Automated Vehicles & Safety

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Redefining Mobility Summit

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Autonomous Vehicle Proposition

- **Driver errors cause >90% of accidents**
- **Including drivers in the loop is not sensible, and drivers can't be expected to take over safely or effectively.**
- **Let's do without Drivers!**

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Things Could Still Go Wrong,

Even if Vehicles are Automated?

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Tesla Fatality Incident (May 2016, Florida)

- **Neither human nor the machine hits the brake.**

- **Driver's hands on wheel for only 25 seconds during 37-minute period**
- **Driver ignored 7 visual warnings and 6 audible warnings during the trip**

- **Tesla cruise control set at 74 mph.**
- **Driver has at least 3.4 seconds to react.**

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Questions and Comments

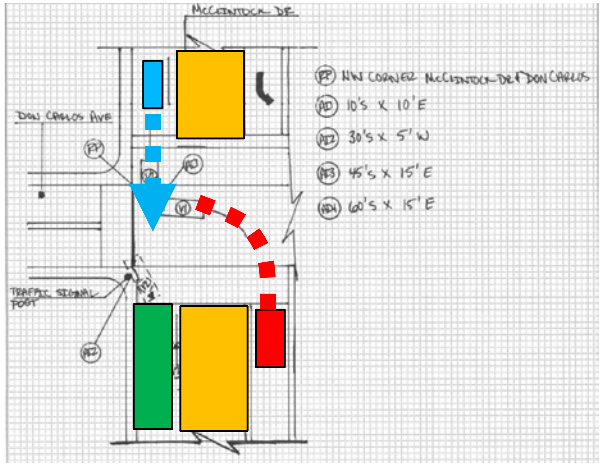
- Supposedly, the driver should still be monitoring the Driving environment. (SAE Level 2)
  - Can we expect drivers to be continuously vigilant?

- Why did the Tesla not slow down?
  - Apparently, the “detection/perception” function failed for the ADS to timely react to the situation.

- Can new generation of technologies, such as Artificial Intelligence, help?

UBER Accident, 03/2017

- **Recent UBER Incident (March 2017, Arizona)**



An Uber SUV crashed in Tempe March 24, 2017. (Photo: Mark Beach)

- **UBER car has the right of way, per police report.**
- **The left-turn car was “at fault,” and cited.**

- **Two inside lanes were grid-locked. (orange)**
- **The outside lane was clear to proceed. (green)**

- **Did the UBER car try to “rush through the intersection”?**
- **Did it make a good judgment?**

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Questions and Comments

- How will a (conservative) human driver behave if he is in the UBER car?
  - Slow down as it approaches, given that the left-lane traffic is congested and partially blocking the view?
- Is this a failure in decision making and driving behaviors?
  - Defensive driving in anticipation of other road users
- Can new generation of technologies, such as AI, help?

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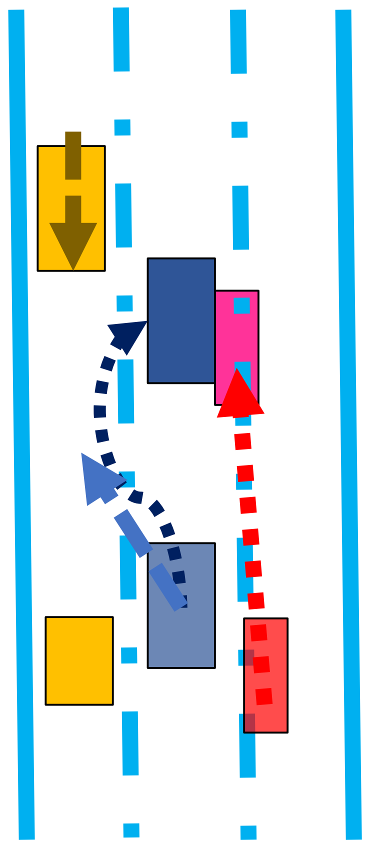
Cruise Automation Accident, 12/2017

- **Recent Cruise Automation Incident (December 2017, SF)**

- Cruise AV intends to change lane, but a van in front slows down
- As Cruise AV aborted a lane change and was re-centering itself in the lane,
- **A motorcycle** that that had just lane-split between two vehicles moved into the center lane, **glanced the side of the Cruise AV, wobbled, and fell over**.
- At the time of the collision,
  - Cruise AV was traveling with the flow of traffic at 12 mph
  - Motorcycle at approximately 17 miles per hour.



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Questions and Comments

- How well can the CA car see the surrounding?
  - Highly instrumented with 3-5 lidars and multiple cameras, plus radar.

- Is an evasive movement possible, to avoid contact with the motorcycle?
  - Approach speed and trajectories of other road users

- Can new generation of technologies, such as AI, help?

