queue frequently blocking circulation or access. Use the 95th percentile queue and compare to storage length.
- **Queue Blocking Percentage:** Generally applied to through travel lanes, this is the portion of the study period (percent of time) where standing queues block the advance of vehicles from the adjoining upstream intersections or block the entrance to turn lanes.
- **Other indicators Include:** Travel time, total delay and total number of vehicle stops.

The evaluations for each alternative should assess all of the selected performance criteria. The results can be used to quantitatively compare and

contrast the outcomes between alternative and No-Build, and each of the respective alternatives to determine the best performing solution.

Analysis Assumptions Relative to No-Build Scenario

Typically, the horizon year travel demand forecast used for the no-build scenario should be applied for each build scenario unless it is determined that the Build scenario would alter the future forecasts for that alternative. For example, where the no-build scenario is heavily capacity constrained, it is likely that diverted traffic will return in the build scenario. If a model is available, both scenarios would be modeled separately. There are two major aspects to consider in making the new travel forecasts: the effects on travel demand and any reasonable changes to the network or operating parameters.

- ***Travel Demand Issues:*** One outcome of the new travel forecasts may be higher overall volumes on a facility compared to the no-build scenario. This is a common result in a highly congested corridor where a share of existing trips use parallel routes and when sufficient capacity is provided nearby, the trips will be re-assigned to the new facility. Typically travel demand model assignments consider the total travel times between the beginning and end of a trip. When new routes are added with shorter travel times, the model compensates by assigning more trips to the improved facility. For a smaller study area, the total travel demand within the system remains constant, but the locally assigned traffic volumes may be re-distributed. This is a common outcome for most projects.

In a larger regional system, the latent demand for travel that was constrained by corridors with severe delays during commute hours can experience changes in both travel mode and time-of-day when new facilities are introduced. The net result is a higher total travel demand compared to no-build. For example, if a new interstate bridge were constructed across the Columbia River between Portland and Vancouver, several changes to the no-build demand forecast would occur. First, the number of commute bus trips would likely decrease as more travelers opted to drive to take advantage of faster travel times. Second, because the peak travel times would be shorter, more commuters would leave their home closer to the start of their work shift. The combination of these factors would dampen the effectiveness of the new bridge facility because of higher total vehicle trips and more vehicle trips during the peak hour.

- ***Network and Operational Issues:*** Care should be taken to consider network or access changes that would substantially change the no-build forecasted volumes on the build network. For example, if the build alternative includes a parallel street extension, major access closure, traffic control change or other action that could re-route traffic flows from one facility to another, or one access point to another within the study area, these adjustments should be made before re-evaluating

performance. These types of changes indicate the no-build forecast should not be used for the build analysis. If a travel model is being used, then the analyst should review the build assignments to ensure that they reasonably reflect the proposed improvements, including comparing to the no-build assignments. If these forecasts are done by manual methods, a controlling factor in making these adjustments is to maintain the total trip origins and destinations for each land use generator within the study area.

For example, if the alternative consolidates access to a shopping center, the sum of vehicle trips in and out of the shopping center should be the same before and after the project. The volumes that used the driveways that would be closed by the project must be re-assigned to other driveways that are accessible from the shopping center. This is an example of maintaining the same trip totals around a periphery of an activity center.

Another example would be where a street extension is proposed to offload local trips from the highway. In this example, the study area includes a one-mile section of a north-south highway that connects to east-west arterials at either end. Before the project there is only one route for all north-south trips. After the project a new parallel north-south collector road is proposed that connects to both of the east-west arterials.

The reasonable check in this case would use a screenline across where the north-south routes connect to the east-west arterials. The total two-way north-south volume should be approximately the same, except for shifts in travel that may have occurred due to the project, for all facilities connecting to the arterials before and after the street extension.

- **Traffic Signal Optimization or Coordination:** The background traffic signal timing parameters should be modified to be consistent with the proposed improvement. Caution should be applied when changing the background signal cycle assumptions for the purposes of future analysis. The analyst should coordinate with the agency responsible for operating the signals to identify upper and lower cycle limits for functional signal operations. Typically the cycle length for the analysis should not exceed 60 seconds for a two-phase traffic signal, 90 seconds for a three-phase traffic signal (e.g., protected highway left turns and permissive side streets left turns), or 120 seconds for a four- or more phased traffic signal.
- **Intersection Approach Lane Changes or Additions:** Any proposed additions or revisions to an intersection approach should be reflected in the capacity analysis and signal phasing, as appropriate. A typical example is adding left turn lanes to serve higher demands during peak hours. New turn lanes may require changes to the background signal phasing to operate safely, and the phasing changes should also be reflected in the analysis. In addition, the geometry of the intersection

should be reviewed to determine if the added approach lane can be served on the exit leg. For the example above, a second left turn lane on one approach requires a second exit lane on the receiving leg of that intersection for a minimum distance to operate effectively.

