Research **challenges and opportunities** in the study of driver **distraction by technology** use throught **naturalistic** methods

Nicole van Nes, Michiel Christoph
SWOV Institute for Road Safety Research, the Netherlands

Kristie Young, David Logan, Michael Lenne
Monash University Accident Research Centre (MUARC)

Background

Collaboration between SWOV & MUARC

Several joint projects

1 year visit

signage of MoU

SWOV
INSTITUTE FOR
ROAD SAFETY RESEARCH

Driver distraction

The relevance of driver distraction by use of in-vehicle systems

INSTITUTE FOR ROAD SAFETY RESEARCH

amount of in-vehicle and portable equipment is increasing rapidly and is expected to increase further in the (near) future

though intended to support the driver, it can also distract drivers

Important to understand the use

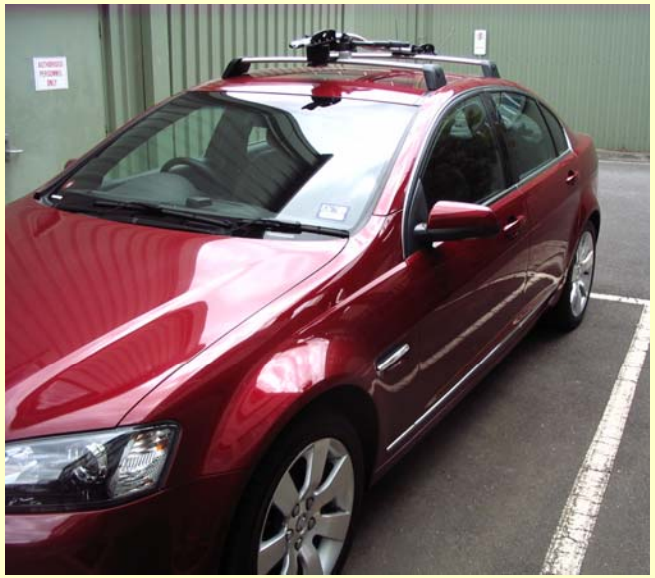
- to develop safe and supportive equipment
- to develop policy initiatives around distraction
  - Prohibit operating GPS systems while driving?
  - Both Victorian and Dutch governments

Experiences

- Previous research by SWOV
  - Survey on distraction by I-pod use
- Previous research by MUARC
  - Survey on driver distraction
  - Simulator study on driver distraction (mobile phones, in-vehicle warnings)

Instrumented Vehicles MUARC

Instrumented vehicles
developed as part of MUARC's involvement in the AutomotiveCRC



