Automated Vehicles: Human Factors Challenges and Solutions


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Overview

- Vehicle Automation
- Human factors challenges and opportunities
- Conclusions

Definition

"Automated vehicles are those in which at least some aspects of a safety-critical control function (e.g., steering, throttle, or braking) occur without direct driver input. "

(NHTSA Preliminary Statement of Policy Concerning Automated Vehicles, p. 3)

Levels of Automation (NHTSA)

- Level 0: No Automation
  - Driver in complete control of primary controls (brake, steering, throttle) at all times
  - Driver solely responsible for monitoring roadway and safe operation of controls.
  - Includes vehicles with warnings systems (eg FCW, LDW) and V2V technology that supports warnings

Levels of Automation (NHTSA)

- Level 1: Function-Specific Automation
  - Driver can give limited authority to a primary control (eg ACC)
  - Vehicle can automatically assume limited authority over a primary control (eg electronic stability control)

Levels of Automation (NHTSA)

- Level 2: Combined Function Automation
  - Automation of at least two primary control functions working together (eg ACC and lane keeping assist)

Levels of Automation (NHTSA)

Level 3: Limited Self Driving Automation

- Driver may concede full control of all safety-critical functions under certain traffic or environmental conditions
- Driver IS expected to be available for occasional control, but with sufficiently comfortable transition time.
- Driver not expected to constantly monitor the road way while driving

Levels of Automation (NHTSA)

Level 4: Self Driving Automation

- Vehicle designed to perform all safety-critical driving functions and monitor roadway conditions for an entire trip
- Driver provides destination or navigation input, but is not expected to be available for control at any time during the trip

Status Quo

- “driverless” cars being tested by Google, Volvo, GM, Audi, Toyota and others
- Level 3 systems in early stages of development (eg Google Car)
- Level 2 and 3 systems require a human in driver’s seat and expect the driver to assume control at when limits of automation requires support

Main HF Challenge

- As long as driver has some expectation of shared authority, automation must be designed so that driver fully understands the capabilities and limitations of the vehicle and maintains full awareness of what the vehicle is doing and when intervention might be needed.
- Failure to do so may lead to crashes that are both automation and driver induced

(Cummings and Ryan, 2014)

Google’s Driverless Car

Google Car

- Travelled around 300,000 miles
- Two reported accidents
- One on road unmapped – automation brittleness

The Driving Task

Complex, multi-task, activity which involves:

- Route finding
- Route following
- Velocity control
- Avoiding collisions
- Complying with rules
- Vehicle monitoring (eg speedo, tacho, distance driven)

(Brown, 1986)

Shared Authority

- Drivers will need to take over control when system limits are reached.
- Take over process involves several processes: take over request; transition time (RT, take over, manual driving)
- Challenge: how to re-engage the driver in manual driving in a way that reduces take over time and maximises take over quality and safety
- Although vehicles might be capable of self-driving, driver might choose to want to drive and play a role in avoiding crashes

Redundancy

- How rubust are driverless cars to system failures (including human failures) and operations in degraded sensor environments?
- (Cummings and Ryan, 2014)

Situation Awareness

- Drivers will need to be appropriately informed of the state of the system, including limitations
- Surprises can occur when a system behaves in unexpected ways.
- Caused by incorrect observation of system status or poor understanding of system capabilities.
- Drivers (and other road users) must not be surprised by automation.

Trust

- Drivers will need to be appropriately informed of the state of the system, including limitations
- If automation is perceived to be reliable and useful, drivers will rely on it heavily and stop utilising their own skills

Risk Homeostatis

Automation may lead to "risk homeostasis" – drivers begin to accept more risk as they perceive automation to be more capable

(Cummings and Ryan, 2014)

Boredom and Distraction

- Automated systems can lead to boredom, which can lead to distraction
- Driver distraction leaves driver:
  - unaware of state of the vehicle ("mode confusion") – makes decisions believing the system is in a different state than it is in.
  - ill prepared to respond quickly and provide vehicle with assistance at precisely the time it needs it

(Cummings and Ryan, 2014)

Acceptance

- Acceptance - If the automation is unacceptable (unreliable or not useful), driver may refuse to use it, and it will have no benefit.
- What do Australian drivers think about the Google car? Do they understand its limitations? Would they buy one? If they did, what would they want to do in it? What about Level 4 vehicles?

Training and Licensing

- Training programs need to develop a different repertoire of skills brought about by changes to the driving task brought about by automation
- What licensing requirements are required for the operation of Level 3/4 vehicles?

