Bicycle Planning and Safety

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I. Introduction

The purpose of this document is to provide guidelines for planning of safe on-road and shared use bicycle facilities. It will provide planners and designers the information to develop the safest most efficient facilities possible.

A. Roadway Design Standards

The Department incorporates the needs of bicyclists into all appropriate construction and RRR (resurfacing, restoration and rehabilitation) projects. In some instances, right-of-way constraints and safety considerations may limit the extent facilities and treatments can be applied in a given section. Considering these limitations, projects are to incorporate the needs of bicyclists to the maximum extent possible.

B. Roadways Promoting Predictable Behavior

This document provides information to help planners accommodate bicycle traffic in all riding environments and encourage predictable bicyclist behavior. Bicyclists can be expected to ride on all roadways except limited access highways. A lack of safe, convenient and appropriate facilities often leads to bicyclists riding in unsafe locations, such as on commercial district sidewalks. Sometimes they ride against traffic.

C. Background

There is a growing need for designers, citizens and others to have a common vocabulary, common concepts and common knowledge of successful bicyclist systems and facilities in different places. Bicycling facilities planning is still not offered in most college and university curricula. This omission results in a wide variance in planning and design concepts, facilities placement and final design by individual designers.

We have become such a nation of specialists. Many planners lack the opportunity to see a project from concept to concrete. This lack of continuity is complicated by the tendency of planners to be assigned a vast territory, which means they rarely live in the neighborhood or even in the city they are helping to design. A consultant in Atlanta, Georgia may be completing a plan for a project in Ft. Myers, Florida. This document allows all of us to have a common general knowledge of how bicycling facilities work. In this way specific projects are more likely to do what they are intended to do – serve the public with well conceived, well located, affordable, safe, secure and friendly environments.

1. The History of Bicycling

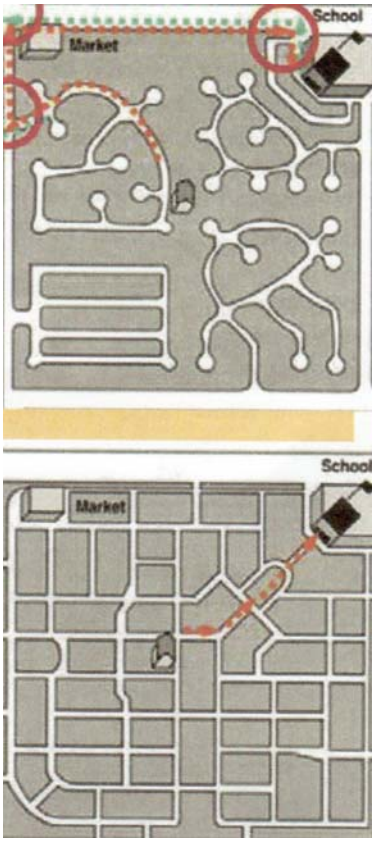
Increasingly, transportation officials throughout the United State recognize bicycles provide a viable mode of transportation. Since the early 1970's, bicycling for commuting, for recreation and for other travel purposes has increased in popularity. Nationwide, people are increasingly recognizing the energy efficiency, economy, health benefits, pollution-free aspects and the many other advantages of bicycling.

Recent legislation such as the federal transportation legislation, the Clean Air Act Amendments and other initiatives now require governments to give full consideration to all modes of transportation. Special emphasis is put on clean, energy-efficient, socially responsible modes, such as bicycling.

2. Improving the Intermodal System

Bicycling can help us create a better, transportation system as follows:

- Achieving intermodal links with transit.
- Creating safe and effective links between neighborhoods, i.e. link neighborhoods to destinations where people go for their daily needs.



The illustration on the top shows the typical development isolating the school and market from the communities surrounding it. There are no direct connections to the neighborhood. This type of development decreases the amount of pedestrian and bicycle trips, thus increasing the number of auto trips resulting in higher peak hour traffic and more unsafe conditions.

The illustration on the bottom shows a development providing a well located school and market laced with greenways for the encouragement of pedestrian and bicycle travel. This was accomplished through the use of a comprehensive plan.

- Reducing complex and costly parking problems.
- Allowing employers to offer choices in mode of transportation for their employees.
- Incorporating greenways development, urban redevelopment and resource preservation.
- Railbank with rails-to-trails conversions.
- Achieving other timely, sensible and sensitive urban and rural land use practices.

Bicycling is for people of all ages. Along with walking, bicycling is more affordable than auto transport, and most people are physically capable of bicycling. Bicycling is more efficient than walking. It is the most efficient means of assuring independent travel for children, elder adults, many people with disabilities and those with limited incomes. Bicycling gives all people mobility at an affordable cost. Bicycling helps keep them fit and improves health. However, bicycling does not replace the car or transit options for longer trips.

Local, state and federal agencies are responding to the increased use of bicycles by implementing a wide variety of bicycle-related projects and programs. The emphasis now being placed on bicycle transportation requires an understanding of bicycles, bicyclists, and bicycle facilities. With adequate planning and facilities development, the bicycle can play an important role in the overall transportation system. Bicycling promotes important land use and conservation policies, which call for compact and integrated land use patterns. These patterns provide reduced parking needs, urban infill, keeping destinations within bicycling distances, mixed use development and more balanced and efficient land use for transport systems.

D. Comprehensive Program

Facilities are only one of the several elements essential to a community's overall bicycle program. A comprehensive community approach to bicycle use also includes bicycle safety education and training, bicycle use encouragement, and the application and enforcement of the Rules of the Road as they pertain to interactions between bicyclists, motorists and pedestrians.

The illustration on the left shows an older roadway built solely for auto transport. The illustration on the right shows a more modern highway built as a shared use facility. The additional width of the bike lane increases the comfort and safety of all roadway users.

E. Definitions

Bicycle – A vehicle having two tandem wheels, either of which is more that 16 inch in diameter, propelled solely by human power, upon which any person may ride.

Bicycle Boulevard – System of roadways and connections between neighborhoods or areas in a community that form a bicycling throughway, but discourages through and higher speed motor vehicle movement.

Bicycle Facilities – A general term denoting improvements and provisions made by public agencies to accommodate or encourage bicycling including bicycle paths, bike lanes parking and storage capabilities, lockers and showers, maps of bikeways, marked routes and shared roadways not specifically designated for bicycle use.

(Bicycle) Bike Lane – A portion of a roadway that has been designated by signing and pavement marking for the preferential or exclusive use by bicyclists.

Bike route – A system of roads and ways that are linked by signs to aid bicyclists.

