Role of Intelligent Speed Assistance in Improving Road Safety

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Overview

- Context for Intelligent Speed Assistance
- Key Research Themes
- Literature search strategy
- Intelligent Speed Assistance
- Overview of Field Trials
- Impact on: Speed; Crash risk; Environment
- Implementation Scenarios
- Cost/Benefit Analyses
- User attitudes and acceptance
- Support for ISA as a speed management strategy
- ISA in the context of Connected and Automated Vehicles (CAVs)
- Conclusions & Recommendations

Road Traffic Crashes: A major societal issue

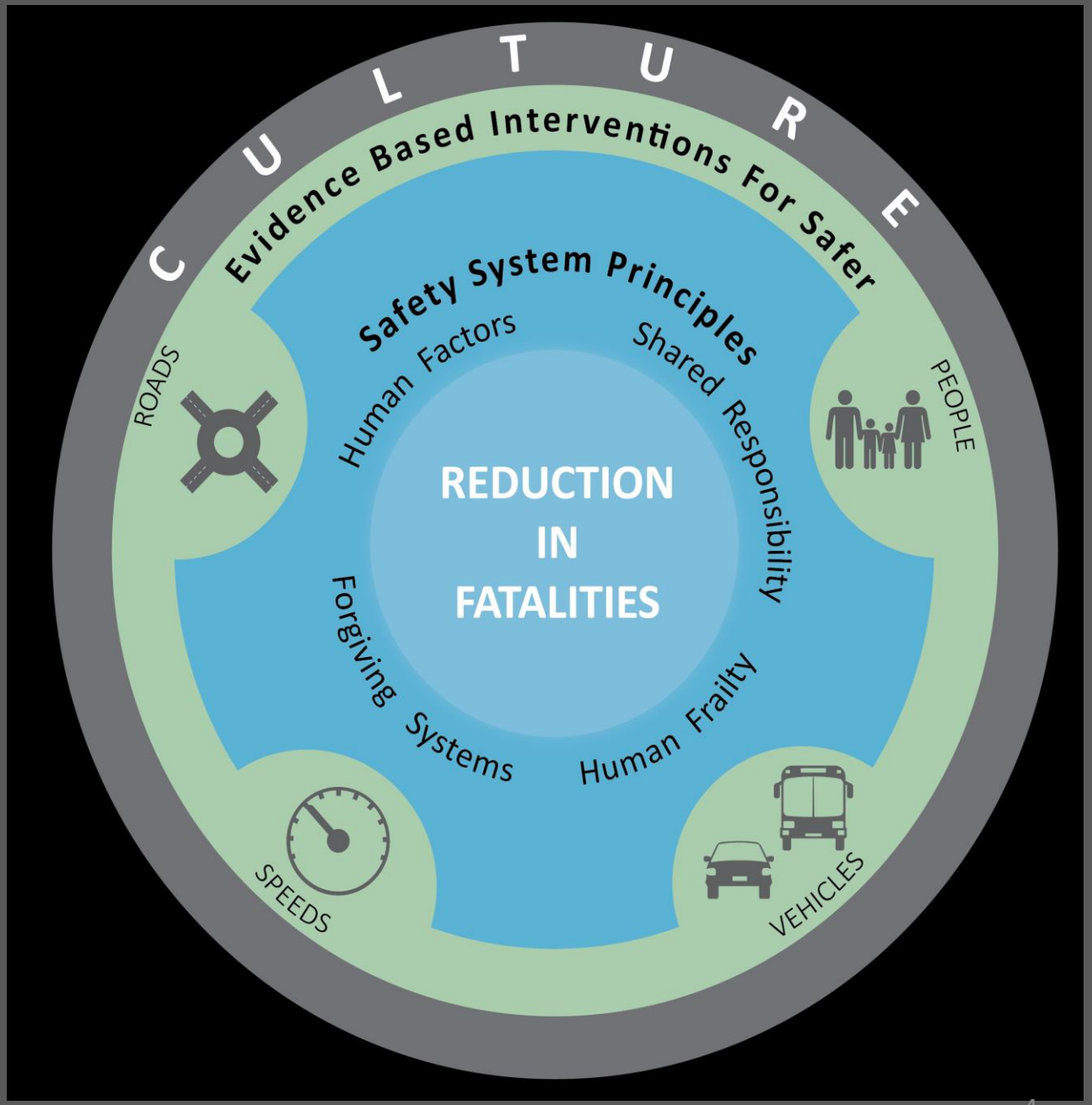
WHO. (2018). *Global Status Report on Road Safety*.