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UBER Accident, 03/2018

https://www.youtube.com/watch?v=hthyTh_fopo

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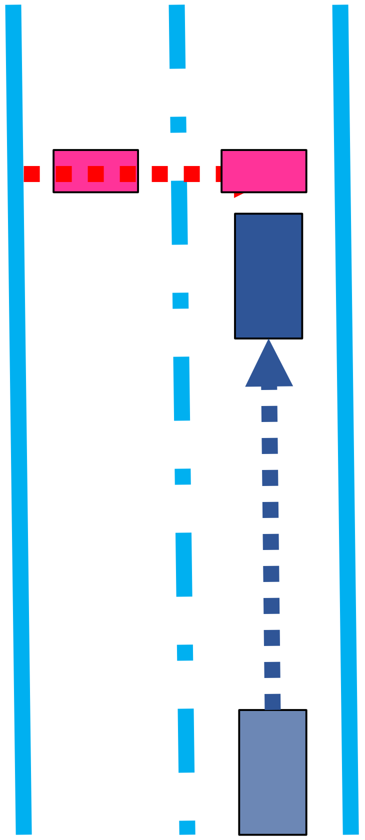
UBER Accident, 03/2018

- **Recent UBER Incident (March 2018, Tempe)**

- Pedestrian walking bike and crossing 2-lane roadway
- Uber vehicle in automation mode cruising at **38 mph**.
- Assuming **ped+bike** is walking 2-3 mph, which is equivalent to 2.93-4.40 ft/sec, it takes **4-6 seconds** to cross one and a half lanes.
- UBER car, if all sensors function properly, will begin to see ped+bike when **half-way into the opposite lane**, at **3-4 seconds** before the crash, at **167 to 223 feet** away.
- Stopping time for 38 mph by reasonable hard braking (0.7g) takes **2.47 seconds** or 69 feet.
- Driver perception and reaction time takes **1.5-2.5 seconds**, so the human driver could barely stop in time.



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Questions and Comments

- Could the driver possibly avoid the accident?
  - Not if the driver is not paying attention
  - Could have slowed down the car

- Could the "machine" see the pedestrian crossing and stop in time?
  - Possibly yes, with lidar and radar
  - Reportedly, lidar was "turned off"

- Can new generation of technologies, such as AI, help?

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Safety Challenges in Real World

- These accidents may be the first to draw attention,
  - But, they won’t be the last
- There is usually a prime culprit of functional failure in the system,
  - But, multiple causes/factors are often involved
- The real world is very complicated
  - How much testing is needed?
  - How do we verify safety?

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Challenges

in

AV Testing and Safety Verification

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How Much Testing Is Needed?
Compared to Benchmark (Human) Performance

- The National Safety Council of US reports a rate (including deaths of pedestrians and cyclists killed in motor vehicle accidents for all roads) of
  - 1.25 deaths per 100 million vehicle miles, or
  - 12.5 deaths per billion vehicle miles) traveled in 2016.

- 80 million vehicle-miles per fatality

  ~= 1 person, 20,000 miles/per year X 50 years X 80 life-times, or

  ~= 4,000 cars X 20,000 miles/per car per year (production), or

  ~= 100 cars X 160,000 miles/per car per year X 5 years (prototype)

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How to Expedite Learning and Testing?

- **Practices of Safety Assurance Testing:**
  - **Learn from database of "corner cases"**
    - **Collection of challenging scenarios and test cases**
  - **"Fleet" Learning, e.g. Tesla**
    - **> 100k vehicles, >1.3B miles driven, >300M miles with AutoPilot on**
  - **"Simulated" Learning, e.g. Waymo CarCraft**
    - **> 25k virtual vehicles, >8M miles daily, >2.5B miles yearly**
- **Advanced computational technologies and AI can help.**

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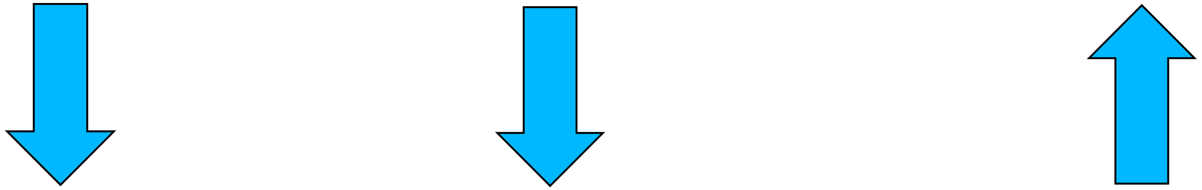
Safety Risks

- Safety Risk =
  Exposure X Severity X Controllability



- Fixed-route, slow-moving (driverless) shuttles minimize safety risks.

- Driverless Automated Mobility Services (Robot-Taxi) must perform well to avoid risks.

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Thank you.

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