Bikeway – Any road, path, or way that in some manner is specifically designated as open to bicycle travel, regardless of whether such facility is designated for the exclusive use of bicycle or is to be shared with other transportation modes.

Rail Trail – A shared use path built within the right-of-way of an existing or former railroad. These may be either paved or unpaved.

Rules of the Road – That portion of a motor vehicle law that contains regulations governing the operations of vehicular and pedestrian traffic.

Shared Use Path – A bikeway physically separated from the motorized vehicular traffic by an open space or barrier and either within highway right of way or within an independent alignment. Shared use paths will be used by pedestrians, skaters and joggers as well as bicyclists.

Undesignated Bicycle Lane – A bike lane that is not designated with the diamond, bike and arrow pavement markings. It is striped as a regular bike lane on the approaches to intersections.

II. Planning

A. Bicycle Planning

Bicycle transportation planning is commonly construed as an effort undertaken to develop complete/comprehensive bicycle facilities for transportation and recreational activities. The resulting system is composed of shared use paths, improved roadways, bicycle lanes, bicycle parking, bicycle mapping and transit links. All facilities are interconnected and spaced closely enough to satisfy the travel needs of bicyclists. Bicycle planning should be pro-active and comprehensive.

1. Bicycles Using the Existing Systems

Bicyclists have the same mobility needs as every other user of the transportation system. They use the highway system as their primary access to goods, services and recreational activities. Existing highways and streets, often with relatively inexpensive improvements, must serve as the base system to provide for the travel needs of bicyclists. Shared use paths and path connectors can augment this existing system in scenic corridors, greenways or places where access is limited. Water and land transit are important future linkages and partners to a comprehensive bikeway system. Thus, bicycle transportation planning is more than planning for bikeways. It is an effort that should consider many alternatives to provide for safe and efficient bicycle travel.

B. Utilitarian and Recreational Bicycling

The wide range of bicyclists' abilities and multitude of purposes for riding must be understood before planning for bicycle transportation improvements. In general, bicycle trip purposes can be divided into two broad types, utilitarian and recreational. For a bicyclist on a utility trip, the primary objective is reaching a specific destination quickly, with few interruptions. The bicycle happens to be the chosen mode of transportation or, in some cases, the only mode available.

Conversely, a bicyclist on a recreations trip is riding for pleasure. The timing to a destination is often of less importance. Of course, for many trips and bicyclists, these purposes are not absolute or mutually exclusive. New bicycle facilities, therefore, should be designed to accommodate different types of bicycle trips.

Bicyclists differ widely in their ability and in their preferences of riding environments. Some bicyclists place high importance on directness and have the ability to ride safely and confidently in heavy traffic. They will often choose to travel on arterial roads in lieu of quieter, more aesthetically pleasing alternate routes, because arterial roads are more direct and result in perceived or actual time savings. Arterial and major collector roads also offer bicyclists

increased signal and operation support, better lighting and other benefits over local and minor collector routes.

If an arterial road is not improved for bicycling, then many novice bicyclists are likely to make use of sidewalks. By doing so, especially in commercial district, they endanger pedestrians and subject themselves and motorists to numerous conflicts that neither is prepared to handle.

Since major attractors are often located on these roadways and rear access to properties is often limited or denied, a significant amount of bicycling should be anticipated by most age groups on all principal roadways.

In some cases, additional design support can be given on parallel roads to attract bicyclists. However, this shift from the arterial road will only occur when bicyclists find the alternate route provides direct access and personal security, as well as traffic safety. Cooperation is sought from each community to incorporate attractive bicycle boulevards, lanes or routes on available roads that parallel principal roadways. Decisions not to fund off-system roads ultimately dictate the best riding conditions on the most heavily traveled principal roadways. Every effort should be made to offer financial assistance for the development, operations and maintenance of bicycle facilities on both principal roadways and quite collectors.

Some bicyclists place more importance on the quality of the trip and are willing to go out of their way to ride on residential streets or paths. While it is important to understand that a range of bicyclists' abilities and preferences exists, it will usually be a mistake to plan or design bicycle facilities primarily or exclusively around the needs of bicycles at either end of this spectrum. Rather, bicycle facilities should be planned and designed to accommodate a broad range of bicyclists.

C. Basic Principles

It is recommended that the following basic principles be considered when beginning any transportation project:

- Assume every street is a bicycling street and any location accessible to a motor vehicle should be accessible by a bike.
- Involve appropriate agencies and general pubic in planning corridors and communities.
- Use public funds for land use development that fully considers bicycling or mitigates the harmful effects caused by that development to bicycling.
- Transportation planning should give high priority to bicycling for all trips under four miles.
- Plans should overcome existing barriers to bicycle travel and create no new barriers.
- Roadway improvements should provide access to all destinations through the most direct or feasible route.

- Involve the public in the conceptual stage, data gathering, goals development and all other reviews and phases of work.
- Planning should be flexible throughout the development process. Accept new design concepts and anticipate future changes to the system.

The effectiveness of the planning process will ultimately depend upon the following:

- Ensuring the integration of the final product into local policy documents by following a clearly defined process involving local elected officials, planners, engineers and the public.
- Identifying the size and nature of the area (urban center or rural locale) being considered for the provision of bicycle and path facilities or programs and tailoring the process to meet the area's needs.
- Identifying the available human, money and time resources.
- This process may involve taking a project through the local Bicycle Advisory Council (BAC) and then having the project reviewed through the Technical Advisory Committee (TAC), the Citizen's Advisory committee (CAC) and then forwarded for final approval by the Metropolitan Planning Organization (MPO).
- Once a project has been approved by the MPO, it is accepted in the community Transportation Improvement Plan (TIP) and prioritized along with other roadway improvement projects.
- In areas not large enough to have an MPO (under 50,000 population), a similar process should be followed. For instance, it is always essential to have a formal BAC or other citizen's group, a technical review committee and then political hearing of commissioners or others that can give final sanction and budget authority to the project.

D. Model Planning Process

The best planning efforts use an integrated approach to bicycle and pedestrian facilities based on the existing roadway system and other urban visions, goals and infrastructure. Using only separate bicycle and pedestrian plans is not recommended. But an independent planning effort is a helpful step in the overall planning process. It will help focus efforts and prioritize projects. However, as stand alone plans, they often fail to integrate the various components needed to develop sustainable communities and facilities. These stand alone plans are only seen by a few and are rarely referenced. This lack of consideration of them often results in many lost opportunities. When stand alone bicycle and pedestrian plans are developed, the information within them should also be incorporated into any other comprehensive plans.

