AUTONOMOUS VEHICLES DEFINED

• “A vehicle capable of sensing its environment and navigating without human input.”

• Can detect surroundings with:
  – Radar (radio wave detection)
  – Lidar (laser detection)
  – Odometry (motion sensors)
  – Computer vision
  – GPS
AUTONOMOUS VS. AUTOMATED

• Autonomous:
  – Has the power for self-governance
  – Acting alone or independently
• Automated:
  – Control or operation by a machine
  – Really the more accurate term for these vehicles, but autonomous is more commonly used and familiar
Level 0: Driver completely controls the vehicle at all times.

Level 1: Individual vehicle controls are automated, such as electronic stability control or automatic braking.

Level 2: At least two controls can be automated in unison, such as adaptive cruise control in combination with lane keeping.

Level 3: The driver can fully cede control of all safety-critical functions in certain conditions. The car senses when conditions require the driver to retake control and provides a "sufficiently comfortable transition time" for the driver to do so.

Level 4: The vehicle performs all safety-critical functions for the entire trip, with the driver not expected to control the vehicle at any time. As this vehicle would control all functions from start to stop, including all parking functions, it could include unoccupied cars.
SOCIETY OF AUTOMOTIVE ENGINEERS VEHICLE CLASSIFICATIONS

- Level 0: Automated system has no vehicle control, but may issue warnings.
- Level 1: Driver must be ready to take control at any time. Automated system may include features such as Adaptive Cruise Control (ACC), Parking Assistance with automated steering, and Lane Keeping Assistance (LKA).
- Level 2: Driver is obliged to detect objects and events and respond if the automated system fails to respond properly. The automated system executes accelerating, braking, and steering. The automated system can deactivate immediately upon takeover by the driver.
- Level 3: Within known, limited environments (such as freeways), the driver can safely turn their attention away from driving tasks.
- Level 4: The automated system can control the vehicle in all but a few environments such as severe weather. The driver must enable the automated system only when it is safe to do so. When enabled, driver attention is not required.
- Level 5: Other than setting the destination and starting the system, no human intervention is required. The automatic system can drive to any location where it is legal to drive.
POTENTIAL BENEFITS

- Less driver errors = reduced accidents = fewer injuries and fatalities
  - 93% of auto accidents are due to human error
  - Currently 30,000 fatalities in the US each year.
  - Computers are predicted to drive much better than humans
- Reduced labor costs (since drivers will not be required)
- Reduced driving and navigation chores = more leisure time
- No need to worry about driver impairment (young age, intoxication, seizures, vision problems, etc.)
- Higher speed limits
- Smoother rides
- Increased road capacity and reduced traffic congestion (due to decreased need for safety gaps)
- Improved traffic flow
- Reduced need for traffic patrol
- Reduced need for auto insurance
- Reduced car theft (due to vehicle’s self-awareness)
- Improved ergonomics inside the vehicle (steering wheel is removed)
- Large vehicles (such as motor homes) will be easier to use
CHALLENGES/PROBLEMS

- Liability placed on manufacturer of device and/or software driving the vehicle.
- Time needed to turn an existing fleet of vehicles from nonautonomous to autonomous.
- Resistance by individuals to forfeit control of their cars.
- Implementation of legal framework and establishment of government regulations for self-driving cars.
- Inexperienced drivers if/when complex situations require manual driving.
- Loss of driving-related jobs. (Resistance from professional drivers and unions who perceive job losses.
- Loss of privacy (sharing of information through vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) protocols.)
- Could be loaded with explosives and used as bombs
- Ethical problems in situations where the car’s software is forced during an unavoidable crash to choose between multiple harmful courses of action.
- Gestures and non-verbal cues by police and pedestrians are not adapted to autonomous driving.
SOFTWARE RELIABILITY

• Software reliability.

A car's computer could potentially be compromised, as could a communication system between cars by disrupting camera sensors, GPS jammers/spoofing.

• Susceptibility of the car's navigation system to different types of weather.

• Autonomous cars may require very high-quality specialized up-to-date maps to operate properly.

• Competition for the radio spectrum desired for the car's communication.

• Current road infrastructure may need changes for autonomous cars to function optimally.

• Cost: currently $70,000-$100,000 additional
  – Once mass production beings, estimated to be $3,000-$5,000
Questions?

Please submit them in the question box of the GoToWebinar taskbar.
Google Self-Driving Cars

• August 2012:
  – Google announced it had completed over 300,000 autonomous-driving miles accident-free,
  – Had about a dozen cars on the road at any given time.

