9th INTERNATIONAL CONGRESS ON TRANSPORTATION RESEARCH
TRANSPORTATION 4.0: THE SMART EVOLUTION

Aspects of Safe Road Design for Aging Road Users

Sophia Vardaki and George Kanellaidis

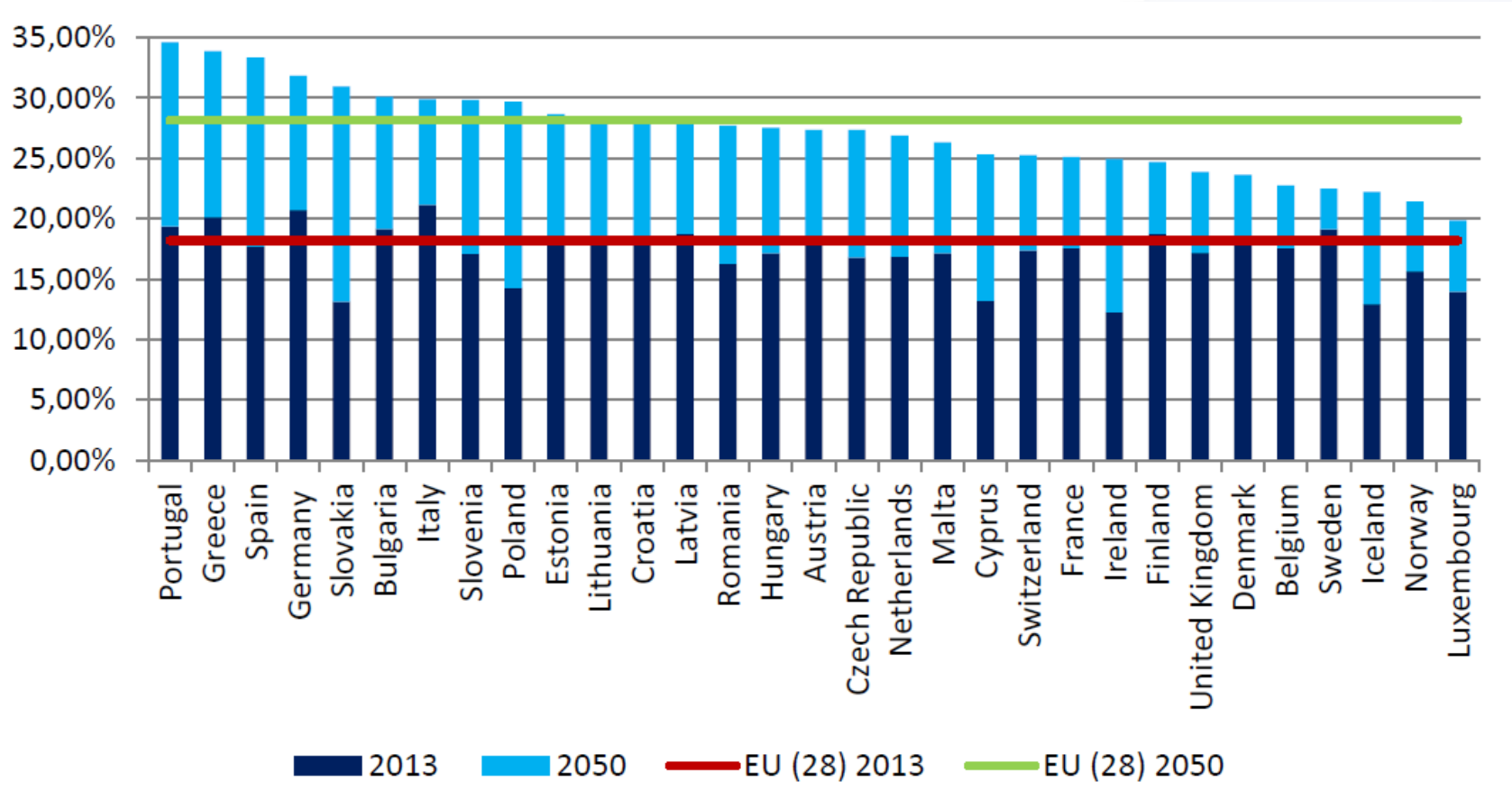
National Technical University of Athens
School of Civil Engineering
Department of Transportation Planning & Engineering

