Commission Briefing Paper 4J-07

Efficacy of Changes to Design Policies and Standards to Accommodate Elderly Users of the Transportation System

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Introduction

This paper presents information on age related changes that older persons experience and how these changes affect their ability to function in the transportation system as drivers, pedestrians, and transit users. It includes a list of recommendations for potential policy revisions and identifies how these recommendations would impact infrastructure construction costs, operations, maintenance, and life safety.

Background and Key Findings

The aging process involves a decline in sensory, cognitive, and physical abilities that can present challenges to elderly users of the transportation system. The rate and severity of these changes reflect individual differences across drivers. Over the next 30 years, the older population is expected to increase. In the year 2000, roughly 13 percent of the US population was 65 or older. This percentage is projected to increase to about 21 percent by 2030 (1). The key findings of this paper are as follows:

- Older adults have an increased risk of crash involvement when crash rates are calculated based on miles traveled and an increased rate of injuries and fatalities from a crash.
- Potential policy revisions to accommodate elderly drivers are identified for the following areas: intersections, interchanges, pavement markings and delineation, and sign enhancements.
- Potential policy revisions to accommodate elderly pedestrians include: slower walking speeds, crosswalk lighting systems, and countdown crosswalk signals.

- Potential policy revisions to accommodate elderly transit users include: comfortable bus stops, well-lit bus stops, and close spacing of bus stops.

Description of the Problem

Age Related Changes

The aging process involves a decline in sensory, cognitive, and physical abilities that can present challenges to the older driver. The rate and severity of these changes reflect individual differences across drivers. Some individuals may experience greater changes in their abilities, while others are less affected. The following are areas were older drivers may experience diminished capabilities (1, 2, 3).

Physical and Psychomotor Changes

Due to reductions in strength, flexibility, and range of motion, older drivers may have difficulty braking, exhibit restricted abilities to turn their heads and bodies and to extend their arms and

legs. This presents a challenge for older drivers when—for example—turning their heads to look for approaching vehicles at intersections or while changing lanes. Due to slower reaction times, older drivers may have a delayed response to traffic control devices or changes in the roadway environment.

Perceptual Changes

Older persons experience reductions in visual acuity and contrast sensitivity, increased sensitivity to glare, increased time for dark adaptation, reduction in color sensitivity, and a reduction in the size of visual field. This can result in difficulty seeing roadway signs, pavement markings, pedestrians, traffic signals, and other vehicles. Driving at night is especially difficult due to these limitations. Hearing loss is also frequently experienced as a function of age, with respect to both general hearing sensitivity and reductions on the ability to hear specific sound frequencies.

Cognitive Changes

Changes in processing time, memory encoding, and memory retrieval can result in a reduced capacity to respond to complex driving situations, difficulties with divided attention tasks and difficulty dealing with unexpected stimuli or navigating, especially on driving routes or in driving situations that are unfamiliar to the driver.

Older Driver Statistics

Percentage of Older Drivers: Over the next 30 years the older population is expected to increase. In the year 2000 roughly 13 percent of the U.S. population was 65 or older. This percentage is projected to increase to about 21 percent by 2030 (1), when it is expected that one in every five Americans will be 65 or older.

Crash Rates and Fatality Risk: When measuring safety based on accidents-per-licensed-driver, older adults do not appear to be at risk. However, when crash rates are calculated based on miles traveled (i.e., accounting for exposure), older adults are at increased risk. Further, older adults have an increased rate of injuries and fatalities. The overall fatality rate is 2 per 1,000 crashes; for persons age 65-74 the rate is 3.2 per 1,000 crashes, while persons age 75-84 have a rate of 5.3 per 1,000. At 85 and above, the rate climbs to 8.6 per 1,000 crashes (4).