Planners and practitioners are strongly urged to build the needs of bicycling and walking into all transportation, land use, school development, utility, conservation, public access and recreational documents. Ensure planning for bicyclists and pedestrians is incorporated into any document, comprehensive plan, or policy statement guiding local and regional Metropolitan Planning Organizations (MPO's), Regional Planning Councils (RPC's) or other municipal or county

officials, boards, councils or commissions. Bicycle facility plans should be included in standard municipal design specifications. By following these steps, financing bicycle facility and construction and maintenance will become a regular part of the budget process. These functions will no longer be considered separate embellishments that can be ignored.

E. Comprehensive Community Planning

Planning for bicycle facilities must be concurrent with planning for other transportation modes, other public works projects and other land use planning. Often an improvement that enhances bicycle travel also benefits other modes of travel and helps a community achieve better lane use and conservation objectives. Highway improvements, through appropriate planning and design, can enhance bicycle travel was well. Plans for implementing bicycle projects must be in harmony with a community's overall goal for transportation improvements. Transportation plans, in turn, should be consistent with overall community vision and goals.

Many bicycling opportunities are missed due to ineffective and uncoordinated land use practices that create sprawl, isolated services and a fragmented community. Although there is much discussion of improved zoning and development leading to more compact and mixed land use, implementation requires commitment and major public involvement. Bicycle planners and project proponents need to remain central to these changes.

Special planning districts that promote alternative transportation, commercial management areas, and transportation exception areas each offer opportunities to promote bicycle transportation.

Additional support can be given to bicycling by regulating changes improving bicycle safety. For instance, bicycling on commercial district sidewalks, a high risk activity, can be restricted. However, such a restriction may prove unpopular and unenforceable if alternate facilities in the roadway section or on parallel streets are not provided. Locking bicycles to light poles, parking meters and other locations, where they become a tripping hazard and clutter the sidewalk, can and should also be regulated. Close cooperation with merchants, and a plan to provide public racks in appropriate locations must be established through public policy.

1. Site Plan Agreements

Proposals for development or redevelopment of residential, commercial and industrial projects often involve site plan agreements. The agreements provide the ideal opportunity to negotiate the inclusion of bicycling facilities into the overall design. The agreements can address parking, internal roadways (bicycle boulevards or lanes) and the locations of structures on the land to be developed or redeveloped.

2. New Subdivision Amendments

Many of the items mentioned in the planning concepts section should also be considered here. Law enforcement should be consulted on proposed circulation patterns. Public notification can assist in developing a mutually acceptable final design. The planning process should examine road patterns and connections with existing transportation routes so that residents of the subdivision will be able to use their bicycles for commuting or other purposes. Main bicycle routes to work places, shopping areas, connecting transit station stops and terminals or other destinations should also be considered. For example, the internal road network should ensure that short trips to schools, recreation center or parks and local shops are easily reached through low volume streets or paths. A return to traditional neighborhood design concepts, where there are many links into and out of neighborhoods, to nearby stores, and schools, are all key to a successful neighborhood.

3. Dedication of Land

Many municipal governments require dedication of land for parks, schools and other public needs. The location of these lands in a central part of the development, or with a perimeter that permits greenways, is key to the success of associated bicycle facilities. Such planning keeps trip distances within range of a bicycle ride.

4. Redevelopment

As environmental issues force reconsideration of formerly underdeveloped lands, opportunities abound for urban infill. Greatly improved bicycling can result from sensitive design, proper increases in density, addition of new links between formerly closed roadways, and the location of schools, parks and other infrastructure.

5. Road Reconstruction

New highways are rarely built. The majority of opportunities to improve conditions for bicyclists are found on roadways bursting at the seams. Often these roadways can and should be improved to provide safer travel for everyone, including bicyclists. These improvements can and should be included on every project, regardless of scale, so that eventually a corridor can provide a continuous facility for bicycling. It is estimated that during the 2000's, project-by-project bicycle sensitive designs increased the total supportive lane mileage from 5% to 40-60% of the urban state system in some districts.

6. Major Urban Infrastructure

Planning and design for bicycles must be incorporated into the fabric of any development project. The bicycle facility is not to be viewed as a separate entity any more than a new arterial road or industrial area is viewed in isolation. The integration of bicycles into the overall transportation network must be dealt with at the base level within the context of

the larger urban area, if it is to be cost-effective, efficient and ultimately successful. The overall concept of an urban design is often lost in the details of many individual projects. Planning for changes to the urban infrastructure is both feasible and practical.

The aspect of budget considerations is of equal importance in the pre-planning stage. The cost of bicycle facilities when they are incorporated into the budget of the project is minor compared to the cost of undertaking such a project separately.

7. Easements

An effective tool for improved bicycling and walking is the acquisition of easements. Easements can:

- be low-cost compared to market value purchase
- have no management responsibility
- have the ability to use land and preserve the scenic views
- provide an option to purchase in the future

F. Ongoing Public Involvement

Ongoing public involvement is crucial to the success of any planning work. Any changes occurring during the planning phases must be communicated to those who have expressed interest in the project. Reasons for the changes must also be clearly explained so that the cooperation between the different groups is not lost.

The following techniques and processes are recommended to involve the public, interest groups and staff in a productive team effort. Bicycle advisory committees (BAC), preliminary meetings, open houses, surveys and an ongoing liaison can be used to engage the public early and often in the planning process.

1. Bicycle Advisory Committees (BAC)

Throughout the planning process, every effort should be made to involve the public and bicycle user groups. This is most efficiently done by forming and making use of local Bicycle Advisory Committees (BAC's). The public should be involved at the beginning of and throughout all public works, land use and transportation projects. Well-intentioned public officials who have not heard from the public until it is "too late", too often make errors. This public involvement process can save costly mistakes. Public involvement must go well beyond traditional bicycle groups. Public participation should include social services, schools, neighborhood groups, employers and retailers.

G. Goals and Objectives

It is important to measure the success of planning and developing bicycling facilities and programs. The state bicycle program and each community should have clear goals and objectives. These goals and objectives should be obtainable both financially and in the allowed time frame. A project should be evaluated to determine if it adds to or fails to satisfy these measurable objectives. Local and regional goals and objectives must be set to help achieve a continuous state system.

H. Inventory of Existing Conditions

Planning for bicycle facilities begins with observing and gathering data on the existing conditions affecting bicycle travel. Problems, deficiencies, safety concerns and bicyclists needs must be identified. The existing bicycling environment should be observed. Bikeways, roadways where bicyclists ride and roadways where bicyclists do not ride should be examined for their suitability for bicycling.