A brief description of the safety of older drivers

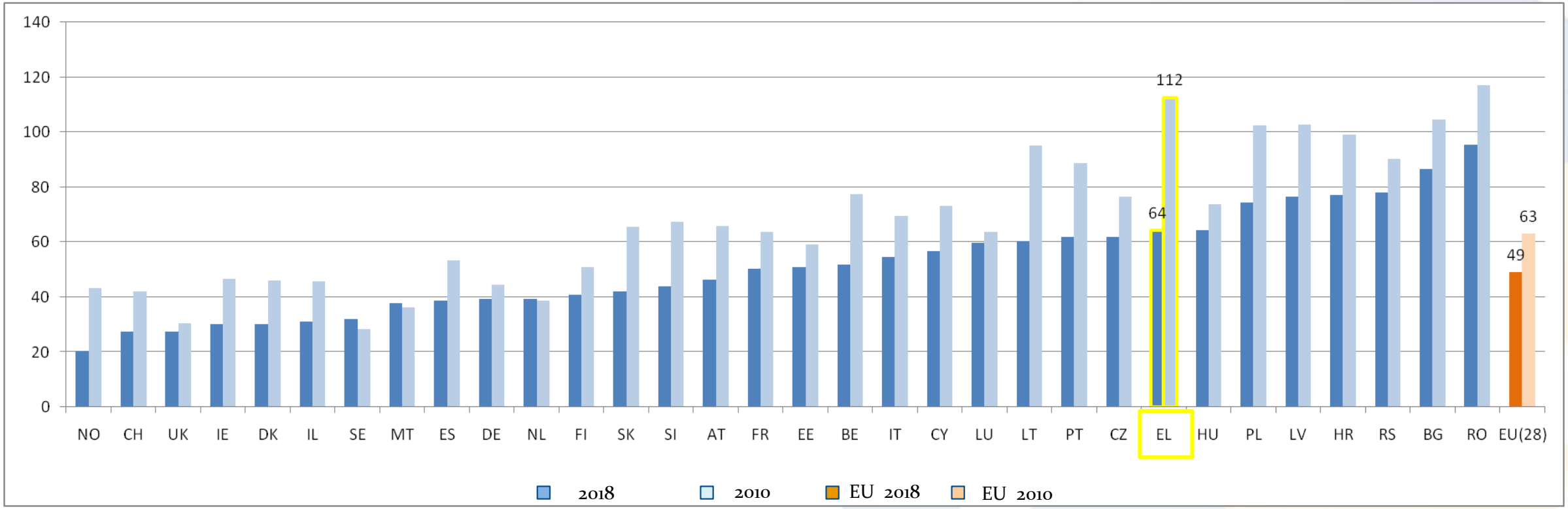
- ✓ "Two main factors determine the road safety of older road users: **functional limitations and physical vulnerability** which both contribute to the relatively high fatality rate for older road users in road crashes."
- ✓ "Older drivers are over-represented in **crashes at intersections**, where older drivers typically turn against oncoming traffic with right of way on the main road."
- ✓ "Only in the case of moderate and **severe visual and cognitive limitations** as a consequence of age-related disorders and diseases does the relationship between functional limitations and **crash risk** become visible."