Policy responses

- EU strategy to half the overall number of deaths between 2010 and 2020
  - 20% reduction from 2010 – 2017
- New EU policy framework 2012 – 2030 (EU Commission, 2018)
  - Reaffirms goal of moving close to zero fatalities and serious injuries by 2050

- Irish Road Safety Strategy (2013 – 2020)
  - Reduce fatalities to 25pm or less by 2020 i.e. 124 per year

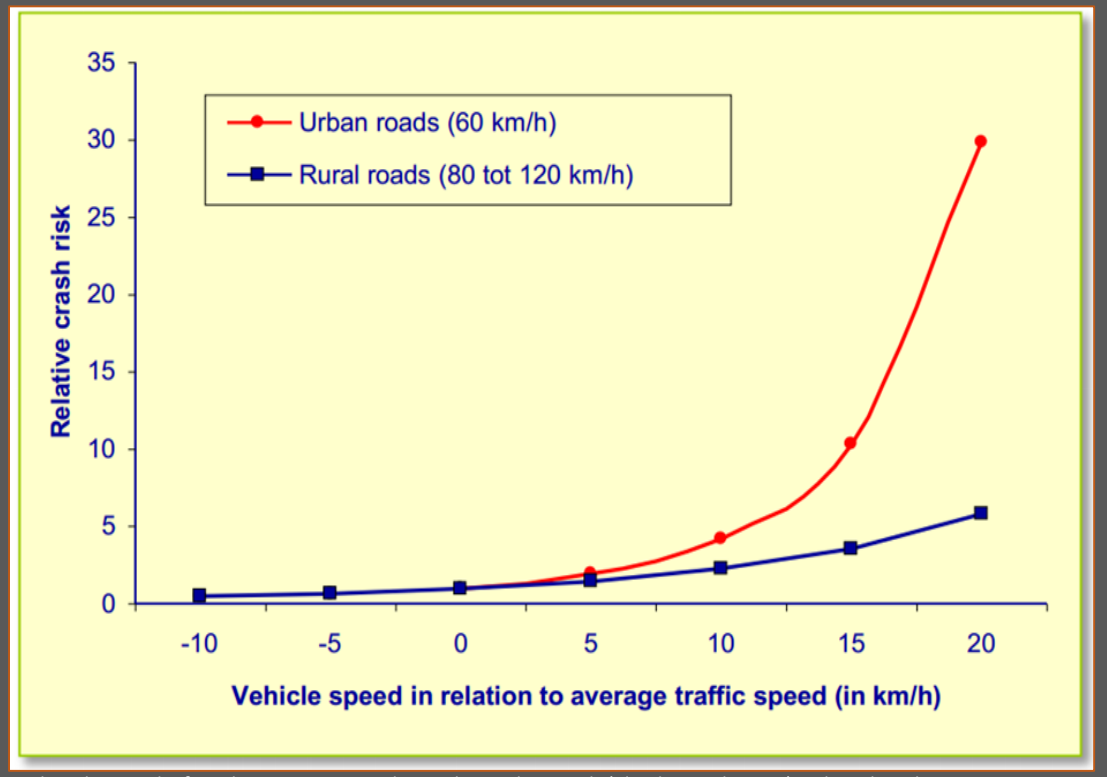
Safe System Approach



Speeding is commonplace

- **OECD**(2006)
  - 50% of drivers are exceeding the speed limit currently
- **RSA Fatal Crash Study** (2008 – 2012)
  - Speed contributed in 1 in 3 fatal crashes
- **RSA Free Speed Survey** (2012)
  - 50% exceeding the speed limit on urban roads and 22% on rural roads
  - Speeding even more prevalent among Group 2 drivers

Speeding increases crash risk



The relative risk of involvement in a casualty crash on urban roads (Kloeden et al., 2002) and rural roads (Kloeden et al., 1997; 2001) for vehicles driving faster or slower than the average speed on that road (=0 km/h deviation). (Source SWOV (2015)).