Infrastructure-Based Design Standards and Policies

The following sections include infrastructure-based recommendations for design policies and standards to better accommodate older drivers, older pedestrians, and older transit users. These recommendations reflect an extensive review of previous research. The list of short-term, low-cost recommendations provided in the 2004 document, NCHRP 500 Report *Volume 9: A Guide for Reducing Collisions Involving Older Drivers* (4) was used as a starting point. Many of the specific recommendations provided below were obtained from the *Highway Design Handbook for Older Drivers and Pedestrians*, 2001 (5). Several of the recommendations include specific values where only general guidance currently exists in the standard or policy. In addition, some recommendations call for more stringent design criteria than currently exist or extend a current practice to a new operation. Although these recommendations are based on the specific needs and capabilities of the elderly, many would benefit the general population as well. Additional recommendations cited in multiple sources were also reviewed and included in this paper.

A complete list of the policy revision recommendations and the standard(s) affected is provided in Table 1. Information regarding the infrastructure construction costs and the impacts on operation, maintenance and life are also included for each recommendation in the table. It should be noted that relatively little data were available to the authors of this paper on which to base precise estimates of costs and benefits associated with the recommendations listed in Table 1. In Table 1, plain, non-italicized text is used in the Infrastructure Construction Cost, Operation Impacts, Maintenance Impacts, and Life Impacts (Benefits) columns to indicate an entry that is directly supported by a referenced data source (usually Volume 9 of the NCHRP 500 report). In these columns, italicized entries reflect judgments made by the authors of this paper.

Potential Infrastructure Revision Recommendations for Elderly Drivers

The main areas for potential policy revisions to accommodate older drivers include intersections, interchanges, pavement markings and delineation, and sign enhancements. Intersections present a situation where drivers need to make complex speed-distance judgments in a short amount of time (5). This can create a problem for older drivers. Roughly half of the fatal crashes involving drivers age 80 and older occur at intersections, compared to the 23 percent or less for drivers age 50 or younger (6). Recommendations for intersections include the following: increased sight-distance, offset left-hand turn lanes, all-red clearance intervals, protected left-turn signals, improved lighting, and reduced intersection skew angles. These are described in Table 1.

Older drivers experience problems merging onto freeways and changing lanes due to the loss in vision and information processing ability, and the decreased range of motion in the neck and upper body. The recommendations for interchanges include longer acceleration and deceleration lanes, and the use of parallel types of acceleration lanes for merging.
Due to changes in vision and visual functioning, older drivers experience difficulties reading signs and detecting pavement markings (7). Improvements in pavement markings and delineation can provide advanced warning that helps drivers make decisions. The recommendations for pavement markings and delineation include the following: improved roadway delineation, raised channelization, higher contrast ratio for curves, oversized glass beads, raised pavement markers, and painted rumble strips. The recommendations for sign enhancements include the following: increased size and letter height of roadway signs; advanced warning signs; internally lit signs; lower mounting heights; and flashing beacons.

Potential Infrastructure Revision Recommendations for Elderly Pedestrians

Due to factors such as a decline in vision, slower decision and reaction times, slower walking speeds and physical limitations, older pedestrians are more at risk than their younger cohorts. At intersections older pedestrians are more likely than younger ones to delay before crossing, spend more time at the curb, take longer crossing, and make more head movements (8). In 2004, there were twice as many pedestrian deaths per 100,000 people for pedestrians age 70 and older than pedestrians younger than 70 (9). The recommendations for older pedestrians include the following: control signal timing that reflects elderly pedestrians' slower walking speeds, provision of median refuges, in-pavement lighting systems in crosswalks, and countdown crosswalk signals.

Potential Infrastructure Revision Recommendations for Elderly Transit Use

One way to help elderly transit users is to improve their ability to access transit vehicles and facilities (10). This includes providing reasonably direct routes that are well-lit and have an even, well-maintained surface. In addition, closely spaced bus stops, and bus stops and pedestrian routes with resting places are important to elderly transit users (10, 11). Many of the recommendations in the previous section for older pedestrians will also benefit elderly transit users. In addition to those recommendations, the following recommendations are included for elderly transit users: comfortable bus stops, well-lit bus stops, and close spacing of bus stops.