The aging population in Europe

Predicted percentage of older people (≥ 65 years) in the population



Road deaths per million inhabitants in 2018 and 2010



13th Annual Road Safety Performance Index (PIN) Report; ETSC (June 2019)

Fatalities as reported in EU countries

Age grou		<15				15 - 17				18 - 24				25 - 49				50 - 64				65+				Overall
Area	nknown*	Motor way	Rural	Urban	Total	Motor way	Rural	Urban	Total	Motor way	Rural	Urban	Total	Motor way	Rural	Urban	Total	Motor way	Rural	Urban	Total	Motor way	Rural	Urban	Total	Total
Belgique/België 2017	6	1	5	8	14	0	8	4	12	15	46	16	77	51	119	71	241	21	62	31	114	8	70	73	151	609
Bulgaria 2015	6	1	8	11	20	0	7	5	12	7	57	33	97	29	165	84	278	17	84	47	148	5	56	86	147	702
Cesko 2017	1	1	6	5	12	0	4	0	4	4	53	11	68	15	142	45	202	4	87	49	140	1	66	83	150	576
Danmark 2017	0	0	2	1	3	0	1	0	1	1	24	8	33	6	24	16	46	4	30	7	41	1	29	21	51	175
Deutschland 2017	3	6	25	30	61	5	55	18	78	52	280	62	394	162	562	193	917	105	421	207	733	79	450	465	994	3177
Eesti 2017	0	0	2	0																						
Éire/Ireland 2015	1																									
Elláda 2016	5																									
España 2016	6																									
France 2017	0																									
Hrvatska 2017	0																									
Italia 2017	53	7	17	19	43	1	28	39	68	21	167	118	306	118	622	392	1132	78	355	234	667	44	411	654	1109	3326
Kypros - Kibris 2016	0	0	1	0	1	0	2	4	6	0	0	5	5	0	3	9	12	1	2	5	8	0	2	12	14	46
Latvija 2017	7	0	4	2	6	0	1	0	1	0	10	5	15	0	34	13	47	0	20	11	31	0	17	12	29	129
Luxembourg 2017	0	0	0	0	0	0	1	0	1	0	5	0	5	3	8	2	13	0	2	0	2	0	0	4	4	25
Magyarország 2017	2	0	6	3	9	0	4	4	8	2	34	8	44	15	161	51	227	10	92	53	155	7	64	109	180	623
Malta 2016	0	0	0	0	0	0	0	1	1	0	0	2	2	0	8	5	13	0	1	1	2	0	0	5	5	23
Nederland 2017	1	3	4	8	15	0	6	7	13	12	31	14	57	42	75	54	171	16	50	22	88	9	70	111	190	534
Österreich 2017	0	0	5	3	8	1	15	4	20	6	33	7	46	24	89	27	140	10	67	22	99	4	53	44	101	414
Polska 2016	1	0	41	31	72	0	42	32	74	6	282	152	440	31	720	393	1144	9	357	273	639	4	259	393	656	3025
Portugal 2017	0	0	1	2	3	0	2	4	6	6	11	31	48	23	78	111	212	10	65	77	152	12	66	103	181	602
România 2017	13	0	19	48	67	0	16	14	30	1	80	115	196	21	282	333	636	8	169	297	474	6	122	407	535	1938
Slovenija 2017	0	0	2	1	3	0	1	2	3	1	4	6	11	14	14	15	43	3	14	6	23	1	9	11	21	104
Slovensko 2010	53	0	4	7	11	0	4	3	7	3	35	21	59	7	79	40	126	4	30	33	67	0	17	31	48	318
Suomi/Finland 2016	0	0	8	2	10	0	3	5	8	2	35	4	41	4	68	13	85	1	32	12	45	0	42	27	69	258
Sverige 2017	8	0	6	2	8	0	1	1	2	6	27	7	40	6	57	18	81	5	31	5	41	3	39	31	73	245
United Kingdom 2016	1	3	30	31	64	2	36	20	58	8	182	89	279	51	446	183	680	18	200	104	322	9	256	191	456	1859
Totals 2017	167	42	277	274	593	17	310	234	561	235	1956	999	3190	897	5187	2729	8813	476	2919	1855	5250	337	2948	3622	6907	25314

Greece (2016)

65+				Overall
Motorway	Rural	Urban	Total	Total
13	99	124	236	819

European Commission / Directorate General Energy and Transport

Safe system approach

A preventive holistic approach to road safety

- The road system should be forgiving of human error and frailty.
- Use of the system should result in no deaths or serious injuries as a consequence of road user errors.
- Road design has been highlighted as the most critical area for improvement