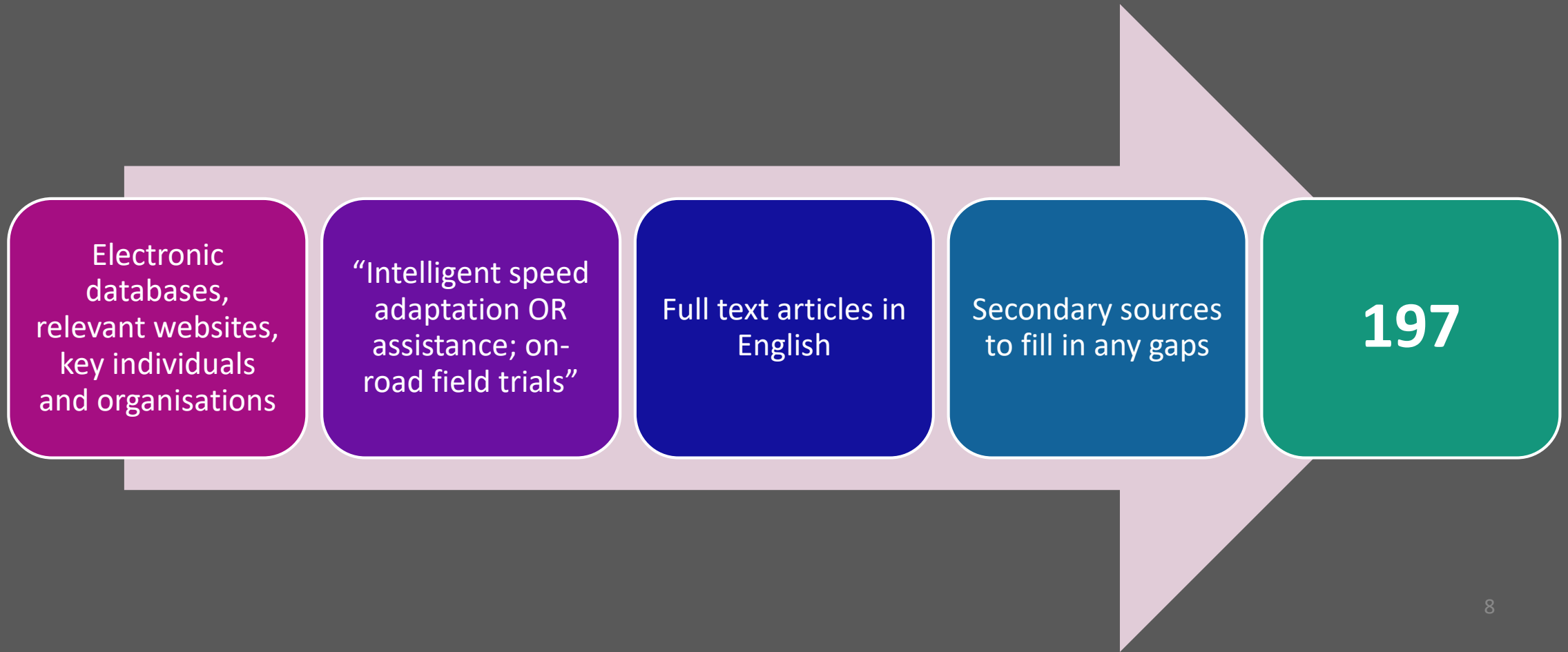
Tackling Speeding

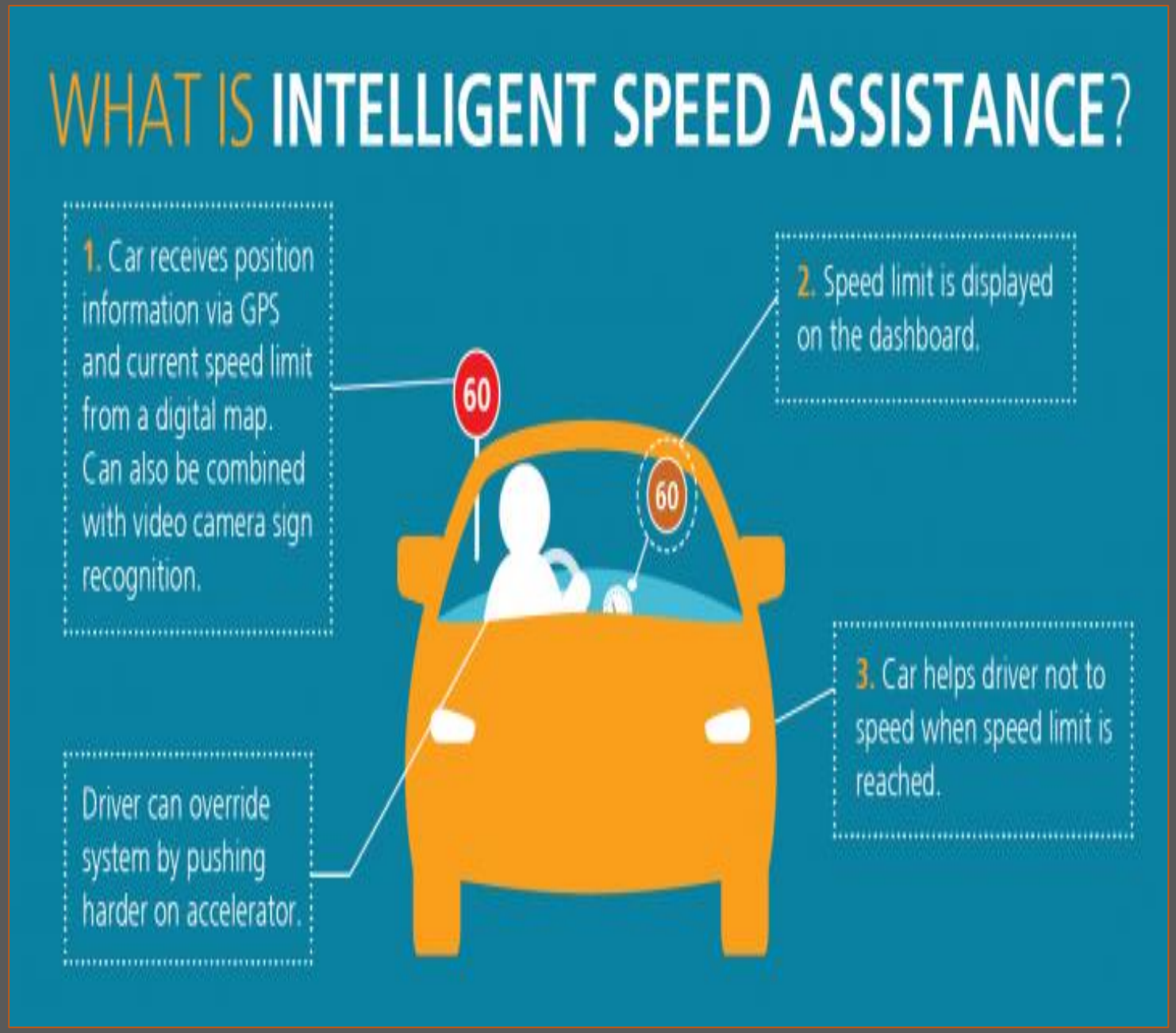
https://fevr.org/etsc-speed-report/

Key Review Themes

Impact on Safety & Driver Behaviour	User Attitudes and Acceptance	Impact on the Environment	Implementation
Crashes	**Attitudes**	**Travel time**	**Implementation scenarios**
Speed and speeding	**Acceptability**	**Fuel economy**	**Cost and benefits**
Gap acceptance / following behaviour		**Emissions**	**Barriers to implementation**
Interactions with other road users			**Policy implications**
Individual difference effects (age, gender, habitual speeding behaviours)			

Literature Search Strategy





- Basic Elements
- Speed Limit Database
- Means of determining vehicle position and direction (GPS)
- In-vehicle speed measurement system
- Comparison of actual speed with appropriate speed.

Types Intelligent Speed Assistance Technologies

Level of support	Type of feedback	Definition
Advisory/Informative	Mainly visual	The speed limit is displayed, and the driver is alerted to changes in the speed limit
Advisory/Warning (open)	Visual/auditory	The system warns the driver if he/she is exceeding the posted speed limit at a given location. The driver then decides whether to use or ignore this information to adjust his/her speed
Supportive/Intervening (half-open)	Haptic throttle/Active accelerator (moderate/low force feedback)	The driver receives force feedback via the accelerator if he/she tries to exceed the speed limit. By applying sufficient force, drivers can still exceed the speed limit
