Legal Implications & Public Policy

Facilitator: Wendy Wagner & Notetaker: Zack Lofton

Introductions:

Professor Wagner
Leroy Alloway – Alamo Area MPO
Becky- TxDOT
Harris - State Leg Affairs
-Work with staff to determine what needs to be changed from a statute perspective
Jason Wagner- TTI
-mentioned projects he is working on
-particularly regarding legal questions and regulations
-economic analysis regarding safety benefits
Kevin Hall - TTI
-Involved in research to model or forecast impacts of AV technology on traffic and other transportation
-Concerned about what impacts may actually be
-Identify what can be adjusted and come up with scenarios to makes suggestions to MPOs
-Also consider the legal impediments for adoption of AVs on a large scale.

Conversation begins: How are the risks posed by C/AVs different than for existing cars in ways that might affect the law?

- Voiced concerns about how certain obstacles in the road may create issues for AVs, some legitimate and some illegitimate (i.e. like a human in the road versus a plastic bag floating in the road)
- There was also talk about how AVs will be regarded from a policy and legislative perspective. Is this an immediate or long-term concern? Some mentioned that forecasting might even be necessary all the way out to 2100.

Question: What are some of the pressure points in new AV technology that might impact legal rules and policy, or visa versa?

- Initially we need to consider and define what the risks are for C/AVs and determine legal responsibilities based on these risks
- We also need to gauge the expectations that consumers have regarding the capabilities of these new (expensive) vehicles. There are potential glitches ahead in how smooth the C/AVs operate in our existing system and the possibility for consumer disappointment. This isn't a legal issue but it certainly will affect policy decisions.
    - What are the choices for an AV if a pedestrian comes onto the street and then the car is not allowed to cross double lane? This is a serious limitation.
    - Also, in light of our current infrastructure that is often at capacity, how are accidents going to impact the flow of traffic if AVs have managed or shared lanes? Clearly there will be differences if lanes are shared or if AVs have their own managed lane like an HOV lane. But it is possible that AVs will be in traffic snarls in ways that look very much like the status quo, with no discernible benefits.
    - How do you determine toll costs if there is an accident in a dynamic pricing lane like the new Mopac (when expectations are that this is a huge advantage and benefit)?
        - You don't promise refunds on the tolls!
        - Will costs adjust quickly and comp the drivers for the slow moving traffic?
    - Whose responsibility is it if infrastructure issues happen? Like if a light is out? TxDOT has certain responsibilities contingent on the amount of information they have. How

much is TxDOT Liability? And what are the policy/political ramifications when infrastructure isn't working properly?

Question: Have you addressed in your work any policy issues regarding integrating C/AVs into our existing transportation system?

- Equity is a concern on a few levels. Policymakers want to be considerate of all commercial stakeholders from a business standpoint and individuals (public) on an equity basis. The goal is to limit any sort of exclusive market and ensure that there is a legitimate opportunity for competition from multiple companies in the autonomous vehicles market, with lower cost vehicles resulting. From an individual equity perspective, we don't want to exclude anyone from potentially utilizing autonomous vehicles.
- As a concept, there are plenty of options for many different populations to capitalize on C/AVs, but we don't want to get in a position where C/AV infrastructure bypasses lower income neighborhoods or the like – or conversely that it concentrates traffic in these areas. So, how do you deal with social inequity? This could even be a section 8 issue.
- You'll really need to consider if there is disparate harm to a low-income community with a managed lane or something? Can discriminatory action occur with these managed lanes? What are the responses if so? As a public policy issue, people complain of discrimination even for toll roads because some can't afford. This is likely to occur from C/AV infrastructure as well, particularly if it is concentrated in areas where folks can't afford the cars but get the increased traffic.
- Platooning is an area gaining traction from a policy perspective. The USDOT is putting forward a standard technology for platooning etc. The reason they set it up this way is for uniformity and consistency. The idea is called the Basic Safety Method. This method will help streamline the necessary functions in a definite way.
- Omni Air is an example of trying to generate uniform policy: It was a statewide NGO drive to develop uniform control standards for the tolling. It worked with the private sector, and all tolling agencies wanted this concept. However, this idea also became challenging for different jurisdictions. Tollways are supposed to be interoperable but often times they are not.
- Furthermore, there can be a patchwork of laws and policies that ultimately create issues with enforcement across jurisdictional lines. In the San Antonio Metro Area, there have been questions and issues regarding hands free and non-hands free areas and how to bridge the two. The same idea goes for ride sharing companies, which creates a problem for regulation. If this is similar to C/AVs, will this create problems across jurisdictional lines? The messiest place of consideration seems to be in the mixed area of smart and dumb cars coupled with different jurisdictional rules.

