# Pedalling into a driverless world: opportunities and threats

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# 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

| SAE level | Name | Narrative Definition | Execution of Steering and Acceleration/ Deceleration | *Monitoring* of Driving Environment | Fallback Performance of *Dynamic Driving Task* | System Capability *(Driving Modes)* |
|---|---|---|---|---|---|---|
| ***Human driver* monitors the driving environment** | | | | | | |
| 0 | **No Automation** | the full-time performance by the *human driver* of all aspects of the *dynamic driving task*, even when enhanced by warning or intervention systems | Human driver | Human driver | Human driver | n/a |
| 1 | **Driver Assistance** | 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* | Human driver and system | Human driver | Human driver | Some driving modes |
| 2 | **Partial Automation** | 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* | **System** | Human driver | Human driver | Some driving modes |
| ***Automated driving system* ("system") monitors the driving environment** | | | | | | |
| 3 | **Conditional Automation** | 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* | System | **System** | Human driver | Some driving modes |
| 4 | **High Automation** | 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* | System | System | **System** | Some driving modes |
| 5 | **Full Automation** | 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* | System | System | System | **All driving modes** |

# 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

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# 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


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# 3 Trial 2 findings to date: the variables

**Independent variables (the AV)**

| Description | Headway (car following) (seconds) | Critical gap (gap acceptance at junctions) (seconds) |
|---|---|---|
| Passive | 2.5 | 5.1 |
| Neutral | 2.0 | 4.0 |
| Assertive | 1.5 | 2.8 |

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

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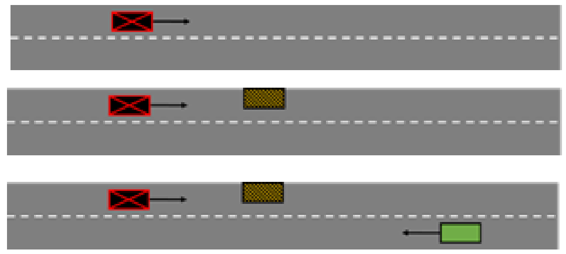
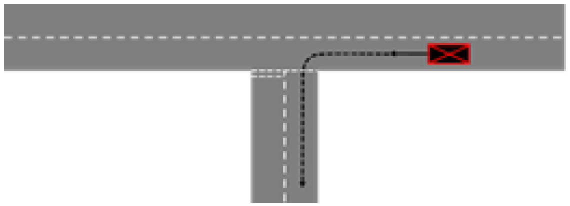
# Trial 2 events