Interoperability

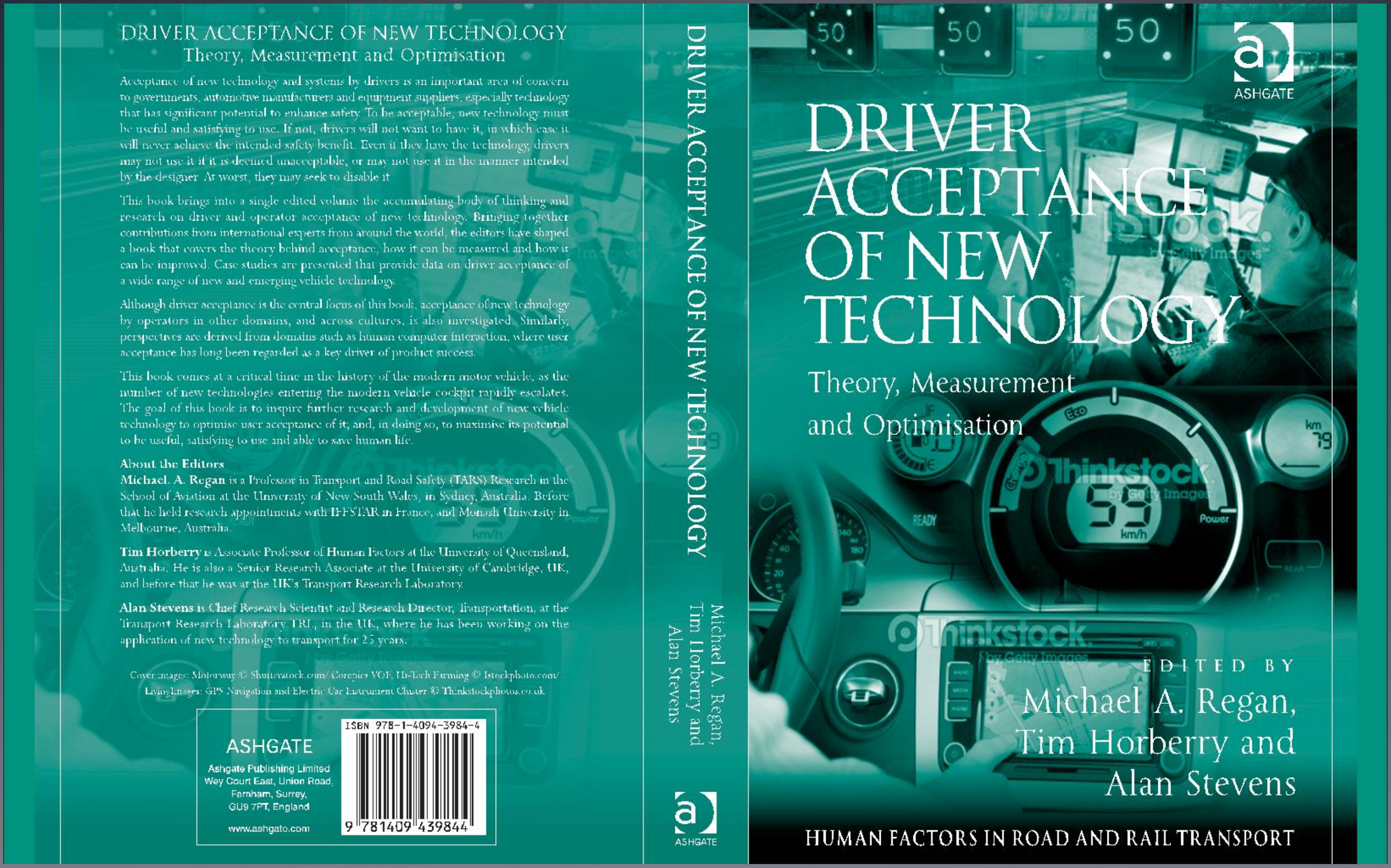
- Drivers change vehicles and different vehicles interact with each other on roads.
- Automation should behave consistently so as not to violate driver and road user expectations
- Automation controls and displays should be uniform across vehicles.