Obstructions and impediments on existing highways, such as unsafe grates, debris, shoulder rumble strips, narrow lanes, driveways, rough pavement, high-speed or high-volume traffic, high truck volume, curbside auto parking, lighting, railroad crossing flanges, bridge expansion joints, metal grate bridge decks and traffic signals that are not responsive to bicycles should be considered for their effect on bicycling. The existing bicycle parking situation should be examined for its adequacy.

Areas near probable bicycle traffic generators, such as major employment centers, schools, parks and shopping centers, should be reviewed to identify existing or potential bicycle travel. Convenient access to mass transit stations and other intermodal transfer points for bicyclists should be checked. Barriers such as rivers and freeways should be identified and examined for their effects on bicycling. The existence of bicycle parking, lockers, showers and other services should be noted.

Bicycle crash locations should be investigated to identify any physical obstructions that may contribute to crashes. Data should be collected on the amount of recreational versus utilitarian riding and on the ages and experience of bicyclists.

Public participation is essential during the inventory of existing conditions or physical factors affecting bicycle transportation. Observations and surveys of active potential bicyclists will be useful, as will the views of the non-bicycling public. The attitudes and needs of destination-oriented, traffic-tolerant bicyclists greatly differ from those of casual, traffic-intolerant bicyclists. Thus, a wide variety of views should be sought. The views of various groups should be weighed against each other and tempered with sound professional judgment.

I. Selection and Development of Options

With goals and objectives set, an inventory completed, and background report written, inadequacies in the system can be addressed. The inventory of existing conditions provides an opportunity to modify and/or refine bicycle-use goals and objectives. Programs and projects for bicycle user encouragement, enforcement, education, and improvements complement each other and are all options that should be considered.

1. Traffic Volumes and Speeds

For facilities on roadways, traffic volumes and speeds must be considered along with the roadway width. Commuting bicyclists frequently use arterial streets because they minimize delay and offer continuity for trips of several miles. It can be more desirable to improve heavily traveled high-speed streets than adjacent streets, if there is adequate width for all vehicles available on the more heavily traveled street.

When this improvement is not possible, a nearby parallel street may be improved for bicycling. Stops must be minimal and other route conditions adequate. When such a parallel facility is improved, care must be taken that motor vehicle traffic is not diverted to the improved facility.

This discouragement can often be accomplished with traffic calming techniques, such as an occasional diagonal diverter that still permits bicycle and pedestrian flow. In general, inexperienced bicyclists will not ride on heavily traveled, high-speed arterials but will prefer quieter streets. Thus, cyclists' preferred routes may change over time as their skills change, or as traffic volume continues to increase.

2. Traffic and Parking Factors

The turnover and density of on-street parking can affect bicyclist safety (e.g., opening car doors and cars leaving angle parking spaces.)

High-speed trucks, buses, motor homes, and trailers because of their aerodynamic effect and width, can cause special problems for bicyclists. Where bus stops are located along a route, conflicts with bus loading and discharging may pose problems. Pavement damage caused by large vehicles may also cause problem for bicycle use.

3. Continuity

Continuity of a bicycle facility system is important to the convenience and safety of bicyclists. When constructing bicycle facilities, provide connections to other facilities. When it is not possible to make a connection, the isolated facility should still be constructed and adjacent connecting facilities added on future projects. It is possible to

provide width for bike lanes in the highway, or provide undesignated bike lanes, and hold off on making them as designated lane until there is sufficient width.

4. Directness

For utilitarian bicycle trips, facilities should connect traffic generators and should be located along a direct line, convenient for users. To encourage bicycle uses, bicyclists should have equal access to all corridors and attractions, especially for short trips within a neighborhood or between neighborhoods. Within a neighborhood, links should be considered through cul-de-sacs, making use of greenways and other open ways.

5. Access

In locating a bicycle path, consideration should be given to the provision for frequent and convenient bicycle access, especially in residential areas. There should be many links to the places people live, shop, attend school, work, and connections to transit. Adequate access for emergency, maintenance and service vehicles should also be considered. Too often bicyclists are denied convenient access to major destinations, including airports, bus/rail stations and seaports. Planners and policy makers must ensure that bicycling access is provided to every public facility and across all waterways where other transportation is being provided. When a corridor formerly accessible to bicyclists becomes a freeway, planners must assure that some alternative access along the route is provided to non-motorized users.

6. Attractiveness

Scenic value is particularly important along facilities intended to serve primarily recreational purposes. Facilities should add to rather than reduce the character of the surroundings. When a facility is attractive, longer bicycling distances and greater use will be achieved.

7. Security

The potential for criminal acts against bicyclists, especially among remote bicycle paths, and the possibility of theft or vandalism at parking locations should be considered. High levels of use, lighting, and environmental design are key factors in assuming a high level of security. During low light hours, lone bicyclists may prefer to travel on roadways that have more pedestrian and vehicular traffic than an adjacent path.

8. Barriers

In some areas, there are physical barriers to bicycle travel, caused by lack of accessible bridges, topographical features, freeways, high speed roadway sections, intersections or other impediments. In such cases, providing a facility or bike on transit service to overcome a barrier can create new opportunities for bicycling.

9. Crashes

The reduction or prevention of bicycle crashes (i.e., bicycle/motor vehicle, bicycle/bicycle, bicycle/pedestrian and single bicycle crashes) along routes is important. The potential for alleviating crash problems through the improvement of a facility should be assessed. The conditions leading to these crashes (i.e., high urban motorist speeds, narrow roads, poor lighting, few alternative bicycle path routes, etc.) continue to dominate. Plans should be reviewed on all proposed roadway and transportation improvements including resurfacing projects to avoid introducing new bike crash problems and to reduce/eliminate existing problems.

10. Delays

Bicyclists have a strong inherent desire to maintain momentum. If bicyclists are required to make frequent stops, they may tend to avoid the route or disregard the traffic controls. Total trip time is important to utilitarian bicyclists. If system delays are substantial, the potential bicyclist is likely to seek some other form of movement. Thus, both point source delays and corridor-long delays should be weighed and measured.

Bike lanes often reduce delays to motorists and bicyclists. This is especially true on crowded arterial and major collector roads. Bicyclists have the opportunity legally and conveniently to move to the head of the queue at each intersection. Motorists may also more easily pass a bicycle.

11. Facility Conflicts

Different types of facilities introduce different types of conflicts. Facilities on the roadway can result in conflicts between bicyclists and motorists. Shared use path conflicts can involve bicyclists, moped operations, roller skaters and pedestrians on the facility. Conflicts arise between bicyclists and motorists at highway and driveway intersections as well.

