DECLINING FUNCTIONAL ABILITIES AND ADVANCED DRIVER ASSISTANCE SYSTEM (ADAS) TECHNOLOGIES

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16. Abstract				
abilities) that are needed for safe drivi maintain safe driving for longer even about which ADAS can be most usefu University of Michigan Transportation	experience declines in vision, movement, ng. Advanced Drive Assistance System (A when faced with declining functional abilial for specific functional ability declines. Be no Research Institute (UMTRI), we have destarting to experience declines in 28 functions with the technology works.	ADAS) technities. There assed on reserveloped a ta	nologies may is little inform earch conduct able that provi	help people nation, however, ted by the ides recommended
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Introduction

As people age, they are more likely to experience declines in vision, movement, and thinking abilities (known as functional abilities) that are needed for safe driving. ADAS technologies may help people maintain safe driving for longer even when faced with declining functional abilities. There is little information, however, about which ADAS can be most useful for specific functional ability declines. Based on research conducted by the University of Michigan Transportation Research Institute (Eby et al., 2008a; 2008b, 2015; Molnar et al., 2010), we have developed a table that provides recommended ADAS technologies for those who are starting to experience declines in functional abilities. Note that this list is not just for the older drivers but can be useful for anyone who is experiencing declines in functional abilities. Also, if you or someone you know is experiencing any of these physical challenges, it is recommended that they have a conversation with their primary care provider about how these declines may relate to driving. It may also be beneficial to have a combination of ADAS to best support your driving needs. Finally, keep in mind that these technologies may not be sufficient to assure a driver's safety-each as each driver's needs are unique.

Declines in Functional Abilities and ADAS to Help Overcome These Declines

Functional Ability Decline	Definition	ADAS
Reduced Visual	Reduction in the eye's	• Adaptive headlights
Acuity	ability to see fine details	• Bicycle detection
	and see images at a distance	• Blind spot warning
	that are in-focus.	• Brake assist
		• Curve speed warning
		• Forward collision warning
		• Left turn crash avoidance
		• Level 2 automated driving system
		• Obstacle detection
		• <u>Pedestrian detection</u>
		• Rear cross traffic alert
		• <u>Sideview camera</u>
Increased Sensitivity	A diminished ability to see	• Adaptive cruise control
To Glare	things in dim lighting	• Adaptive headlights
	conditions when bright	• <u>Bicycle detection</u>
	lights (glare), such as	• Blind spot warning
	headlights, are present,	• Brake assist
	making it harder to see well	• <u>Curve speed warning</u>
	at night.	• <u>Drowsiness alert</u>
		• Forward collision warning
		• <u>High speed alert</u>
		• <u>Hill descent assist</u>
		• <u>Hill start assist</u>

		• Lane departure warning
		• Lane keeping assist
		• Left turn crash avoidance
		• Level 2 automated driving system
		Navigation assistance
		• Obstacle detection
		Pedestrian detection
		• Rear cross traffic alert
		• Sideview camera
Dada and Davimbanal	Diminish at abilities to an	Voice activated controls
Reduced Peripheral	Diminished ability to see	Automatic parallel parking
Vision	objects at the edges of one's	• Bicycle detection
	field of view.	• Blind spot warning
		• Brake assist
		• Curve speed warning
		• <u>Drowsiness alert</u>
		• Forward collision warning
		• Lane departure warning
		• <u>Lane keeping assist</u>
		• <u>Left turn crash avoidance</u>
		• Level 2 automated driving system
		• Navigation assistance
		• Obstacle detection
		• Parking sensors
		• <u>Pedestrian detection</u>
		• Rear cross traffic alert
		• <u>Sideview camera</u>
		<u>Voice activated controls</u>
Reduced Contrast	Diminished ability to	• Adaptive headlights
Sensitivity	distinguish differences	• Bicycle detection
	between objects and the	• Blind spot warning
	background, which often	• Brake assist
	makes it difficult to see at	 Forward collision warning
	night.	• Left turn crash avoidance
		• Level 2 automated driving system
		Obstacle detection
		• Pedestrian detection
		• Rear cross traffic alert
		• Sideview camera
Poor Depth	Diminished ability to	Adaptive cruise control
Perception	determine spatial	Automatic parallel parking
•	relationships, namely	• Bicycle detection
	distances between objects,	• Blind spot warning
	in three dimensions.	• Brake assist
	in three difficultions.	• Curve speed warning
		• Drowsiness warning
		• Forward collision warning
	1	- I of ward combion warning