• May 2014:
  – Revealed a new car that was 100% autonomous with no steering wheel, gas pedal or brake pedal

• March 2016:
  – Google had test driven fleet of driverless cars in autonomous mode almost 1.5 million miles.
Google’s Accident Rate:  14 accidents

- Rear-ended at a stop sign or traffic light (9)
- Vehicle was side-swiped by another driver (2)
- Another driver rolled through a stop sign (1)
- Google employee was driving car manually (1)
- Car attempted to avoid sandbags and struck a bus (1)
Tesla Model S
TESLA (May 2016)

• Falls between Level 2 and Level 3 on the NHTSA classification scale.
• May 2016: first fatal accident with an 18-wheeler
  – According to Tesla
    • “neither autopilot nor the driver noticed the white side of the tractor-trailer against a brightly lit sky, so the brake was not applied.”
    • Car drove under the 18 wheeler, killing the driver
    • Tesla’s first known autopilot death in over 130 million miles driven by its customers with Autopilot engaged.
      – There is a fatality every 94 million miles among all type of vehicles in the U.S. (again, this is according to Tesla)
    • Cannot play movies on the car’s screen
  – According to Truck Driver
    • Driver was “playing Harry Potter on the TV screen“
  – According to Highway Patrol
    • There was an after market DVD player in the car
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Policy Implications
Disruptive Innovation Defined

- An innovation that creates a new market and value network. It eventually disrupts an existing market and value network, displacing established market leading firms, products and alliances.
Are all levels of AV driving really safe?

- Think about the Tesla accident…
- The driver was not able to reengage in time to avoid the accident, even though the technology was clear—the driver MUST remain alert.

“Levels 4 and up are viable approaches. The Tesla accident does not only show a software problem; it illustrates the dangers of levels 2 and levels 3.”

--Dr. Alexander Hars

(http://www.driverless-future.com/?p=955)
Problem Area: Levels 2 & 3

- Level 0: Driver completely controls the vehicle at all times.
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Issue: Impact on Driving Behavior

• Will make driving easier, and thus increase miles driven?
  – Fuel consumption
  – Increased traffic and road congestion (but the driverless technology could actually improve traffic flow due to elimination of behaviors like rubber-necking).

• Will facilitate car and ride sharing, so maybe it will decrease miles driven?

• Cars will enable better carpooling, less idling in traffic, and smarter route-planning. Computers won't waste gas getting lost or circling for parking spots. Total miles traveled and greenhouse gases will decline.

• Will driving to work now be a joy, encouraging more urban sprawl?
Issue: Assigning Liability / Insurance Implications

• If driver behavior is taken out of the accident equation:
  – Claims for accidents will be based more on products liability than on driver error
  – The need for auto insurance will go down
  – The auto insurance market will shrink

• When accidents do occur, who will be at fault?
  – The people who made the hardware?
  – Or the software?
  – Or the mapping platform?
  – Or maybe we blame another car that sent a faulty signal on the highway?
Issue: Is our Infrastructure Ready?

- What kind of lighting do we need on city streets if we're trying to optimize for radar vision instead of human sight?
- Can a computer process a street sign that's covered in graffiti?
- Will automakers want to make autonomous cars if only a few places in the country are ready for them?
- If we need to invest in radically changing our roadways — networking streetlights, installing sensors — how will we pay for that?
  - 2012: computer scientists began developing smart intersections designed for autonomous cars.
    - Intersections have no traffic lights and no stop signs, instead using computer programs that will communicate directly with each car on the road.
Issue: Decline in State and Local Revenue & Jobs

• Reduction in human traffic errors
  – Fewer traffic citations = less government revenue = less need for traffic patrol officers
  – Fewer insurance claims = less demand for claims adjusters
  – Fewer insurance claims = less revenue for body shops, chiropractors, emergency rooms and attorneys
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Legislation to Date
States that Allow Autonomous Vehicles
Legal Issues

• Who is responsible for overseeing autonomous vehicle safety and testing?
• How many people must be in the vehicle during tests? During ordinary driving?
• What limitations are there on driver behavior?
  – Can they text?
  – Can they watch movies?
Sample Law: Nevada (Enacted June, 2011)

- Gave DMV authority to regulate safety and specify allowed testing areas for cars
- Requires a person behind the wheel and one in the passenger seat during tests.
- Drivers can still not text and drive
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NOW AND THE FUTURE
There have been several surveys and opinion polls taken, both domestically and internationally.

2014 US telephone survey by Insurance.com:
- 75%+ of licensed drivers said they would at least consider buying a self-driving car, rising to 86% if car insurance were cheaper.
- 31.7% said they would not continue to drive once an autonomous car was available.

2015: Delft University of Technology surveyed 5,000 people from 109 countries
- Respondents enjoyed manual driving the most
- 22% did not want to pay any money for a fully automated vehicle
- 5% indicated they would pay more than $30K for a fully automated vehicle
- 33% said fully automated driving would be highly enjoyable
- 69% estimate that fully-automated driving will reach a 50% market share by 2050

Concerns of Respondents:
- Software hacking/misuse
- Legal issues and safety
- Transmission of data
Market Forecasts for AV Availability

- Volkswagen: 2019
- GM: 2020 or sooner
- BMW: 2021
- Ford: 2020
- Baidu: Mass production by 2021
- Tesla: 2018
- Uber’s Fleet: Completely driverless by 2030
- Audi: 2017
- Jaguar and Land-Rover: 2024
- Daimler: 2025
- Nissan: 2020
- Google: 2018

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