Mandatory Limiting/ Automatic control (closed)	Haptic throttle (strong force feedback) & Dead throttle	The maximum speed of the vehicle is automatically limited to the speed limit in force. Drivers' requests for a speed beyond the speed limit are simply ignored

Overview of ISA Field Trials

The outcomes from a wide range of field trials conducted in Europe, North America and Australia featured in this report

None were sufficiently large to provide empirical evidence demonstrating a reduction in crashes as a result of using ISA: Some used data modelling to predict changes in crash risk

The safety effects of ISA technologies depend on the type of ISA system used, the type of road environment and the penetration level of ISA equipment in the vehicle fleet: True effects of ISA will only emerge when a larger percentage of vehicles equipped with ISA are being used.

Overview of Key On-road Trials (n=32)

Sweden	UK	Netherlands	France	Denmark	Belgium	Spain	Finland	EU	Australia	Canada	US
Lund	EVSC	Groningen	ONSER	INFATI	Ghent	Jiménez et al., 2008	Päätalo et al., 2002	Prosper	TAC SafeCar	Speed Choice	Kalama zoo
Eslöv	ISA UK Cars & Trucks	AVV Tilburg trial	LAVIA	Pay-as-you-speed (PAYS)				Master	RTA-NSW	Safe Miles	
“Right Speed” - Borlänge	ISA UK Simulator	ISA for speed offenders							ISA Heavy Vehicles		
“Lund ISA”	ISA UK Motorcycle										
“Smart Speed" Umeå	Lancashire										
“Lidköping"	London Bus										
ISA for Stockholm											
Transtek Gothenburg											
8	**6**	**3**	**2**	**2**	**1**	**1**	**1**	**2**	**3**	**2**	**1**

