Field Operational Test of Intelligent Speed Adaptation, Following Distance Warning and Seatbelt Reminder Systems: Methods, Findings and Lessons Learnt from the Australian TAC SafeCar Project

Michael Regan, PhD
Research Director
French National Institute for Transport and Safety Research (INRETS)

Adjunct Professor
Chalmers University of Technology, Sweden

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TAC SafeCar Project

- First Australian FOT of Advanced Driver Assistance Systems (ADAS)
- Started June 1999; finished August 2005
- 3 main project partners:
  - Transport Accident Commission of Victoria (TAC)
  - Monash University Accident Research Centre
  - Ford Motor Company of Australia
All Partners

• Key Partners
  – MUARC (Project Manager)
  – Transport Accident Commission
  – Ford Australia

• Government/Industry Partners
  – Autoliv
  – Barker Technic
  – Bosch
  – OzTrak
  – Royal Automobile Club of Victoria
  – VicRoads
  – Digital Device Development Group
  – Intelematics
  – PC Host
  – Wiltronics Research
  – Victoria Police
MUARC Researchers

- A/Prof Michael A. Regan
- Prof Tom J. Triggs
- Kristie L. Young
- Nebojsa Tomasevic
- Eve Mitsopoulos
- Karen Stephan
- Prof Claes Tingvall (then Director MUARC)
Location: Melbourne
Aims

- evaluate technical operation of three ADAS technologies – ISA, FDW and SBR
- evaluate driver attitudes to and acceptance of these technologies
- determine impact of technologies on driving performance - separately and together
- estimate safety and other benefits
- ultimately, stimulate demand in Australia for ADAS
Phase 1. Identification of candidate ADAS technologies likely to have large safety benefits.

Phase 2. Fitment and pilot testing of ADAS technologies identified in Phase 1 to two pilot vehicles.

Phase 3. Equip 15 Ford passenger cars with Intelligent Speed Adaptation, Following Distance Warning, and Seatbelt Reminder systems.

Phase 4. Run FOT and complementary simulator study (on ISA effectiveness)
Final Reports


Available: www.monash.edu.au/muarc/reports/rpts06.html


• Young, K. L., Regan, M.A., Triggs, T.J., and Jontof-Hutter, K. (2009). Intelligent Speed Adaptation: Effects on experienced and inexperienced drivers’ behaviour and acceptability. *(Accident Analysis and Prevention; accepted with revision)*

The “FOT Chain”

MONASH University
Accident Research Centre

Function Identification and Description
Use Cases
Research Questions and Hypotheses
Measures and Sensors
Study Design
Performance Indicators

WP2.1
WP2.3
WP2.5
WP3, WP4, WP5
WP6.3
WP2.4
WP2.6

Socio-Economic Impact Assessment
System and Function Analysis
Research Question and Hypotheses Analysis

Data Decoding
Data Acquisition
Data Analysis

Ethical and Legal Issues

Database

WP3, WP4, WP5

Implementation Plan

Research Question and Hypotheses Analysis
Vehicles

- 23 Ford passenger cars – “SafeCars”:
  - 15 treatment vehicles
  - 8 control vehicles
- leased by 9 corporate car fleets from in and around Melbourne
Intelligent Speed Adaptation

- Following Distance Warning + audio warning
- Seat Belt Reminder + audio warning
- Reverse Collision Warning audio warning
- ISA + upward accelerator pressure
Following Distance Warning

- Following Distance Warning
  + audio warning

- Seat Belt Reminder
  + audio warning

- ISA
  + upward accelerator pressure

- Reverse Collision Warning
  audio warning
Seat Belt Reminder

Following Distance Warning

+ audio warning

ISA

+ upward accelerator pressure

Reverse Collision Warning

+ audio warning

Seat Belt Reminder
Support Systems

- Log In/Log Out system with I-button
- System Override Button
- Master Pushbutton – “if you’re not the designated driver, press the flashing button”
- Message Priority System – used ISO standard
- Data Logging System
- Visual Display
- Master Volume Control
Hypotheses

- Tested 24 hypotheses:
  - Baseline driving behaviour (systems off)
  - ISA
  - FDW
  - SBR
  - System interactions
Driver Characteristics

(Independent variables/co-variates)

- Age, gender, education, experience, driving record, impairments
- Travel patterns
- Driver Behaviour (DBQ)
- Vehicle Purchase Criteria
- Experience with technology
- Awareness of Road Safety issues
- Attitudes towards ITS technologies
- Attitudes towards road safety measures
Performance Indicators (ISA)

- Mean speed
- Speed distribution
- 85th percentile speed
- Maximum speed per trip
- Median speed
- SD speed
- Percentage of time the treatment drivers spent driving at 2, 5 and 10 km/h or more above the speed limit
- Percentage of time the treatment drivers spent driving at 2, 5 and 10 km/h or more above the speed limit
- Mean travel time per trip
- Risky driving episode
- Percentage of time and distance spent in each speed zone (50, 60, 70, 80 and 100 km/h)