Improving the Performance of Safe System Infrastructure: Final Report
Austroads Research Report AP-R498-15 (2015)

Physical vulnerability

Safe System aspirational operating speeds are as follows:

- 30 km/h - Where there is the possibility of a collision between a vulnerable road user and a passenger vehicle
- 50 km/h - Where there is the possibility of a right-angle collision between passenger vehicles
- 70 km/h - Where there is the possibility of a head-on collision between passenger vehicles
- ≥100 km/h – Where side or frontal impact between vehicles or impact with vulnerable road users are not possible

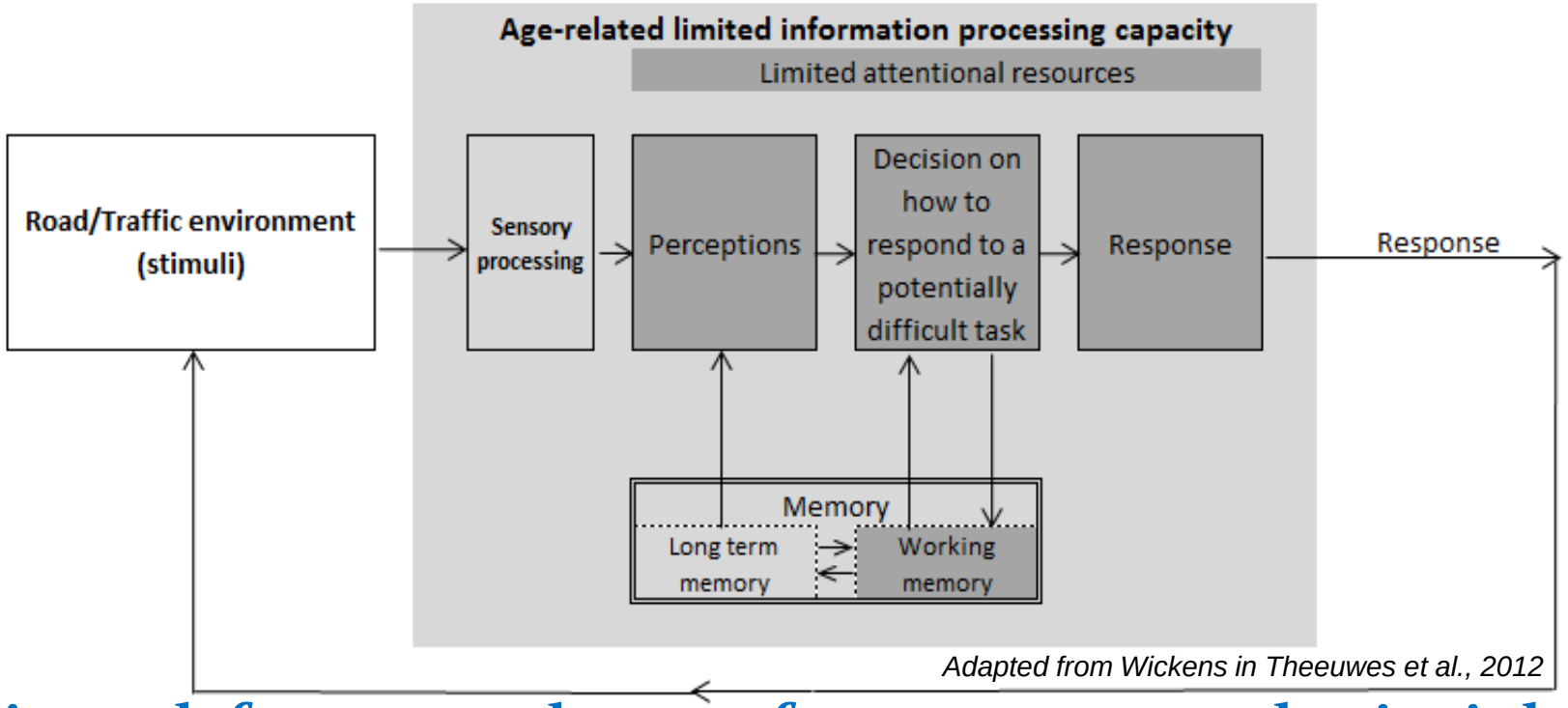
Safe road design for aging road users

Sustainable Safety Principle of *Psychologics*

The design of the traffic system is well-aligned with the general competencies and expectations of road users, particularly senior road users: the information from the traffic system is perceivable, understandable, "self-explaining", credible, relevant and feasible.

Human centered design entails the need for road designers to understand road-user demands, needs and capabilities in relation to the road system and how to adapt the properties of the system to these capabilities.

Link between age and unsafe responses



Adapted from Wickens in Theeuwes et al., 2012

This work focuses on human factor aspects and principles that guide a safe road design favorable to older drivers in terms of task demands, with the potential to *prevent* unsafe -unintentional- responses and discourage errors.

Age-related limitations

