Driverless Car Summit 2012:

Conference Report

2 August, 2012

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The Summit Brought Key Organizations Together to Share Perspectives in a Lively Format

As a large non-profit global trade organization, AUVSI focuses on unmanned aerial, underwater, and ground vehicles.   With the "Driverless Cars 2022" initiative, AUVSI has set a ten year "stretch goal" for achieving a new era of road transportation with self driving cars.   The first meeting of its kind, the 2012 Driverless Car Summit brought together the key players in vehicle automation to better understand the issues and ways forward. The 2012 Summit is intended as the first of a series of annual events leading to the 2022 goal.

Building on similar activities in UAVs, AUVSI seeks to play a technology advocate role in the civilian ground transportation sector. AUVSI sees its role in vehicle automation as maintaining momentum by bringing the industry together, providing greater coherence, disseminating information, and identifying and filling gaps in addressing important policy matters regarding automated vehicles.

The Summit was conducted as a single-track event. In order to create a rich medium for discussion and understanding the issues in-depth, a unique meeting format was employed with minimal presentations and a primary focus on panels and on-stage interviews, led by a skilled facilitator. The result was a relaxed yet engaging format which involved the audience in extensive Q&A.   Comments received during and after the event confirmed that this was a very effective approach.

Participants Represented the Full Range of Vehicle Automation Players

Michigan Governor Rick Snyder opened the Summit, which was attended by over 200 experts from across the automation domain. High level representatives from the White House Office of Science and Technology Policy, USDOT Intelligent Transportation Systems Joint Program Office plus the National Highway Traffic Safety Administration (NHTSA) were present, as were USDOD executives from the Office of the Secretary of Defense, the Robotic Systems Joint Program Office, the Tank and Automotive Research, Development, and Engineering Center (TARDEC) and the Army Research Laboratory.   Leaders from State DOTs and Motor Vehicle Administrations attended from Florida, Illinois, Michigan, and Nevada.

From the traditional automotive industry, many vehicle manufacturers and suppliers were represented. Car manufacturers included Chrysler, Daimler, Ford, GM, Honda, Nissan, Toyota, Volkswagen, and Volvo Cars.

From the private sector technology world, Google plus numerous firms active in ground vehicle robotics were there.   Transportation engineering was represented by several infrastructure and traffic operations firms.

Key industry organizations were present, including the Alliance of Automobile Manufacturers, Global Automakers, ITS America, the National Federation of the Blind, the Society of Automotive Engineers, and the Royal Dutch Touring Club.

Subject matter experts came from the fields of law, cybersecurity, human factors, and other domains.

Academic representatives included Carnegie Mellon University, the Georgia Institute of Technology, the University of Michigan, the Massachusetts Institute of Technology, Princeton University, Santa Clara University, and the Virginia Tech Transportation Institute.

Major Themes

The concept of automated vehicles was originally introduced by General Motors at the 1939 World's Fair. In the ensuing decades, prototypes were developed based on available technology, and evaluated as to performance and cost. As recently as 1997, USDOT sponsored an extensive demonstration of automated vehicle capability. DARPA took up the charge in the last decade with the Grand and Urban Challenges. Google's recent entry into this space has fascinated the public and catalyzed new market activity.

From a car industry perspective, the advent of vehicle automation is by now a given. The major companies have been working quietly on this capability continually for years. Systems are being designed to handle the roads and traffic "as-is." The role of the infrastructure is open, as to how traffic management and mobility enhancement systems adapt. Expanding mobility for the disabled and elderly is an exciting new opportunity, especially compelling giving the aging of the Baby Boom generation.

> From a car industry perspective, the advent of vehicle automation is by now a given.

New driving laws allowing for testing of automated vehicles on public roads are now in place in two states, and more are expected to the same in the coming months and years.

As product development ramps up in the private sector and the states allow public road testing, USDOT is turning its attention to assessing the risks and addressing the challenges. In parallel, USDOD is beginning deployments for specific vehicles and operational environments. Active collaboration between these Departments is being explored.

Terminology must be addressed, so that we don't confuse each other and the public. Driverless cars, self-driving cars, automated driving, autonomous vehicles, cooperative automated vehicle are just a few of the terms in use, whose meanings overlap and differ depending on who is using the term.