Facilities should be designed and located to minimize conflicts with cross traffic, especially through access management use of raised medians, regulatory control of turning movements, in commercial districts and other measures.

12. Sight Distances

Adequate sight distances must be maintained, especially to aid bicyclists and motorists in detecting each other at key conflict locations.

13. Maintenance

Maintenance-sensitive design and constant attention to maintenance are important. An improperly maintained bikeway will often be shunned by bicyclists in favor of a parallel

roadway. Regularly scheduled sweeping of roadways and bike lanes is essential, especially on popular route and bridges.

Bicycles are disproportionately affected by roadway maintenance. Bikeways must be free of bumps, holes and other surface irregularities if they are to attract and satisfy the needs of bicyclists. Utility covers and drainage grates should be at grade and, if possible, relocated to outside the expected area of travel.

Approaches to railroad crossings should be improved as necessary to provide for safe perpendicular bicycle crossings. Bridge decks should be designed to minimize the effect of expansion joints and deck surfaces on bicyclist stability.

14. Bridges

Bridges serve an important function by providing bicycle access across barriers. However, some features found on bridges can be unsuitable where bicyclists are to be accommodated. The most common of these are curb-to-curb widths that are narrower than the approach roadways (especially where combined with relatively steep grades). Open grated metal decks found on many movable spans, low railings or parapets, and certain types of expansion joints can cause bicyclists steering difficulties or swallow a narrow wheel.

15. Conditions at Intersections

A high proportion of bicycle accidents occur at intersections. Facilities should be selected so as to minimize the number of crossings, reduce turning speeds of motorists, provide responsive side street signal detection for bicyclist entry, provide adequate night lighting, and make certain that the clearance interval accommodates bicycle crossing speeds.

16. Traffic Laws and Local Ordinances

Bicycle programs must reflect local laws and ordinances. Bicycle facilities must not encourage or require bicyclists to operate in a manner inconsistent with the adopted rules of the Road. Lack of adequate facilities may encourage unlawful behavior such as:

- wrong way riding
- running stop signs and signals
- commercial district sidewalk riding
- erratic riding when lanes are too narrow or the road is bumpy

J. Analysis of Improvements

Bicycle-use goals and objectives must be in harmony with the overall transportation, land use, urban design and environmental policies of the community and state. The end result is a plan of

proposed improvements for bicycle travel. The following types of improvements should be considered:

- Facility improvements such as roadway improvements, maintenance and operations improvements implemented as part of normal processes.
- Reduce conflicts between pedestrians, bicyclists and motorists through separate facility types.
- Improvements to drainage grates, speed humps, utility caps, railroad grade crossings, pavement surfaces, traffic signals, signing and markings will be beneficial.
- Bicycle routes can provide continuity to other bicycle facilities.
- Bicycle boulevards can provide continuity and direct links to key destinations.
- Bicycle lanes, together with signs and pavement markings, can improve conditions in corridors where there is significant or potential bicycle demand.
- Shared use paths can provide enjoyable recreational opportunities as well as desirable commuter routes.
- Bicycle parking facilities are essential to encourage all types of bicycling.
- Bike racks on buses and bicycle parking at transit stops can increase transit use.

K. Selection of Projects

Selection is based on the evaluation of the options developed in the planning process step. Each option is evaluated further with respect to goals, objective and benefit/cost analysis. There are five basic factors to consider:

- Community vision, transportation goals
- Roadway design criteria
- Bicyclists' needs
- Other users' needs
- Cost

If there is effective interaction during the planning process between user types and groups, the bicyclist criteria should closely match the criteria or the motorist and the community/transportation vision and goals. Likewise, design criteria may be modified to permit flexibility for a community to achieve its goals and objectives. It is important to recognize that this is a dynamic process that can be achieved only with full involvement of the community in each phase of planning. If this process has not been effective, major planning revisions are usually necessary at every stage of the project.

Selection of location will normally involve a cost analysis of alternatives. Funding availability can limit the alternatives. However, it is important that a lack of funds not result in a poorly designed or constructed facility. It is usually more desirable not to construct a bicycle facility than to construct a poorly planned or designed facility. The decision to implement a bikeway plan should be made with a conscious, long-term commitment to a proper level of maintenance. If only a small amount of funding is available emphasis should usually be given to low-cost

improvements (i.e., bicycle parking, removal of barriers and obstructions to bicycle travel, roadway improvements and non-construction projects such as mapping).

L. Development of Implementation Strategy

There are three steps in developing a strategy for implementation:

- Identify required actions and the department or agencies to carry them out;
- Develop a budget; and
- Develop a work program schedule.

M. Assessment

The success of any program or planning exercise can only be determined by assessment at regular intervals. Feedback can be obtained from surveys, usage rates, comments and complaints and from comparison of observed behavior and crash statistics before and after implementation. This monitoring can lead to reassessment of the goals and objectives and/or the selected option.

III. Bicycle Safety

Bicyclists are involved in highly characteristic crashes often associated with age, experience and ability. While only 15% of bicycle crashes involve a motor vehicle, these crashes tend to be the most serious, and hence have been studied more. The two types of crashes (motor vehicle related and non-motor vehicle related are detailed below. By studying the forensics of injuries related to bicycle or path related crashes, it is possible to see how a particular design influences or fails to change essential human performance.

A. Bicycle Falls and Crashes

Non-motor vehicle bicycle crashes are quite common. Only one in ten bike crashes are reported to police. Yet bike crashes make up as much as 15% of emergency room care. We lack a complete understanding of their nature. We do know the bicycle helmets can greatly reduce the likelihood and severity of head injury. It is important to understand that a simple fall can produce "g" forces to the brain three times the force required to produce death. Bike helmets save lives.

In many non-motor vehicle bicycle crashes the bicyclist loses control of the bicycle, going off the road or path. Causes of crashes include hitting an obstruction, skidding on sand, ice, water, wet leaves; or hitting a seam, pothole or other surface irregularity that affects the wheels and hence the stability of the bicycle.

Another common form of non-motor vehicle crash is a bicycles colliding with another bicyclist, a pedestrian, in-line skater, dog or other moving object. Such crashes can be serious. Thus, attention to proper maneuvering widths and sight distances to help bicyclists maintain control are essential on pathways and other locations where mixed use can be anticipated.