Question: Is there a lot of talk about state legislation?

- TxDOT: yes, we met with Google to talk about policies and legislation, but ultimately it was to no avail. Our anticipation is that larger more progressive cities in the state will have to participate in these talks to push the agenda. Smaller cities may not be as willing because of political issues and/or because they are less likely to have C/AVs on their roads any time soon.

Question: How will these different municipal perspectives impact regulation? Is it a matter of V2V or V2I?

- If it's V2V this may not be as big a problem. V2I isn't required for all technologies on AVs. Much of the technology is focused on V2V, which helps C/AVs when traveling through areas with disparate infrastructure. Ultimately, it will depend on the location and scenario.
- One other wrinkle: Some test projects in San Antonio: could be a savings if C/AVs create less need for infrastructure like signs etc. If signs etc. are no longer needed, how will this be

regulated? C/AVs may even be viewed as a tax benefit if costs can be decreased through less infrastructure provision and maintenance.
- What if you have a medical emergency? Using flashers etc. on way to ER, You probably can't do it in a C/AV because the car will be interpreting the speed limit unless there is some emergency signal that can be transmitted.

Question: Are privacy issues something people are considering and how are MPOs handling the use of data?

- Yes, but MPOs are not doing too much about this. Most data currently is Bluetooth travel data about real time conditions and not projected data. This helps keep the MPO and/or TxDOT from liability regarding personal/confidential info with respect to data they have.
- Trying to identify threats to security and cyber security is definitely an area that people are talking about with regard for privacy. Overall security is in line with cyber security and hacking. It's like C/AVs will enable more data collection, which will then provoke more issues.
- Data can be patched together from many different sources. Many feel that transportation data would be vulnerable and could be used for things users would not appreciate.
- How to make data anonymous? It would be good but can be very difficult.
- Toll tag data has now been exempted from disclosure (under open records as a legislative matter? Not sure?). Divorce attorneys were trying to get this data to determine travel and use it for evidence etc.
- Uber has gotten trouble on using data for "rides of shame," like late night solitary rides etc. adultery etc.
- Data management is tremendously varied across agencies, even within agencies like TxDOT.
- Need to protect data but main concern is what the government is going to do with the data?
- Toll data is unable to be used for other projects like modeling and forecasting traffic demand etc.

Question: Do manufacturers want consumer data on who is driving these vehicles?

- We assume that the C/AVs will store this data. Kind of like black box type data. Do manufacturers have access to this data in ways that consumers themselves may not appreciate? Will they use this to manipulate the market?
- What does this data mean for the insurance market? Can they access this data? Will it help insurance companies and others in placing responsibilities on various actors or hurt them in some way?

Public Outreach & Steakholder Education

Facilitator: Johanna Zmud & Notetaker: Aqshems Nichols

Attendees: Dr. Johanna Zmud of TTI, Mrs. Lisa Loftus-Otway, LL.M. of CTR, Aqshems Nichols (Notetaker)
Breakout Session: "*Public Outreach and Stakeholder Education*"

This breakout session mainly focused on community and stakeholder education on AV technologies. The participants voiced concern on the amount of misinformation and lack of knowledge regarding AV technology that exists within entities including, but not limited to, state legislatures, metropolitan planning organizations (MPOs), city councils, and local communities. A participant noted that one of major research issues concerns how to reach all of these entities in an effective manner to better inform them of these emerging technologies.

Some of the existing problems noted by the participants included the tendency of pro-AV groups to tout the benefits while neglecting to thoroughly discuss the costs. Additionally, the participants

addressed the problem of the various interest groups not using the same language and acronyms, which is causing some confusion amongst some of the groups. Dr. Zmud and Mrs. Loftus-Otway also mentioned that state and local agencies have invested a relatively small amount of resources into engaging the public on these issues. They also believe this to be symptomatic of private sector dominance in AV tech development and research, as public entities may have ceded the discussion to be governed by the private sector. Other problems addressed include state agencies unwillingness to invest in AV technologies until other invest first. These entities want to see the results of investments before committing themselves.