- NB (constrained and free flow speeds were measured)
Performance Indicators (FDW)

- Mean time headway
- Percentage of total driving time spent at each of three pre-selected time headways
- Mean minimum time headway reached per trip
- Number and duration of level 6 FDW warnings
Performance Indicators (SBR)

- Percentage of trips undertaken when seatbelt unbuckled
- Percentage Total Driving Distance Spent Unbuckled
- Mean time (in seconds) taken to fasten seatbelt in response to the Stage 1 SBR warnings
- Percentage of times occupant buckled up in response to the Stage 1 and Stage 2 SBR warnings
- Average speed reached before buckling up
- Average peak speed reached before buckling up
- Proportion of time spent driving at dangerous speeds (40 km/h and over) while occupant was unbuckled
Performance Indicators
(acceptance and workload)

- Perceived usefulness
- Perceived effectiveness
- Usability
- Affordability
- Perceived social acceptability
- Subjective mental workload
Situational Variables

- Day/Night
- Time
- Speed Zone
- Driving period (before, during, after)
Study Design

• Mixed experimental design:
  – Within groups: driving behaviour compared before, during and after system use
  – Between groups: driving behaviour compared between treatment and control subjects in equivalent before, during and after periods
Participants

• **Treatment Group:**
  - 14 males & 1 female
  - Mean age: 43.7 yrs (SD= 8.5)

• **Control Group:**
  - 7 males & 1 female
  - Mean age: 44.5 yrs (SD= 9.23)
Phase 4 FOT: Design

- 15 Treatment participants each drove car for 16,500 km
- exposed to all 3 ADAS – ISA, FDW and SBR
Phase 4 FOT: Design

- 8 Control participants
- exposed to SBR only
Total Driving Exposure

• Each driver (treatment and control):
  – 16,500 kms
  – approx 5 months

• All drivers:
  – 379,500 km with SBR
  – 90,000 km with ISA
  – 90,000 km with FDW
Procedure

- Allocation to treatment or control group
- Briefing and training session
- System refresher (booklet)
- Complete Questionnaires at Baseline, Before 2, During 1, After 1, During 2, After 2, After 3, End of study
- Monitor participant progress (hotline)
- Exit interview
Data Acquisition

- custom-built data logger
- recorded data from the CAN bus and other sensors (GPS, radar)
- sampling rate - 5Hz for speed, braking status, time headway
- all other measures - 1 Hz
- logged data stored on flash memory cards
- downloaded manually, once a month
- subjective data collected via questionnaires and driver interviews
Measures

- date
- time
- milliseconds since startup
- login
- system state
- configuration
- no. km travelled
- user ID
- GPS latitude
- GPS long
- GPS speed
- Speed (odometer)
- braking status
- wiper status
- headlight status
- current speed limit
- speed warning status
- speed request button status
- time headway
- following distance warning system status
- seatbelt warning system status
- system override status
- reverse collision warning system status
- system shutdown status
- turn indicator status.
Data Analysis
(Logged Data)

- Treatment subjects – before, during after system exposure
  - Series of planned comparisons and one-way repeated measures
- Treatment versus controls – before, during and after system exposure (equivalent intervals)
  - Series of 2- and 3-way mixed model ANOVAs
- Alpha = 0.05 for all analyses
- Socio-economic Impact Assessment:
  - Fuel consumption
  - Emission Volumes
  - Crash reduction benefits
Data Analysis

(Questionnaire Data)

• Comparison of questionnaire ratings for treatment and control groups, prior to the treatment group using the ISA, FDW and SBR systems.

• Comparison of questionnaire ratings for treatment and control groups over time (ie in equivalent before, during and after periods).

• Used parametric (Wilcoxon and Friedman) and non-parametric statistics (Mann-Whitney)
Results - ISA

- Mean speed reduced by up to 1.5 km/h
- 85\textsuperscript{th} percentile speed reduced by up to 2.7 km/h
- Maximum speed per trip reduced by up to 2.6 km/h
- Speed variability reduced by 1.1 km/h
- Spent 64\% less time travelling 5km/h or more over speed limit
Results - ISA

• Corresponding reductions in the control drivers’ speed were not found.
• ISA more effective at reducing speed when used in combination with FDW.
• Speeds increased again after ISA was turned off, indicating that speed reduction benefit of ISA is only obtained while ISA active.
• FDW alone did not affect speed.
• ISA did not increase trip time.
Results – Following Distance

• Mean time headway increased by up to 0.13 secs, in most speed zones.
• Up to 40 percent reduction in amount of time spent at time headways below 1.1 secs.
• Increase in minimum time headway reached per trip (up to 0.15 secs).
• Time headway variability reduced.
Results – FDW

- Corresponding reductions in control drivers’ following behaviour were not found.
- FDW no more effective at increasing time headway when used in combination with ISA.
- Time headway decreased again after FDW was turned off.
- ISA alone did not affect time headway.
Results – SBR