Impact on Speed

Date	Study Location	Driver/Vehicles	Advisory	Supportive	Mandatory	Recording	Average	Variation	Maximum	Speeding	% spent speeding	85th Percentile
		Nos.	ISA System				Speed Choice					
	Sweden											
1993	Lund	75	√		√		↓					
1996	Eslöv	25	√		√		↓			↓		
2000-2001	"Right Speed" - Borlänge	400	√				↓	↓			↓	
2000-2001	"Lund ISA"	290		√			↓	↓				
2000-2001	"SmartSpeed" -Umeå	4000	√				↓					
2000-2001	Lidköping – Spearheading the way to vision zero"	280	√	√			↓		↓			
2004	"ISA for Stockholm"	130	√				↓			↓		
2002-2003	Gothenberg	16 busses		√						↓		
	Netherlands				√							
1998	Groningen	24	√				↓	↓				
1999	Tilburg	479			√		↓	↓		↓		
2011	ISA for serious offenders	51			√	√		↓				
2001	Finland	24			√	√	↓			↓	↓	
	Denmark											
2001	Alborg INFATI	24	√				↓					↓
2007-2009	Alborg - "Pay-as-you-Speed"	146	√			√				↓		
2002	Belgium - Ghent	37 vehicles		√			↔					
2001	France - LAVIA	100	√		√		↓					
	UK											
1997-2000	EVSC	24			√				↓			
2001-2005	ISA UK	79		√					↓		↓	↓
2010-2011	Lancashire	402	√				↓				↓	↓
2015	London Bus				√		↓				↓	
	EU											
-1998	Master	60			√	√	↓	↓				
-2006	PROSPER	64	√	√			↓	↓				↓
	Australia											
2002-2004	"TAC Safe Car"	23		√			↓	↓	↓	↓	↓	↓
2010	New South Wales "RTA-NSW"	110	√				↓				↓	↓
	North America											
2011	USA - Kalamazoo, Michigan	50	√			√	↓			↓	↓	
-2006	Speed Choice, Canada	79	√	√								
2006	Safe Miles, Canada					√				↓		

Changes in Speed / Speed Reduction

I[st] Author/Study	Location	Study Year	Vehicles/Drivers	Speed Zones (Km/h)	Mean speed change (km/h)	Speeding reduction
Advisory/Informative ISA trials						
SNRA/ Borlänge	Sweden	2000	/400	30-70	-0.6 to -2.8	10-77%
Lahrmann/INFATI	Denmark	2001	20/24	Undefined	-	5-6%
Päätalo	Finland	2001	24	40-80	-2.8	39%
Driscoll/LAVIA	France	2001	10	Undefined	-0.8	-
Brookhuis/Groningen	Netherlands	1998	/24	50-120		4%
Taylor/Ottawa	Canada	2006	20	14-100	-	13-22%
/Lancashire	UK	2011		30-70mph	- 1 to – 3	30-70%
Advisory/recording ISA involving incentives						
Lahrmann/PAYS	Denmark	2008	/146	50-130	-3.6 to -8.5	-77%*
Supportive ISA trials						
MASTER	NetherlandsSpain & Sweden	1997	64-68	30-120	+2.4 to -16.1	-
SNRA/Lund	Sweden	2001	/290	30-70	-0.8 to -2.0	20-53%
Driscoll/LAVIA	France	2001	10	30-120	-1.4 to -2.0	-
Vlassenroot/Ghent	Belgium	2002	37	30-90	+0.7 to -1.1	-
Regan/Melbourne	Australia	2003	15	60-100	-1.4	57%
Lai/ISA-UK	UK	2007	80	32-113	-0.4-3.1	2-22%
Transek/Stockholm	Sweden	2005	20/120		-	30%
Taylor/IMITA	Canada	2006	10	40-100	-	2-19%
Carsten/ISA-UK	UK	2006	79	30-100mph	n.a.**	n.a.**
Mandatory/Limiting ISA trials						
Besseling/Tilburg	Netherlands	2000	21/140	30-80	-3 to -8.3	-
Päätalo	Finland	2001	24	40-80	-3.4	74%
Carsten/EVSC	UK	1998	1/24	30-100mph	n.a.**	n.a.**

Impact on Crashes

- None large enough or long enough to measure impact on crashes directly
- Some used data modelling to predict changes in crash, injury and death rates.

Crash reduction

ISA Type	Injury Severity	Study				
		EVSC	LAVIA	ISA-UK	TAC SafeCar	Doecke & Wooley
Advisory	Fatal	18-24%	4-7%			11%
	Serious	14-18%	0-3%			8.3%
Supportive	Fatal	19-32%	3-17%	21%	9%	18.4%
	Serious	15-25%	1-11%		7%	15.6%
Mandatory	Fatal	37-59%	8-16%	46%		28.3%
	Serious	29-48%	0-9%			26.5%

Speed Zones

Speed Limit (km/H)	Advisory	Supportive	Mandatory/ Limiting
50	6.5%	19.6%	42.4%
60	2.1%	9.4%	15.8%
80	14.4%	12.3%	23.3%
100	17.3%	28.8%	35.9%
110	4.6%	12.4%	21.7%

