RTCC SMART Series

Autonomous Vehicles: Driving the Future of the Research Triangle Region

May 19, 2017
Mission
Accelerate the cleantech economy through collaboration and partnerships which promote innovation and sector growth
Leadership Members & Project Partner

Leadership Members

[Logos of Electricities of North Carolina, Inc., NC Electric Cooperatives, KILPATRICK TOWNSEND, G+H Business Communications, and EPA]

Project Partner

[Logo of Chatham Park]
SMART Series

Autonomous Vehicles: Driving the Future of the Research Triangle Region
John Hodges-Copple
Regional Planning Director
Autonomous Vehicles
Driving the Future of the Research Triangle Region

John Hodges-Copple
Triangle J Council of Governments
May 19, 2017
Triangle J Council of Governments

- 7 counties and ~ 30 municipalities
- Voluntary organization
- 3 program areas
  - Regional Planning
  - Aging Services
  - Member Services
- Planning program focus:
  - Water Resources
  - Energy & Environment
  - Development & Infrastructure
  - Economic Development
    - Comprehensive Economic Development Strategy
    - Foreign Trade Zone
    - NC Next Generation Networks (Gigabit Broadband)
Triangle J Council of Governments

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Taxation Regulation
(Un)Official Transportation Planning Chart

**Actual Decision-Making Organizations**

- 2 Metropolitan Planning Organizations
- NCDOT (multiple geographic & modal divisions)
- GoTriangle
- Counties (transit plan ➔ $ale$ tax)
- Cities (roads & transit & walking/biking)
  - Transit agencies (GoDurham, CHT, GoRaleigh, GoCary)
- North Carolina Railroad (if in their corridor)
- Federal (Highway or Transit or Railroad) Administration
- Anchor Institutions (if applicable)
  - Universities (Duke Transit, Wolfline)
  - Research Triangle Park
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**Distracted Driver on Autonomous Vehicle**
## Levels of Automation

<table>
<thead>
<tr>
<th>SAE Level</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>The human driver does everything</td>
</tr>
<tr>
<td>1</td>
<td>An automated system on the vehicle can sometimes assist the human driver conduct some parts of the driving task</td>
</tr>
<tr>
<td>2</td>
<td>An automated system on the vehicle can actually conduct some parts of the driving task, while the human continues to monitor the driving environment and performs the rest of the driving task</td>
</tr>
<tr>
<td>3</td>
<td>An automated system can both conduct some parts of the driving task and monitor the driving environment in some instances, but the human driver must be ready to take back control when the automated system requests</td>
</tr>
<tr>
<td>4</td>
<td>An automated system can conduct the driving task and monitor the driving environment, and the human need not take back control, but the automated system can operate only in certain environments and under certain conditions</td>
</tr>
<tr>
<td>5</td>
<td>The automated system can perform all driving tasks, under all conditions that a human driver could perform them.</td>
</tr>
</tbody>
</table>
The cars of future past

Research Triangle Region
The cars of future past
The cars of future past
Framework

Autonomous vehicle deployment will hinge on at least 4 factors:

- **Technology**
  - What are we able to do?

- **Cost**
  - What can we afford to do?

- **Regulation**
  - What should we do (as a society)?

- **Culture/Behavior**
  - What are we willing to do (as individuals)?
Technology

The technology will doubtless be safer and more efficient than people, and yet ...

- Hacking?
  - The banks told us we were safe, the retailers told us we were safe -- if our credit cards crash, it is one thing, but if our cars crash ...

- Nausea (hacking of a more “visceral” kind)!
  - ~ 5-10% of adults are expected to feel nauseous riding in an autonomous vehicle

- Human error is tragic but understandable, technological error is unforgiveable
  - The dreaded left-turn-running-over-an-unpredictable-child
Cost

To succeed, companies are going to have to make money from AV, and consumers are going to have to save money over competing alternatives for market penetration to be deep. In general ...

- **Autonomous technology** raises the unit cost of the vehicle
  - Many estimates ~5%

- **Moderate cost savings come in shared vehicle ownership**
  - A trip in a shared AV car might be ~20% less costly than the privately-owned non-AV car

- **Significant cost savings likely come with shared vehicle travel**
  - But that involves other people, no matter how compatible and how identical their trip, and carpooling has had only modest (and generally declining) success
Regulation

Government responses are unpredictable and can shift

- **Insurance & liability**
  - Insurance costs from actual crashes very likely to be much cheaper; liability costs for those crashes that do occur ...?