Risks Associated with Changing Design Policies and Standards to Accommodate Elderly Users of the Transportation System

Although Table 1 below describes a number of costs and impacts associated with implementing the various recommendations associated with elderly drivers, pedestrians, and transit users, there may be other, more general, risks associated with implementing these recommendations and changing current policies and standards.

These risks primarily reflect the fact that, even for those recommendations deemed appropriate by the FHWA and state/local DOTs, not all recommendations can be implemented at the same time or implemented in the same manner across states, cities, or even individual neighborhoods. Thus, elderly users of the transportation system will be (and currently are) faced with different and inconsistent infrastructure designs. Thus (as examples), some intersections provide protected left-turn signal phases and others do not; some roadways have lighting that is specifically designed to improve older driver's visibility, while others are poorly lit. These differences reflect a number of realities, including costs, time required to make decisions about infrastructure enhancements, construction delays, etc. And, clearly, these differences across the transportation systems are not intended to negatively impact elderly drivers, pedestrians, and transit users.

However, these differences can impact elderly users, particularly in the area of driver performance. A driver needs to be able to accurately predict the roadway environment ahead in order to minimize confusion and errors. If intersection and roadways are inconsistent, it may violate the drivers' expectancies and lead to higher workload. For example, advanced warning signs to inform drivers of potentially hazardous conditions are an infrastructure design feature that should be applied consistently (4). The possibility that differences in infrastructure design could lead to driver performance problems may also increase state and local DOTs liability in the case of crashes that could be linked to these differences.

CONSOLIDATED COMMENTS FROM MEMBERS OF THE BLUE RIBBON PANEL OF TRANSPORTATION EXPERTS - PAPER 4J-07

One reviewer commented as follows:

1. The suggested modification to the AASHTO policy to provide access to a bus stop within a mile walking distance is unlikely to benefit seniors. Persons of all ages are reluctant to use transit stops greater than a quarter mile distant.

2. More transit shelters (with roofs, protection from wind, lighting) are needed relative to the number of bus stops. But many shelters (as well as stops) are not ADA compliant (e.g. no nearby curb cuts). In many cases institutional impediments inhibit construction and improvements of shelters, such as onerous easement and other permit policies and procedures from state DOT's and local governments.

3. Seniors are often reluctant to use transit due to a lack of familiarity with the service and fear of the unknown. Customer information technologies and travel training are possible remedies. In general, policies should include training to ensure the most beneficial results.

Another reviewer commented as follows:

This paper provides a review of potential infrastructure revisions for elderly transportation users. Because of the lack of data, the efficacy of changes to design policies and standards can only be qualitatively assessed. As the elderly population continues to increase, the need to accommodate elderly travelers is critical. AASHTO, MUTCD and HCM manuals contain standards and guidelines for signal control timing, intersection design and capacity considerations under assumptions of the presence of elderly population in traffic stream. Some of the suggested changes to the current policies seem to be regressive. For example, the suggested modification to the AASHTO policy to provide access to a bus stop within a mile of walking distance will adversely affect elderly travelers. Transit stops should be within a quarter mile instead. Transit stops should have adequate protection from weather and they should be ADA compliant. In addition, efforts that can enhance personal security should be pursued along with the easy availability of real time transit schedule information.