Percentage reduction in the risk of injury crashes in Australia (SOURCE: DOECKE AND WOOLLEY, 2010)

Implementation Scenario Mandatory ISA

Crash type	Market-Driven	Authority-Driven
Slight (Minor)	4%	15%
Serious	8%	25%
Fatal	13%	30%

ISA-UK Carsten, Fowkes et al., 2008)

Impact on the Environment

Study Location	Drivers/Vehicles	Journey time	Fuel Consumption	NO_x Emissions	CO_2 Emissions
	Nos	Environment			
Sweden					
Lund	75	↑	↔	↓	↓
Eslöv	25	↑	↑	↓	↑
"Right Speed" - Borlänge	400	↔	↓		
"Lund ISA"	290	↔	↓	↓	↓
“SmartSpeed” -Umeå	4000	↔			
Lidköping – Spearheading the way to vision zero”	280	↔			
Gothenberg	16 busses	↔			
Netherlands					
Tilburg	479		↓		
Alborg - "Pay-as-you-Speed"	146	↔			
EVSC	24	↑	↓		
EU					
Master (Sweden, Spain, Netherlands) (3X20 subjects)	60	↑			
Australia					
"TAC Safe Car"	23	↔	↓		↓

Impact of Mandatory EVSC ISA system on different road networks

Network	Saturation Penetration	Travel Time	Fuel Consumption	Emissions*
Urban Peak	100%	+2.6%	-8.0%	No impact
Urban Off-Peak	100%	+6.4%	-8.5%	No impact
Rural	60%	+0.4%	-3.0%	+1%
Motorway	0%**	0%#	0%#	No impact

Implementation Scenarios: 2 approaches (RoSPA, 2016)

Market driven

- Emphasises the role of car manufacturers and consumer choices of individuals and fleet managers

Authority driven

- ISA encouraged initially and then required
  - Official support including compulsory fitment to public service vehicles, incentives from insurance companies, incentives offered to high-risk groups

Market penetration (Lai, Cartsen & Tate, 2012)

- Market driven: Advisory ISA would predominate
- Authority driven: Non-mandatory systems would be superseded by mandatory systems by mandatory systems by 2045

Relative impact on crash risk (Lai et al, 2012)

- Market Driven: Fatal crashes reduced by 13% and Serious crashes reduced by 8% -Overall -5%
- Authority Driven: Fatal crashes reduced by 30% and Serious crashes reduced by 25% - Overall -16%

Cost and benefits analyses

Comparison of the net present value of the overall benefits of an intervention to the overall costs

- A B/C threshold ≥ 3 is considered as the threshold for justifying investment in safety schemes

ISA Method accounting for GDP growth

System	Low GDP growth[a]			High GDP growth[b]		
	Fixed	Variable	Dynamic	Fixed	Variable	Dynamic
Advisory	5.0	5.3	7.0	6.9	7.2	9.6
Driver select	3.7	4.0	6.1	5.0	5.4	8.3
Mandatory	7.4	8.0	12.2	10.0	10.9	16.7

EVSC UK (Carsten & Tate, 2005)

Implementation Scenarios

Implementation Scenario	Lowest estimated BCR	Highest estimated BCR
Market-Driven	1.6	3.1
Authority Driven (2045)	2.8	5.5
Authority-Driven (2040)	3.0	5.7
Authority-Driven (2035)	3.1	5.7

ISA UK (Carsten et al., 2008)

Country	Market-Driven Scenario	Authority-Driven Scenario
Belgium	3.5	4.5
Britain	3.1	4.0
France	2.4	3.3
Netherlands	2.6	3.8
Spain	2.0	2.5
Sweden	2.5	3.4

EU-PROSPER (Cunningham & Sundberg, 2006)

User Attitudes and Acceptance

- 25% of European drivers believed ISA devices would by useful for preventing speeding (SARTRE 3 & 4)
- Majority of drivers in favour of the principle of speed limiting devices
- Support was inversely related to the amount of control over driving speed choice
- Drivers who participated in the field trials were more positive about ISA than the average driver with no direct experience with the technology
- Drivers who would benefit most from ISA are least willing to use it
  - Danger of self-selection bias if ISA introduced in a voluntary basis

Unintended consequences of ISA

Driver distraction

- **Careful consideration needed regarding ISA HMI**
  - **Differential effects on drivers**