- **Market penetration needed to transform infrastructure?**
  - Average age of car on the road today is 11 years, many are much older. What degree of market penetration at what technology level is needed to substantially achieve benefits?

- **There is often little reward for legislators to move quickly and take risks**

  *Senate leaders tap brakes on 'platooning' trucks*
Culture/Behavior

Most autonomous vehicle discussions seem to have a cultural assumption that everyone will embrace technologies based on exciting features, evidence-based benefits, and the guidance of experts, but ...
The Intersection of Technology, Cost & Behavior

- Assuming a stable regulatory environment
- Applying the filters of trip type and cost of competing mode
Community Planning Implications?

Uncertainty is the key word -- flexibility and adaptability would seem to be important components moving forward.

- Road capacity and design?
  - Induced travel
  - Sending the car home and summoning it again: 2 trips where there used to be one
  - Platooning, lane width reductions (12’ → 8’)

- Parking supply, cost and location?
Community Planning Implications?

- Transit vehicles and infrastructure
  - Busway ➔ HOV lane ➔ Managed (“HOT”) lane ➔ Managed Autonomous Lane?

- Land use and urban design
Panelists

John Hodges-Copple  
TJCOG

Missy Cummings  
Duke University

John Breitenbach  
Real-Time Innovations

Beau Memory  
NC Turnpike Authority
The Carbots are Coming!

John Breitenbach, Field Applications Engineer (and gearhead)
Carbots will change society

- Auto industry
- Roads
- Insurance
- Body shops
- Trucking
- Mass transit
- Air travel

- Cities
- Real estate
- Hotels
- Finance
- Power grid
- Oil & gas industry
- Law
Carbots are all about data

<table>
<thead>
<tr>
<th>Data source</th>
<th>Data type</th>
<th>Data Volume</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cameras</td>
<td>video stream</td>
<td></td>
</tr>
<tr>
<td>Lidar</td>
<td>data list</td>
<td></td>
</tr>
<tr>
<td>Radar</td>
<td>point clouds matrix</td>
<td></td>
</tr>
<tr>
<td>GPS</td>
<td>data message</td>
<td></td>
</tr>
<tr>
<td>Control Cmd</td>
<td>data message</td>
<td></td>
</tr>
<tr>
<td>Error Context</td>
<td>text strings</td>
<td></td>
</tr>
</tbody>
</table>

Heterogeneous data source with various volume and frequency

Real time Data logging
Carbots’ real value is in the network

- Value of network is # of interoperable connections

"Physio-Control is utilizing RTI Connext DDS to exchange critical patient care information throughout the system of care."

-- Dale Pearson, VP Data Solutions

We envision a society in which no person dies from acute, treatable medical events
Carbot Architecture

Cloud Services
- Traffic
- Maps

Databus

Error Management

Databus

Vehicle Platform

Visualization

Navigation

Sensing
- Cameras, LIDAR, Radar...

Situation Awareness

Planning

Vehicle Control

Logging

Localization

Data Fusion

Situation Awareness

Situation Awareness

Sensing

Cameras, LIDAR, Radar...

…

Databus

Vehicle Platform

Visualization

Navigation

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Carbot regional network

Fielded systems (Fog)

Area 1

Area 2

Area N

L1

L2

L3

DDS DataBus

Datacenter systems (Cloud)

Vehicles

Road-Side Units

Smart Gateways

Databus

Storage/
Big Data

Processing/
Analytics

Monitoring
Visualization
Command &
Control

Planning,
AI

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Carbots: DDS On Board

- Many OEMs, Tier-1s, & tool vendors support DDS
- RTI Carbot designs include major-brand passenger cars, trucks, mining vehicles, EV startups, campus shuttles
- >10 of these *production track*
Finally! Flying Carbots!
Current State of the Art in Perception
2Hrs 50 Min - Driver Crashes. You can observe the phone in his hand and his surprise.
Where the Driverless Cars Are

Here are some of the states where automated prototype cars are already being tested on roads, usually with humans at the ready as backup.

