What is an AV?
Building a Smart Madison for Shared Prosperity
Trends and Outcomes

- Safety
- Vehicle Miles Traveled (VMT)
- Sprawl
- Parking
- Energy
- Air Quality
- Public Health
- Equity
- Accessibility

Mobility

- Electric
- Shared
- Connected
- Automated
Traffic Fatalities Rising

Nationally:
- Increased for 2nd straight year
- Largest two-year increase in 50 years
- Approaching 40,000 deaths

Wisconsin:
- Pedestrian deaths now up to 15% of all traffic fatalities
Motivations and Opportunities

- **Safety**
  - ~90% of crashes attributable to human error
  - Approaching 40,000 deaths
  - Distracted driving continues to worsen
  - Need to carefully navigate the era of partial automation

- **Equity**
  - Accessibility
  - First mile / last mile

- Many other motivations:
  - Economic development, startup and tech jobs
  - Underutilized vehicles
  - Efficient use of infrastructure and land
  - Health care, agriculture, and other sectors
How AVs Operate

- **CAMERAS**: Cameras gather visual information from the road and traffic control and send them to the controller for processing.

- **LIDAR**: LiDAR sensors bounce lasers off of detected objects. LiDAR can detect road lines and assets and differentiate objects.

- **RADAR**: Radar sensors bounce radio waves off detected objects. Radar cannot differentiate objects.

- **GPS UNIT**: The GPS unit identifies the precise position of the vehicle and aids in navigation.
# SAE Levels of Automation

<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>
Levels Depend on Circumstances

Critical implications:
• Human operator expectations, “re-engagement”
• Where certain vehicles can safely operate
Tesla doesn’t stop, hitting the trailer and traveling under it.

Trailer turns left in front of the Tesla.

Tesla veers off road and strikes two fences and a power pole.

Tesla Florida
May 2016
Tesla, March 2017
June 17, 2017

Destroyer Fitzgerald and ACX Crystal
Uber, March 2017
The Road to Autonomous through Advanced Driver-Assistance Systems (ADAS)

- Driver alert systems
- Forward collision warning / automated braking
- Adaptive cruise control
- Lane keeping / departure warning
- Automated lighting
- Automatic parking
- Traffic warnings
- Smartphone/GPS connectivity
- V2V systems
- V2I/V2X systems
Back-Up Camera
Shows you a view behind your car when backing up

Automatic Emergency Braking System
May brake for you if a front-end crash is imminent

Blind Spot Monitor
Helps you know what cars might be hidden to your left or right

Lane Departure & Lane Keeping Systems
Warns you if you’re drifting out of your lane and may steer you back

Automatic Parallel Parking
Helps you safely navigate into a parallel spot. You control braking, it controls steering

MyCarDoesWhat.org
A website that answers all your questions about new car safety technologies.

…and so much more
Federal AV Policy

- Released Sep 20, 2016
- Updated Sep 12, 2017
- Voluntary guidelines
  - Not regulations
- Level 3+ Only
- 12 Safety Elements
- Guidance for State Policy
NHTSA’s 15 Safety Elements

1. System Safety
2. Operational Design Domain
3. Object and Event Detection and Response
4. Fall Back (Minimal Risk Condition)
5. Validation Methods
6. Human Machine Interface
7. Vehicle Cybersecurity
8. Crashworthiness
9. Post-Crash ADS Behavior
10. Data Recording and Sharing
11. Consumer Education and Training
12. Federal, State and Local Laws
13. Privacy
14. Registration and Certification
15. Ethical Considerations
15. Ethical Considerations
USDOT AV Proving Grounds

- Peer network
- Advise government
- Validate industry
- Awarded January 2017

...no funding
Ten Designated AV Proving Grounds

- American Center for Mobility (ACM) at Willow Run
- City of Pittsburgh and the Thomas D. Larson Pennsylvania Transportation Institute
- U.S. Army Aberdeen Test Center
- North Carolina Turnpike Authority
- US Department of Transportation
- Texas AV Proving Grounds Partnership
- Central Florida Automated Vehicle Partners
- San Diego Association of Governments
- Iowa City Area Development Group
- Contra Costa Transportation Authority (CCTA) & Go Mentum Station
- University of Wisconsin-Madison
Range of RDT&E Environments

- Simulation
- Lab
- Closed Track
- Controlled Demo
- Limited Facility
- Public Roads
**TESTING FACILITIES**

