

Background Paper #1

**Functional Integrity
of the Highway System**

prepared for

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by

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Disclaimer

This background paper represents the viewpoints of the authors. Although prepared for the Oregon Department of Transportation (ODOT), they do not represent ODOT policies, practices, nor procedures.

General Objective

This and other background papers were prepared for the purpose of stimulating discussion among interested individuals representing a variety of agencies and groups having an interest in Oregon's highways, and for the purpose of providing technical background information for policies on this topic.

Specific Objectives

The specific objectives of this background paper are:

- Provide an overview of the relationship between transportation, land use and economic activities.
- Define the critical importance of protecting the functional integrity of the highway system.
- Introduce access management as the set of tools that could preserve the utility of arterial highways.

Acknowledgments and Credits

Mr. Del Huntington is project manager for ODOT. Dr. Robert Layton, Professor of Civil Engineering at Oregon State University is project director for the Transportation Research Institute (TRI). Dr. Vergil G. Stover is consultant to TRI on this project. This paper, though written by Dr. Layton, has received input, review and editorial comment from numerous interested persons.

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Functional Integrity of the Highway System

Introduction

There are approximately 100,000 miles of public roads in the state of Oregon. These are under the jurisdictions of U.S. Forest Service, U.S. Bureau of Land Management, U.S. Bureau of Indian Affairs, counties, cities and the state. While all of these facilities provide vital services for the state, the emphasis for Oregon Department of Transportation (ODOT) is on the approximately 7,500 miles of state owned, maintained and managed highways. These highways carry the majority of people and goods across the state and between cities. In addition, they often function as Main Street for many cities in the state. There is increasing pressure on these highways caused from additional traffic, growth and prosperity. Combined with the likelihood that few new state highways will be built in the foreseeable future, it is of paramount importance that these highways be managed wisely.

The functional integrity of the street/highway system is the effectiveness or reliability with which it provides personal mobility, freight delivery, cargo transport and access to land use activities. It further recognizes the need for effective performance by each individual street/highway section for the entire system to have integrity. The preservation of the functional integrity of the highway system in Oregon serves to enhance multimodal transportation for the state since the highways carry not only passenger cars and trucks, but also transit in the forms of buses, vans and carpools, and bicycles.

The preservation of the functional integrity of the highway system is needed to assure that the necessary capabilities of various highway classes are protected so they can accommodate the transportation needs of society. The functioning of any society and culture, especially modern society, has transportation as an integral part. Transportation by itself is a derived or secondary activity, that supports and enhances basic economic, social, and leisure activities. Societal objectives and activities are variously impacted by the nature and quality of transportation services available. With

industrial growth and development of commercial activities, the need for efficient freight transport, personal mobility, and convenient access to land use activities increase dramatically. The ease, safety, speed and effectiveness with which people and goods can be moved directly impact the quality of life and prosperity in an area. The size of the market area for commercial activities is directly impacted by the travel time to those areas for potential shoppers. Clearly, the health of the local, regional, and national economies depend on the mobility provided by the transportation system. A well-developed street or highway system can provide for the necessary mobility, as well as the desired access to property.

A clear understanding of the terms mobility and access is provided by the following definitions:

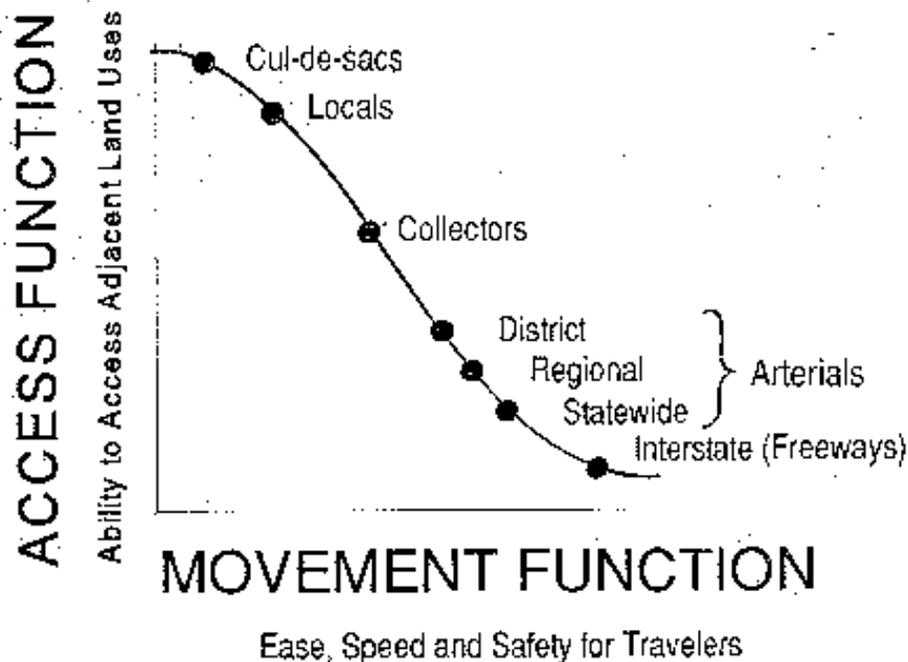
- Mobility, or the movement function, is the ease, speed, safety, comfort, and convenience of travel. Mobility is achieved through the elimination of congestion, provision of capacity, maintaining reasonable and uniform speeds, and limiting stops.
- Property access, or the access function, is the ability to reach land use activities and adjacent properties. Access to property from roads is accommodated through on-street parking, driveways, unsignalized intersections with low-volume access facilities, and at times signalized intersections.