* The California Department of Motor Vehicles reports that 21 companies have obtained permits to test autonomous vehicles on public roads there.
Automated Vehicles Roadmap for NC

The NC General Assembly and NCDOT developed the Automated Vehicles Roadmap for North Carolina program.

ncav.org

Program Goals

• Assess NC’s current AV conditions and recommend changes
• Benchmark against industry and current initiatives of other agencies
• Provide near-term actions for NCDOT and key state agencies
North Carolina Turnpike Authority

- Advertisement 11/22/2016
- Proposal submitted 12/19/2016
- One of 10 sites chosen
- 64 proposals received
- Why pursue?
  - Safety of our customers is paramount
  - Support our customer base
  - We have the infrastructure to support this technology
Triangle Expressway

- Second All-Electronic Toll (AET) facility in US
- First new toll road designed as an AET facility from inception
- 18.8 mi between I-40 (near Durham) and NC 55 Bypass (near Holly Springs)
- Six-lane, 70 mph, full access controlled facility
- 10 interchanges and 18 AET tolling points
- Weekday Traffic Growth ~ 21% YOY
Triangle Expressway

Morrisville Parkway
- Cooperative effort between NCTA, NCDOT, and Town of Cary
- Open to traffic in late 2019

Veridea Parkway
- Design-Build contract was awarded in June 2015
- Open to traffic April 2017
Triangle Expressway

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Complete 540

- Approximately 30 miles
- 70 mph, full access controlled AET facility
- 3 phases
- Phases 1 & 2 scheduled for construction contract award in 2020

Complete 540 Preferred Alternative Corridor
Research and Partnerships

- NCDOT’s Research and Development Unit
- Regional Transportation Alliance
- University of North Carolina - Chapel Hill Highway Safety Research Center
- Institute of Transportation Research and Education
- Duke University’s Humans and Autonomy Lab
- University of North Carolina - Charlotte Center For Transportation Policy Studies
- North Carolina Agriculture and Technical State University
U.S. Department of Transportation Designates 10 Automated Vehicle Proving Grounds to Encourage Testing of New Technologies

The Proving Ground designees are:

1. City of Pittsburgh and the Thomas D. Larson Pennsylvania Transportation Institute
2. Texas AV Proving Grounds Partnership
3. U.S. Army Aberdeen Test Center
4. American Center for Mobility (ACM) at Willow Run
5. Contra Costa Transportation Authority (CCTA) & GoMentum Station
6. San Diego Association of Governments
7. Iowa City Area Development Group
8. University of Wisconsin-Madison
9. Central Florida Automated Vehicle Partners
10. North Carolina Turnpike Authority
Proposed Contributions

Digital Mapping

• Study and test AVs on newly opened roadways and interchanges
  • Veridea Pkwy interchange in 2017
  • Morrisville Pkwy interchange in 2019
  • NC 540 phased in future years

Work Zone Traffic Control (WZTC)

• Study and test AVs in real-world Work Zone conditions
  • TriEx Maintenance of Traffic (MOT) Evaluation Plan
  • New WZTC guidelines and best practices to accommodate AVs
Proposed Contributions

Incident Management

• Study and monitor effectiveness incident management strategies and policies for AVs
• Utilize NCTA’s TMC and TIMS

All-Electronic Tolling (AET)

• Study interactions between AVs and tolling systems

Big Data Analysis

• Comprehensive ITS infrastructure for research data collection
• University and business partners to analyze data
NCTA Readiness

Ability to Test
- Triangle Expressway is fully operational for immediate testing with newly available facilities opening in coming years

Ability to Share Data
- Open data sharing through NCDOT’s R&D Unit and NCTA’s partners

Designated Safety Officer and Safety Systems In Place
- DSO is committed to ensuring the program is an active, integral contributor to the advancement of AV technology.

Community Engagement
- Ready to engage nearby communities and promote public involvement in advancement of AV technology
Next Steps

• Memorandum of Agreement with USDOT

• Memorandum of Understanding with trucking industry representatives for a platooning trial

• Develop a proposal to attract auto industry testing in North Carolina
Upcoming Events

May 25 – RTCC Membership Orientation
Upcoming Events

June 1 – Marketplace: Meet the Developers of Chatham Park

Marketplace.

Meet the Developers of Chatham Park.

A new series by the Research Triangle Cleantech Cluster
Upcoming Events

June 6 – Show Me the Money – Venture Capital in Cleantech & RIoT Annual Startup Pitch Night
Upcoming Events

June 26-28 – Smart Cities Connect Delegation
Upcoming Events

September 14 – RTCC Annual Meeting
THANK YOU