Table 1. Potential revisions, as well as potential costs, impacts, and benefits

Potential Revision	Recommendation Detail	Primary Policy Impacted	Infrastructure Construction Cost	Operation Impacts	Maintenance Impacts	Life Impacts (Benefits)
Intersections						
Sight-distance	When sight-distance requirements for a left-turn maneuver from a major roadway are based on a gap model, it is recommended that a gap of no less than 8.0 s, plus 0.5 s for each additional lane crossed by turning driver be used for passenger cars (5)	AASHTO	*Low-Moderate*	*Low*	*Low*	*Safety*
Offset left-hand turn lanes	When unrestricted sight distance is not feasible, positive left-turn lane offsets are recommended (5)	AASHTO	Moderate - High	*Low*	*Low*	*Safety*
All-red clearance intervals	An all-red clearance interval should be consistently implemented, with length determined according to the ITE Engineers (1992) specification (5)	MUTCD	Low	*Low*	*Low*	*Safety*
Protected left-turn signal phases	Protected-only operations are recommended, except when, based on engineering judgment, an unacceptable reduction in capacity will result (5)	MUTCD	Low	*Low-Moderate*	*Low*	*Safety*
	Use of a separate signal face to control turning phase is recommended (5)	MUTCD	*Low-Moderate*	*Low*	*Low-Moderate*	*Safety*
	Where minimum sight-distance requirements are not practical to achieve, or where a pattern of permitted left-turn crashes occurs, it is recommended that permitted left turns be eliminated and protected-only left-turn operations be implemented (5)	MUTCD	*Low-Moderate*	*Low-Moderate*	*Low-Moderate*	*Safety*
Reduce intersection skew angle	In the design of new facilities where right-of-way is not restricted, it is recommended that all intersecting roadways meet at a 90 degree angle (5)	AASHTO	Moderate - High	*Low*	*Low*	*Safety*
	If right-of-way is restricted, intersecting roadways should meet an at angle of not less than 75 degrees (5)	N/A	Moderate - High	*Low*	*Low*	*Safety*
	At intersections where the approach leg to the left intersects the driver's approach left at an angle of less than 75 degrees, the prohibition of right turn on red is recommended (5)	MUTCD	*Low*	*Low*	*Low*	*Safety*

Potential Revision	Recommendation Detail	Primary Policy Impacted	Infrastructure Construction Cost	Operation Impacts	Maintenance Impacts	Life Impacts (Benefits)
Improve lighting	Wherever feasible, fixed lighting installations are recommended as follows: where the potential for wrong-way movements is indicated through crash experience or engineering judgment, where pedestrian volumes are high, where shifting lane alignment, turn-only lane assignment, or a pavement-width transition forces a path-following adjustment at or near the intersection (5)	AASHTO MUTCD	Moderate - High	*Moderate - High*	*Moderate - High*	*Safety Mobility*
Interchanges						
Longer acceleration/ deceleration lanes	Acceleration lane lengths should be determined using the higher speed-change lane criteria values and assuming a 40 mi/h ramp speed (5)	AASHTO	High	*Low*	*Low*	*Safety*
Provide parallel-type acceleration lanes for merging	A parallel versus a taper design for entrance ramp geometry is recommended (5, 4)	AASHTO	High	*Low*	*Low*	*Safety*
Pavement marking and delineation						
Improve roadway delineation	Wider lane lines or edge lines with raised pavement markers (4)	MUTCD	Low	*Low*	*Moderate – High*	*Safety*
	Minimize in-service luminance contrast level between the marked edge of the roadway and the road surface be maintained as follows: at intersections with overhead lighting, a contrast of 2.0 or higher is recommended, at intersections without overhead lighting, a contrast of 3.0 or higher is recommended (5)	MUTCD	*Low*	*Low*	*Moderate – High*	*Safety*
Raised channelization	Use raised channelization with sloping curbed medians instead of channelization through the use of pavement markings (flush) for the following operating conditions: Left- and right-turn lane treatments at intersections on all roadways with operating speeds of less than 40 mi/h and right-turn treatments on roadways with operating speeds equal to or greater than 40 mi/h	AASHTO MUTCD	Moderate	*Low*	*Moderate to High*	*Safety*