Functional Hierarchy

The road system must function to provide both mobility and access to property, that is, access to spatially separated locations and adjacent land use activities. To achieve effective transportation service in any area, it is necessary to have a blend and balance of road facilities where each perform its unique function, since no single functional class can provide both high levels of mobility and access to property. As shown in the previous figure, there is a trade-off between access and mobility for each functional class.

Local streets and cul-de-sacs provide unrestricted access to adjacent properties and activities. Collector streets or collector highways have a balanced responsibility to provide access to property and mobility. Arterial streets or arterial highways have primary responsibility for mobility, or the movement function, that is, reasonable speeds, capacity, safety and freedom from interruption.

The design geometrics and features of each of these facility classes are



matched to the functional requirements, that is, the speed, capacity, and operational characteristics. Capacity or design criteria set the typical operating ranges for each of the functional classes. Typical spacings between the facilities of each class and access points along these facilities are shown below.

Facility Class	Spacing Between Facility of this Class (miles)	Access Spacing (miles)
Freeway	4 - 10	1 - 4
Arterial	1/2 - 1	1/8 - 1/2
Collector	1/4 - 1/2	1/20 - 1/10
Local streets	1/8 - 1/20	1/80

The design geometrics, location and functioning of these facilities would typically serve operating volumes of 50,000 - 160,000 vpd for freeways, 5,000 - 50,000 vpd for arterials, 2,000 - 5,000 vpd for collectors, and 100 - 500 vpd for local streets. These volumes are representative of the operations of these facilities and are not used as criteria to assign the functional class.

Functional Utility

Each functional class can be defined uniquely, and its design characteristics related to its specific function. However, the utility of each class of facilities must take account of how all the interrelated street/highway facilities serve the entire trip purpose of a traveler, and the intersections between the facilities of differing functional classes and the connections to the land use system they serve. It is helpful to recognize that a trip may be made up in six separate steps; movement, transition, distribution, collection, access, and termination.

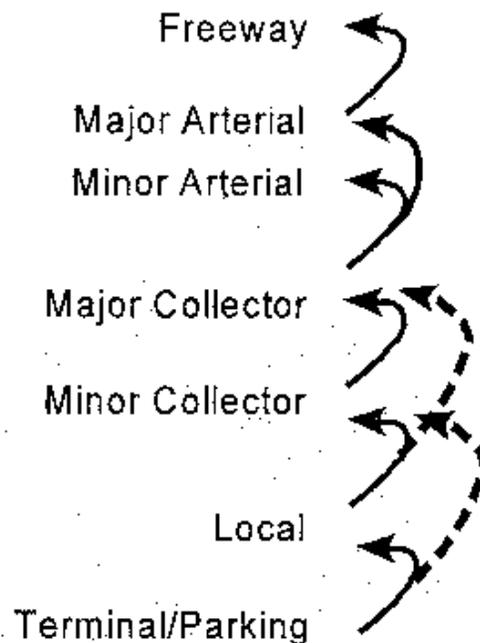
Movement occurs on a freeway or high type arterial where the movement function is facilitated with uninterrupted, high speed flow. As the vehicle nears its

destination, the vehicle slows on a transition roadway or freeway ramp. The vehicle then moves onto a moderate speed arterial which serves as a distributor to carry the vehicle to a collector. The collector facility then carries the vehicle to a local access facility. At the destination the traveler completes the trip at a parking terminal. These separate components of a typical trip could be handled by separate facilities, but it is not always necessary to have a separate class of facility for each step. It does demonstrate that these facilities link together as a chain. However, it is important for safe and efficient operation that the facilities not jump more than one functional class between trip steps due to the variation in the operational capabilities of the designs for various functional classes, and the associated driver expectations and speeds.