There is a general consensus that connected vehicles and automated vehicles are separate topics yet inter-related and complementary. In the longer term, exchange of data between vehicles promises to enhance performance overall. Cybersecurity is a significant concern with future transportation systems, as it is with current ones, and this must be addressed.

Several different forms of automated vehicle operation were discussed at the Summit. In the near term, car-makers are ready to take the step beyond automated longitudinal control (Adaptive Cruise Control or ACC) to add some level of automated lateral control (lane centering). Since the driver must still maintain vigilance as to any unusual situation on the road, the combination of these systems raises challenges regarding driver engagement. Yet the user pull is there and these products are poised to enter the market. How successful will these systems be in maintaining driver engagement? Will driver monitoring become common? The answers will propagate forward into the human-machine interface approaches to more advanced systems, such as a Traffic Jam Assistant (full control below a speed threshold on highways) or automated urban "citycars."

Legal issues arise quickly in discussing automated vehicles, and the Summit addressed them head-on, as described below. The challenges differ between the U.S. and Europe, and yet overall the situation appears to be work-able.

Key Take-Aways

The Big Picture

Governor Snyder started off the first day by drawing the big picture: *this is about more than driverless cars – it is about the next era of mobility.*   Dr. Chris Urmson, Technical Lead for the Google self-driving car team, noted that they seek to "improve people's lives by transforming mobility." Dr. Luca Delgrossi, Director of Driver Assistance & Chassis Systems U.S., Mercedes-Benz Research & Development North America, Inc., said they are motivated chiefly by safety, along with relieving the driver of the driving task, assisting the elderly and disabled, and improving fuel economy.

Many noted the extensive hype self-driving cars have seen in the media and elsewhere. Is it too much, a liability?   Chuck Thorpe of OSTP felt that we should "surf the existing wave of hype to move forward." Others emphasized the need to articulate the vision and "tell the story" in a way that moves the public and keeps these initiatives from being labeled only as "technology push."

Nevertheless, Bran Ferren of Applied Minds challenged the group, saying the term "driverless car" is wrong and will not play well with the public. Gary Smyth, Executive Director for GM's North American

Science Labs, noted that they prefer terms like "automated" and "autonomous" for this field. Other terms were voted on later in the Summit, including self-driving car, automated vehicle, and autonomous vehicle. Results were inclusive, but it is likely the term "driverless car" may be replaced. Paul Perrone, CEO of Perrone Robotics and Chair of the new SAE On Road Autonomous Vehicle Standards Committee, briefed the group on the Committee's first task – clarifying terms and definitions for the industry, which will be completed in the coming months.

Whatever the name, Dr. Chuck Thorpe provided a perspective from OSTP and decades of working in the robotics field: while there are many issues and challenges, if nothing else, let's remember that driverless cars are better than the worst driver on the road, and keep moving forward.

> "This is about more than driverless cars – it is about the next era of mobility." – Governor Rick Snyder

How Will Humans Interact with Hyper-Intelligent Machines on the Road?

A wide array of user issues were addressed in a panel led by Doug Frasher, Strategic Design Chief at the Volvo Cars Monitoring and Concept Center. He was joined by Wil Botman, Senior Advisor Public Affairs with the Royal Dutch Touring Club, and Mark Riccobono, Executive Director of the Jernigan Institute within the National Federation of the Blind.

In recent polls of their four million members, Wil Botman noted that their top priority is safety. In envisioning an automated vehicle world, he cited the complexity of urban environments, where drivers are constantly interacting with those outside their car – other drivers, bicyclists, pedestrians – sometimes only centimeters away. Cyclists must be confident they are "seen" in entering an intersection, and they confirm this by looking at the driver: how will the self-driving car "communicate" in such a situation and share the road space appropriately? For the vehicle occupants, we need to understand driver perception and decision-making to create a ride that all feel comfortable with.

From the perspective of the blind, Mark Riccobono noted the recent success of the Blind Driver Challenge, in which vehicle sensors translated perception information into non-visual cues, allowing the a blind driver to drive (in this case, himself). He challenged the group, saying that much more is possible than what we've been thinking about in this space. His aim is to empower blind people to drive the cars of the future and wants to make sure future vehicle designs take this into account.