- 48% reduction in percentage of trips where occupant unbuckled at any time
- 96% reduction in the percentage of driving distance spent unbuckled
- 77% reduction in the time taken to buckle up
- 20% reduction in peak speed reached per trip prior to buckling up
- Almost 100% reduction in time spent driving unbuckled at speeds above 40 km/hr
Estimated Crash & Injury Cost Reductions

**ISA** – Nilsson Power Model
- 8% reduction in fatal crashes (ISA alone)
- 6% in injury crashes (ISA alone)
- 9% reduction in fatal crashes (ISA and FDW)
- 7% reduction in injury crashes (ISA and FDW)

**FDW**
- 34% reduction in amount of time spent in ‘rear-end collision mode’ (FDW alone)

**SBR - HARM**
- Saving of $335 million per year in injury costs
Fuel Consumption & Emission Volumes

- **Fuel Consumption**: No. litres of fuel used per 100km travelled.
- ISA and FDW reduced fuel consumption in 80 km/h zones only.
- ISA and FDW reduced Carbon Dioxide emissions in 80 km/h zones only.
- ISA and FDW reduced Nitrogen Oxide & Hydrocarbon emissions in 60 and 80 km/h zones.
Driver Feedback

- FDW – about half would keep it; no perceived reduction in workload; some frustration with nuisance alarms, most considered system more effective than originally thought.
- ISA - vast majority would keep it; no perceived reduction in workload; necessary in all but 50 km/hr zones; minority considered system less effective than originally thought.
- SBR – vast majority would keep it; reduced workload; fantastic for passengers; not useful when reversing; considered no more or less effective than originally thought.
All systems – not considered to be distracting; lose trust if system issues false warnings/doesn’t give warnings when it should; systems not too controlling.
Conclusions

• ISA, FDW and SBR all appear to have a positive effect on driving behaviour.

• ISA reduces average speeds and speed variability, but has little or no effect on trip times.

• The speed reduction effects of ISA were obtained only while ISA active and also appear more pronounced when ISA used in conjunction with FDW.

• The FDW system is effective in making drivers spend less time at shorter time headways.

• The SBR system is effective in decreasing the percentage of unbelted trips driven, the percentage of total driving time spent unbelted, and time taken to buckle up in response to SBR warnings.
Lessons Learnt

Activity 1: Convene teams/people
- don’t let sponsor co-manage FOT – complicated, timely and costly
- Choose contractors with backup
- Keep steering committee in the loop
- Over-resource rather than under-resource

Activity 2: Aims, objectives, research questions etc
- Talk a lot with people who have run FOTs

Activity 3: Develop project management plan
- Budget more money and time than you think necessary
- Bring on side those who can’t see the point of FOTs
Lessons Learnt

Activity 4: Stakeholder communication
- We underestimated media interest
- Didn’t anticipate requests for early data

Activity 5: study design
- Didn’t anticipate cut in project size
- Too many questionnaires
- Keep questionnaires simple, and relatable to logged data

Activity 7: select/obtain vehicles
- Much easier to use production systems in production vehicles
Lessons Learnt

Activity 8: obtain systems and functions
- Selecting, sourcing and procuring systems very time consuming

Activity 9: Data collection and transfer
- Too much driver involvement eg flash cards
- Not enough computer grunt for boot up and system operation
- Not enough spare parts in stock

Activity 11: Equip vehicles with technologies
- Not all systems operate identically across vehicles
Lessons Learnt

Activity 12: Driver feedback systems
- Fuel dockets – terrible problem

Activity 13: Data storage and management
- Didn’t decide early what to do with post-project data

Activity 14: Acceptance testing
- Lots of flat batteries
- Corrupted flash memory cards over time

Activity 15: Recruitment strategy
- Company drivers a nightmare to recruit and keep
- Women MUCH harder to recruit than men
- Hard to adhere to ethics requirements for company drivers
Lessons Learnt

Activity 16: develop driver training and briefing materials
- Very time consuming!!

Activity 17: Pilot testing
- Not long enough to reveal some problems

Activity 18: Run FOT
- Don’t assume that systems are working and recording data
- Drivers need regular reminding and follow up if you want them to do things for you
Lessons Learnt

Activity 18: Run FOT
- Automate subjective data collection if possible eg use internet

Activity 19: Data Analysis
- Run reality checks on data regularly to ensure they are “clean”
- Sponsors may want supplementary analyses done

Activity 20: Write minutes and reports
- Don’t allow sponsor review of final deliverables to drag out
Lessons Learnt

Activity 21: Disseminate Findings
- Sponsor delayed dissemination
- No funding left for major EC-style workshop

Activity 22: Decommission FOT
- Lost momentum at end – took a while to implement recommendations. Not enough lobbying.
Conclusion

- FOT was ahead of its time in Australia
- Plenty of ISA activity now in Australia
- Most new Australian cars now equipped with SBRs
- ISA high on Australian political agenda, and society now ready for it
THE END

Contact:

michael.regan@inrets.fr