Focus of the study

Focus of the study

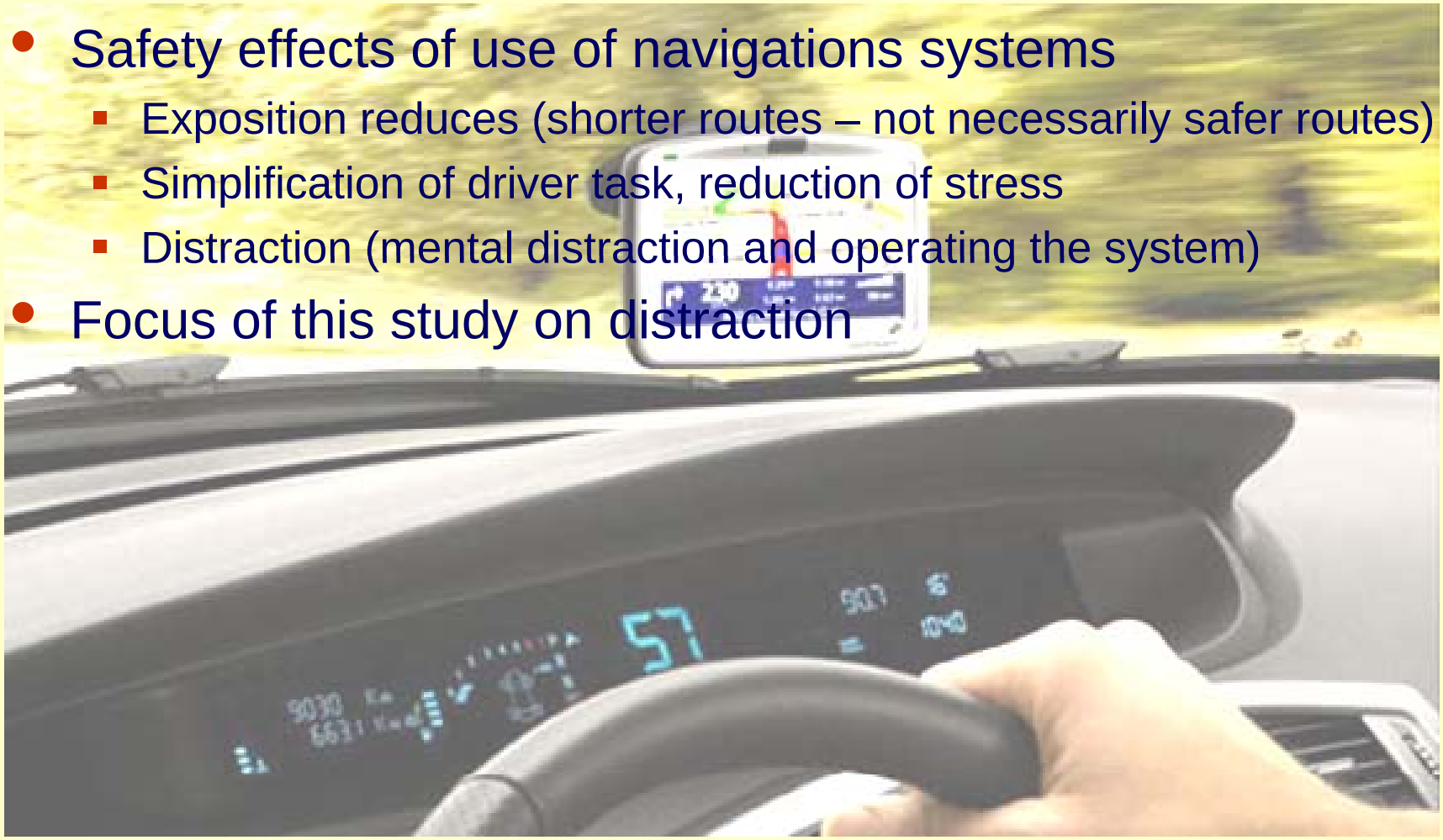
INSTITUTE FOR ROAD SAFETY RESEARCH

Navigation systems (after market)