Potential Revision	Recommendation Detail	Primary Policy Impacted	Infrastructure Construction Cost	Operation Impacts	Maintenance Impacts	Life Impacts (Benefits)
	Where raised channelization is implemented at intersections, median and island curb sides and curb horizontal surfaces should be treated with retroreflectorized markings and be maintained at a minimum luminance contrast level as follows: With overhead lighting a contrast of at least 2.0, without overhead lighting, a contrast of at least 3.0 (5)	AASHTO MUTCD	*Moderate*	*Low*	*Moderate – High*	*Safety*
High contrast ratio for curves	Maintain a minimum in-service contrast value of 3.75 for pavement edge lines on horizontal curves when median barriers effectively block a driver's view of oncoming headlights or the median width exceeds 15 m (5)	MUTCD	*Low*	*Low*	*Moderate*	*Safety*
Additional general recommendations	Use oversized glass beads (on the edge lines and centerlines), raised pavement markers (longitudinal markings for the overall roadway and work zones), and painted rumble stripes (rumble stripes topped with 7.6 to 15.2 cm longitudinal paint stripes) (7)	AASHTO	*Low*	*Low*	*Moderate*	*Safety*
Sign Enhancements						
Increase size and letter height	On high-speed limited-access highways for new or reconstructed installations at time of sign replacement, calculate letter size requirements for signing on the basis of no more than 10 m (22 ft) of legibility distance for each 25 mm (1 in.) of letter height(5)	MUTCD	Low	*Low*	*Low*	*Safety Mobility*
	A mixed-case font-should-be used for ground-mounted signs on the side of the road (5)	MUTCD	*Low*	*Low*	*Low*	*Safety*
Street sign letter height	Use a minimum letter height of 150 mm (6 in.) for post-mounted street-name signs (5)	MUTCD	*Low*	*Low*	*Low*	*Safety Mobility*
Provide advanced warning signs for intersections and curves	Use for the following situations: where speed may have to be reduced, where lateral placement may have to be modified, potential conflict zones, construction and maintenance zones, and dead end streets, restricted clearance, frequent wild animal crossing (4)	MUTCD	Low	*Low*	*Moderate*	*Safety Mobility*

Potential Revision	Recommendation Detail	Primary Policy Impacted	Infrastructure Construction Cost	Operation Impacts	Maintenance Impacts	Life Impacts (Benefits)
Additional recommendations	Internally lit signs (recommended at signalized intersections, especially in urban areas), lower mounting heights (for wrong-way and do-not-enter signs on freeway entrance ramps), and flashing beacons (over the center of intersections with stop control on the minor roads) (7)	MUTCD	*Low*	*Moderate*	*Moderate*	*Safety Mobility*
Pedestrians						
Provisions for slower walking speeds	Calculate pedestrian control-signal timing based on an assumed walking speed of 0.85 m/s (2.8 ft/2) (5)	MUTCD	*Low*	*Low*	*Low*	*Safety Mobility*
Median refuges	Provide median refuge islands, with appropriate signage, that allow pedestrians to stop midway through the crosswalk and stand safely until the next signal cycle (5)	AASHTO MUTCD	*Low-Moderate*	*Low*	*Low-Moderate*	*Safety Convenience*
Crosswalk lighting system	Activate in-pavement lighting when there is someone in crosswalk (1)	AASHTO MUTCD	*Moderate*	*Moderate*	*Moderate - High*	*Safety Mobility*
Leading pedestrian interval	Allow pedestrian to start crossing before the light turns green for vehicles driving in the same direction (2)	MUTCD	*Low*	*Low*	*Low*	*Safety Mobility*
Transit Users						
Pedestrian infrastructure	Above recommendations for pedestrian infrastructure will benefit transit users					*Safety Mobility*
Bus stop waiting area	Provide comfortable seating and standing room for large groups (11)	AASHTO	*Low*	*Low*	*Moderate*	*Convenience*
Lighting	Provide well-lit waiting area at bus stops and pedestrian infrastructure (11)	AASHTO	*Moderate*	*Moderate*	*Moderate*	*Safety Convenience*
Spacing of bus stops	Provide access to a bus stop within a mile walking distance (11)	AASHTO	*Moderate*	*Low*	*Low*	*Mobility Convenience*

Note: For the Infrastructure Construction Cost, Operation Impacts, Maintenance Impacts, and Life Impacts (Benefits) columns in this table, plain text is used to indicate an entry that is directly supported by a referenced data source (usually Volume 9 of the NCHRP 500 report). In these columns, *italicized* entries reflect judgments made by the authors of this paper.

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