Driving difficulties and weaknesses of older drivers include:

- ✓ difficulty judging whether fellow road users are moving and at what speed they approach intersections

  [motion perception and contrast sensitivity]

- ✓ overlooking other road users while merging and changing lanes **[peripheral vision and flexibility of head and neck]**

- ✓ overlooking traffic signs and signals

  [selective attention]

- ✓ increased reaction times as the complexity of the traffic situation increases

  [speed of processing information and decision making, divided attention, performance under pressure of time]

Lessons from Fuller's framework

- ✓ Age-related limitations do not lead automatically to higher accident risk because many older drivers tend to take **compensatory measures**.
- ✓ Their experience allows them to be proactive in avoiding complex situations and to built **anticipation**.
- ✓ Crash involvement can be reduced either by improving the driver or by **making the driving task easier**.
- ✓ **Adjustments to the infrastructure** can make the driving task easier: the older driver will still be in command of the situation despite his/her reduced capabilities.

Demands of the road environment

Factors that contribute to task difficulty (task demand)

- The *complexity* of a traffic situation

  Amount of information, quality of information, time pressure

- Whether or not the driver has to make a *decision*

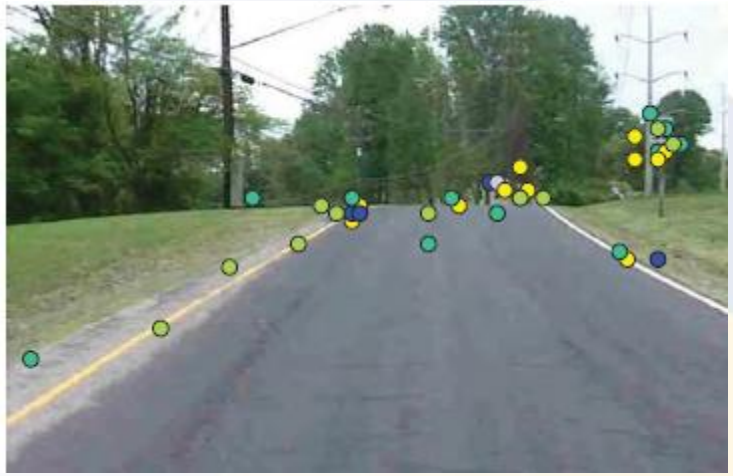
- Availability of proper *mental schemata* that trigger appropriate actions