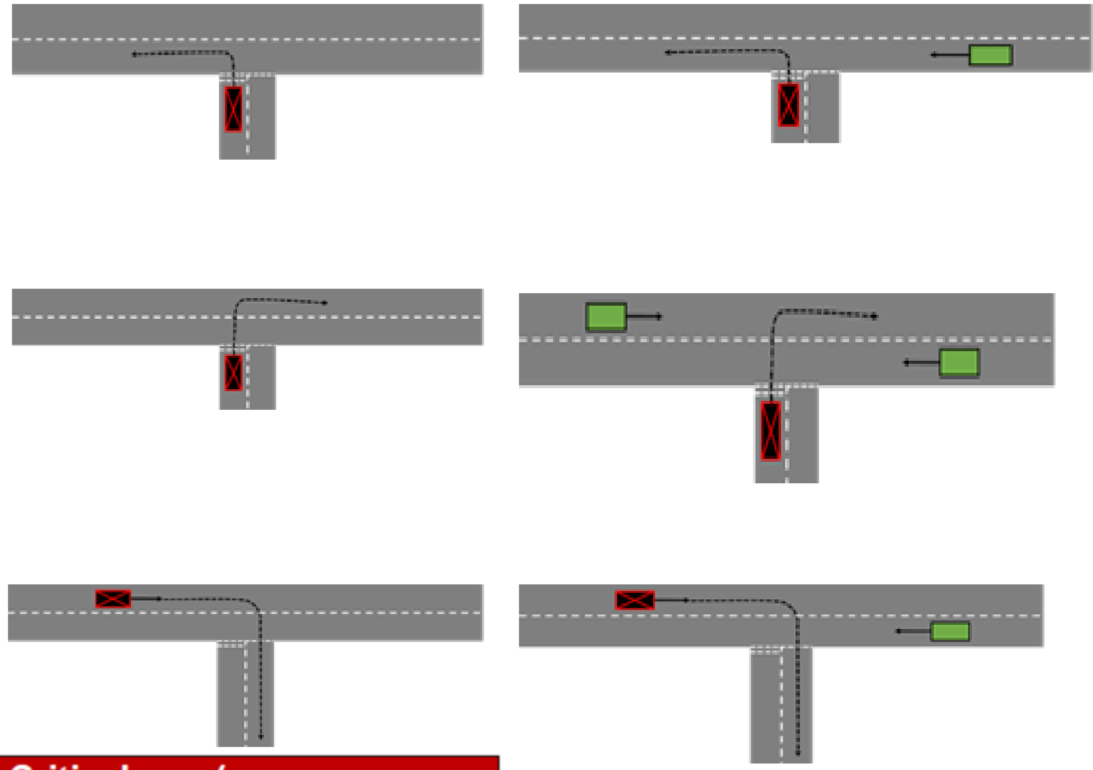
Links



Left turn into side road



Give ways



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# The Wildcat AV and Venturer simulator



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# 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)

| Behaviour | Wildcat | Simulator |
|---|---|---|
| Rejected gap | ✓ | ✓ |
| Accepted gap | | ✓ |

# 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 on-coming vehicle than without.
- Turning right into and out of side road with an on-coming 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

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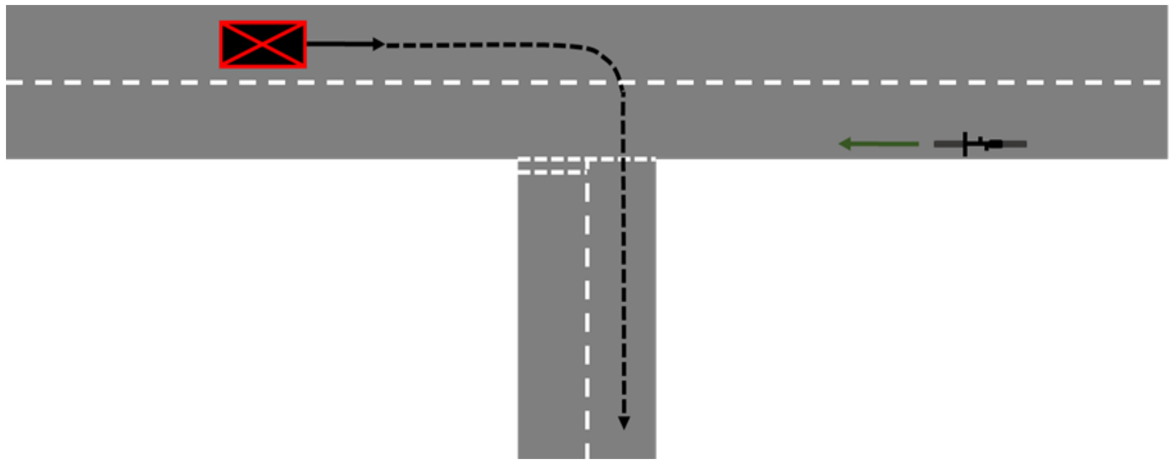
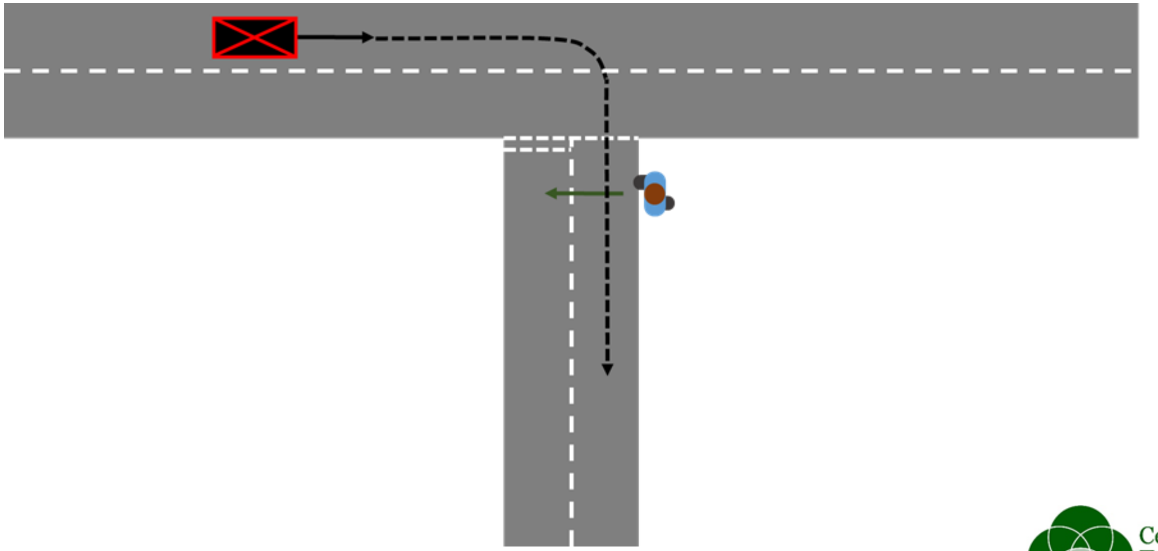
# 4 Trial 3 preview