Behavioural adaptation

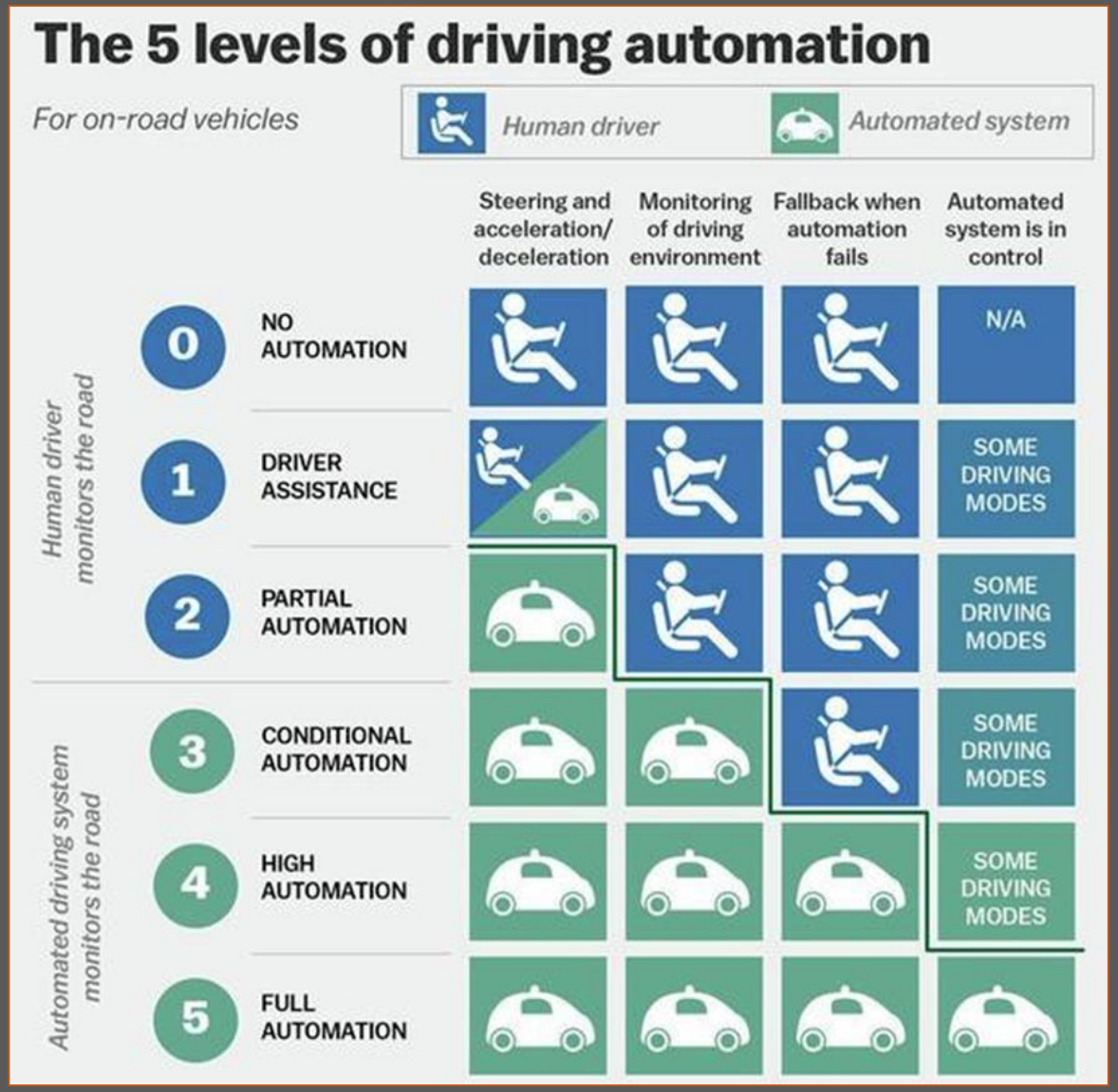
- Frustration, leading to unsafe actions and/or less safe interactions with other road users
- Driving faster on road segments where ISA is not active
- Using shorter headway and gaps when driving in traffic (risk compensation)
- Overreliance on the system to the extent that drivers neglect to monitor and/or adjust driving speeds appropriately (diffusion)
- Tendency for non-ISA users to intimidate ISA users
- Decreased effects of voluntary ISA systems on driving speed over time (habituation)

Strong support for ISA as a speed management strategy

- European Parliament
  - Mandatory provision of overridable ISA on all new vehicles from 2022
- Euro NCAP protocol (2018)
  - Active support for ISA
    - Advisory, Informative, Mandatory
- ETSC (2018)
  - This single measure could eventually reduce EU road deaths by 20%

ISA in the context of CAVs

- ISA is a Level-1 system
- Self-driving cars @ Levels 3 – 5
- Market penetration of fully autonomous cars will occur slowly
  - 15% of all new vehicles by 2030
  - 80% by 2040
- Just 26% of Irish people interested in owning a self-driving car (RSA, 2018)
- Personal control will be even more of an issue for self-driving cars