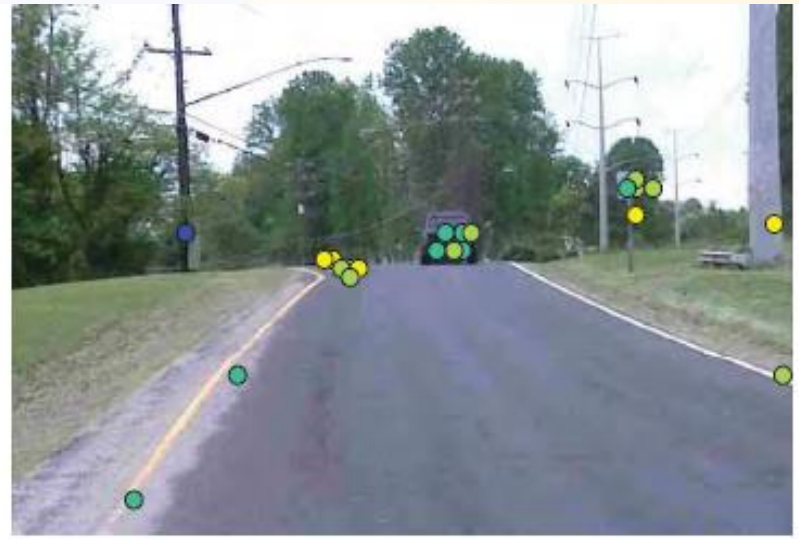
Driver Workload Management

- ✓ The key to workload management is to **anticipate the moment at which the workload increases**.
- ✓ The concepts of **consistency** and **self-explaining roads** (SERs) are associated with road layouts and traffic situations that are in line with road users' expectations.
- ✓ SERs allow routine-based performance without much effort and thus with **fewer driver errors**: the elderly can use their experience and existing automatisms.
- ✓ **Complex tasks** can be simplified through design that enables the driver to perform the task in a self paced way and separate the driver actions.
- ✓ **Older drivers** will benefit from measures that **reduce task demands and increase decision time**.

The Most Meaningful Information

- ✓ The time (distance) needed by a driver to respond to a stimulus depends on road elements and human elements, including age, information processing, driver alertness, driver expectations, and vision.
- ✓ **Time and how road users use it** are important factors to consider and should be integrated into road design and traffic engineering.





Human factors guidelines for road systems (NCHRP Report 600), TRB (2012)

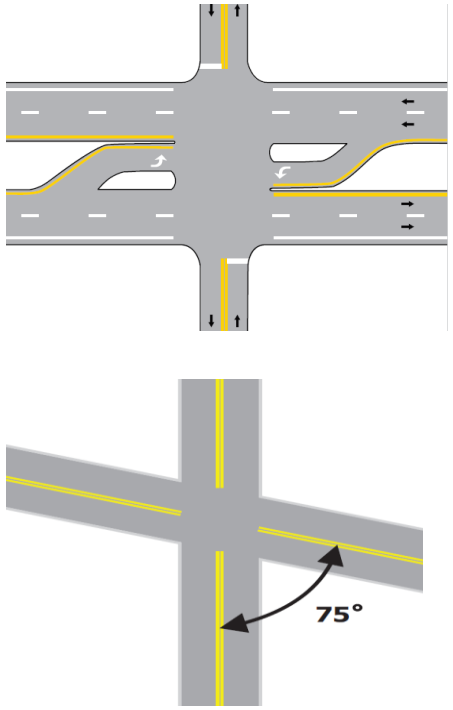
Time (Decision time)

- ✓ **Elderly drivers** may quickly experience **overload** when confronted with complex road environments.
- ✓ Decision sight distance provides **a safety margin for error** and allows drivers to make a decision and maneuver along a sufficient distance with the same or lower speed.

Merging at a busy high-speed motorway: Compensatory behaviors do not always work

- ✓There is a need to take a complicated decision quickly
- ✓There are high demands from more than one source of information
- ✓There is a need to process large amounts of information at a time