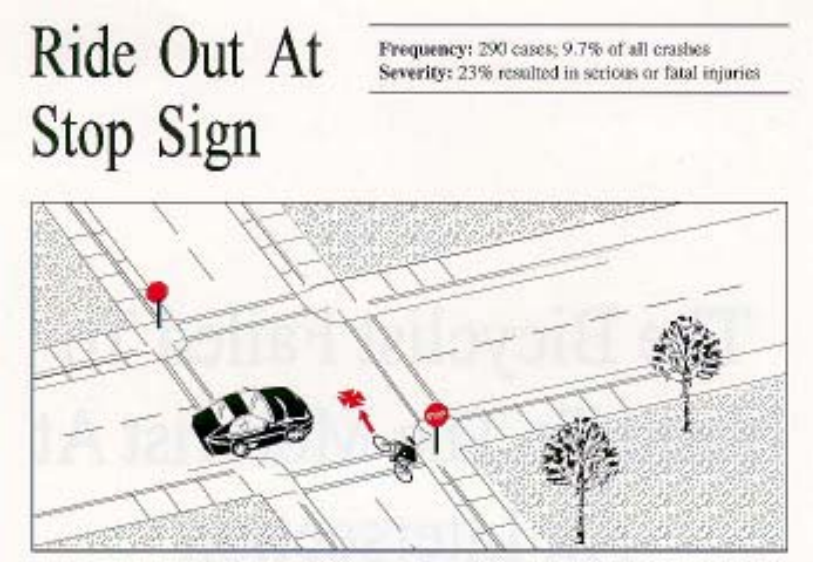
Non-motor vehicle crashes comprise over 85% of all crashes. Yet they are studied less, since only 10-15% of fatal or severe trauma crashes occur in this way. We need more knowledge about their causes.

1. Potholes and Longitudinal Seams

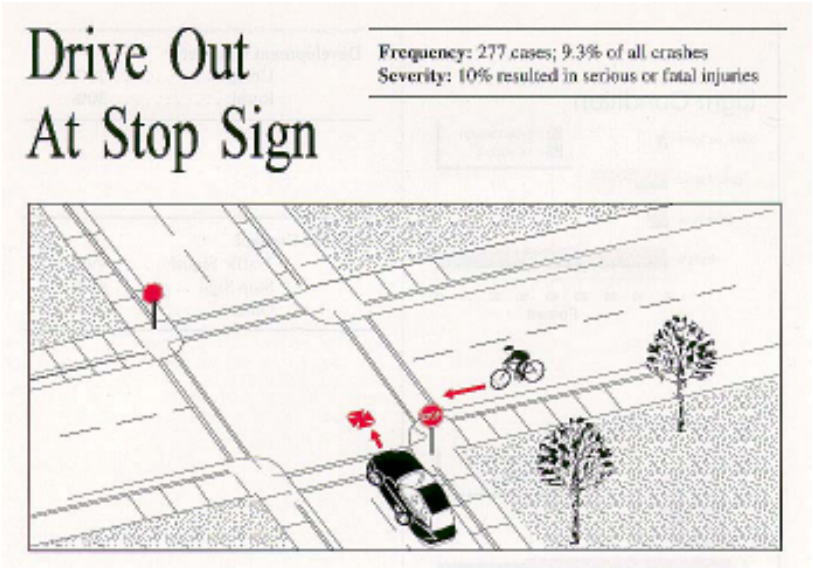
Bicyclists are most likely to hit potholes when traveling at higher speeds, such as on a downhill descent, or when light conditions are poor. Another significant maintenance problem for all bicyclists are longitudinal seams, such as those created by a dropoff from the roads or path edge, bridge expansion joint or skewed railroad crossings and drainage inlets.

B. Common Bicycle – Motor Vehicle Crashes

According to FHWA research, there are 8 common types of motor-vehicle/bicycle related crashes. They are detailed below.

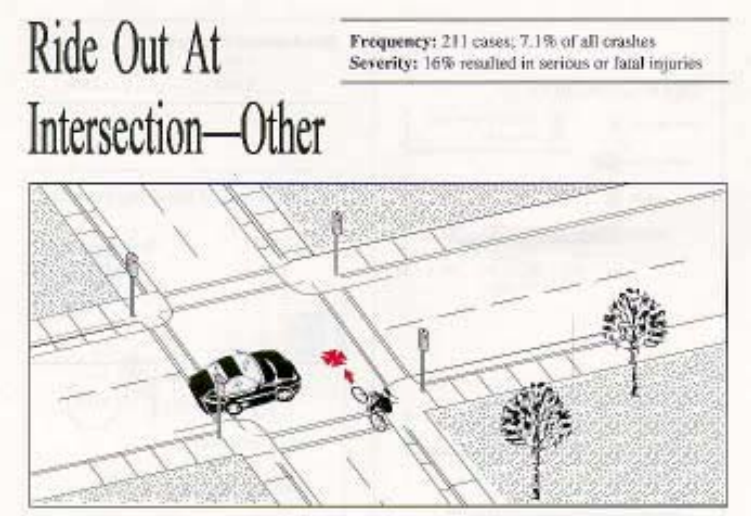


The "*Ride Out At Stop Sign*" occurs when a bicycle pulls out of a side street, alley, driveway or parking lot exit to a motorist's right or left. The motorist has already passed the front of the bicycle, which then strikes the vehicle. Or the bicycle pulls out far enough at the last second to block the motorist's right-of-way, making it impossible for the motorist to avoid a collision with the bicycle.

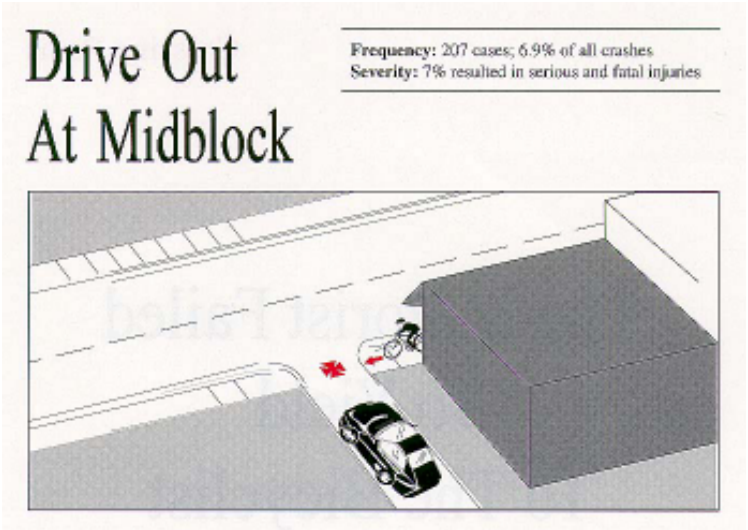


The "*Drive Out at Stop Sign*" is very similar to the driveway ride out. The motorist fails to yield the right of way, usually at non-signalized intersections.