	T	
		• Lane departure warning
		• Lane keeping assist
		• <u>Left turn crash avoidance</u>
		• <u>Level 2 automated driving system</u>
		• Navigation assistance
		• Obstacle detection
		 Parking sensors
		Pedestrian detection
		• Rear cross traffic alert
		• Sideview camera
		Voice activated controls
Visual Scanning	A decreased ability to	Adaptive cruise control
Deficits	search the environment to	• Automatic parallel parking
Deficits		
	keep track of what is going	• Bicycle detection
	on around us	• Blind spot warning
		• Brake assist
		• <u>Curve speed warning</u>
		• <u>Drowsiness alert</u>
		 Forward collision warning
		• <u>High speed alert</u>
		• Hill descent assist
		• Hill start assist
		• Lane departure warning
		• Lane keeping assist
		• Left turn crash avoidance
		• Level 2 automated driving system
		Navigation assistance
		Obstacle detection
		• Parking sensors
		• Pedestrian detection
		• Rear cross traffic alert
		• Sideview camera
View amodial Dafiaita	A decreased shiliter to thirds	Voice activated controls
Visuospatial Deficits	A decreased ability to think	• Adaptive cruise control
	about and perceive the	Automatic parallel parking
	arrangement of objects in	• Bicycle detection
	space, including one's	• <u>Blind spot warning</u>
	position relative to the	• Brake assist
	environment and	• Curve speed warning
	recognizing differences in	• <u>Drowsiness alert</u>
	the shape, size, proportion,	 Forward collision warning
	and angle of objects.	 Lane departure warning
		 <u>Lane keeping assist</u>
		• Left turn crash avoidance
		• Level 2 automated driving system
		Navigation assistance
		Obstacle detection
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		▲ Darking concors
		• Parking sensors
		• Pedestrian detection
		• Push button start
		• Rear cross traffic alert
		• <u>Sideview camera</u>
		• <u>Temperature warning</u>
		 Voice activated controls
Divided Attention	A reduced ability to do two	 Automatic parallel parking
Deficits	things at once, such as	• Bicycle detection
	keeping track of ones	• Blind spot warning
	driving speed and what	• Brake assist
	other cars are doing.	• Curve speed warning
	other cars are doing.	• Forward collision warning
		• Lane departure warning
		_
		• Lane keeping assist
		• <u>Left turn crash avoidance</u>
		• Level 2 automated driving system
		• Navigation assistance
		• Obstacle detection
		• <u>Parking sensors</u>
		• <u>Pedestrian detection</u>
		• Rear cross traffic alert
		• Sideview camera
		 Voice activated controls
Difficulty Following	Difficulty with following an	Blind spot warning
Directions	instruction or series of	Brake assist
	instructions for doing or	• Forward collision warning
	finding something.	• Left turn crash avoidance
	imang something.	• Level 2 automated driving system
		• Navigation assistance
		• Obstacle detection
		• Pedestrian detection
G '' D' 'I'	A 1 1 1 1 1 1 1 1 C	Voice activated controls
Cognitive Rigidity	A decreased ability to shift	• Adaptive cruise control
	focus away and consider	• Blind spot warning
	alternative actions,	• <u>Lane departure warning</u>
	thoughts, or solutions.	• Lane keeping assist
		 Level 2 automated driving system
		 Navigation assistance
		<u>Voice activated controls</u>
Selective Attention	A diminished ability to	• Automatic parallel parking
Deficits	ignore what is not	• Bicycle detection
	important while focusing on	• Blind spot warning
	what is important, such as a	• Brake assist
	driver quickly directing	• Curve speed warning
	their attention to the most	• Forward collision warning
	then attention to the most	_
1	İ	 Lane departure warning