1. **ROAD AMERICA**
   Elkhart Lake, WI

2. **MILWAUKEE AREA FACILITIES**
   City of Milwaukee and UW-Milwaukee

3. **MGA RESEARCH GROUP**
   Burlington, WI

4. **MADISON AREA FACILITIES**
   City of Madison, Epic, Mandli Communications, and UW-Madison

5. **CHIPPEWA VALLEY REGIONAL AIRPORT**
   Eau Claire, WI

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**PROPOSED AV CORRIDORS**

- **MadMSP Corridor**
  WisDOT, MnDOT

- **Sheboygan to Milwaukee Corridor**
  WisDOT

- **Burlington to Milwaukee Corridor**
  WisDOT

- **MRCM Corridor**
  WisDOT, iDOT, IL Tollway

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**COMPREHENSIVE SPECTRUM OF TESTING/RESEARCH ENVIRONMENTS**

- Computer Simulation
- Virtual Reality Simulation
- Controlled Campuses
  - Epic, RA
- Closed Course
  - MGA
- RC Car and Golf Cart Modeling
- Comprehensive Spectrum of Testing/Research Environments

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**MAP**

- Regional Airport
- Road America
- Milwaukee Area Facilities
- MGA Research Group
- Madison Area Facilities
- Chippewa Valley Regional Airport

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**INSTITUTIONS**

- Southeast University
Wisconsin Facilities
UW-Madison College of Engineering

Full Scale Driving Simulator
Wisconsin Facilities
MGA Research, Burlington

- 400 acres, private and secure, numerous testing capabilities
Wisconsin Facilities
Road America, Elkhart Lake

- Road track: 4.05-mile length, 30-foot width
- 1-mile combo paved-dirt track
- 12+ miles off-road
- 10+ miles access roads
- Major race events and media presence
Wisconsin Facilities

Campuses

- Corporate Campuses
- UW-Madison Campus
- City of Madison
Wisconsin Facilities
Connected Park Street Corridor

- Piloting CV technology to improve:
  - Safety
  - Mobility
  - Bus on-time performance
  - Equity
- V2I, V2V, V2X
- Madison and Wisconsin as the Upper Midwest hub for CV & AV development
Governor’s Committee on Automated and Connected Vehicles

- May 2017 EO #245
- Sept 2017 Kickoff
- June 2018 Report Due
- Members:
  - Government: WisDOT, WSP, WEDC, Assembly, Senate, Iowa Co Sheriff, Insurance Commissioner
  - Academic/Nonprofit: UW-Madison, Tech Council, ABATE
  - Industry: MGA, Roadview, Waymo, Uber, Tesla, AAM, Global Automakers, Dealers Assn, Harley, Schneider, HNTB

“the removal of barriers to the testing and deployment of automated and connected vehicle technology in Wisconsin”
Transportation in an Automated Vehicle World
Steve Caya - President of Roadview, Inc.

- Member of Governor’s Steering Committee on Autonomous Vehicles (AV)
- Member of the Wisconsin AV Proving Grounds
- Board Member of Geospatial Transportation Information Management Association (GTiMA)
- UW-Madison - Detachment 925 Air Force ROTC Alumni Captain, United States Air Force
About Roadview

- A dedicated geospatial data collection, processing, and delivery company
- Based in Fitchburg, WI
- Worked with over 30 State DOTs
- First pavement collection in 2002
- 35 years experience in the Transportation industry
Technology

- LiDAR
- Positional Systems
- Imaging
- LCMS – Laser Crack Measurement System
- Software for data extraction and visualization
Thousands of Miles Collected
Technology
**Imaging**

Roadview’s 2D imaging system is capable of recording high-resolution images in a variety of weather, speed, and lighting conditions. The operator can monitor all images being collected by the system in real-time. Each camera runs at a resolution up to $3296 \times 2472$ pixels and captures at a selectable rate of 100 to 500 frames per mile, with vehicle speeds ranging up to 65 mph during collection.
LiDAR

Mandli’s LiDAR data collection system creates an accurate three-dimensional model of a scanned environment in a single pass of our collection vehicle. The system collects up to 1.4 million points of data per second at highway speeds, at ranges exceeding 100 meters. The point cloud produced by the system can be utilized to take 3D measurements of roadside assets, including width, height, and length, surpassing the measurement capabilities of 2D images.
Collection System
Spatially Accurate Maps
LCMS

https://www.youtube.com/watch?time_continue=68&v=j_oW2q7jkjE
LCMS
### Assets Collected

