Elisabeth Uhlemann

Autonomous Vehicles Have Entered the Off-Road Market

... But the Lack of Unified Standards on Connecting On-Road Vehicles Delays Deployment

The past year has taught us to expect the unexpected. While digital meetings have gotten increased momentum, the pandemic has put most other platforms for technical development on hold. I have written before in this column about the fact that autonomous vehicles are emerging. A few years ago, there was a sort of mental setback when several companies pioneering autonomous vehicle testing said that the task was more complex than people may think and that fully autonomous vehicles were much further into the future than it may appear from the outside. Based on the stories collected for this issue, however, it is apparent that autonomous off-road vehicles like baggage tractors, drone-based surveillance systems, and vehicles in mines or construction sites are already operational. This may have several different causes. From a researcher's perspective, I would say that it is not until you start to really dig into a topic that you realize its full complexity and how little you actually know. It is therefore likely that the company representatives expressing doubt about fully autonomous vehicles a few years back were behaving just like normal Ph.D. students who generally always doubt their ability before they start to produce sensational results. It is also likely that off-road vehicles are easier to design, in that they operate in a confined area that can be better controlled and defined. This also affects the communication abilities of the vehicles. Basically, all autonomous vehicles, whether they operate off- or on-road, need to be connected. In a confined area, it is possible to deploy Wi-Fi access points enabling reliable connectivity to the autonomous vehicles, coupled with teleoperating abilities for added safety. For on-road vehicles covering a larger geographical area, another type of connectivity is needed, which requires harmonization among technology providers, vehicle manufacturers, legislation, and spectrum authorities. One show-stopper in this respect is the recent spectrum setbacks in the United States, where the entire spectrum previously reserved for dedicated short range communication (DSRC), was given away to Wi-Fi and cellular technology [1]. The spectrum authorities in Europe and Australia support a technologically agnostic approach, but the setback in the United States is also affecting these markets as it is unclear what will happen with the huge investments already made in DSRC and its European counterpart called ITS-G5. However, as I wrote in a previous column, the vehicle industry is using this peculiar time to analyze and plan ahead. To this end, Waymo is simulating how the Waymo Driver would behave if involved in a fatal crash reconstructed from statistics obtained from the National Highway Traffic Safety Administration (NHTSA)—it turns out that autonomous vehicles avoid many accidents simply by following the traffic rules. In addition, Volvo Cars has launched a portal making different resources (such as car dashboard data, charge/fuel level, and distance traveled) available to developers and other third parties to build new services. When life gives you lemons, make simulations and share data.

Digital Object Identifier 10.1109/MVT.2021.3065792
Date of current version: 24 May 2021

The Internet of Things

Aurrigo Tests Autonomous Luggage System in Heathrow, U.K.

The aviation sector is going through one of the worst periods in its history. Hence, all types of cost savings are of interest. One way to do this is through a new autonomous luggage and cargo system recently launched by Aurrigo, a U.K.-based company focusing on autonomous vehicles. The system, called Auto-Dolly, aims to give airports the opportunity to move luggage and cargo around indoor and outdoor settings without the need for human operators. An Auto-Dolly can navigate autonomously from one task to another, collecting and dropping off

1556-6072/21/©2021IEEE

luggage or cargo automatically using a powered roller deck, and also can also move sideways when docking and parallel parking.

Aurrigo claims that Auto-Dollies operate in snow, heavy rain, direct sunlight, and fog. A recent trial at London's Heathrow airport and a digital-twin project with a leading Asian airport revealed that the technology can reduce by two-thirds the number of traditional tugs and trailers used to transport luggage and cargo as well as substantially cut carbon emissions.

The autonomous vehicles are controlled by a fleet management system, which assigns Auto-Dollies to meet operational deadlines at the airport. In addition, a simulation tool is released to aid customers in baselining current operations and modeling how to migrate from manual methods to fully automated operation. Using Auto-Dollies will improve efficiency in the way that aircraft luggage and cargo are loaded, unloaded, and handled.