The participants suggested several actions that could be taken to improve stakeholder education and breakdown communication barriers. Most prominently, the two participants expressed support for efforts to translate the research being produced into less technical documents in order to reach a broader audience. To give an example, the two researchers recommended that TXDOT require policy briefs be drafted in addition to technical reports for the projects they fund. Mrs. Loftus-Otway and Dr. Zmud noted that the Policy Research Center requires this for their studies. The technical briefs should include as much non-technical information that can be extracted from the research being produced at the university level. Mrs. Lisa Loftus-Otway also recommended that TXDOT require more production of literature that can be used alongside technical briefs to assist policymakers in understanding the research. They posed the question of whether funding needs to be incorporated into research budgets for the purpose of making documents more readable by non-technical stakeholders.

The two experts also mentioned that more research needs to be implemented to provide policymakers more opportunities to actually visualize the results. They also agreed that public outreach is less of a concern until stakeholders are more comprehensively informed, and it is important to educate stakeholders first because they can strongly help or hinder the efforts of researchers and the private sector. Another challenge to address is that people are busy and it takes considerable time to read technical and non-technical documents.

Mrs. Loftus-Otway and Dr. Zmud also briefly discussed the role of the MPOs in this process. The two experts mentioned that one of the best ways to help implementation of AV technology is to persuade MPOs to include AV and CAV planning in their long range plans. Contrastingly, Dr. Zmud mentioned that she has communicated with MPOs, and the onset of CAVs is actually influencing MPOs to not pursue some traditional alternatives such as road projects. Though influencing MPOs and state legislatures are important, public outreach cannot be disregarded because local communities can strongly influence the directions taken by the respective city councils.

Traveler Choices and Transportation Planning

Facilitators: Tom Williams & Kara Kockelman & Notetaker: Gleb Domnenko

Participants:

A.: Andrew Mao, TxDOT Houston District
D.P.: Darin Parish, Southwest Research Institute
D.S.: Darcie Schipull, TxDOT San Antonio
K.: Kara Kockelman, UT Austin
T.: Thomas Williams, TTI

Conversation (largely recorded on smartphone & then enhanced):

K.: This break-out session is devoted to key issues, key opportunities, and important questions in the areas of consumer choices and transportation planning. Let us discuss new ideas and technologies, vehicle ownership decisions, and how the Texas Department of Transportation (TXDOT) can provide more demand-responsive service.

D.S.: One of the biggest problems is convincing the public to talk about these issues. Some people claim that there will be no need for cars in the future, but the truth is: car ownership is not going to just go away. Oil price boom did not make everybody suddenly let go of all the cars. And the switch to public transit is not happening; in fact, in San Antonio, we have seen a decrease in transit ridership.

T.: There is a group of people who just do not want to see changes. They will resist further capacity additions arguing that it is possible to increase the existing capacity four times using AV/CV technology with the resources already available. I think what we need to do is develop a language and a common understanding to be able to respond to such claims. We need to do it quickly because there could be legal challenges when it comes to National Environment Policy Act (NEPA) and other environmental regulations. If autonomous vehicles (AVs) turn out to offer reasonable and practical alternatives, but we do not consider this in our regulatory documents, we may face serious problems.

D.: We are in the process of constructing a new travel demand model. We plan to do include Dynamic Traffic Assignment (DTA) modeling. We do not yet have a peak time of the day modeling included, and we can really improve our models by incorporating the mode choice change.

K.: I would suggest including vehicle ownership in the models as well.

T.: The research by Dr. Boyles and Professor Kockelman is critical: the definition of capacity with AV/CV technology is fundamental. We rely on the Highway Capacity Manual (HCM), and it is important that we gain an understanding of how AV/CV technology can change our standard definition of roadway capacity. It increased over the years, from 1,800 vehicles per hour per lane to over 2,000 vehicles per hour, and we will probably experience another big leap if AV/CV technology pans out.

K.: Capacity concerns become more important with the mixture of vehicles (AVs and conventional vehicles) on the same road. Is it possible that there will be cities that will only permit smart cars to run downtown or in high-crash locations?

A.: It can be achieved. As regulators, we can require drivers to have a Toll Tag, or an extra passenger to ride in a HOV lane. Therefore, we can also require connectivity. Then we will just have to make sure that the vehicles can talk to each other and to the infrastructure. These standards are not yet there, but just like with the cell phones, we can make the devices share some common standard and update firmware accordingly.