- Driver support system and designed for in car use
- Use is rapidly increasing

Focus of the study

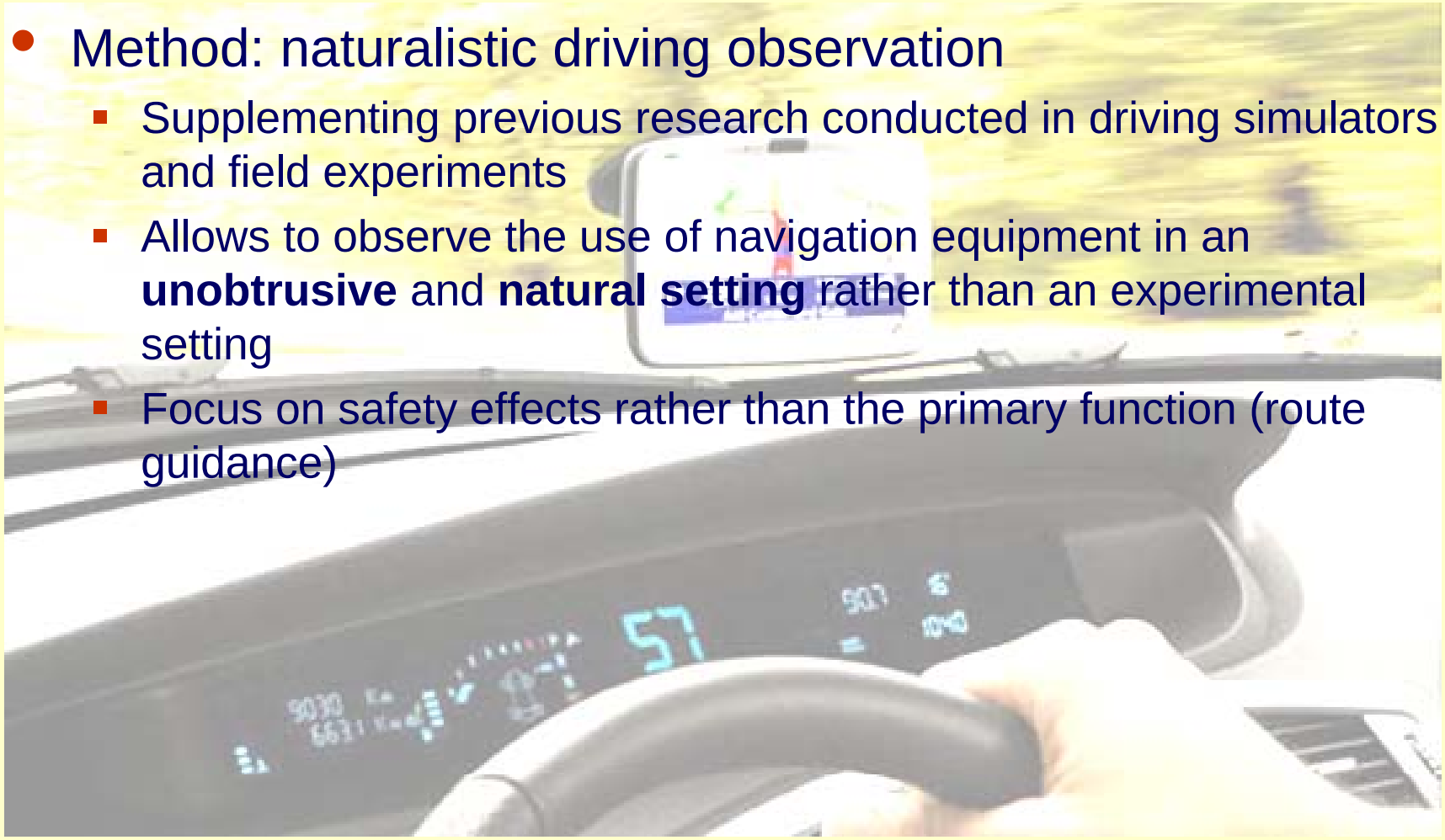
INSTITUTE FOR ROAD SAFETY RESEARCH



- Safety effects of use of navigations systems
  - Exposition reduces (shorter routes – not necessarily safer routes)
  - Simplification of driver task, reduction of stress
  - Distraction (mental distraction and operating the system)
- Focus of this study on distraction

Focus of the study

INSTITUTE FOR ROAD SAFETY RESEARCH



- Method: naturalistic driving observation
  - Supplementing previous research conducted in driving simulators and field experiments
  - Allows to observe the use of navigation equipment in an **unobtrusive** and **natural setting** rather than an experimental setting
  - Focus on safety effects rather than the primary function (route guidance)

Focus of the study

- Study design
  - **naturalistic driving** method to unobtrusively observe
  - **driver distraction** of daily use of
  - **navigation systems**

Design of the Study

- What do we want to know? → research questions
  - What to measure?
  - What to compare? (cases, situations)
  - Sample and test site selection
- What can we measure? → vehicle instrumentation
- Can we measure what we want?
- What can we analyse?
  - Data processing steps and prognoses

Research questions

INSTITUTE FOR ROAD SAFETY RESEARCH

1. What is the safety impact of distraction from use of navigation systems?
   - Physical distraction
   - Mental distraction
   - Driving behaviour

2. Is the pattern of use different for different situations?
   - Average distraction behaviour versus behaviour in relatively dangerous and relatively safe situations
   - Average distraction behaviour versus behaviour in relatively complex instruction situations and relatively simple instruction situations

3. Is the pattern of use different between the countries?

What do we want to measure?
RQ1 How to measure the safety impact?

- Safety measures for distraction:
  - Physical distraction (operating the system)
    - eyes on navigation system – frequency and duration
    - operating system manually – frequency and duration
  - Driving behaviour
    - driving speed
    - homogeneity of speed
    - steering behaviour
    - brake power/ deceleration rate
  - Mental distraction
    - situation awareness – e.g. attention for signs, other traffic
    - response time
    - listening to voice instruction

What situations to compare?

RQ2 Is the pattern of use different for different situations?