All agreed that a series of demonstrations and public campaigns will be important to inspiring public confidence in automated driving.

Where is the Technology Heading?

As Jim Overholt of TARDEC interviewed Dr. Henrik Christenson of Georgia Tech, they discussed the low hanging fruit in the light of the new Robotics 3.0 roadmap developed for the NSF's National Robotics Initiative. Potentially automation will come first in military applications, agriculture, container movement, and other relative safe scenarios, with deployment on the roadways later.   Dr. Christenson emphasized the importance of developing a roadmap for vehicle automation.

However the automakers are moving quickly. Dr. Gary Smyth of General Motors sees significant vehicle evolution in the next decades, with an expansion of the DNA of today's personal mobility vehicle to include electrification, electronics, and connectivity. In terms of timing, he expects "transferred control" (hands/feet off) by mid-end decade and autonomous driving by the end of the decade.   He focused on their "Super Cruise" capability which combines radar-based Adaptive Cruise Control and automatic steering, which he said they are developing for the near term. Knowledge of the driver state and vehicle capability is essential; therefore, they have invested significant effort into understanding transfer of control – this has to be done successfully in 2-3 seconds.

Similarly, Christian Schumacher, Director, Systems & Technology, for Continental noted their work in combined longitudinal and lateral control, using equipment currently on the car and implementing new features through sophisticated software. Luca Delgrossi of Mercedes spoke to Daimler's stepwise approach to automated driving.   Daimler is looking at autonomous driving as their final goal and going step by step to get there. He described their F800 prototype which performs a Traffic Jam Assistance function. This prototype fully controls the vehicle in slow speed congested traffic conditions, at the same time requiring the driving to touch the steering wheel at regular intervals to stay engaged.

At Google, a key priority is to program the vehicle to operate as if driven by a human, according to Chris Urmson.   With 250,000 miles of testing so far, they have focused strongly on defining performance metrics and have found time-to-collision and longitudinal acceleration to be particularly useful. For TTC below 4 seconds, he noted that their automated vehicle spends substantially less time in that realm compared to human drivers.   Regarding introduction, he stressed that "the perfect is the enemy of the good," meaning that we should not wait for perfection. Lives can be saved and time can be returned to people by getting this technology in the hands of the public.

Technical Challenges: Beware the Bouncing Ball

Many speakers discussed and were questioned about the "hard" technology problems. Chuck Thorpe noted the unusual obstacles, such as a mylar ballon (with a large radar cross-section) or a bouncing ball (likely to be followed by a child racing to retrieve it). Wil Botman from the Royal Dutch Touring Club, when speaking on the User Panel, showed complex scenarios on the streets of Amsterdam involving pedestrians, bicyclists, unstructured intersections, etc. as examples of the challenges faced.

When asked about situations the Google car cannot handle, Chris Urmson cited erratic behavior by other drivers or extreme and rare situations such as a vehicle entering the highway the wrong way via

an off ramp. Overall, their toughest technology challenge is "perception." When asked how often the test driver must intervene, he replied "a lot" but the interventions are rarely due to safety critical situations.

In particular, pedestrian interactions with cars frequently involves eye contact between the pedestrian and the driver to confirm they are aware of each other. How will this change with self-driving cars? Mr. Nicholas Pennycooke of the MIT Media Lab described their CityCar for urban driving, which aims to give an autonomous vehicle the means to sense other people and objects and intuitively react. So, a pedestrian might be acknowledged by a movement of the headlights, mimicking eye contact. Others such as Dr. Chris Urmson of Google felt that, while human-like vehicle operation is key, actual eye contact is not so important.

USDOT Ramping Up Major Research Program

John Augustine, Managing Director of the Intelligent Transportation Systems Joint Program Office in USDOT, looked back to their Automated Highway System program of the 1990's. The proof of concept was successfully demonstrated, but at the time the technology was costly, rendering deployment unfeasible.   Fast forwarding to today, the technology is feasible and deployment achieveable. As such, automation can help across the board in addressing road transportation goals.   Beginning this year, the JPO is funding a multi-agency Automated Vehicle Exploratory Research program encompassing passenger cars, heavy trucks, and transit.

