Pedalling into a driverless world: opportunities and threats

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International Cycling Conference, Mannheim

19th to 21st September 2017
Outline

1. State-of-the-art in autonomous technology
2. Use scenarios and the challenge
3. Trial 2 findings to date
4. Trial 3 preview
5. Regulatory and moral issues
# 1 State-of-the-art

<table>
<thead>
<tr>
<th>SAE level</th>
<th>Name</th>
<th>Narrative Definition</th>
<th>Execution of Steering and Acceleration/Deceleration</th>
<th>Monitoring of Driving Environment</th>
<th>Fallback Performance of Dynamic Driving Task</th>
<th>System Capability (Driving Modes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>No Automation</td>
<td>the full-time performance by the human driver of all aspects of the dynamic driving task, even when enhanced by warning or intervention systems</td>
<td>Human driver</td>
<td>Human driver</td>
<td>Human driver</td>
<td>n/a</td>
</tr>
<tr>
<td>1</td>
<td>Driver Assistance</td>
<td>the driving mode-specific execution by a driver assistance system of either steering or acceleration/deceleration using information about the driving environment and with the expectation that the human driver perform all remaining aspects of the dynamic driving task</td>
<td>Human driver and system</td>
<td>Human driver</td>
<td>Human driver</td>
<td>Some driving modes</td>
</tr>
<tr>
<td>2</td>
<td>Partial Automation</td>
<td>the driving mode-specific execution by one or more driver assistance systems of both steering and acceleration/deceleration using information about the driving environment and with the expectation that the human driver perform all remaining aspects of the dynamic driving task</td>
<td>System</td>
<td>Human driver</td>
<td>Human driver</td>
<td>Some driving modes</td>
</tr>
<tr>
<td>3</td>
<td>Conditional Automation</td>
<td>the driving mode-specific performance by an automated driving system of all aspects of the dynamic driving task with the expectation that the human driver will respond appropriately to a request to intervene</td>
<td>System</td>
<td>System</td>
<td>Human driver</td>
<td>Some driving modes</td>
</tr>
<tr>
<td>4</td>
<td>High Automation</td>
<td>the driving mode-specific performance by an automated driving system of all aspects of the dynamic driving task, even if a human driver does not respond appropriately to a request to intervene</td>
<td>System</td>
<td>System</td>
<td>System</td>
<td>Some driving modes</td>
</tr>
<tr>
<td>5</td>
<td>Full Automation</td>
<td>the full-time performance by an automated driving system of all aspects of the dynamic driving task under all roadway and environmental conditions that can be managed by a human driver</td>
<td>System</td>
<td>System</td>
<td>System</td>
<td>All driving modes</td>
</tr>
</tbody>
</table>

*Automated driving system ("system") monitors the driving environment*
The critical Level 3

Volvo:

• Follow lanes
• Follow cars
• Adapt speed
• Merge
• ‘fail safe’.

Tesla:

• Auto steer
• Auto lane change
• Automatic emergency steering
• Emergency collision warning
• Side collision warning
• Auto park

Google car: trials with a safety driver

Volvo: trials announced

Tesla: on the open market
Trajectories for use

Car
Taxi
Shared taxi
Bus
Lorries ...and so on ...or ‘pods’
2 Use scenarios

1 Fully segregated
   • Completely segregated
   • Have their own system
   • Interact only with other Avs

2 Motorways and expressways
   • With high volume and speed human drivers
   • Only motor traffic present
   • Infrastructure highly engineered

3 Typical urban roads (next slide)

4 Shared Space
   • Carefully designed to reduce traffic speeds
   • Only regulation is ‘share sociably’
   • Interaction theoretically equitable
Challenge: (3) typical urban roads

Range of:

- Road types (arterial roads, distributor roads, high streets, access roads and local streets)
- User types (vehicles and drivers, pedestrians, cyclists)

Variability in:

- Lane types and widths
- Forms of junction control
- Levels of traffic regulation
- Levels of place as well as movement function
### Trial 2 findings to date: the variables

#### Independent variables (the AV)

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<th>Headway (car following) (seconds)</th>
<th>Critical gap (gap acceptance at junctions) (seconds)</th>
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</thead>
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<tr>
<td>Passive</td>
<td>2.5</td>
<td>5.1</td>
</tr>
<tr>
<td>Neutral</td>
<td>2.0</td>
<td>4.0</td>
</tr>
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<td>Assertive</td>
<td>1.5</td>
<td>2.8</td>
</tr>
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Headway = time gap a driver leaves to vehicle in front (Lewis-Evans et al., 2010)

Critical gap = gap 50% of drivers would accept (Ashalatha and Chandra, 2011).

#### Dependent variables (human response)

- Trust
  - 0 = ‘no trust’ to 10 ‘complete trust’

- Comfort

- Post- questionnaires and nausea rating scores

- Personality questionnaires
  - Driving experience
  - Faith and Trust in General Technology
  - Trust in automation
  - Impulsivity
  - Self-control
  - Risk taking
  - Distractibility
  - Personality
  - Sleep
  - Mood
  - Cognitive workload
Trial 2 events

Links

Give ways

Left turn into side road

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The Wildcat AV and Venturer simulator
The respondents and comparisons

46 Participants (20 female)

8 (17%) ≥ 65 years, 4 (8%) relatively inexperienced < 5 years driving

Three observations of each event

The decision management system either:
• ‘rejected the gap’, i.e. proceeded at the critical gap, or
• ‘accepted the gap’, i.e. did not proceed at the critical gap

Within subjects analysis:

1. Between events
2. Between platforms
3. Between rejecting and accepting gap (simulator only)

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<thead>
<tr>
<th>Behaviour</th>
<th>Wildcat</th>
<th>Simulator</th>
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<tr>
<td>Rejected gap</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Accepted gap</td>
<td></td>
<td>✓</td>
</tr>
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</table>
Some results

Wildcat, trust higher:
• On empty link compared to overtaking a parked car with and without an oncoming vehicle.
• Overtaking a parked car with an oncoming vehicle than without.
• Turning right into and out of side road with an oncoming vehicle than without.

Personality data
• Trust scores valid and reliable (higher general trust = higher trust in the trial events)
• Driver age and experience not associated with trust ratings of events

Venturer Simulator, trust higher:
• On empty link compared to overtaking a parked car with and without an on-coming vehicle
• Overtaking a parked car without an on-coming vehicle than with
• Turning right into side road with an on-coming vehicle than without.

Between Platforms, trust higher in Venturer Simulator
• On an empty link and overtaking a parked car with and without an on-coming vehicle
• Turning left with and without an on-coming vehicle
4 Trial 3 preview
5 Regulatory and moral issues

• Private car is a deeply ingrained cultural icon (Thrift, 2004)

• Driving is not done in a social vacuum (Wilde, 1976)

• “The car is all too capable of undermining its own utility” (Shaw and Docherty, 2013, p12)

• There is a social layer of rules, customs, and bespoke modes of communication

Issues:

• Road users may not behave in a sufficiently patterned way for machine intelligence prediction

• Communication subtle and culturally specific
Ethics

‘Should driverless cars kill their own passengers to save a pedestrian?’ Goldhill (2015)

- **Utilitarianism / moral obligation:** ‘maximises happiness’, therefore minimise loss of life

- **Incommensurability / participation in a moral wrong:** AVs programmed to save those outside vehicle, and AV users should know the risks

Bonnefon et al. (2015):

- 75% say do not kill pedestrians
- Effect dramatically weakened if they were in the car

Adams (2015)

- ‘Deferential’ programming = AVs ‘going nowhere’