<table>
<thead>
<tr>
<th>Category</th>
<th>Items</th>
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<tr>
<td>Acceleration/Deceleration Lanes</td>
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<td>Attenuators</td>
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<td>Barriers</td>
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<td>Bridges</td>
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<td>Control Fences</td>
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<td>Culverts</td>
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<td>Curbs &amp; Gutters</td>
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<td>Delineators</td>
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<td>Ditches</td>
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<td>Intersections</td>
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<td>Passing Lanes</td>
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<td>Paved Shoulder Width</td>
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<td>Paved Turnouts</td>
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<td>Paved/Unpaved</td>
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<td>Railroad Crossings</td>
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<td>Raised Pavement Markers</td>
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<td>Ramps</td>
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<td>Rest Areas</td>
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<td>Right Turn Lanes</td>
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<td>Road Surfaces</td>
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<td>Trail Heads</td>
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<td>Tunnels</td>
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<td>Turn Lanes</td>
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<tr>
<td>Wildflowers</td>
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</tbody>
</table>
Terabytes of Data

- 2010: 37.48 terabytes
- 2011: 42.82 terabytes
- 2012: 126.64 terabytes
- 2013: 130.44 terabytes
- 2014: 147.86 terabytes
- 2015: 214.50 terabytes
- 2016: 412,000 terabytes
Data Examples
Roadways in a Automated world

- **Smaller and More Efficient ROWs:** AVs’ unique navigation capabilities are expected to enable narrower traffic lanes, reduce the number of lanes needed to accommodate traffic demand, and remove the need for medians.

- **A Drop-Off Revolution:** AVs are expected to create demand for drop areas that are as close as possible to the entrances of destinations.

- **Signage & Signalization:** The future will not have large numbers of traffic signs and signals, as traffic information can be transmitted to AVs wirelessly in real-time.

- **Parking:** AVs will bring massive changes to the location, form, and amount of parking, as AVs can park themselves or remain in the transportation network while awaiting their next rider.
Smaller and More Efficient Right-of-ways

- AVs have the potential to travel more precisely than human operated vehicles and in harmony with other AVs.

- **Reduced Lane Widths:** Lanes are designed to account for driver wander and human error. If lanes were designed to the width of a AV the lane width could be reduced by as much as 20%.

- **Fewer Traffic Lanes / Reduced Lane Expansion:** AVs will be able to safely travel closer together than human-operated vehicles. This will significantly increase the throughput of each vehicle lane.
  
  - 25% of congestion is caused by traffic incidents, since 93% of crashes are caused by human error there should a significant reduction in congestion.
Smaller and More Efficient Right-of-ways

- **Smaller Medians:** The primary purpose of medians today is to provide a safety buffer between two lanes of traffic heading in opposite directions. If AVs become reliable, as promised, the need for medians may be kept for aesthetic value only.
**Figure 2.2** - 2016: Today an average urban roadway has wide lanes and medians, narrow sidewalks and street parking.
Figure 2.3 - 2060: Because AVs need less wide lanes and no medians to travel safely, this space can be freed up for more pedestrian and bicycle infrastructure.
Figure 2.4 - 2060 2: Alternatively, in some places, AVs increased efficiency may allow for the removal of one travel lane, which can open up space for dropoff lanes and significantly wider pedestrian and bicycle infrastructure
Access Management

- The ability of AVs to drop-off passengers before going to park themselves or to pick-up another passenger is expected to bring a drop-off revolution to the transportation system.
- Emergence of drop-off and pick-up areas
Signage & Signalization

- Signs and signals are among the most important features of today’s transportation systems. They provide drivers with all the information they need to keep the transportation system running smoothly and efficiently.

- Emergence of Vehicle to Vehicle (V2V) and Vehicle to Infrastructure (V2I) technology will revolutionize the how information is transmitted.
Transformation of Urban Centers

- Separation between human drivers and AVs
- Enclosed environments, such as college campus, where AV-only zones are plausible
- Land use changes may also be more prominent along highways with dedicate AV-lanes, along AV-only drop-off and pick up areas, and in the areas surrounding AV-only parking facilities.
Dedicated AV lanes

- State and federal highways may present easier opportunities for dedicated lanes initially because they have simpler traffic patterns, fewer intersections, and fewer points of ingress/egress than local roadways.
Dedicated AV lanes in Wisconsin???
Hyper Lanes

In Summary

Figure 3.28 - The transformation of a city block, showing expansion, new streetlights, and increased parking, with continued, more efficient use of land. The plan will improve the overall street, pedestrian, and vehicle access, with safer pedestrian crossings.
THANK YOU