John Maddox, Director of Vehicle Safety Research at NHTSA, placed a stake in the ground by asserting that autonomous vehicles must be "better than humans."   He provided some insight into their newly defined automated driving research program, which spans the next ten years. Noting that safety is the primary motivation for automation, he set the goal for automated vehicles as "crash-less … I don't think people are willing to accept robotic error resulting in killing people."

While there are many challenges, he believes they can be met. He noted these challenges include sensor performance, artificial intelligence decision-making capability, electronic control systems safety, cybersecurity, human factors, performance requirements, objective testing for various levels of automation, and liability. He affirmed automation as a worthy goal which has great potential for improving vehicle safety and other transportation goals.

Legal Issues Probed by Experts

A distinguished Legal Panel was moderated by Tiffany Rad, a lawyer specializing in cybersecurity for Battelle. Other panel members were Mark Johnson, a private practice attorney focusing on connected vehicles; Bryant Walker-Smith, Fellow with the Center for Automotive Research Stanford; Dorothy Glancy, Law Professor at Santa Clara Law School; Steve Wu, in private practice; and Steve Wood from NHTSA's Office of Chief Counsel.

One of the initial questions raised was, "do we need to change the legal infrastructure to enable automated vehicles, or change the vehicles to adapt to existing law? The general feeling was that

vehicles would adapt to the law – it is not realistic to seek for laws to be passed just to address liability issues with automated vehicles.

Steve Wu stated the obvious: in a product liability world, a group of lawyers "will put target on manufacturer's backs" as increasingly automated systems evolve. Given this environment, Steve Wood emphasized the value of electronic data recorders, noting that on-board data helped to bring the Toyota unintended acceleration crisis to a close by clearly showing driver error. Steve Wu noted that, with electronic discovery of evidence, companies can prepare the way today for lawsuits tomorrow, using data to prove in court when the vehicle is not responsible for a mishap. This aligned with remarks made by Chris Urmson during his talk: with respect to litigation and liability, "data is key -- information for crash reconstruction is essential when an autonomous vehicle crashes; having this data will clarify the situation." As to related issues in the insurance domain, he said "We'll have a story about reliability, based on our data, and insurance companies will love that. There will be rich data to pull from, which will drive insurance costs down."

Bryant Walker-Smith noted that the significant uncertainty in the legal realm is inhibiting the industry. Steve Wu noted that product liability suits against robotic companies or unmanned vehicles have thus far concentrated on catastrophic injury; here, finding out the real cause is key, typically using expert testimony. When the panel was asked if useful lessons could be learned from other domains, they noted there are very few precedents in general. Dr. Glancy cited civilian drones which are much further down the deployment path, yet the legal situation is still evolving.

DMV Panel Grapples with the Need for New Driving Laws

John Maddox of NHTSA moderated a panel which consisted of Bruce Breslow, Director, Nevada Department of Motor Vehicles; Kirk Steudle, Director, Michigan DOT; Douglas MacDonald, former Secretary, Washington State DOT; and Brian Blanchard, Assistant Secretary for Engineering and Operations, Florida DOT.

Mr. Breslow was one of the most outspoken. He pointed out that, if you want to move quickly with an initiative, take it out of the hands of government. With the Google experience, once people saw the vehicle and what it could do, they wanted it. So rather than starting with the bureaucratic side, it is better to get to the legislators and compel them to act. Mr. Steudle, amongst all the talk about autonomous driving laws, asserted that testing of new vehicle technology by manufacturers and suppliers has been going on in Michigan for decades; a new law to allow this for autonomous cars is not necessary. Their current law covers this. Mr. Blanchard offered his opinion that the Federal government will eventually develop standards which will supersede state standards.

In response to the question, "will automation be limited to interstates only?" the panelists noted that the highway case is simpler than rural roads or neighborhoods. However, the technologies have to go everywhere, or the state has to have the ability to limit areas of operation. The latter is the case in Nevada currently.