K.: Standardization is, in fact, not a big issue. Basic messaging is pretty simple. The pieces of information that will be exchanged are limited: location, direction, speed, acceleration (& perhaps whether one's lights & window wipers are on, to indicate lighting & weather conditions). And connectivity is going to be required in the near future. However, instead of simply using a cell phone, there will probably be a specific device for cars, like the one Chris Claudel was discussing in his presentation earlier today.

A.: Another issue is that although we have a lot of mandatory requirements for the DSRC, a lot of enterprises provide proprietary enhanced features that affect communication.

K: I think the main channel of any complex communications (e.g., routing recommendations) will be via a cell phone tower, or perhaps a series of overlapping (in range) single-carrier Wi-Fi spots. Specialized alert information (e.g., slippery pavement ahead) that requires high-speed DSRC channels needs cars to be listening. It may not be required, but there will be a market for it. And if the car is automated, it will potentially be able to respond to all sorts of alerts without needing the driver to react.

A.: What if one car has this system and another one has not?

T.: We really do not know definitively just yet. Having a mix of cars with and without automation may even exacerbate current congestion problems.

K.: I think coordinated adaptive cruise control (CACC) will be relatively standard on good share of new vehicles before long. In terms of avoiding crashes, CACC is supposed to be very useful, and since 25% of congestion comes from crashes, that portion of congestion may largely disappear. However, we do not know if people are going to start abusing this technology by, for example, jumping in front of the cars. We do not expect much abuse, but there may different scenarios.

T.: There have been a lot of discussions about ethics of AV/CV, driverless vehicles, versus humans. Computers cannot yet tell a difference between a large paper bag and a baby carriage. However, to be realistic, the number of people who push baby carriages on the road is low, and a lot of these reports in my opinion are therefore sensationalism. We as a society accept some level of risk with all technologies, and the same will hold true for AV technology.

K.: Let us talk about the travel demand models and behavioral shifts with CAVs & fleets of SAVs in the mix. The biggest model that I've used so far is my recent doctoral student's 100 mi x 100 mi idealized city setting, but with no network links and no congestion feedback. The biggest one my students have used with real links, but still without congestion feedback, is 12 mi x 24 mi, for the central Austin region. In the current paradigm, we can no longer follow just the traveler: we have to follow all vehicles and all travelers because vehicles can pick up somebody else or at least head somewhere to self-park. It also is no longer a static trip table, but a dynamic system. If people start getting used to just-in-time ordering of the vehicles, then we will have a very computationally intensive setting.

T.: Yes, and if you add the idea that somebody may order a premium service where you go by yourself, you listen to your own music, and the car takes you directly from the origin to your destination, then it becomes even more complicated. Other service levels may need to serve other passengers, and the routing becomes changed in the midst of the original, shared, passenger's trip.

K.: There is a paper about dynamic ridesharing on my website, but because of the computational issues we were unable to simulate everybody in the model, even in the 12 mi x 24 mi setting: we only got up to 20% of central Austin's personal trips. However, there is software called MATsim that can help with some of the computational issues. It is open source, and it requires professional coders, but it allows for more than traditional demand modeling software.

T.: Unfortunately, we cannot wait for best tools to come out; we need to continue with making transportation plans. New tools are needed, but we must do with what we have for now. We need to come up with the ways of talking about new technologies, estimating their impact, and envisioning the consequences of their implementation. Ultimately, we need to find the ways to aggregate all this into viable policy recommendations. Even with best simulation tools, there will always be a whole sphere of behavioral impacts we cannot model because there is just no data available, there is nothing to calibrate to. Right now, we are only doing stated preference surveys to understand what the public perceptions of these technologies are to get a glimpse at what behavioral impacts might be.

D.S.: What also matters is where to allocate investments. For example, a lot of Intelligent Traffic Systems (ITS) are old. How do we upgrade those? What technologies must be used? What type of investment should we be making: some small upgrade or switch to a completely new technology?

A.: Personally, I think we need to invest in communication system such as fiber because a lot more data are going to be running along it. Everything connected to the system, for example variable message signs & cameras, may become obsolete quickly, but this information highway along the actual highway is not going to be outdated fast.

D.P.: I would add a radio piece to this system. We really want to get to the vehicle ultimately.

K.: The radio spectrum is an issue. Infotainment companies and auto manufacturers wanted part of the DSRC spectrum. Right now, it is not wide enough to carry more than basic safety messaging for perhaps 100 vehicles coming to the same intersection and relaying quickly and properly. The DSRC spectrum is insufficient for complex message transmissions, like suggested routings to a specific vehicle. If we want something more complex, we need to use cell towers or other means.