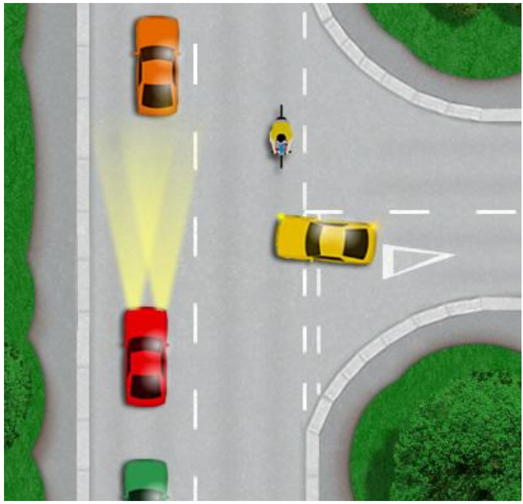


# 5 Regulatory and moral issues

- 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



**Rule 110**

**Flashing headlights.** Only flash your headlights to let other road users know that you are there. Do not flash your headlights to convey any other message or intimidate other road users.

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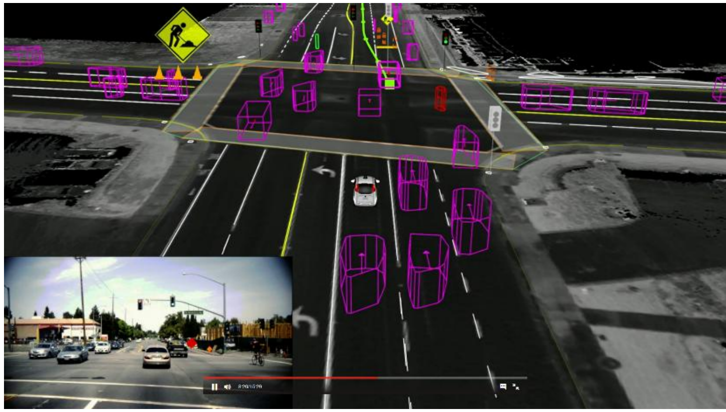
# Ethics

'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'

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