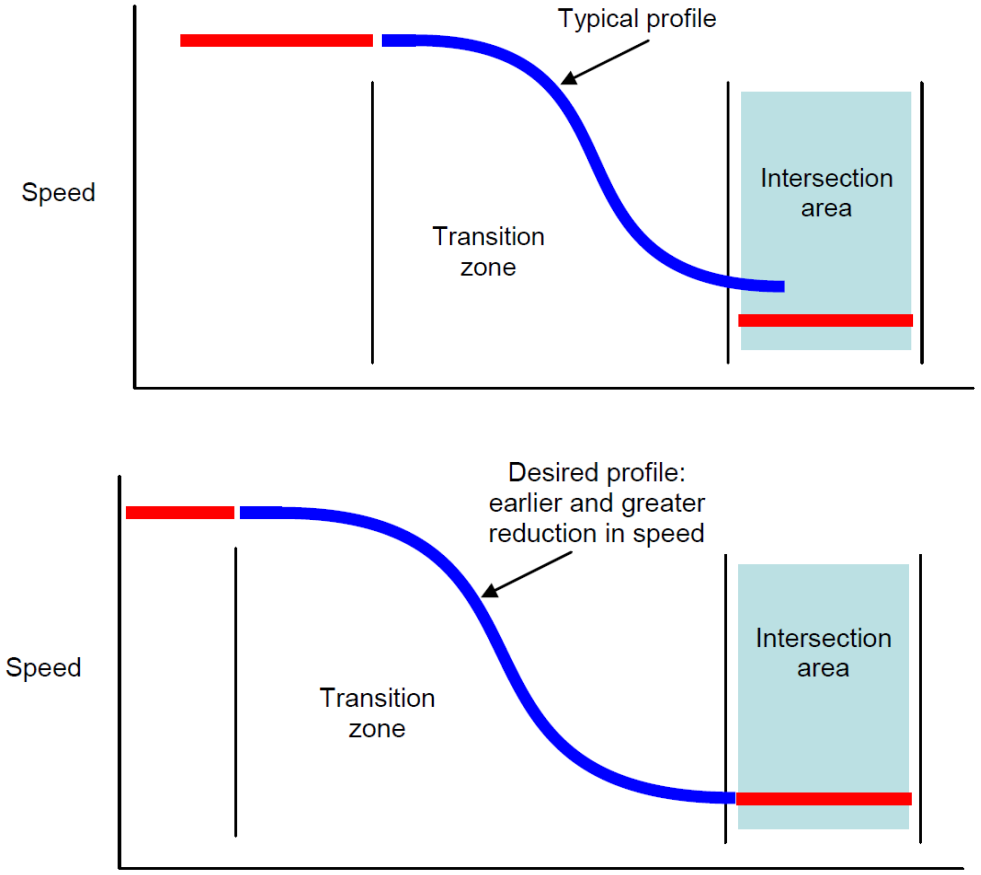
Intersection designs more favorable to the elderly



Handbook for Designing Roadways for the Aging Population. Report No. FHWA-SA-14-015 (2014)

- ✓Timely information and better visibility of the approaching road situation- longer sight distances, advance warning signs
- ✓Unobstructed view of important features - positive offset of opposing left-turn lanes, intersecting angle, fixed lighting
- ✓Interactions with conflict traffic separated in time – conflict free regulation

Lengthened transition zone on approach to intersections: Reduction of approach speeds



Safe Intersection Approach Treatments and Safer Speeds Through Intersections: AP-R385-11 (2011)