	important things happening outside the vehicle.	Lane keeping assistLeft turn crash avoidance
	outside the vehicle.	• Level 2 automated driving system
		Navigation assistance
		• Obstacle detection
		• Parking sensors
		Pedestrian detectionRear cross traffic alert
		• Sideview camera
		• Voice activated controls
Slowed Information	An ingressing delay or	• Adoptivo ornigo control
Processing	An increasing delay or reduction in the ability of	Adaptive cruise controlBicycle detection
Trocessing	one's mind to consistently	• Blind spot warning
	monitor what is going on in	• Brake assist
	the environment and one's	• Curve speed warning
	body to react appropriately.	• Drowsiness alert
	l l l l l l l l l l l l l l l l l l l	 Forward collision warning
		• Lane departure warning
		 <u>Lane keeping assist</u>
		• <u>Left turn crash avoidance</u>
		• Level 2 automated driving system
		• Navigation assistance
		• Obstacle detection
		• <u>Pedestrian detection</u>
		Rear cross traffic alertSideview camera
		Voice activated controls
Forgetfulness	A diminished ability to	• Adaptive cruise control
	remember information that	• Adaptive headlights
	is important for doing one's	• Bicycle detection
	current activity, such as a	• Blind spot warning
	familiar traffic route of the	• Brake assist
	rules for safe driving	 Curve speed warning
	behavior.	• <u>Drowsiness alert</u>
		• Forward collision warning
		• <u>High speed alert</u>
		• Hill descent assist
		 <u>Hill start assist</u> Lane departure warning
		Lane keeping assist
		• Left turn crash avoidance
		• Level 2 automated driving system
		Navigation assistance
		• Obstacle detection
		• Pedestrian detection
		• Rear cross traffic alert

	1	- Cidenian comerc
		• <u>Sideview camera</u>
C.A. T.A	TT 11 (C' 1	Voice activated controls
Getting Lost	Unable to navigate or find	• Blind spot warning
	one's way in a familiar	• Level 2 automated driving system
	area.	• <u>Navigation assistance</u>
		Voice activated controls
Confusion	Inability or delay in ability	• <u>Bicycle detection</u>
	to process information and	 Blind spot warning
	make critical judgments	• Brake assist
		• <u>Curve speed warning</u>
		• <u>Drowsiness alert</u>
		 Forward collision warning
		• Lane departure warning
		 Lane keeping assist
		• Left turn crash avoidance
		• Level 2 automated driving system
		• Navigation assistance
		Obstacle detection
		• Pedestrian detection
		• Push button start
		• Rear cross traffic alert
		• Sideview camera
		• Temperature warning
		Voice activated controls
Impaired judgment	Diminished ability to assess	
ımpan eu juugment	conditions and draw	• Bicycle detection
		Blind spot warningBrake assist
	reasonable conclusions.	
		• Curve speed warning
		• Forward collision warning
		• <u>Lane departure warning</u>
		• Lane keeping assist
		• <u>Left turn crash avoidance</u>
		• Level 2 automated driving system
		• Obstacle detection
		• <u>Pedestrian detection</u>
		- Doom among traffic alout
		• Rear cross traffic alert
		• Sideview camera
Depression		• Sideview camera
Depression	A disorder characterized by	Sideview camera Bicycle detection
Depression	an inability to concentrate,	 Sideview camera Bicycle detection Blind spot warning
Depression	an inability to concentrate, insomnia, loss of appetite,	 Sideview camera Bicycle detection Blind spot warning Brake assist
Depression	an inability to concentrate,	 Sideview camera Bicycle detection Blind spot warning Brake assist Curve speed warning
Depression	an inability to concentrate, insomnia, loss of appetite,	 Sideview camera Bicycle detection Blind spot warning Brake assist
Depression	an inability to concentrate, insomnia, loss of appetite, feelings of extreme sadness,	 Sideview camera Bicycle detection Blind spot warning Brake assist Curve speed warning
Depression	an inability to concentrate, insomnia, loss of appetite, feelings of extreme sadness, guilt, helplessness and	 Sideview camera Bicycle detection Blind spot warning Brake assist Curve speed warning Drowsiness alert
Depression	an inability to concentrate, insomnia, loss of appetite, feelings of extreme sadness, guilt, helplessness and hopelessness, and thoughts	 Sideview camera Bicycle detection Blind spot warning Brake assist Curve speed warning Drowsiness alert Forward collision warning
Depression	an inability to concentrate, insomnia, loss of appetite, feelings of extreme sadness, guilt, helplessness and hopelessness, and thoughts	 Sideview camera Bicycle detection Blind spot warning Brake assist Curve speed warning Drowsiness alert Forward collision warning Left turn crash avoidance