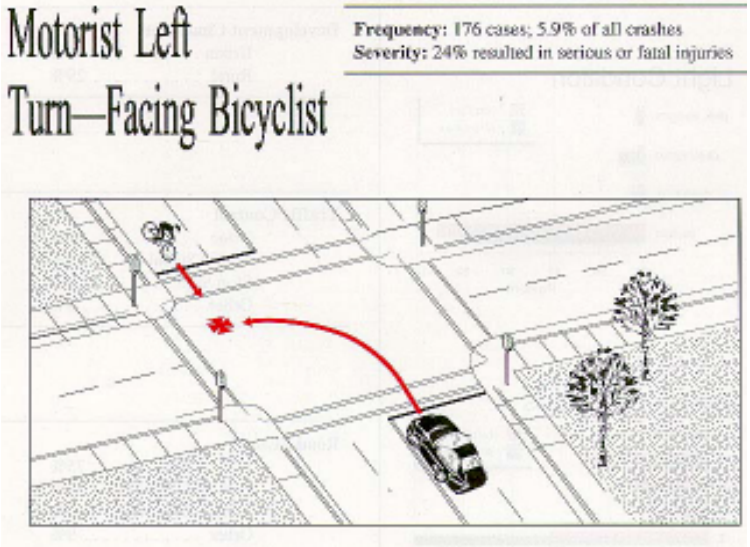
Most often the intersections involved are familiar to the bicyclists. These bicyclists rarely encounter any traffic and thus fail to make adequate searches.



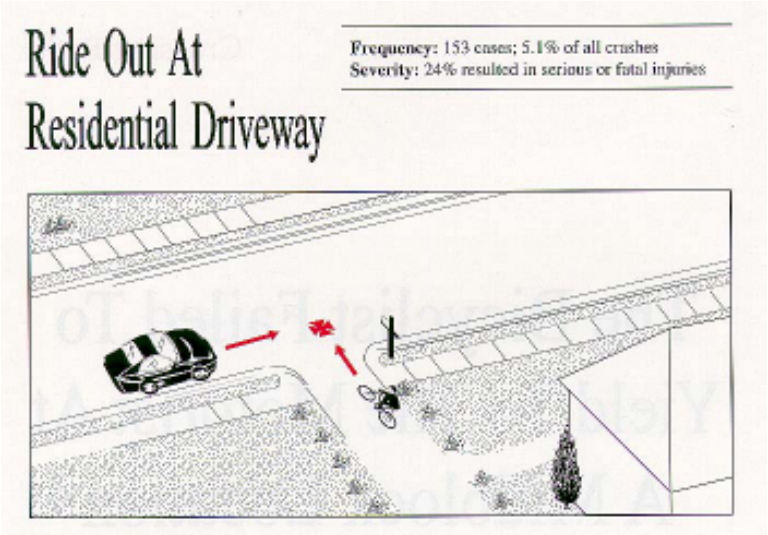
In the "*Ride Out at Intersection – Other*" scenario, bicyclists fail to yield the right of way at signalized intersections. Most often the intersections involved are familiar to the bicyclists. These bicyclists rarely encounter any traffic and thus fail to make adequate searches. On sub-class of this crash involves bicyclists who enter an intersection with latent green phase signals. Due to inadequate clearance intervals, they become trapped in the intersection.



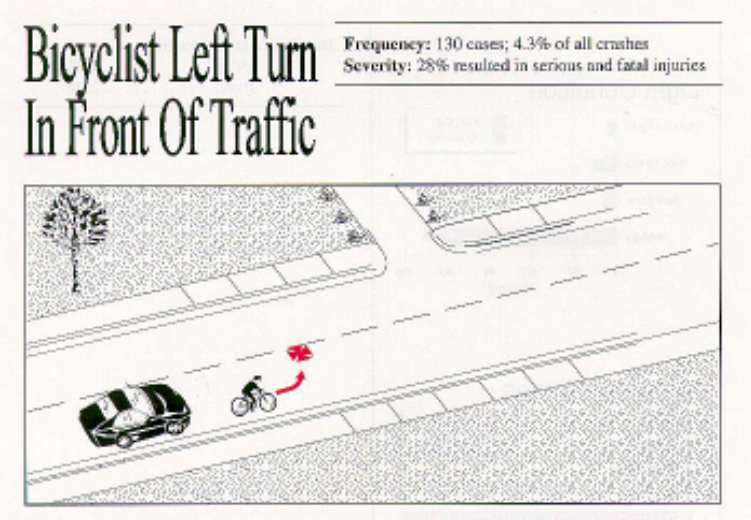
In the "*Drive Out at Midblock*" scenario, the motorist fails to detect the bicyclist. This is largely due to the bicyclist travelling in the wrong direction or on a sidewalk. Generally, these are low speed crashes that do not result in serious injury or fatality.



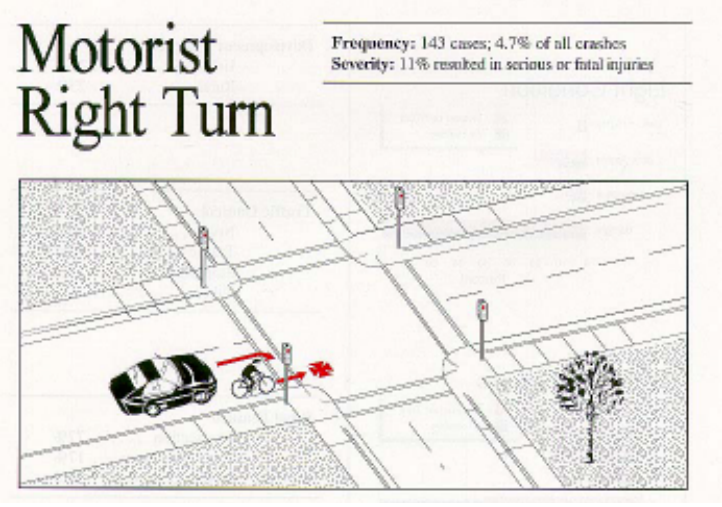
In the "*Motorist Left Turn – Facing Bicyclist*" scenario, nearly all cases motorists turn directly into paths of bicyclists (left and right turns). Usually bicyclists are coming from unexpected directions (on sidewalks or wrong way lane positions). The most serious of these crashes occur when motorists turn left into the path of bicyclists (either on roadways or sidewalks). These crashes tend to be higher speed, resulting in more severe injuries. These unexpected left turns are the most serious bicycle crashes, in many college communities. Glare, inattentiveness and information overload to motorists are suspected to be major contributing factors to this crash class. Driveway access management (right in, right out) should be considered as an engineering countermeasure in some locations. Motorists' right turn crashes are often caused by serious misjudgments of the speed of bicyclists just passed by these motorists. Bicyclists traveling undetected on sidewalks contribute significantly to this crash class.