How to Evaluate Severely Congested Facilities

The performance analysis of severely congested roadways and intersections should recognize that many of the conventional (or default) assumptions used in computer software tools are not necessarily appropriate in these cases. For this discussion, severe congestion occurs when the observed demand exceeds facility capacity (v/c is over 1.0). The *HCM* analysis methods for roadways and intersections are not appropriate in cases where the volume substantially exceeds facility carrying capacity.

When the facility is heavily congested in the base case, the analyst should verify through field studies, additional surveys, or other measurements that the observed conditions are reasonably similar to the computer software results. These procedures were covered in Chapter 7, Intersection Analysis. For example, if an intersection analysis indicates v/c ratio near 1.0, it should be noted that intersection evaluations are based on the number of vehicles entering the intersection during the assessment period and may not be the same as the total demand at that location. A field observation may show that heavy vehicle queuing occurs during the peak hour and a substantial share of the actual demand is queued and not served at the intersection during the peak analysis period. In this case, the demand is greater than the actual count of traffic that enters the intersection during the analysis period. When facilities approach capacity levels during the peak hour, one result is for commuters to shift their travel times outside of the busiest hour to reduce their overall travel times. This phenomenon is referred to as peak hour spreading.

For future analysis, a v/c ratio calculation may result in a value higher than 1.0 for an isolated intersection. This condition may result from existing latent demand or excessive future demand of vehicles at an intersection. This should be considered as a d/c rather than an actual v/c ratio, and would indicate conditions where mitigation could be considered to improve intersection operations.

Severe forecasted congestion at one location may influence and impact conditions at other intersections within the local transportation system. For example, spillback from one intersection may block traffic from proceeding through a nearby intersection, even when the traffic signal indication permits it. In addition to the intersection v/c ratio analysis, the analyst should review average and maximum (95th percentile) vehicle queues within a congested local system to identify potential cases of secondary congestion impacts, which could reduce the performance otherwise indicated by an isolated intersection analysis for that location. In these types of situations, it is not sufficient to only conduct isolated intersection methods. A more reasonable tool would be a microsimulation, which

accounts for interaction between locations, queue spillbacks, blocked intersections, and serving excessive demand between signal cycles. See details in Chapter 8.

10.6.2 Progression Analysis

Traffic Signal Progression Analysis

This section pertains to planning analyses as provided for traffic signal engineering investigations, corridor studies, and other planning efforts. Oregon Administrative Rule (OAR) 734-020-0480 stipulates that a progression analysis is required for the approval of new or revised traffic signal systems if the proposed location is within ½ mile of an existing or possible future traffic signal. The roadway segment analyzed, to the extent possible, shall include all traffic signals in the existing or future traffic signal system. The purpose of a planning progression analysis is to ensure that a new signal or revised traffic signal will function acceptably with other nearby signals.

At the start of a project, ODOT traffic operations staff will determine whether the analyst should use the existing signal timings for all analysis scenarios or develop optimized timings for the coordinated system. If the existing timings are to be used in the analysis, Region traffic shall provide timing files, timing sheets, or Synchro files of the existing settings. If optimized timings are to be developed, those settings are subject to approval by ODOT, and those conditions become the baseline for all comparisons. The following settings should be optimized for each analysis scenario when the analyst is asked to use optimum coordination settings:

- Cycle Length;
- Side Street Phase Lengths (Splits);
- Phase Sequence (Lead/Lag Left Turns);
- Intersection Offsets; and,
- Link Speed or Progression Speed

The optimum settings must meet the criteria established in OAR 734-020-0480 as it relates to progression analysis while also attempting to find the lowest intersection v/c ratio and minimizing queue lengths. This OAR only applies when modifications are proposed to a signal which would affect the settings of the coordination plans. Examples of these modifications are changes in cycle length, decreased green time for mainline, additional phases, longer crosswalks and intersection relocation.

Requirements for Signal Progression Analysis

For planning analysis, the following requirements must be met:

- Demonstrate acceptable existing and future traffic signal system operation during commute peak hours
- Provide for a progressed traffic band speed within 5 mph of the existing posted speed for both directions of travel during the off-peak periods and within 10 mph of the existing posted speed during peak periods. Approval by the State Traffic Engineer, or designated representative, shall be required where speeds deviate more than the above.
- Demonstrate sufficient vehicle storage is available at all locations within the traffic signal system without encroaching on the functional boundaries of adjacent lanes and signalized intersections. The functional boundary of an intersection shall be determined using procedures specified by the ODOT Access Management Unit.
- Provide a common cycle length with adequate pedestrian crossing times at all signalized intersections.