T.: Infrastructure investment is an interesting problem to consider. How should we react on the public side to all the changes that are happening on the private side? Take networked traffic signals, for instance. Are they really difficult to implement? We now have them in downtown and other small areas, but we have never seriously focused on this technology. What if we decided to make implementation of automated/connected infrastructure a megaproject, and focused our resources on this just as we have on large capacity projects in the past?

A.: Actually, this may be easy to implement. The ITE developed a standard called advanced transportation controller (ATC), and I was the early adopter of it in the Houston area. Harris County now has thousands of these controllers. Basically, these are computers with operating systems. So to make a local intersection a DSRC location, we just need to update software and then hook-up a DSRC radio device. You can also add GPS, Bluetooth, etc.

K.: I do not think the public sector needs to worry about making these investments much. Connectivity is going to happen quickly (when required on new vehicles sold, and hopefully soon added to existing vehicles), but our agencies will have some time to adapt. They will be able to identify where it would be the most cost effective to put roadside units. Maybe dangerous-curves alerts first, then alerts about red-light runners at the most dangerous intersections, then, longer term, maybe wrong-way-driver alerts at problematic ramps. Once you have many cars instrumented, it will be easy to implement.

T.: Basic assessment of where to invest first is based on safety, usage, cost effectiveness, and policy, of course.

K.: Please send us your questions. We are going to keep investigating such details, and we are going to keep conversing. We will love to have your questions and suggestions. ***Thank you all for being here today.***

Traffic Impacts & Simulations

Facilitators: Steve Boyles & Peter Stone & Notetaker: Tianxin Li

Dr. Stone mentioned that our government has the plan of investigating huge amount of money (~$20 billion) in transportation infrastructure, e.g., build new roads, increase the traffic capacity of the current links, and set up toll roads, which would absolutely play a significant role in our current traffic condition, though the impact are hard to predict precisely. If we do nothing, however, we are clear in mind that the Austin network will become a huge parking lot in the near future because of the population growth and traffic demand increase. The question is whether this huge investment can benefit AV technologies or

what is the best way to make our plan to take AV into consideration in the future years when taking into account the uncertainty?

Dr. Boyles pointed out that in order to solve this question, we have to figure out what the differences between the infrastructural requirements of the conventional vehicles and AVs. In addition, many different scenarios should be set up to estimate their traffic impacts. Dr. Boyles also mentioned that he has a proposal relevant to this issue, which provides suggestions for what is the best traffic infrastructure plan in the limit of certain budget, and what will benefit our transportation most if have extra budget.

Dr. Stone and Dr. Boyles also mentioned that 5-year term would be better to review and design transportation planning, which gives more flexibility to the planner because of having the chance to adjust plans based on the quick technologies alternation. On the other hand, it is good to investigate the next step of money after we see the certain results obtained from the previous plan.
Dr. Stone noticed that to test the AV network in the real city will have lots of risk and uncertainty, but at the same time, to test the AV in the real world would bring huge benefits too. Dr. Boyles extended this topic by saying that it is important to determine the extent of risk tolerance of the local government can accept to spread the AV technology.

Google assumed that there is no need for new infrastructure for the AV tech. Dr. Stone, however, cast doubt on this assumption by pointing out that we still need new infrastructure for the CAV tech, e.g., infrastructure to assist the connected vehicle in the intersection, though it is not a huge amount of money. In addition, we can set up, for example, the downtown of Austin to be a district without any kinds of vehicles except for the AVs, so we don't need the parking lots in this area, which could bring huge impacts to our land use. We have, however, to build parking lots outside this area to let the people park their car before transfer to the AVs, which will increase the money of infrastructure building.

TxDOT staff joined our session. She mentioned that from the view of TxDOT, they don't want to build new roads or add more links in the current network. On the other hand, they want to find a more efficient way to increase the road capacity, which CAV might help. They have a big project going on that is they plan to install sensors all around the network to support the autonomous vehicle. In addition, she mentioned that they already have a concept that to set up an area full of CAV and shared AV, but not at Austin. Dr. Stone suggested that Austin would be the ideal place to test this assumption because residents here are more likely to see the high tech.

