Roadmap

• Automated driving is here.
• After decades of false starts, why now?
• What makes it real?
• What if it all goes wrong?
• How is government active?
• Bringing It All Together
Road Travel: *The Ultimate Vision*

- Safe
- Smooth
- Uninterrupted
- Expeditious
- Restful / entertaining

- Productive time
- Affordable
- Connected and aware
- Good for me, good for society
- **Trustworthy**
The Automation Wave is Upon Us
Decades of bold initiatives
Decades of bold initiatives
Decades of bold initiatives – last decade
What Held Automation Back?

- Processing speed / power
- Cost
- Packaging
- Vehicle / Highway Intelligence
- Deployment Investment
Today: Driver Assistance Systems Have Matured

- Crash Warning / Prevention
- 360 degree monitoring/warn/assist systems
Active Safety = Crashes Avoided

- Traffic-Adaptive Cruise Control
- Electronic Stability Control
- Forward collisions
- Lane Centering
- Lane departure
- Blind spot
- Pedestrians
- Fatigue
- Night Vision
- Speed Sign Recognition
Inflection Point

- Suppliers selling millions of units per year.
- Active safety systems offered on dozens of car models.
- Volvo Cars: 1 million auto-braking cars sold
What’s Available on a $30,000 Car?

• Adaptive cruise control
• Forward Collision Mitigation
• Blind spot information system
• Traffic sign recognition
• Lane keeping aid
• Driver alert

Ford Focus

“The Thinking Car”
One hour TV documentary
streaming at
www.snagfilms.com
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Is Automated Driving “Real” This Time?

• Or is it all hype?
• Barriers of the past have been largely overcome.
  ✓ Processing speed / power
  ✓ Cost
  ✓ Packaging
  ✓ Vehicle intelligence alone sufficient
  ✓ Deployment investment? Not needed.
Automated Driving Starts on the *Highway*

• **Traffic Jam Assist**
  – Mercedes, BMW *launching this year*
  – Volvo, Audi, others to follow quickly

• **Highway Pilot**
  – Mercedes, GM, BMW very active

• **Pacing factor:** role of the driver
Mercedes 2014 S-Class

- traffic jam assistant with ACC and Heading Control for low speed traffic
- limited hands-off-allowance
  - prototype requires driver engagement every 8 seconds
- Highway speed lateral assist
Upcoming Demonstrations

USA - Now

Tokyo -- October
Videos

- **Nissan Autonomous Drive**

- **Audi Traffic Jam Assist**
  - http://www.youtube.com/watch?v=JnPJse5yYbc

- **BMW Highly Automated Driving**
  - http://www.youtube.com/watch?v=DglAs3sBxCQ

- **Audi Valet Parking**
  - http://www.youtube.com/watch?v=rgN8MOrss40&list=TLJoBL8F6vrjg
Rollout Timing: Highway Driving

• 2014 - 2016:
  – Combined lateral and longitudinal control
  – Slow speeds initially …evolving to full highway speeds
  – Driver monitors system
  – *Driver prepared to take over at any moment*

• 2018 - 2020:
  – Highly automated driving at highway speeds
  – Active monitoring of the system not required
  – *Driver prepared to take over with some lead time.*

• 2025:
  – Fully automated driving
  – Monitoring of the system is not required
  – *Driver does not need to take over driving at any time.*
Rollout Timing:  *Street Driving*

- Urban driving presents very complex situations
  - Extremely challenging
  - U. Parma
    - http://www.youtube.com/watch?v=PLaT5kudGrA
- 2030 or later
  - Early systems in protected environments could come much sooner
- Transit implications
- Parking implications
U. Braunschweig:
Urban Automated Driving
Google?

• Major step by Google will stimulate the market...
• .... but the big volumes will stay with car-makers.
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How to gain the public's trust?
Challenges

- Liability
- Test and evaluation
- Regulation
- Privacy?
- Connectivity?
- Cybersecurity?
- Government, industry, and interest groups are working together.
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US Department of Transportation

- **Intelligent Transportation Systems Joint Program Office**
  - Automation Strategic Plan being published this Fall

- **Federal Highway Administration**
  - Exploring “High Performance Vehicle Streams”
  - Based on automation and connectivity

- **National Highway Traffic Safety Administration**
  - Ongoing human factors research for automated driving
  - Team members include GM, Google
  - More work planned
NHTSA: Key Issues

- Understanding benefits / disbenefits
- Performance Requirements
- Objective testing
- Certification for public use
- Field studies
- Human factors
- Electronics reliability
- Cybersecurity
- Policy / legal aspects
NHTSA Policy Document

- NHTSA Preliminary Statement of Policy Concerning Automated Vehicles (May 30)
  - Levels of Automation
  - Guidance to States
  - Research Roadmap

New European Work: Highway Driving

- **AdaptIVe**: Automated Driving Applications and Technologies for Intelligent Vehicles
  - €25M budget
  - start January 2014
  - supervised automated driving
  - 10 car-makers, led by Volkswagen