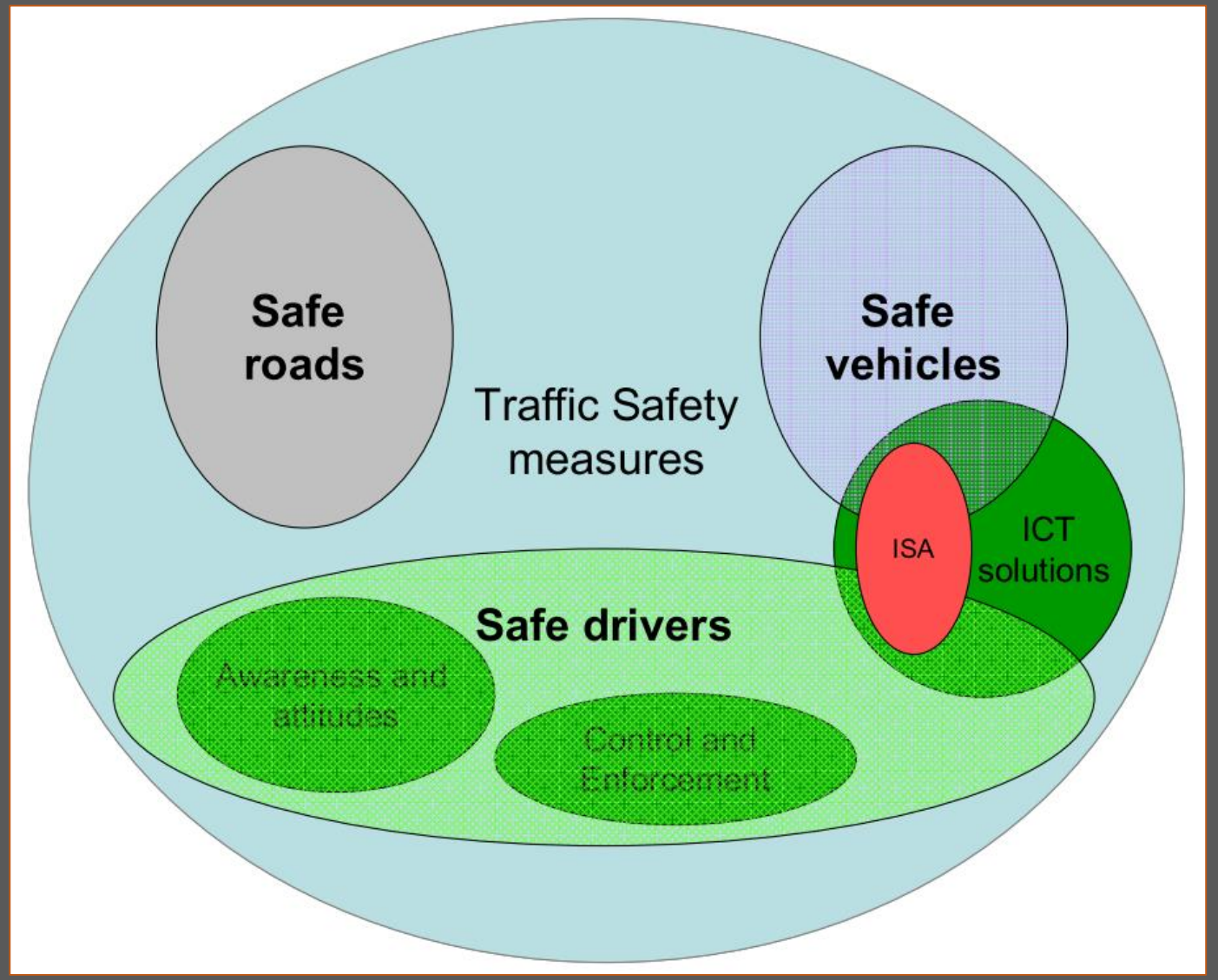


The 5 levels of driving automation. (Source: SAE https://www.sae.org/standards/content/j3016_201806/)

Conclusions & Recommendations

- ✓ISA is effective in supporting drivers with managing speed
- ✓Effective in reducing excessive and inappropriate speed
  - Improving road safety
  - Expected impact may be somewhat reduced due to behavioural adaptation
- ✓Large-scale deployment of ISA is possible in the short-term
- ✓Benefits of ISA greatly outweigh the costs
- Implementation strategy will dictate the pace of ISA proliferation
- Roll-out depends on development and testing of digital speed maps
- More public engagement required to
  - Gauge acceptance for ISA variants
  - Identify ways to encourage uptake of ISA
- ✓ISA quicker, easier and cheaper to roll-out than automated vehicles
- General reluctance to relinquish control over speed choice shown in the ISA research
  - More research needed to identify instrumental and psychological needs that are fulfilled by speeding and possible alternative ways to address these
  - Reluctance to relinquish control is likely to be an issue also with CAVs

ISA as part of a Safe System approach



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