Dr. Stone's intersection reservation video attracted the TxDOT stuff, which is the first concept of Dr. Stone's research. Dr. Stone's team is investigating the possibility of dynamic lane reversal, e.g., add one additional lane to the two-lane road and alternate the added new lane to proper direction hour by hour based on the traffic demand condition. Although this can be effective now with conventional vehicles, most of the benefits of this dynamic lane tech will depend on the AV tech.
Dr. Boyles started a new issue that is how to simulate the technologies hasn't been realized yet and then to investigate the technology's impacts. Dr. Jia Li indicated Micty concept developed by University of Michigan, Ann Arbor, which is a project t to establish the real test field to estimate the impacts of CAV technologies. In addition, Dr. Li believed it would be beneficial for the government and research institution if the test data can be shared.

Dr. Boyles and Dr. Li stated that it is very essential to take into consideration the human behavior in the simulation part. Dr. Stone pointed out that we should find a way to simulate human behavior, e.g., creating a virtual scenario which can let the driver to experience the differences of CAV, which can give us more information about the impacts of technologies for the human drivers. With this information, we can better establish our simulation models. In terms of simulation, TxDOT staff mentioned that someone

tested the impacts of traffic jam assist got an accident during the period of testing, which might not be able to be simulated in the study. She also pointed out that L2 AV and L3 AV would be much more dangerous for the users because users will have trouble taking over the control the vehicles from the automated mode.

The TxDOT staff stated that the TxDOT are planning to share their available traffic data as soon as possible to the public, so that these data can be used more effectively and generate more benefits for the public, e.g., crash data and sensor data. Actually, the crash data has been shared with research institution already. The timeline for sharing other traffic data with the research institution and manufacturers will be possible around 2018. The staff at the end mentioned that not like Michigan and Florida, who have their own test platform, Austin doesn't have a real test field yet. Dr. Stone suggested that we can take the overall lead position by close the downtown of Austin and only let AVs be operated in this region to see the impact of AV tech.

Technology, ITS Strategies, & Device Development

Facilitators: Paul Avery & Chris Claudel & Notetaker: Kapil Sharma

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Participants: Christian Claudel, Paul Avery, Jianming Ma, Randy Roebuck, Zachary Elgart, Joseph Carrizales, Andrew Mao, Jason JonMichael

The discussion started with Dr. Claudel's description of the device/hardware that is going to be used in the 6838 project for collection of data. The device is supposed to be an IMU and GPS integrated sensor having a USB interface which can be plugged in any car (in case when a USB plug is not present the driver can use any Geo USB charging point). The USB interface provides as the power source and also keeps the device attached to the automobile for accurate readings. And he also explained why the IMU sensors in our smartphones couldn't be used, because of random motion and orientation of the phone in the car. The device dimension will be of the order of 1-2 inches. In phase 1 of the project 20 devices are made and will be distributed among routine drivers in different parts of the town. Also, Kapil will develop an interface application via which the user can monitor the values of this data. The potential candidates for collecting this data will be for instance TxDot employees, UT students or UBER etc. The communication technology that this device will use is Bluetooth. Randy and Joseph regarding the feasibility of Bluetooth as the means of signal exchange then raised questions. Discussion about the range, size of payload, compatibility etc. was done. Paul and Dr. Claudel both told the forum that the size of the payload depends on the granularity of the data, no. of sample points, severity of the event etc. But it was noted by the participants that Bluetooth based warning system though good in urban environment with average speed of 30 or so miles, may fail on highways.

Estimation strategy that is going to be used at these RSEs will be distributed traffic state estimation. Each RSE will have same code run in parallel generating detailed maps with relative positioning of the vehicles. This in turn will have advantage in terms of distribution of processing so that the real time estimation is very accurate even with less power computers. Here, there was a small discussion about the reducing cost of the computers. With members pointing different types of low cost computers like Raspi and ASICs etc. There was a discussion about how these low cost computers will affect all technologies.

Some features of these devices:
Localized security: In real implementation this will only need the IMU sensors for relative positioning and eliminating the need for a GPS device which can be spoofed and can cause havoc.
Privacy concerns: since the devices will be based on measuring relative trajectories and talking only with the nearby driver and RSEs (Road Side Equipment). Data localization.

No absolute positioning like GPS required
These sensors are much more accurate then GPS and have really fast refresh rate.
Better management and better sensing.
Minimize traffic measurement noise due to effects like urban canyon effect

Dr. Claudel then explained the need for this type of traffic sensing and its feasibility. He was of the opinion that since these technologies do not depend on sensors embedded in the roads, the infrastructure cost can be a plot less. The devices that we are going to use will be retrofitted in cars. On this several participants raised the question on various liability issues since no auto manufacturer will assume liability based on some retrofitted sensors. In reply Dr. Claudel explained that in the real implementation these will be part of the new car system since most of these sensors are very cheap, costing 30-40 $. They are not included in the automobiles till now just because the manufacturers till now did not have the idea of how to use the data that these sensors generate. Paul pitched in with his observation that some manufacturers in fact have these sensors but they are used for some other purpose like ABS and auto transmission etc.