EasyMile Tests Autonomous Luggage System in Schiphol, Amsterdam

TractEasy is collaborating with KLM Ground Services and Smart Airport Systems in a trial taking baggage to the aircraft on the apron at Schiphol airport (Figure 1). The aim is to prove the technology's safety and efficiency as well as how driverless vehicles can be integrated with other traffic at the airport. Operations will start in a defined area where the baggage process is simulated. In the second phase, the trial will continue in an operational environment, bringing baggage to the aircraft. The autonomous vehicle will be loaded in the baggage area, after which it will navigate to an aircraft stand via a fixed route.

Air France Was First to Test Autonomous Baggage Tractor

An autonomous electric baggage tractor has been operational at Toulouse-Blagnac airport since 15 November 2019. The baggage tractor is a coinvention among several airport players who have been working together to design the airport of the future. It is developed by a subsidiary of Charlatte Manutention and NAVYA. TCR handles the tractor's daily maintenance requirements. The autonomous vehicle is supervised by agents from Groupe 3S who have expertise in ground handling operations. Air France also shares its support and expertise with Toulouse-Blagnac airport by integrating its operations and infrastructure into the tests.

The baggage tractor is a smart vehicle that moves autonomously around the airport to reach the Air France aircraft. Its destination is preprogrammed via a touchscreen by an agent from Groupe 3S. As it nears the aircraft, the tractor stops, and the agent takes control of the vehicle and subsequently loads the baggage in the aircraft hold.

To carry out its tasks and integrate ramp traffic, the vehicle is equipped with intelligent sensors that enable it to recognize its environment, position itself with great precision, detect obstacles at 360°, and make decisions. Thanks to its sensors (lidar, camera, GPS, and odometer) and its autonomous steering software, the vehicle can move around the airport autonomously. It also communicates with the hub's traffic signals.

Testing the Use of Autonomous Drones for Safety Enforcement at the Port of Antwerp

An autonomous drone developed in collaboration with the company DroneMatrix will be deployed at the Port of Antwerp. The drone will test out various use cases such as infrastructure inspection, surveillance and monitoring, incident management, berth management, and oil spill or drift waste detection. The objective is to test the various applications in a realistic and complex environment (Seveso companies, wind turbines, high voltage, and so forth) so that they can support the Harbor Safety and Security Department in the future. Several tests with other autonomous systems will follow over the course of 2021 in preparation for an operational network of autonomous drones ready to be deployed in 2022.

The drone departs from a fixed operating base near Kieldrecht Lock and follows a fixed route in the port. In addition, the drone can fly on demand, for example, in emergencies where an overview of the situation is critical. The drone operates completely independently and charges itself through an intelligent docking station that is centrally managed from a web platform.

FIGURE 1 Look! No hands!!! Testing autonomous baggage tractor. (Source: TractEasy with EasyMile's autonomous technology at Schiphol airport.)

The port of Antwerp covers more than 120 km^2 and is part of Belgium's critical infrastructure. The use of drones can make a significant contribution to overall safety, enabling port authorities to manage, inspect, and supervise a large area quickly and safely.

Several tests with other autonomous systems will follow over the course of 2021 in preparation for an operational network of autonomous drones ready to be deployed in 2022.

Toward Autonomous Vehicles

Simulations Show That the Waymo Driver Mitigates Fatal Crashes

Waymo has made simulations on how its autonomous technology performs in real-life scenarios that led to fatal crashes by human drivers. This was done by extracting some scenarios from NHTSA statistics about fatal crashes that took place in Chandler, Arizona, between 2008 and 2017. Data from the scenarios were then used to reconstruct each crash based on best practice methods. Thereafter, it was simulated how the Waymo Driver might have performed in each scenario.