The analysis must demonstrate that the additional or revised signal still allows the signal system to have a progression bandwidth as large as that required, or as presently exists, for through traffic on the state highway at the most critical intersection within the roadway segment. The most critical intersection is the intersection carrying the highest through volume per lane on the state highway. Unless directed otherwise by ODOT traffic signal operations staff, the analysis should use optimized timing settings. The carrying capacity of the progression bandwidth should be estimated with the following equation:

$$\text{Bandwidth Capacity (veh/cycle)} = \frac{(\text{Bandwidth(sec)} - 4) \times (\text{Adj. Sat. Flow Rate})}{3600}$$

This capacity should be compared with the average platoon size expected to arrive at the most critical intersection for both directions of travel. The average platoon size may be found by the following simplified calculation.

$$\text{Average Platoon Size} = \frac{C * V}{3600}$$

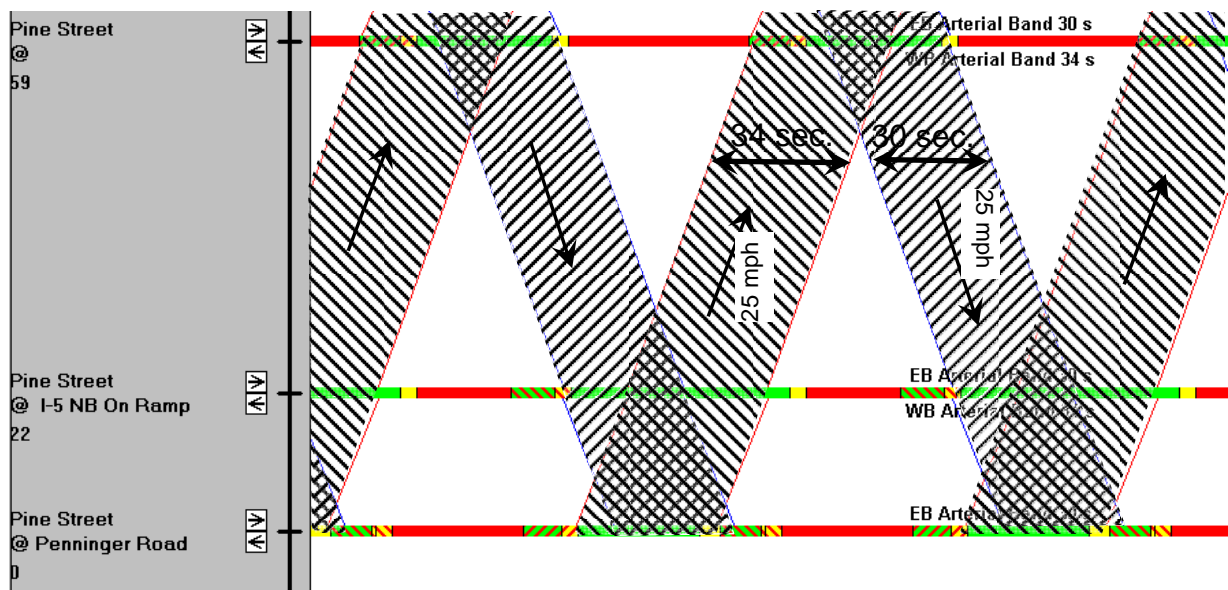
Where: C = cycle length
V = volume (adjusted for PHF)

Complete time-space diagrams are required for each of the analysis scenarios, including the existing coordinated system. They should indicate the offsets, phasing, and split times for each of the signals in the system. If using Synchro, the bandwidth shall be reported for the maximum green times or the 90th percentile arrival rates. The reported bandwidth may include green and yellow clearance times. An example time-space diagram is shown in Figure 7-3.

If the analysis shows that the proposed signal will not meet the requirements of OAR 734-020-480, other alternatives should be evaluated. These may include:

- Moving the new/revised intersection;
- Reducing phases on one or more signals;
- Providing additional lanes to reduce side street green or increase mainline capacity
- Decrease side street demands through TDM measures or construction of alternative routes.

Figure 10-8 Illustration of Bandwidths on a Time-Space Diagram



Available Analysis Tools

To implement the requirements of OAR 734-020-480, analysts may use the coordinated system software program of their choice. Hand calculations and time-space diagrams are also acceptable. A few of the computer software programs capable of performing these types of analyses include:

- **Synchro:** The ODOT preferred software application for optimizing traffic signal timing and performing capacity analysis. The software optimizes splits, offsets and cycle lengths for individual intersections, an arterial, or a complete network. Synchro performs capacity analysis using both the ICU and HCM methods. Synchro provides detailed time space diagrams that can show vehicle paths or bandwidths. Synchro can be used for creating data files for SimTraffic and other third party traffic software packages.

The software supports the Universal Traffic Data Format (UTDF) for exchanging data with signal controller systems and other software packages. Synchro is available from Trafficware.

- **Passer II:** A software application developed by the Texas Transportation Institute (TTI) used to determine offsets and optimize bandwidths, efficiency and attainability along signalized arterials.

Microsimulation programs such as SimTraffic, CORSIM and VISSIM do not produce signal progression timing. They can model signal progression timing as an input. SimTraffic automatically models progression timing developed in Synchro.