The "*Ride Out at Residential Driveway*" occurs when a bicyclist pulls out of a side street, alley, driveway or parking lot exit to a motorist's right. The motorist has already passed the front of the bicyclist, which then strikes the bicyclist. Or the bicycle pulls out far enough at the last second to block the motorist's right-of-way, making it impossible for the motorist to avoid a collision with the bicyclist.



In the "*Bicyclist Left Turn in Front of Traffic"* scenario, bicyclists suddenly turn left without warning. About half of the bicyclists initiated unexpected turns at intersections or driveways. The other half made turns mid-block toward unidentified points. In 94% of the cases bicyclists failed to conduct an adequate search. Researchers suspect that bicyclists in such cases are relying on auditory cues to detect the presence of overtaking cars. Too often, however, the sounds of cars may be masked by other traffic, wind, or other noise. It is also suspected that many, especially younger bicyclists, feel uncomfortable scanning to the rear. This task often causes them to steer toward the traffic lane.



In the "Motorist Right Turn" scenario, motorists fail to yield the right of way to bicyclists at a controlled intersection, a driveway or other road entry. Although motorists stop or slow significantly, they fail to detect or respond to the presence of bicyclists. Low speed conditions often result in minor injuries, although both bicyclists and motorists often feel victimized by the conditions that created the crash scenario. In many cases bicyclists complicate the situation by coming from unanticipated directions, such as from the motorists' right side on a sidewalk or wrong way street approach (62.5%). In some cases, motorists are making right on red turns and fail to detect or respond to bicyclists. In 75% of these cases bicyclists are on sidewalks coming from unanticipated directions. Increased bicycle friendly roadway operating conditions on multi-lane highways can substantially reduce these surprised-condition crashes.

C. Types of Bicyclists

Some states have a high percentage of citizens that do not own or operate automobiles. Unfortunately, harsh roadway conditions where they live and must travel make their movement challenging. Many of these people must use bicycles during all times of day, and many times in low light (on the way to school), exposing them to higher risk. Their crash involvement can be 3-8 times that of the general population. Extra efforts must be made to provide safe roadway environments in low socioeconomic environments. Affordable housing and quality, low-speed roadways need to be synonymous.

From a planning and design perspective, bicyclists can be divided into six overlapping categories that cover a range of physical, psychological, physiological and emotional abilities, experience and skill. In general, these abilities are broken down by age and experience. The age and abilities of bicyclists are far more varied than those of motorists. Indeed, before, during and after motorists gain or lose their ability to drive, they bicycle for mobility.

Young Children – Ages 5-11

At a young age children lack traffic experience. They are often impulsive. They have limited peripheral vision and cannot easily detect the source of sounds. They feel compelled to complete an action they have started and they think grown-ups will look out for them. Young children have not fully developed depth perception, gap assessment, peripheral vision and sound directionality. Since children do not drive cars, they have difficulty understanding why adults cannot see and respond to them. They are primarily involved in class A, B and E crashes, and numerous non-motorized crashes.

Youth – Ages 12-15
Children at this age take increased risks, travel farther from home, ride at night, and use main roads to access shopping malls, schools, parks and other places they wish to go. Children of this age often overestimate their abilities. They are primarily involved in class A, B, C and E crashes.

Young Adult – Ages 16-22
People of these ages now travel at higher bicycling speeds. Many have developed a keen sense of invincibility and have increase experimentation with drugs and alcohol. For some, bicycles may be their only means of transportation to school or work. Many of this age work night jobs and rely on bicycles for transportation. They know the basics rules of the road. They are primarily involved in class C, D and F crashes.

Novice Adult – Ages 23-64
The majority of adults (95%) are novice bicyclists. This category of bicycle riders uses bicycles too infrequently to develop many cycling skills. Some ride at night, greatly increasing their risk. They are primarily involved in class C, D and F crashes.

Senior Adult – Ages 65+
Senior adults increasingly experience some physiological decline, especially in vision. There are pronounced loss of physical abilities starting around age 75 which can include: loss of balance, vision, hearing, and strength. Reduced bicycling speed is common to this age group. Their needs to be independent, to get exercise and to move about the community do not diminish. They are primarily involved in class A, B, C and F crashes.

Proficient Adult – All Ages
These cyclists comprise on 1-4% of the bicycling population. But their frequency of bicycling on major roadways is high. These cyclists tend to ride in all seasons and weather. Some ride mostly for recreation, others mostly for primary transportation. They most often have highly predictable road behavior. Speeds of 18-24 mph are common for this category of cyclist. They are primarily involved in class D and F crashes.

D. Intersection and Path Junction Crashes
Nationwide, it was found that 57 percent of pedestrian and 73 percent of bicyclist crashes occurred at junctions. Sensitive design of path and roadway junctions is vital to safe path development.

E. Bicycle Helmets

Bicycle helmets save lives. A full 75% of bicycle fatalities and permanent injuries are head injuries. At least 60% of all fatalities include only a brain injury. Thus, bicycle helmets can eliminate up to 60% of all fatalities. Most states have laws requiring anyone under 16 years of age to wear a bicycle helmet.

A bicycle helmet works by reducing the "g" forces to the brain. A fall while a person is sitting stationary on a bike onto a concrete surface can produce forces of nearly 2,000 g's. It only takes 150 g's to produce minor injury, 300 g's to produce permanent injury. At 600 g's no one survives. A bicycle helmet reduces the nearly 2,000 g's from a hard fall or crash to often below 150 g's.

IV. Summary

Through this course, a background of bicycling including common vocabulary, concepts and knowledge was discussed. The history of bicycling and improvement to the intermodal system was covered.

Bicycle planning issues were also covered. Utilitarian and recreational bicycling were compared. The basic principles to be considered for a transportation project were also included. The process of utilizing comprehensive planning, selection and development of options was provided. An overview of comprehensive community planning and selection/development of options was provided as well as post design assessment.

Bicycle safety was discussed. The most common bicycle-motor vehicle crashes were compared. The types of bicyclists and their associated risks was also covered.