Many of the crashes involved two vehicles. In these scenarios, the Waymo Driver first replaced the vehicle that initiated the crash (the "initiator") and then replaced the vehicle that responded to the other vehicle's actions (the "responder"). That resulted in 91 simulations in total, of which 52 simulated scenarios involved the Waymo Driver as the initiator.

Since the Waymo Driver obeys the traffic rules, it avoided all crashes when it played the role of the initiator simply by obeying the speed limit, not running red lights, executing proper gap selection, and so forth.

Scenarios where the autonomous vehicle takes the role of the responder are important for understanding how well autonomous driving systems perform in response to mistakes made by humans. In the scenarios when a human driver did something to initiate a crash, such as running a red light, and the Waymo Driver was placed in the responder role, it completely avoided 82% of the simulated crashes. Moreover, it did so with smooth, consistent driving—without the need to brake hard or make an urgent evasive response. In another 10% of the scenarios (all involving intersections when the human driver turned across its path), the Waymo Driver took action that mitigated the severity of the crash. Finally, in 8% of the responder simulations, the crash was unchanged. In all of these, the human-driven vehicle struck the rear of the simulated Waymo Driver when it was either stopped or traveling at a constant speed. Since 94% of crashes involve human error, Waymo sees an opportunity to improve road safety by replacing the human driver with the Waymo Driver.

It should be noted that only scenarios within the correct operational design domain (ODD) have been selected from the NHTSA statistics. The ODD defines the type of situations the autonomous vehicle is designed for and able to handle. Common ODD factors are time of day, weather, terrain, and road features. The Waymo Driver is designed to automatically detect weather or road conditions that would affect safe driving (that is, outside the ODD) and return to base or come to a safe stop (i.e., achieve a "minimal risk condition") until conditions improve. For the simulations, the crash cases were shortlisted based in the ODD of the Waymo Driver, that is, in Phoenix, where the Waymo Driver is currently trained, indicating some sort of sandbox reality. Yet the results are promising.

Autonomous Hop-On, Hop-Off Shuttle in Australia ...

A driverless bus known as Murray is part of a new trial in Renmark, South Australia, ending in June 2021. Guided by a range of GPS, cameras, and odometry sensors, Murray is in constant communication with infrastructure such as traffic lights, sending signals to the shuttle, which then analyzes and makes the decision to continue its route or stop. Murray will provide a free hop-on and hop-off service at six bus stops along the 2.4-km loop from Murray Avenue to the Fourteenth Street shopping precinct. There is no need to book a ride in advance, as customers are invited to use the service whenever they want during operating hours, on Tuesdays from 10 a.m. to 1 p.m. and Wednesdays to Saturdays from 10 a.m. to 4 p.m.

A key focus of the project is to support those in the community with restricted transport opportunities as well as the tourism sector. The trial is a joint project among the Department for Infrastructure and Transport, Renmark Paringa Council, Flinders University, autonomous technology provider EasyMile, and multimodal transport operator Keolis Downer.

... And, in an Australian Mine, an Autonomous Light Vehicle Operates

Fortescue Metals Group in the Pilbara region of Western Australia has successfully deployed autonomous light vehicles (ALVs) at its mining operations in the Chichester Hub as a solution to improve the efficiency of the mobile maintenance team, removing the need for fitters to drive around collecting equipment and parts.

With the assistance of Ford Australia, four Ford Rangers have been retrofitted with an onboard vehicle automation system. The system features an integrated lidar/radar perception system that facilitates obstacle detection and dynamic obstacle avoidance, a comprehensive independent safety management and fail-safe braking system,

A SATELLITE-BASED NAVIGATION SYSTEM SUCH AS GPS OPERATES IN A MANNER THAT IS DISTINCTLY DIFFERENT FROM TERRESTRIAL-BASED COMMUNICATIONS SERVICES.

and extensive built-in system monitoring and fault response capability.

The ALVs make around 12,000 28-km round trips annually to provide driverless equipment transfer services that improve efficiency and safety by enabling maintenance team members to spend more time on maintaining assets.