- Focus only on period of time the navigation system is in use
- Averages values for safety impacts measures over full test period

- Compare pattern of use for different situations
  - High versus low driving speed
  - More and less dangerous situations
    - More dangerous situation:
      - Eg busy intersection, weaving area, heavy traffic, rain, fog
    - Less dangerous situation:
      - Eg waiting at traffic light, waiting at traffic jam, quiet simple intersections
  - More and less complex instruction situations
    - More complex instruction situation:
      - Eg small distance between side streets, complex intersection, many side streets, main road/side street confusion
    - Less complex instruction situation :
      - Eg no instruction – going straight, few side streets

Sample and test site

- Sample size: N=10 per country
- Duration: 5 weeks
- Participant selection criteria
  - Minimum number of driving hours: 10 per week
  - Experienced user of navigation system
- Test site selection criteria
  - Representative area within the country
  - Comparable between the countries (in terms of rural/urban area)

Design of the Study

- What do we want to know? → research questions
  - What to measure?
  - What to compare? (cases, situations)
  - Sample and test site selection

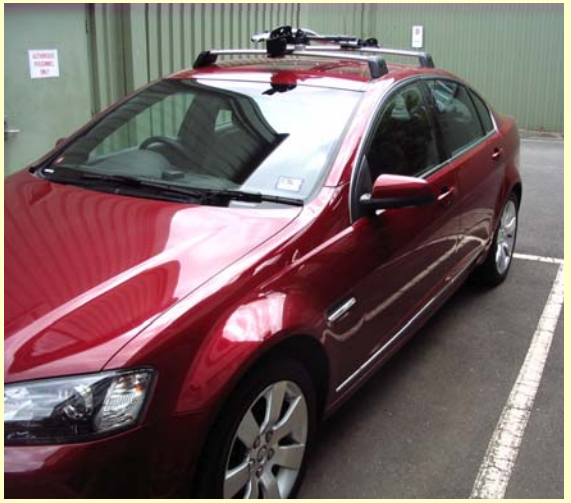
- **What can we measure? → vehicle instrumentation**

- Can we measure what we want?

- What can we analyse?
  - Data processing steps and prognoses

What can we measure?
Vehicle instrumentation

- Vehicle data is acquired from the vehicle network and includes:
  - Vehicle speed
  - GPS location
  - Accelerator and brake position, as well as vehicle lateral and longitudinal velocity and acceleration
  - Steering wheel angle
  - Secondary controls (sat-nav system, entertainment system, HVAC, etc.).
  - Lane tracking and headway logging
  - Primary controls (windscreen wipers, turn indicators, headlights, etc.)
- Eye tracking
- Cameras:
  - four exterior
  - three interior



Design of the Study

- What do we want to know? → research questions
  - What to measure?
  - What to compare? (cases, situations)
  - Sample and test site selection
- What can we measure? → vehicle instrumentation
- **Can we measure what we want?**
- What can we analyse?
  - Data processing steps and prognoses

Can we measure what we want?

INSTITUTE FOR ROAD SAFETY RESEARCH

	What we want to measure	***MUARC instrumented vehicle***
Physical distraction	eyes on navigation system – frequency and duration	Interior video on the face + Interior video on navigation device
	operating system manually – frequency and duration	Secondary controls (sat-nav system) + Interior video on navigation device
Driving behaviour	homogeneity of driving speed	Vehicle speed
	steering behaviour	Steering wheel angle + Lane tracking and headway logging
	Brake power/ deceleration rate	Accelerator and brake position, as well as vehicle lateral and longitudinal velocity and acceleration
Mental distraction	Situation awareness - attention for signs, other traffic	*Hard to measure in on road ND study, not to be measured in this study*
	Response time	*Hard to measure in on road ND study*
	listening to voice instruction	Measure sound production from navigation device
Situational condition	Different situations: more and less dangerous + more and less complex	Exterior forward facing video
	other, like location, type of road	GPS location
Other	Navigation system on or of	Interior video on navigation device

Can we measure what we want?