Then Paul Avery from South West Research Institute (SWRI) explained that they are doing a similar experiment but using different sensors (mostly GPS) and DSRC (Dedicated Short Range Communication).

Then the discussion about various techniques of traffic sensing was done.
IMU-GPS based technologies: as described above
Only GPS based sensors: this is the predominant technology used in nowadays vehicles.
Video cameras: Machine vision algorithms based sensing.
LIDAR: laser base sensing technology

Jianming then asked why not use LIDAR, in response Paul answered that nowadays video processing is much faster than LIDAR sensing due to having these dedicated chips for graphics processing. Also, he pointed out in the coming days the DSRC devices will be really small and cheap and hence the technique looks promising to be used in the future.

Joseph asked Paul why not integrate these systems with the CAN bus that is connecting the entire vehicle. In response Paul as well as some other participants pointed out that most of the manufacturers have these proprietary OEMs for CAN protocol, and most of them are not very forthcoming with the inner details of these, and rightly so as they cannot read the intentions of the person who can use this data for malicious intents creating high liability issues for the vehicle manufacturer. Also there are compatibility issues since integrating these devices with CAN is really difficult and the situation is further worsened by each manufacturer having their own OEM for the CAN bus protocol.

Jianming questioned about whether there will be provision of EDRs (Event Data Recorders like black box in a plane), since all these sensors will have to store data somewhere, and in case of an accident this data needs to be analyzed for cause detection. Paul pointed out that there needs to be some sort of an EDR, and these recorders will have to distinguish between significant and non-significant events. And since most of the causal events are a result of many earlier events it is important that the system does this reliably. And then there are issues like the size of the rolling window, capturing all inputs to an event. Then the group discussed about the Prius issue in which the acceleration somehow malfunctioned and they were not able to pin point the cause.

The discussion concluded with different participants pitching in about the need for an integrated mobile solution for CAVs, AVs etc. with a really strong emphasis on safety.

Freight Effects of C/AV Technologies

Facilitators: Curtis Morgan & Notetaker: Michele Simoni

Participants: Curtis, Duncan, Stephan (SwRI), Mike Lukuc-TTI

1. Introduction of participants

Curtis: he deals with freight, rail, freight pipelines, plus 6837, 6838
Duncan: he's volunteering at CTR, his primary task it to make people (students and researchers) to think like TxDOT. Especially from a legal point of view.

2. First round of conversation, more or less brainstorming

- One issue is: We have a lot of trucks on the highways. Trucks take more room and they travel at different speeds. There are upfront benefits of C/AV technologies for freight applications: higher efficiency and so on. The flip side might be privacy issues…
- Google has the approach that the vehicle can do everything. For TxDOT it would be great if this approach worked, but is it really going to be?
- TXDOT provides the paths on its network. A statewide control system is missing and that's an important need for truck drivers.
- AV allows us to reach easily everyone and provide advice about speeds and routes. But on the flipside: there is a problem of privacy (private companies and public authorities).
- Freight is important factor of congestion statewide. More people and trade is growing: so, we need to do something about congestion.
- Idea: managed lanes with tolls.
- Local approaches (e.g. at intersection level) looks more problematic, hard to be implemented with freight vehicles in mix
- Convoys of trucks are also a possibility that should be discussed/investigated
- The operator (UPS, HEB or whoever) should be in charge of saying whether their vehicles are capable to platoon or not. Shall we let the market do that or TxDOT needs take care of that?

Freight first or freight around? Who's driving C/AV development?