The autonomous light vehicle project builds on Fortescue's autonomous haulage system program, further advancing its in-house automation capability.

Cooperative ITS

The GPS Innovation Alliance Urges the White House National Economic Council to Make the FCC Reconsider

With an estimated 900 million receivers, GPS has become a fundamental technology across nearly every business sector including agriculture, transportation, construction, electricity, and finance. A satellite-based navigation system such as GPS operates in a manner that is distinctly different from terrestrial-based communications services. Due to this, there are fundamental differences in power between the two, and thus GPS services risks being annihilated by other types of communication services in the same frequency band.

In April 2020, the U.S. Federal Communications Commission (FCC) approved an application from Ligado Networks to deploy a terrestrial network in the L band to advance 5G and Internet of Things (IoT) solutions for the industrial sector, utilizing satellite and terrestrial services to deploy customized private networks. The approval is coupled with stringent conditions to prevent harmful interference to GPS.

The GPS Innovation Alliance (GPSIA) seeks to protect, promote, and enhance the use of GPS. The GPSIA argues that it is paramount that policy formulation regarding spectrum draw upon the expertise of the U.S Space Force and Department of Transportation, the U.S. government's lead military and civilian agencies, respectively, for the criticality of GPS to their missions and operations. These and several other U.S. federal agencies coordinate their spectrum management requirements and positions through the National Telecommunications and Information Administration (NTIA), while the FCC maintains responsibility for licensing the commercial spectrum.

In February 2021, the GPSIA sent a letter to the White House National Economic Council asking the new administration to adjust the federal spectrum decision-making processes:

> Unfortunately, though, activities leading up to the adoption of the FCC's April 2020 Order, authorizing the deployment of a nationwide terrestrial wireless network by Ligado Networks, LLC (Ligado), demonstrate that the current coordination process needs reform. For example, in the Ligado case, despite the stated objections of 13 federal agencies and departments, the FCC proceeded independently, ignoring expert federal agencies whose missions and responsibilities include management, operation, and reliance upon GPS. Interagency disputes involving spectrum, though, are not unique to GPS. In recent years, the FCC has found itself at odds with NTIA and other federal agencies on spectrum allocated for intelligent transportation systems (5.9 GHz) and with spectrum located near satellites used for weather forecasting (24 GHz). While GPSIA takes no position on the substance of these matters, they reflect a continued pattern by which shared decision-making is replaced by the FCC acting with exclusive authority as the final arbiter.

Proposed Regulation on How to Assess Driver Drowsiness and an Attention Warning System in Europe

Currently, there are no European New Car Assessment Programme (EURO NCAP) protocols for testing vehicles' driver drowsiness and attention warning (DDAW) systems. However, all types of motor vehicles in Europe must be equipped with DDAW systems beginning 6 July 2022 and all new motor vehicles two years later. Since the existing technologies are still under development, there is an initiative from the European Commission on how to test the effectiveness of these systems, covering the human–machine interface aspect and the environment, where the DDAW must warn the driver.

The initiative, which includes detailed rules concerning the specific test procedures and technical requirements for the type-approval of motor vehicles with regard to DDAW systems, was published 22 January 2021. The method is based on tests run with human participants, either in a simulated environment or in a test vehicle, and the results are a compilation of successful drowsiness warnings and failure to warn the driver. This regulation provides a reference scale to be used by manufacturers and technical services to measure driver drowsiness. The technical services will assess the technical documentation and the results from the tests performed by the manufacturers and may rerun tests on predictable aspects of the system. Vehicle manufacturers have to propose at least one test protocol for checking the capability of DDAW systems to provide a warning to the driver. The technical

services will carry out testing in accordance with this test protocol. The proposal was open for comments during 60 days of being published.

THIS REGULATION PROVIDES A REFERENCE SCALE TO BE USED BY MANUFACTURERS AND TECHNICAL SERVICES TO MEASURE DRIVER DROWSINESS.