Functional integration of the highway system for both access and mobility is necessary for economic prosperity and quality of life. Freeways have primary responsibility for mobility with access only allowed at controlled locations. The arterial streets and highways are the key to maintaining the utility of the highway systems with their primary responsibility to provide for mobility, capacity, reasonable speeds, and safety; they have limited responsibility to provide access. However, all facilities except arterials have their functional utility preserved by the character of their use or design. Other than freeways, arterials by their nature carry the heaviest volumes, highest speeds, and attract the most intense development and desire for access. Commercial activities and economic developments prefer locations with maximum exposure and convenient high mobility transportation service; properties along arterial streets and highways provide both. If arterials are allowed to degenerate through excessive or uncontrolled access the entire transportation system is in jeopardy of failing, since the highway system is only as effective as its weakest link. The failure of the entire transportation system results in breakdown of flow characteristics, excessive delay, delayed shipments, interrupted deliveries, loss of potential customers, and transfer of business activity to other more easily accessed business activities. Further, the

effectiveness of access itself may be impaired by lack of access control since it is influenced by how easily turns can be made to enter, how long vehicles must wait for gaps to exit, and how readily large trucks can make deliveries. Also, driver perception and irritation level at not being able to get back into the traffic stream can impact the acceptability of a property for a business activity.

The functional integrity of the system is also preserved by assuring that the appropriate transition from access to movement, or vice versa, is achieved. Conceptually, a facility should not connect to a facility that is more than one functional class higher or lower. For example, an intersection between a major arterial and a local facility would be inappropriate because the drivers mind set and expectations are significantly different on each facility. The appropriate intersections, as shown in the following figure, should be employed where possible. In practice, this concept must be weighed against concerns for providing connectivity and pre-existing highway locations and patterns. As shown, on-street parking is not compatible with the character of arterials.



Legend: Arrows show compatible connections between functional classes

-  Transitions applicable to all facilities, public and their private access equivalents
-  Transitions applicable in residential subdivisions only

Preservation of the Transportation System Functional Integrity through Access Management

The impacts of uncontrolled or excessive access to arterials include congestion, increased delays, more frequent accidents, greater air pollutant emissions, excessive energy consumption, capital investment degradation, local business deterioration, and dampening of economic prosperity. The success of access management depends on well-integrated site design, land use planning and transportation facility design and control.

Effectiveness management of access location, control and design can result in:

- Improvement of the safety, public health and welfare - over 50% of the accidents on arterials are access related.

- Increase of capacity and reduction in congestion by controlling left and right turns, lateral friction, and speed of access and egress. Capacity can be increased by 25-35% with access control.
- Extension of the functional life of existing highways, by preserving or increasing their capacity, reducing the need for new capital construction to meet increasing system demands.
- Assurance of consistent and equitable treatment for all; local properties and business activities, and arterial street operations and access are treated equally and consistently.
- Protection of the economic viability of abutting properties and private investments in arterial corridors - congestion, delays and unsafe conditions will drive prospective clients and shoppers to other less congested locations.
- Reduction of travel time and delay, by 40-60% as a result of fewer stops, and less deceleration and acceleration.
- Decrease in the amount of energy consumption by 35-50%, also through reduced stops and fewer deceleration and acceleration cycles.
- Reduction of the amount of air pollution emissions of all important air pollution species by reducing stops, deceleration and acceleration.
- Reduced costs to travelers, commercial shipments and services.

These benefits are primarily achieved when access management is applied on arterial highways. However, significant improvements to operations, safety and performance may be realized on collectors where access management practices are employed.