INSTITUTE FOR ROAD SAFETY RESEARCH

	What we want to measure	***MUARC instrumented vehicle***
Physical distraction	eyes on navigation system – frequency and duration	Interior video on the face + Interior video on navigation device
	operating system manually – frequency and duration	Secondary controls (sat-nav system) + Interior video on navigation device
Driving behaviour	homogeneity of driving speed	Vehicle speed
	steering behaviour	Steering wheel angle + Lane tracking and headway logging
	Brake power/ deceleration rate	Accelerator and brake position, as well as vehicle lateral and longitudinal velocity and acceleration
Mental distraction	Situation awareness - attention for signs, other traffic	*Hard to measure in on road ND study, not to be measured in this study*
	Response time	*Hard to measure in on road ND study*
	listening to voice instruction	Measure sound production from navigation device
Situational condition	Different situations: more and less dangerous + more and less complex	Exterior forward facing video
	other, like location, type of road	GPS location
Other	Navigation system on or of	Interior video on navigation device

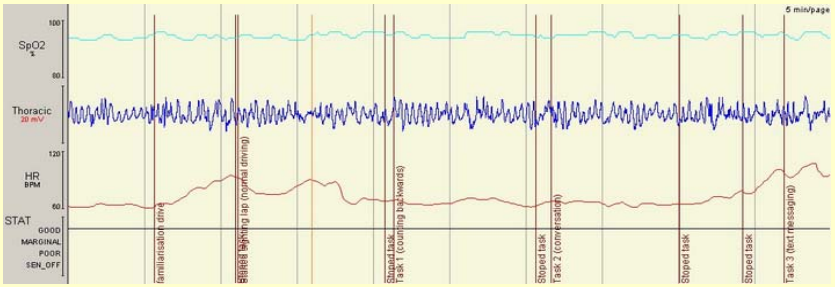
Design of the Study

- What do we want to know? → research questions
  - What to measure?
  - What to compare? (cases, situations)
  - Sample and test site selection
- What can we measure? → vehicle instrumentation
- Can we measure what we want?
- **What can we analyse?**
  - **Data processing steps and prognoses**

Steps in data analyses

- Data transfer
- Data cleaning
- Video coding ←
- Analyses

What can we analyse?



Manual video coding required

INSTITUTE FOR ROAD SAFETY RESEARCH

	What we want to measure	***MUARC instrumented vehicle***
Physical distraction	eyes on navigation system – frequency and duration	Interior video on the face + Interior video on navigation device
	operating system manually – frequency and duration	Secondary controls (sat-nav system) + Interior video on navigation device
Driving behaviour	homogeneity of driving speed	Vehicle speed
	steering behaviour	Steering wheel angle + Lane tracking and headway logging
	Brake power/ deceleration rate	Accelerator and brake position, as well as vehicle lateral and longitudinal velocity and acceleration
Mental distraction	listening to voice instruction	Measure sound production from navigation device
Situational condition	Different situations: more and less dangerous + more and less complex	Exterior forward facing video
	other, like location, type of road	GPS location
Other	Navigation system on or of	Interior video on navigation device

Manual video coding required

INSTITUTE FOR ROAD SAFETY RESEARCH

	What we want to measure	***MUARC instrumented vehicle***
Physical distraction	eyes on navigation system – frequency and duration	Interior video on the face + Interior video on navigation device
	operating system manually – frequency and duration	Secondary controls (sat-nav system) + Interior video on navigation device
Driving behaviour	homogeneity of driving speed	Vehicle speed
	steering behaviour	Steering wheel angle + Lane tracking and headway logging
	Brake power/ deceleration rate	Accelerator and brake position, as well as vehicle lateral and longitudinal velocity and acceleration
Mental distraction	listening to voice instruction	Measure sound production from navigation device
Situational condition	Different situations: more and less dangerous + more and less complex	Exterior forward facing video
	other, like location, type of road	GPS location
Other	Navigation system on or of	Interior video on navigation device

Codes

- Eyes on navigation system - frequency and duration
- Operating system manually - frequency and duration
- Different situations
- Navigation system on/off

Photo by Peter Macdiarmid/Getty

Codes for ‘Different situations’

- More and less dangerous
  - More dangerous
    - (rural/high speed): highway at weaving area, quite heavy traffic
    - (urban/low speed): urban intersection, other traffic, no signalization
  - Less dangerous
    - (rural/high speed): traffic jam at highway
    - (urban/low speed): urban intersection, waiting for traffic light