<u>Multiple Initiatives Underway Within DOD</u>

Dr. Jim Overholt, Senior Research Scientist for Robotics within the US Army Tank and Automotive Research, Development, and Engineering Center (TARDEC) is a central force within DOD for advancing robotics, including autonomous vehicles. As he put it, he "wants to allow soldiers to do something else while doing the mundane task of driving."   His group has established the Ground Vehicle Robotics Innovation Center and is pioneering the application of autonomous vehicles to real-world needs at military bases with the Autonomous Robotics for Installation and Base Operations (ARIBO) program. Since the roads and facilities at these bases are not public, they can serve as a more "protected" environment compared to the open road, even while the actual activities are very similar to public roads. Therefore the Army sees these bases as a good testbed for autonomous operations, and possibly as a way to collaborate with USDOT for testing.   Currently they are pursuing implementing robotic vehicles at Fort Bragg to ferry "wounded warriors" to medical care facilities on-base, as well as using convoy technology at Fort Leonard Wood to deliver meals to soldiers at remote training facilities. Another TARDEC initiative, RobotTown, is described as a "living laboratory for robotic technology in the Detroit area."   The goal is to "provide an environment where people can come to learn, play, test, create, socialize, innovate, discover, and share knowledge about robotics." Site discussions are currently underway.

Developing a Path Towards Driverless Cars in the Next Ten Years

Michael Toscano, AUVSI CEO, closed this first Driverless Car Summit by noting the extensive expertise among the assembled group and the richness of the discussions. Enthusiasm was appropriately balanced by a clear recognition of the challenges.   While we will always have cars, crashes and congestion do not have to be a given. The activities described here are causing a change to take place in the car's DNA; in essence, with these discussions we are preparing an evolutionary approach to a revolutionary capability.   Going forward, telling the story is important -- we need a strategy and plan in educating the public.

> "We are preparing an evolutionary approach to a revolutionary capability."

Clearly, the Summit succeeded in bringing the key players in vehicle automation together for the first time. The state of the industry and key issues were presented, resulting in greater mutual awareness and new relationships, setting the stage for follow-on activities.

Maintaining Momentum

Continued engagement with government and industry, plus ongoing technical and scientific work, is essential. In bringing new resources and a new constituency to the table, AUVSI is in a position to engage with key players to maintain awareness of key issues and developments, serving as a clearinghouse for information and a convener of ad hoc meetings as needed. Because there are so many "moving parts" in this space, it is challenging for organizations to keep track of all the activity. AUVSI will bring greater coherence to the vehicle automation domain by producing a periodic Update Report which defines and tracks the major issues, highlights important developments, and provides perspectives from key figures. The Update will provide the foundation for other activities which may be launched as needs arise. As a result, industry players will have a greater awareness upon which to base their strategy development.

The Update Report will address areas such as developments at the legislative and state level with new driving laws, technology challenges and progress, deployments in the military domain, USDOT research, and a continuing focus on the "long view" towards self-driving cars and the resulting evolution for society as a whole.   AUVSI will focus on the problem set and key issues, develop metrics to track progress, and report on progress in the Update. Look for the first issue in late 2012.

In parallel, AUVSI will maintain a focus on "telling the story" by working with other industry leaders to develop the strategy and plan for educating the public, as called for during the Summit.

Preparing for Detroit 2014

Each year, the ITS World Congress is held to showcase the latest developments and debate the issues of the day, attracting well over 10,000 participants and key public figures. The Congress comes to North America every three years, with the next being Detroit in 2014, giving an opportunity to showcase the latest self-driving capabilities to bring greater awareness to the public.   AUVSI will be working with ITS America and others to craft the best possible presentation of the future of vehicle automation, to include demonstrations and /or pilot deployments.

Summit 2013

AUVSI plans to hold a Summit every year for the foreseeable future. What will the 2013 meeting focus on? The aforementioned Update Report will identify key technical and regulatory areas that need to be addressed to meet the ten year goal. We can expect to see a focus on these areas needing the most attention with updates from Federal and State regulatory entities, technology enablers, and others entities contributing to solutions.   The meeting will be held in Spring 2013 at a location soon to be announced.

See for Yourself

Go to www.auvsi.org to download Driverless Car Summit 2012 presentations.   Videos of the entire event are available for purchase.