Access Management Concept

Access management yields the safe and efficient flow of traffic through the road system and access to their destinations. Access management is the provision and control of access to adjacent properties through policies, statutes, regulations, standards and guidelines. Comprehensive access management is the strict and consistent control of the location, design and operation of all intersecting roads, streets and driveways. It is critical that land use planning, development and site design be coordinated with highway or street planning, design, operations and control. This coordination is implemented by the access management processes. The aim is the appropriate balance between traffic movement and access consistent with the functional objective of the facility. Access management techniques can reduce congestion, enhance capacity, decrease accidents, conserve energy and reduce air pollutant emissions through smooth traffic flow, fewer conflicts, and uniform travel speeds.

A successful access management program requires laws, access management policies, land use and site development policies, access design and spacing standards, and access permit procedures.

Access management can be applied with benefit to any high volume facilities, and particularly on those that also carry high speed traffic, where speed reductions caused at access points are greater. The efforts and energy should be focused on preserving the functional integrity of those facilities that are of greatest importance to the state's economic, population-serving activities, land use, health and welfare interests, that is, the strategic highway system. However, significant benefits can be realized by local jurisdictions if access management is applied to their highway systems.

Strategic Highway System

The link between the vitality of the basic economic, land use and population-serving activities and the transportation service is well recognized and understood. To provide for economics and land use development into the future and to preserve existing economic interests along highway corridors, the utility and functional integrity of a critical system of streets and highways must be preserved. Thus, a system of the most critical highways that are needed to move raw materials, people, and finished products should be designated and that system's functional utility protected to the highest level.

Certain critical streets and highway sections within the state comprise the integrated highway system that will support significant economic centers, agricultural areas, natural resource regions, and tourism locations. Other important highway segments into and through urban areas are needed for uninterrupted service through urban areas. Many of these facilities are state highways, however, some are under local agency jurisdiction. Sections of highways and streets that cross freeways or expressways must have controlled access to assure the ramps and ramp terminals of the interchange function properly, regardless of their functional class or ownership.

In general, the strategic highway system is the designated National Highway System, which has already been identified as the most critical highways in the state. These highways provide a transportation backbone system for the state. These critical streets and highways include at a minimum highways of the greatest interstate and inter-regional significance, such as the freeway system and the highways currently having the interstate and statewide levels of importance designation. Other important regional or district levels of importance highways may be included as important connectors to the backbone system. City streets or county highways may also be included if they are critical elements of the state's highway system.

The strategic highway system must serve economic, tourism, agricultural, natural resources and social needs now and into the future. The candidate facilities include:

- Major high volume routes. Those routes by their nature and location serve high volumes of traffic today or in the future. These are currently multi-lane streets and highways.
- Service to Trade Centers. These highways interconnect trade centers of regional or statewide importance, according to their employment, population, and sales volumes and potential.
- Service to Industrial Locations. These highways connect to locations where present or projected industrial activity warrants arterial highways service based on their economic value and/or employment levels.
- Service to Agricultural Areas. These highways connect the agricultural producing areas with interstate and regional routes to ports and distribution centers. These highways include major connectors to arterials that must handle the inter-regional agricultural truck traffic at acceptable levels of capacity, speed, safety and operating costs.
- Service to Natural Resources Areas. These highways serve as connectors to those areas within the state that possess and harvest timber and other resources.
- Service to Recreational / Tourism Locations. Significant economic returns are provided to the state by these locations, though they are often not on high volume routes. Routes connecting to these locations attract use from within Oregon and out- of-state travelers.
- Freight Serving Facilities. Many of the highway links that are needed to serve heavy truck volumes will have been designated based on some of the

other criteria listed above, however, those segments that serve heavy truck volumes should also be included in the critical highway system, such as those serving ports or distribution centers.

- Freeway Interchange Crossroads. The operation of cross roads at interchanges must not generate operation problems to the ramp and ramp terminals through increased local travel demand, impacts on capacity, inappropriate turning movements, queuing, slow maneuvers, or other conflicts.

In general, these critical streets and highways would include those facilities that meet the “interstate” and “statewide” levels of importance criteria. Many “regional” level of importance highways may also be included. Some “district” level of importance facilities that serve as important arterials for local jurisdictions would also be critical. Portions of crossroads at freeways that could impact freeway operations would also be included; these may be state or local facilities.

Conclusion

The preservation of the functional integrity of the critical streets or highways is of major importance to the present and future well-being and quality of life for the state of Oregon. This can be achieved through a comprehensive Access Management Program that incorporates well-conceived statutes, policies, guidelines and standards. The program will be applied to those highways on the state highway system. The policies, guidelines and standards may also be applied to local highway agency facilities that do not impact state highways, at the discretion of the local highway agencies.

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