- Also in the transition phase how do you deal with freight?
- It is clear applications of C/AV technologies need to be applied to freight first, but how…?
- Developers of future systems should design something that works for freight and also for cars rather than vice versa
- Truck drivers need level of sophistication
- From the department perspective, we need to figure out what can we do

Freight-related infrastructure needs

- Truck parking. For example, terminal in Houston problems: pavement and truck congestion. Hence, on roadways we need safety rest areas
- In urban areas perhaps any sort of guidance for trucks could be a solution. There do already exist ones for heavy weight ones, but companies do not want to share data.
- Check what has been done in Georgia, in Savannah where they provide truck sequences.
- Ports-RailRoads-Inland Ports have been mentioned as worthy of investigation for potential investigations.
- The penetration rates of C/AV technologies will grow slow for small operators (20 years)

Freight-related operator needs

- Safety is the main reason that drives technologic improvements and adoption of C/AV technologies. It's interesting because, statistically the cars are the ones who crash the most against trucks. So, for sure there will be benefits, but far from being significant.
- One participant looks skeptical about being able to develop all this automation…
- Description of the following interesting aspect concerning TxDOT, which has to deal with tailpipe emissions. All construction projects and so on, they have to demonstrate that air quality will not worsen in non-compliance areas.. If they can't reach conformity, they won't be able to receive new roadway funding from the government. This means there is a sort of budget in terms of miles/travelled. Hence, if we have a technology that generates more VMT in a defined area than what we can "afford" there's a problem and this would likely be the case of C/AV vehicles.

Large vs small scale freight implementation of C/AV

Large companies and small ones. Different limits? Conformity?
What's going to be an issue?
Shared fleets for urban freight? Any sort of uber for freight?

- There are already a lot of existing tools. Big carriers like UPS, DHL will probably come up with some innovative ideas for urban delivery for sure.
- Huge trucks driving around the neighborhood represent a problem.

Conclusions

- There is definitely need for policies, but it is not easy to
- In Australia, for example they have a national transport organization. In between running road-trains and other vehicles, they have a separate regulatory group that monitors compliance of technologic things (this is not government or private companies). This allows sharing of info more easily and providing priority routes for road-trains.

Opportunities & Issues for Transit Users & Non-Motorized Modes

Symposium Break-out Session Notes
Facilitator: Katie Turnbull & Notetaker: Rahul Patel

Participants: Katie Turnbull, Texas A& M Transportation Institute
Allie Blazosky, Alamo Area MPO
Marc Segal, Atkins North America, Inc.
Recorder, University of Texas

Issues and Opportunities – Participants discussed a variety of issues and opportunities with C/AV technologies and transit/non-motorized modes. Numerous opportunities to enhance transit operations and mobility, as well as making all non-motorized modes safer for users were discussed.

A/CV can be an asset to transit not a hindrance
A/CV could save resources for providers and users
A/CV could reduce crashes involving different modes of transportation

Pedestrians:
Apps warning distracted Pedestrians of oncoming vehicles.
Same warning can be utilized in vehicles for pedestrians
Cameras on buses that notifies driver of pedestrians

Physical sounds saying “bus turning” to warn pedestrians of turning buses or vehicles
Will there be increase in personal amenities for pedestrians with not having their own vehicles with AVs?
Reduction of parking and enhancing roadside amenities
It has been suggested that there could be upwards of a 90% decrease in parking with A/CV
Could have a city park system in which A/CVs can go through that system
A/CV could increase the pedestrian experience
How could A/CV detect transit users?
Either vehicle sensing pedestrian or pedestrian sensing and being sent message for vehicles

Morality of decision making for cars
Google is programming their AVs with mass amounts of information and data for detecting different pedestrians and situations

Shared Services:
This could be the initial platform for A/CV (Uber)
Transit applications could be after freight and commercialization of A/CVs
Newer ideas and apps for bicyclists to hold green lights for them longer
Vibration of handle bars on motorcycles or bicycles as a warning system or for GPS capabilities
Use of AVs can cut travel times by a large amount in different situations

Other Topics and Ideas:
Use of AVs in closed loop systems such as campuses, malls or airports
Trolley systems could turn to autonomous systems
There are a lot of applications for this idea
TXDOT project for transport safety focus and transit opportunities
Reduction of accidents
Final product is Concept of Operations (ConOps) plan for actual testing and demonstrations
Small demonstration using camera technology and A&M buses

Accident numbers are breaking records and making safer roads and transportation should be a priority
Slows down traffic
Almost breaking 40,000 fatalities
Seeing at night and inclement weather is important
Need technologies that work in the day also to work at night efficiently
Public entities coordinating infrastructure possibly not expanding due to weather or night time accidents

How can AVs see at night? (Or through rain and fog?)

Rio Grande bike system
Two way bike lanes on a one way street how will people traveling opposite direction
Bikes with lights when wheels spin giving signals for safer biking
San Antonio geared towards protected bike lanes
Need to focus on, on-road network