- ✓ Advance warning
- ✓ **Advance warning and engineering treatments**

Tunnel entrance: a high workload situation

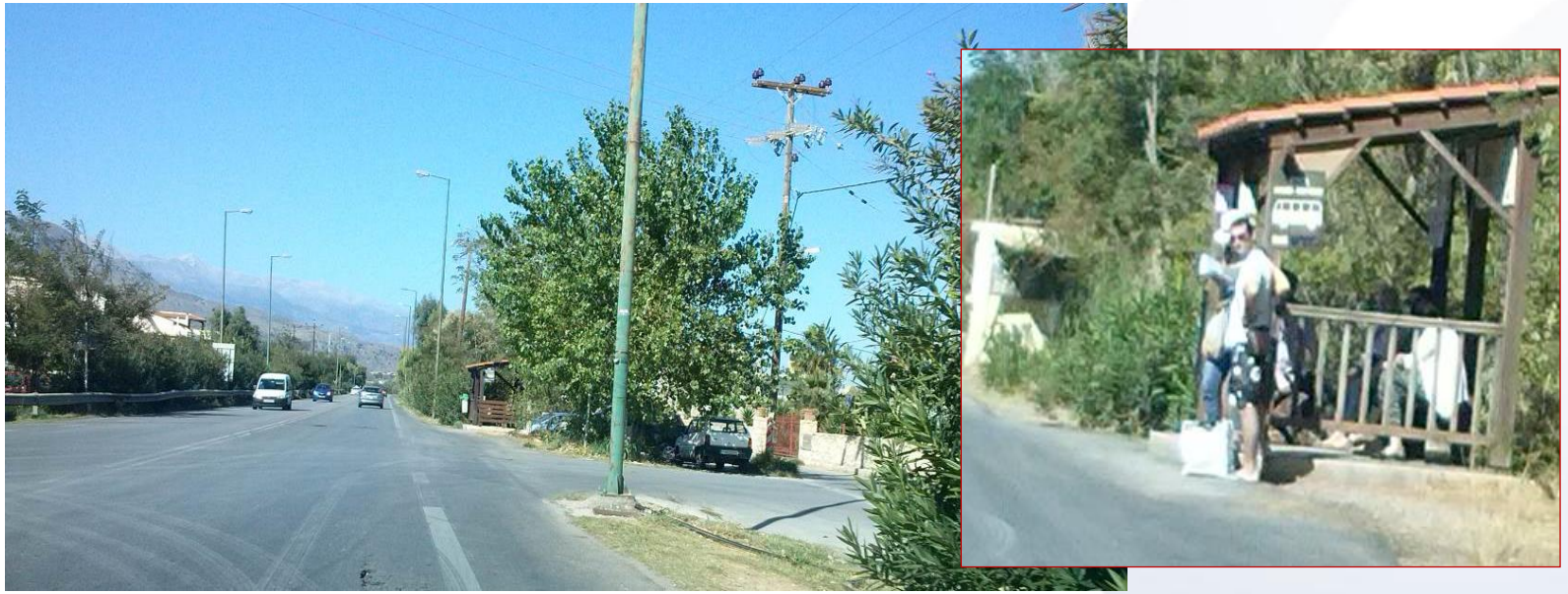
- ✓ Each level of the driving task has its own information processing requirements.
- ✓ An important design consideration is the separation of both information provision and task execution in place and time.

Roadworks

- ✓ Elderly drivers require advance and clear roadside information at roadworks.
- ✓ Presenting information sequentially, rather than all at once, for each of the control, guidance, and navigation tasks.
- ✓ Control and guidance of the driving task are of higher primacy than navigation in terms of information provided.

Perception of road environment

- ✓When the workload is high, signs or other road users at ***unexpected*** places may not be detected.



Discussion (1/2)

- Despite the increasing potential of **developments in vehicle technology** in improving road safety, these are perceived as **difficulties**.
- Until these developments fully penetrate the fleet, there will still be **a need for a forgiving road environment that discourages errors.**
- As a result of the rise in population age and mobility, road designers face the challenge of providing **a safe road environment for older people** with increased mobility needs.
- Designing the traffic system according to the needs of aging road users will help improve **the safety of other road users**.

Discussion (2/2)

- **Human-centered design** requires that road engineers are aware of human limitations and motivations.
- Extensive (and transformative) **professional development courses** will enable engineers to conceive Safe System principles and apply the knowledge of the 'human dimension' in road design.
- The **commitment of road authorities** and other traffic professionals to the aim of sustainable safety is expressed through the application of modern road safety practices and effective measures and also the dedication of time to road safety education and training.

9th INTERNATIONAL CONGRESS ON TRANSPORTATION RESEARCH
TRANSPORTATION 4.0: THE SMART EVOLUTION

Aspects of Safe Road Design for Aging Road Users

Sophia Vardaki and George Kanellaidis

National Technical University of Athens
School of Civil Engineering
Department of Transportation Planning & Engineering