		• <u>Pedestrian detection</u>
		• Rear cross traffic alert
		• <u>Sideview camera</u>
		 Voice activated controls
Drowsiness/Sleepiness	A state of impaired	Adaptive cruise control
F	awareness associated with a	• Adaptive headlights
	desire or need to sleep.	• Bicycle detection
	desire of need to steep.	• Blind spot warning
		• Brake assist
		• Curve speed warning
		• Drowsiness alert
		• Forward collision warning
		• Lane departure warning
		• Lane keeping assist
		• Left turn crash avoidance
		• Level 2 automated driving system
		• Navigation assistance
		• Obstacle detection
		Pedestrian detection
		• Rear cross traffic alert
		• Sideview camera
		Voice activated controls
High Levels of Pain	A high level of suffering or	Adaptive headlights
9	painful sensations that are	• Bicycle detection
	at a level that disrupts	• Blind spot warning
	normal activities.	• Brake assist
		• Curve speed warning
		• Drowsiness alert
		• Forward collision warning
		• Left turn crash avoidance
		• Level 2 automated driving system
		Navigation assistance
		Obstacle detection
		• Pedestrian detection
		• Push button start
		• Sideview camera
		• Temperature warning
		<u>Voice activated controls</u>
Anxiety	Feelings of nervousness	Adaptive cruise control
11111101	and/or fear, as a reaction to	Automatic parallel parking
	a stressful situation.	• Bicycle detection
	a suessiai situatioli.	• Blind spot warning
		• Brake assist
		• Curve speed warning
		• Drowsiness alert
		- DIOMPHIESP GIEIT

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		• Forward collision warning
		• <u>High speed alert</u>
		• Hill descent assist
		• <u>Hill start assist</u>
		• Lane departure warning
		• Lane keeping assist
		• Left turn crash avoidance
		• Level 2 automated driving system
		Navigation assistance
		Obstacle detection
		• Parking sensors
		• Pedestrian detection
		• Push button start
		• Rear cross traffic alert
		• Sideview camera
		• Temperature warning
		Voice activated controls
Impulsiveness	Personality trait associated	Adaptive cruise control
impuisiveness	with lack of control over	Automatic parallel parking
		Bicycle detection
	emotions, especially anger,	_
	difficulty delaying	Blind spot warning Charge and a warning
	gratification, and novelty	• <u>Curve speed warning</u>
	seeking.	• <u>Drowsiness alert</u>
		• Forward collision warning
		• Level 2 automated driving system
		• Navigation assistance
		• Obstacle detection
		• <u>Parking sensors</u>
		• Rear cross traffic alert
		• <u>Sideview camera</u>
		Voice activated controls
Upper Body Stiffness	Decrease in upper-body	 Automatic parallel parking
	range of motion and the	• <u>Bicycle detection</u>
	decreased ability to move	• Blind spot warning
	the upper body easily or	• Brake assist
	comfortably.	• Curve speed warning
		• <u>Drowsiness alert</u>
		 Forward collision warning
		• Lane departure warning
		• Lane keeping assist
		• Left turn crash avoidance
		• Level 2 automated driving system
		• Navigation assistance
		Obstacle detection
		• Parking sensors
		• Pedestrian detection
		• Rear cross traffic alert
	l	TOUT CLOSS HATTIC MICH