- **RESPONSE4**: Code of Practice (COP) for Highly and Fully Automated Driving
  - Addressing regulatory changes to allow market introduction
Automation Projects: Asia

• Japan
  – Ministry of Economy, Trade, and Industry
    • Energy ITS: truck platooning for reduction of fuel / emissions
  – Ministry of Land, Infrastructure, and Transport
    • New program to be announced in October

• China
  – Limited activity

• Korea
  – Limited activity
Research Trends Globally

- **USA**
  - NHTSA initiating new program

- **Europe**
  - New round of major funding starting now
  - Further funding ramping up ~2015

- **Asia**
  - Japan: continuing and new work
  - China, Korea activity not significant

*Private sector investment dwarfs public sector!*
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- **Bringing It All Together**
Mapping to Transportation Objectives

- **On-Board Sensors**
- **Connectivity**
- **Automation**

- **Safety**
- **Mobility**
- **Environment**
- **Quality of Life**

Bar chart showing the mapping to transportation objectives.
Key Research Questions

- TRB Joint Committee on Road Vehicle Automation
- Summer workshop July 2013 at Stanford
- www.vehicleautomation.org
TRB Joint Committee on Road Vehicle Automation: Breakout Groups for Research Q’s

- Automated commercial vehicle operations
- Cybersecurity and resiliency
- Data ownership, access, protection, and discovery
- Energy and environment
- Human factors and human-machine interaction
- Infrastructure and operations
- Liability, risk, and insurance
- Shared mobility and transit
- Testing, certification, and licensing
- V2X communication and architecture
Thank You

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Conceptual Framework - Levels of Automated Driving (Draft)

• Level 0
  No Automation
  • No steering or braking/throttle control
  • e.g., crash warning systems, including V2V applications

• Level 1
  Function Specific Automation
  • Braking/throttle and/or steering control, but not designed to work in combination to enable hands free/foot off pedal operation
  • e.g., automatic braking systems, lane keeping systems

• Level 2
  Combined Function Automation
  • Integration of braking, throttle, and steering control designed to enable “hands free/foot off pedal operation”
  • Driver available at all times to retake control

• Level 3
  Limited Self Driving Automation
  • Integration of braking, throttle, and steering control
  • Driver expected for occasional control
  • Driver can cede full monitoring and control authority

• Level 4
  Full Self Driving Automation
  • Integration of braking, throttle and steering control
  • Driver NOT expected for control
  • Responsibility for safe operation is solely rests with the vehicle
Levels of Automation

• Level 0 -- No Automation: Human driver executes manual driving task
• Level 1 -- Function-Specific Automation: The driver permanently controls either longitudinal or lateral control. The other tasks can be automated to a certain extent by the assistance system.
• Level 2 – Combined Function Automation: The system takes over longitudinal and lateral control, the driver shall permanently monitor the system and shall be prepared to take over control at any time.
• Level 3 – Limited Self-Driving Automation: The system takes over longitudinal and lateral control; the driver must no longer permanently monitor the system. In case of a take-over request, the driver must take-over control with a certain time buffer.
• Level 4 -- Full Self-Driving Automation: The system takes over longitudinal and lateral control completely and permanently. In case of a take-over request that is not carried out, the system will return to the minimal risk condition by itself.
Levels of Automation

- **Level 0: No Automation**
- **Level 1: Function-Specific Automation**
  - either longitudinal or lateral control
- **Level 2: Combined Function Automation**
  - longitudinal and lateral control
  - driver is monitor
  - ready to take over control
- **Level 3: Limited Self-Driving Automation:**
  - longitudinal and lateral control
  - driver need not monitor the system
  - driver must take-over control within a time buffer
- **Level 4: Full Self-Driving Automation:**
  - system takes over control completely and permanently
  - if needed, system attains minimal risk condition automatically
Automated Driving and The Law

• **USA**
  - Everything is permitted unless prohibited
  - Several states have authorized automated driving for testing
  - Government guidelines more likely than regulations

• **Europe**
  - Vienna Convention of 1968 may need changes to enable automation

• **Manufacturer Liability**
  - For automakers, lawsuits are a given
  - Introduction of any new safety technology a business calculation
  - Automation forces development of new test and evaluation procedures
Other Work in U.S.:
FHWA/PATH Truck Platoon Tests (2010)

Fuel economy improvements:
4-18%

6 m gaps
Other Work in U.S.:
ARMY AMAS

- Autonomous Mobility Appliqué System (retrofit)
- **Aim**
  - Better surveillance for threats
  - Less stress, fatigue for soldiers
  - Less personnel exposure to threats
  - Increase soldier protection from road crashes
- **Two year demonstration program begins this summer**
- **Army moving into production?**
  - active safety (commercial systems)
  - truck convoying / autonomous capability