(Burns, 2014)

Misuse and Abuse

- People will dream up unanticipated ways to use their automated vehicle, operating it outside of design parameters
- “Negative behavioural adaptation” may encourage drivers to, for example, drive to the system rather than to prevailing conditions eg cruise control around corners

Shameless Promotion



System Capabilities and Limitations

- Drivers must understand the capabilities and limitations of the automated systems they interact with.
- If not, they may overestimate system capabilities, fail to appreciate system limitations, ignore the system when it issues correct advice etc
- Eg driver hits a child when reversing because s/he relies on a reverse warning system that is not capable of detecting children at rear

Risk Exposure Change

- New technologies can change drivers’ travel patterns and, hence, exposure to risk.
- Satellite navigations systems, for example, can encourage people to take more trips to more unfamiliar locations
- This may be problematic for some user groups (eg the elderly)
- It’s a largely unexplored issue for most automated systems

Individual Differences and Preferences

- Vehicle manufacturers will want to design automation to cater for individual differences and preferences
- Should drivers be allowed to personalise automation to accommodate their own tolerances?
- Catering for individual differences and preferences for automation without compromising safety will be a great challenge for the HF community

Design Challenges

- The challenge is to provide appropriate feedback to the driver on their performance and the performance of the automation.

- Automation should be capable of describing its performance and limitations to the driver.

- Automation should be able to sense when driver is performing poorly, or even dangerously, so it can support driver or take over control.

(Cummings and Ryan, 2014)

Philosophical and Moral Issues

- Should machines be allowed to take the life of a human under any circumstances?
- (Cummings and Ryan, 2014)
- Are philosophers working with designers to solve moral dillemmas like "do I run over the baby or swerve the car to avoid the baby but in doing so hit a tree that could kill me"?

Steven M. Johnson, New York Times, 2013

Societal Issues

- Manufacturers providing documentation describing how these issues are being addressed through design and evaluation?
- These issues lie outside typical tests performed by regulatory bodies in assessing safety.
- Until such issues have been addressed through Independent human-in-the loop testing with representative user populations, should regard these vehicles as experimental.

Cummings and Ryan, 2014)

The HF Verdict

- Until tests show that “driverless” vehicles account for these issues, the cars will not be safe for unrestricted access on public roads

(Cummings and Ryan, 2014)

Occupant Protection Challenges for Automation

Minor changes in occupant position can have a significant impact on their interaction with safety systems.

- Keep occupants in position
- Protect out-of-position occupants, otherwise…
- Perfect reliability and have failsafe automation.

(Burns, 2014)

Human Factors Research Needs - TRB

TRB Automation Workshop (TRB, 2013) identified 4 top human factors research priorities (in order):

1. How do we re-engage the driver in manual driving?
2. What should the user interface contain to convey limitations?
3. What kind of misuse will occur and does automation need to monitor the driver to address this?
4. Should drivers be allowed to personalize automation to accommodate their own tolerances?

Human Factors Research Needs – NHTSA

- “developing requirements for the driver-vehicle interface (DVI) such that drivers can safely transition between automated and non-automated vehicle operation and that any additional information relevant to the safe operation of the vehicle is effectively communicated to the driver.”

Human Factors Research

Topics – NHTSA

- Ensuring proper allocation of vehicle control functions between the driver and the vehicle:
  - Division of labor and control authority – assuring that either the driver and/or vehicle are in control all the time
  - Transitions – investigating appropriate means of transferring control from driver to vehicle and vice versa
  - Driver/vehicle interaction – Evaluating communication methods between driver and vehicle to ensure safe vehicle operation

Human Factors Research

Topics – NHTSA

- Override - evaluating override requirements such that the driver can always, or when appropriate, override the automated system and regain control

Human Factors Research

Topics – NHTSA

- Driver acceptance – Factors leading to driver acceptance (false alarm rates, nuisance warnings, automation system availability and reliability)
- Driver training – Evaluating training requirements that may be needed for level 2 and 3 systems
- Developing human factors research tools – Developing the appropriate test and evaluation tools (e.g. simulators, test vehicles, etc.) to evaluate driver and system performance for various automated vehicle concepts

Human-Centred Design of Automated Vehicles: General Principles

- Controls should be easy to access /activate quickly and difficult to activate inadvertently.
- Status of automation should be clearly visible to drivers at all times.
- Drivers must have a clear understanding of system capabilities and limitations and have appropriate trust - *proper instructions, driver training, supporting materials and accurate marketing are essential.*
- Identify potential unsafe side effects of automation and design for foreseeable misuse.
- Automated vehicles should encourage regular manual driving to maintain driver skill and enjoyment.
- Establish standards for consistent ‘look and feel’ to limit interoperability issues.
- (Burns, 2014)

Conclusion

- Automated vehicles will enhance the safety, enjoyment and amenity of driving
- User-centred design of automation will be critical for the success of these technologies
- There is a lot we can be doing in Australia community to support the international human factors effort.
- The "Driverless Vehicle Initiative", led by ARRB, will provide an important national platform for human factors research.

THE END

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