	-	• Cidaviavy gamera
		• Sideview camera
Trala I and a GIT	D	• <u>Voice activated controls</u>
High Level of Upper	Decrease in ability to resist	• Bicycle detection
Body Weakness	strain or stress, or exert	• Blind spot warning
	physical force using the	• Brake assist
	upper body, such as	• Curve speed warning
	pushing oneself out of a	 Forward collision warning
	seating position.	 Lane departure warning
		 Lane keeping assist
		• Left turn crash avoidance
		• Level 2 automated driving system
		Obstacle detection
		Pedestrian detection
		• Rear cross traffic alert
		• Sideview camera
Claryad Dhygiaal	Dalay on madvation in ana's	
Slowed Physical Movements	Delay or reduction in one's	• Adaptive cruise control
Movements	ability to change the	• Bicycle detection
	direction or motion of one's	• Blind spot warning
	body parts, such as reaching	• Brake assist
	for something.	• <u>Curve speed warning</u>
		 Forward collision warning
		 Lane departure warning
		 Lane keeping assist
		• Left turn crash avoidance
		• Level 2 automated driving system
		Obstacle detection
		Pedestrian detection
		• Rear cross traffic alert
		• Sideview camera
Endurance	A diminished ability to	Adaptive cruise control
Endurance	_	Bicycle detection
	maintain normal physical	
	functioning without	• Blind spot warning
	becoming excessively	• Brake assist
	fatigued over time.	• <u>Curve speed warning</u>
		• Forward collision warning
		• Lane departure warning
		• Lane keeping assist
		• Left turn crash avoidance
		• Level 2 automated driving system
		Navigation assistance
		Obstacle detection
		Pedestrian detection
		• Rear cross traffic alert
		• Sideview camera
		Voice activated controls
Nouronathy Foot	The presence of unusual or	
Neuropathy-Feet	The presence of unusual or	• Adaptive cruise control
	unpleasant sensations such	Automatic parallel parking

	4:1: 1 '	D' 1 1 ()
	as tingling, burning,	• Bicycle detection
	itchiness, clumsiness,	• Blind spot warning
	and/or a prickling sensation	• Brake assist
	and sensitivity to touch in	• Curve speed warning
	one or both feet.	• Forward collision warning
		• High speed alert
		• <u>Hill descent assist</u>
		• Hill start assist
		• Lane departure warning
		• <u>Lane keeping assist</u>
		• <u>Left turn crash avoidance</u>
		• Level 2 automated driving system
		Obstacle detection
		• Parking sensors
		• <u>Pedestrian detection</u>
		• Rear cross traffic alert
		• <u>Sideview camera</u>
Impaired	A diminished ability to	• Adaptive cruise control
Coordination	performed organized	• Bicycle detection
	actions of muscles or	• Blind spot warning
	groups of muscles in the	• Curve speed warning
	performance of movements	• Forward collision warning
	or tasks, making it more	• Left turn crash avoidance
	difficult to control the	• Obstacle detection
	steering wheel, hold onto to	• <u>Pedestrian detection</u>
	the car key and operate the	• <u>Sideview camera</u>
	ignition, and use other	
	vehicle controls.	
Tremors	An involuntary trembling or	Adaptive cruise control
	quivering often caused by	Automatic parallel parking
	nervous agitation or	• Bicycle detection
	weakness	• Blind spot warning
		• Curve speed warning
		• Forward collision warning
		• Left turn crash avoidance
		Obstacle detection
		• Parking sensors
		• Rear cross traffic alert
		• Sideview camera
		• <u>Staeview camera</u>

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