- More and less complex instructio
  - More complex
    - (rural/high speed): highway at w highways
    - (urban/low speed): urban interse close after each other – have to
  - Less complex
    - (rural/high speed): highway at w
    - (urban/low speed): urban interse side street – have to make left t

Photo by Peter Macdiarmid/Getty

Expected hours of video data

Expected hours of video data	1000
vehicles	10
hours per week	10
weeks	5
hours per country	*500*

Estimated time for video coding

INSTITUTE FOR ROAD SAFETY RESEARCH

Total video data: 1000 hour	***time required per hour video (hour)***	**time required for analyses of all video data (hour)**	**remarks and assumptions**
Data Coding	*3*	3000	depends on ease of event selection, not all data needs to be viewed
Coding Quality	*0,3*	300	10 % of the data double coding required for consistency between coders
Video viewing during analyses	*0,1*	100	5 % of the video time needs manual viewing during analyses, each of this fragments is viewed twice on average
		3400	**hour**
		26,6	**MM**
		2,2	**fte**

Manual video coding is very labour intensive !

Challenge: reduce video coding time!

INSTITUTE FOR ROAD SAFETY RESEARCH

- Smart technology
  - Automatic video coding
  - Use of sensors
- Investment in smart technology is earned back by reduction of coding time
- Focussed research questions

Challenge: reduce video coding

INSTITUTE FOR ROAD SAFETY RESEARCH

Smart technology for this study

- Navigation system on/off
  - Automatic coding for navigation device on/off
    - Expected reduction 50%
- Eyes on navigation system - frequency and duration
  - Automatic eye movement detection without calibration
    - Reduces coding + increases validity of coding
- Operating system manually - frequency and duration
  - Automatic coding for operating navigation system
- Different situations
  - Recording sound from navigation + automatic detection of navigation instructions, e.g. left turn
    - Mental distraction
    - Recognition of intersections
    - Recognition of manoeuvres, e.g. turn left, turn right

Research questions

- Focus on automatic measures as much as possible
- Limit number of situations: e.g. pp 10 of each situation

New estimation for video analyses time

INSTITUTE FOR ROAD SAFETY RESEARCH

Total video data: 500 hour	***time required per hour video (hour)***	**time required for analyses of all video data (hour)**	**remarks and assumptions**
Data Coding	*3*	1500	depends on ease of event selection, not all data needs to be viewed
Coding Quality	*0,3*	150	10 % of the data double coding required for consistency between coders
Video viewing during analyses	*0,1*	100	5 % of the video time needs manual viewing during analyses, each of this fragments is viewed twice on average
		1750	**hour**
		13,7	**MM**
		1,1	**fte**

Timelines

preparation of field study	M 1	M 2	M 3	M 4	M 5	M 6	M 7	M 8	M 9	M 10	M 11	M 12	M 13	M 14	M 15	M 16	M 17	M 18	M 19	M 20	M 21	M 22	M 23	M 24	M 25	M 26	M 27
final definition of research questions																											
final definition of measures																											
definition of video coding required																											
define equipment																											
purchase and develop equipment																											
equipment ready to test																											
test equipment and install for pilot																											
test software (coding)																											
field study																											
setup, pilot, subjects																											
data gathering																											
data transfer and data cleaning																											
data coding																											
data analyses																											
reporting																											

Conclusions

Challenges
the study design

INSTITUTE FOR ROAD SAFETY RESEARCH

BE AMBITIOUS IN THE TECHNOLOGY

- Reduce manual video coding
  - Try to make use of automatic coding as much as possible
  - Investment in technology is earned back by reduction of coding time
- Estimate coding time

BE FOCUSSED IN RESEARCH QUESTIONS

- Limit need for manual video coding

Opportunities
expected findings

- driver distraction
  - Natural patterns of use of navigation devices
  - Patterns of use for different situations (driving speed, more and less dangerous situations + more and less complex situations)
  - Patterns of use for different countries
- directions for safe design of navigation systems
  - Increased understanding of daily use and miss-use
  - Importance of clear (voice) instructions, overall and in different situations
- policy initiatives and other countermeasures
  - Increased understanding of safety effects of current pattern of use
  - Need to prohibit or to take other measures

INSTITUTE FOR
ROAD SAFETY RESEARCH

INSTITUTE FOR
ROAD SAFETY RESEARCH