Volvo Cars Launches Portal With Extended Application Programming Interface

Volvo Cars has launched a portal called Innovation Portal that makes a variety of resources, including extended application programming interfaces (APIs), available to external developers.

The resources available on the Innovation Portal include an emulator that recreates the Android Automotive Operating System and Google apps used in new Volvos, providing developers with an accurate in-car experience of the system on their computer. This emulator tool is helpful in supporting app developers to design, develop, test, and publish apps directly on Google Play in the car.

The platform will also feature the Extended Vehicle API. With customers' consent, the API allows developers and other third parties to access car dashboard data, such as charge/fuel level and distance traveled, and use these data to build and provide new services.

Other resources include a lidar data set and a downloadable production 3D car model of the fully electric Volvo XC40 Recharge. The lidar data set is released together with Luminar and Duke University and can help researchers improve algorithms related to long-range lidar detection. The high-fidelity 3D car model is developed in collaboration with Unity. The car model and an accompanying 3D environment are suitable for use in visualization applications, virtual reality, cinematic experiences, and car configurators. These resources are also available as base tools on Unity's developer hub together with tutorials on how to use the template.

Volvo Cars promises that the Innovation Portal will grow continuously, with more resources to be added over time. During Spring 2021, a fully functional 3D car model was released, featuring digital replications of the car's physical sensors, allowing users to test sensor data for research and education purposes.

The City of Interconnected Ecosystems Has Begun Construction in Susono City, Japan

Toyota and Woven Planet started to break ground for the construction of Woven City on 23 February 2021 at the old vehicle yard adjacent to the former Higashi-Fuji plant site of Toyota Motor East Japan. Woven City is a project aiming to demonstrate a human-centered approach to community development. In Toyota's planned shift from an automobile manufacturer to a mobility company, the project will help bring new technology to life in a real-world environment across a wide range of areas, such as automated driving, personal mobility, robotics, and artificial intelligence. It is expected to provide a number of opportunities for businesses and researchers around the world to prepare for an era in which all ecosystems that support everyday life are connected with data.

Woven City will have three types of streets interwoven with each other on the ground level: one dedicated to automated driving, one to pedestrians, and one to pedestrians with personal mobility vehicles. There will also be one underground road used to transport goods. The community will start with roughly 360 residents, mainly senior citizens, families with young children, and inventors, and will eventually have a population of more than 2,000 individuals including Toyota employees. The infrastructure of Woven City aims to create an environment where inventions with the potential to solve social issues are created on a timely basis.

Cellular Communications

FCC Unanimously Approves Ligado's Application to Support 5G and IoT Services

The FCC has approved Ligado's application to deploy a low-power terrestrial nationwide network in the L band that will primarily support 5G and IoT services. Ligado's application promises to ensure that adjacent band operations, including GPS, are protected from harmful interference. The commission included stringent conditions to ensure that incumbents would not experience harmful interference. For example, the commission mandated that Ligado provide a significant (23-MHz) guard band using its own licensed spectrum to separate its terrestrial base station transmissions from neighboring operations in the Radionavigation-Satellite Service allocation. Moreover, Ligado is required to limit the power levels of its base stations to 9.8 dBW, a reduction of 99.3% from the power levels proposed in Ligado's 2015 application. The order also requires Ligado to protect adjacent band incumbents by reporting its base station locations and technical operating parameters to potentially affected government and industry stakeholders prior to commencing operations. In addition, Ligado is required to continuously monitor the transmit power of its base station sites and comply with procedures and actions for responding to credible reports of interference, including rapid shutdown of operations where warranted.

Reference

[1] K. Sjöberg, "Resilience and recovery [connected and autonomous vehicles]," *IEEE Veh. Technol. Mag.*, vol. 16, no. 1, pp. 93–96, Mar. 2021. doi: 10.1109/MVT.2020.3044123.

VT