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FIT TO DRIVE

A Reliable Framework for Delivering Safe Driving in an Imperfect World

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The safety promise of self-driving vehicles is that they will save hundreds of thousands of lives, and greater transportation efficiencies will reduce pollution and improve the time we spend traveling. But that future is at least a decade away. Smart and integrated transportation systems that work perfectly in every instance, predicted or not, are very difficult to realize.

In the meantime, we will continue to live in an imperfect world for which we must configure the development of automotive safety technologies to achieve the greatest possible benefits for the largest number of drivers, passengers, and pedestrians as soon as possible.

We call this making every vehicle and driver Fit to Drive

An Expanding Safety Tech Remit

The popular media have been eagerly awaiting the arrival of the first fully autonomous car, though most experts agree it will be just another step in an ongoing evolution of the personal and social benefits of ADAS. By definition, evolution doesn't happen at the same time and in the same way everywhere. Any self-driving car technology will add to a muddled wash in which we will drive and live for the foreseeable future, and where:

- **Smart tech isn't evenly distributed** – Different cars and trucks will possess and use different levels of smart tech, which means that staying safe on the road will require that variable actions and reactions are considered by the decisions made by those vehicles and drivers. This will represent a significant added layer of complexity that will need to be factored before safety tech can provide its benefits.
- **Sensors aren't bulletproof** – As a growing number of external-facing sensors find their way into vehicles (radar being a prime example), it will become increasingly possible that they could be impeded by weather or road conditions. Or simply function at different levels of reliability based on hardware or software differences. A sensor knocked out of alignment by a street curb isn't so "smart" anymore.

- **Drivers remain inherently inconsistent** – It is unlikely that human beings will get better at focusing or even staying awake for the foreseeable future, which means that driver assist safety technologies will need to be just as aware of driver conditions as they are of the road ahead. Facilitating this "two-way" relationship, in which people and their vehicles collaborate as the performance responsibilities of drivers as well as vehicles vary depending on the environment, will be key to delivering safety.
- **Vehicles share the road** – A network dependent on beacons won't notify a driver if a pedestrian with no charge in her smartphone was crossing the road, and the same is true for mechanical and e-bikers and people on scooters (not to mention the complexity of mapping and predicting their movements). Vehicles will need a robust selection of tools to maximize safety for everyone on or near them.
- **Surprises will happen** – Adding together the variability of smart tech, sensor availability and reliability, driver condition, and literal moving parts on and near roads produces a perfect storm in which surprises will inevitably occur. In fact, a reference to storms is revealing: Climate change means future weather will not be wholly predictable based on the historical record, which will affect how we drive, too.

Overlying these facts is the matter of the continuing evolution of user interaction with automated safety technology. When it comes to realizing safety benefits of AD as well as ADAS, its imperfect or incomplete implementation could well serve to impede people from using it. This may create a negative feedback loop that holds back its implementation, as OEMs don't see growing demand for offering it.

The safety remit for the next decade and beyond is to incorporate and address the varied interactions between people, technology, and environment to maximize road safety outcomes for all.

The Missing Component: Fit to Drive

As AD and ADAS technologies have evolved, there has been a true revolution in automotive compute and electrification. Even mass market vehicles today are complex systems on wheels comprising a variety of internal and external sensors, electrified control and distribution infrastructures, increasingly moving toward localized computing power (also referred to as processing "at the edge").

This revolution supports advancements in safety tech but doesn't ensure its implementation or benefits. That's because safety is not a technology problem to solve; any "accident" is the result of a bespoke set of conditions and actions comprised of:

- **Control** — Control of vehicular movement is shared in real-time between human drivers and automated technologies, making mutual awareness and trust central to safety performance.
- **Environment** — Robust perception and measurement requires recognition that circumstances do and will change, and that some of the elements within a particular scenario may not be wholly visible and could change the import of others.

For years, Veoneer has been working on delivering safety at this confluence of technology, control, and environment. We call this collaborative driving, and it takes these variables into account, managing hard to predict situations through knowledge of each others' capabilities and limitations, such as:

- Driving over a curb damaged one of the sensors on which your car depends for judging distance. Will it compensate and how will you know?
- The car in front of you has a similar problem, or the driver is sleepy and might not respond to his lane departure warning.
- A worker just knocked down a traffic sign and put up a temporary directive in a new space, angling it the wrong way. Will your car recognize it and respond appropriately?

A vehicle that takes these condition-based factors into account to yield a best in place and time decision is deemed "fit to drive". As such, the sources and application of that fitness will change moment to moment, and it will be accomplished by designing for the vehicular interactions that collaborate with drivers and external infrastructure & environment.

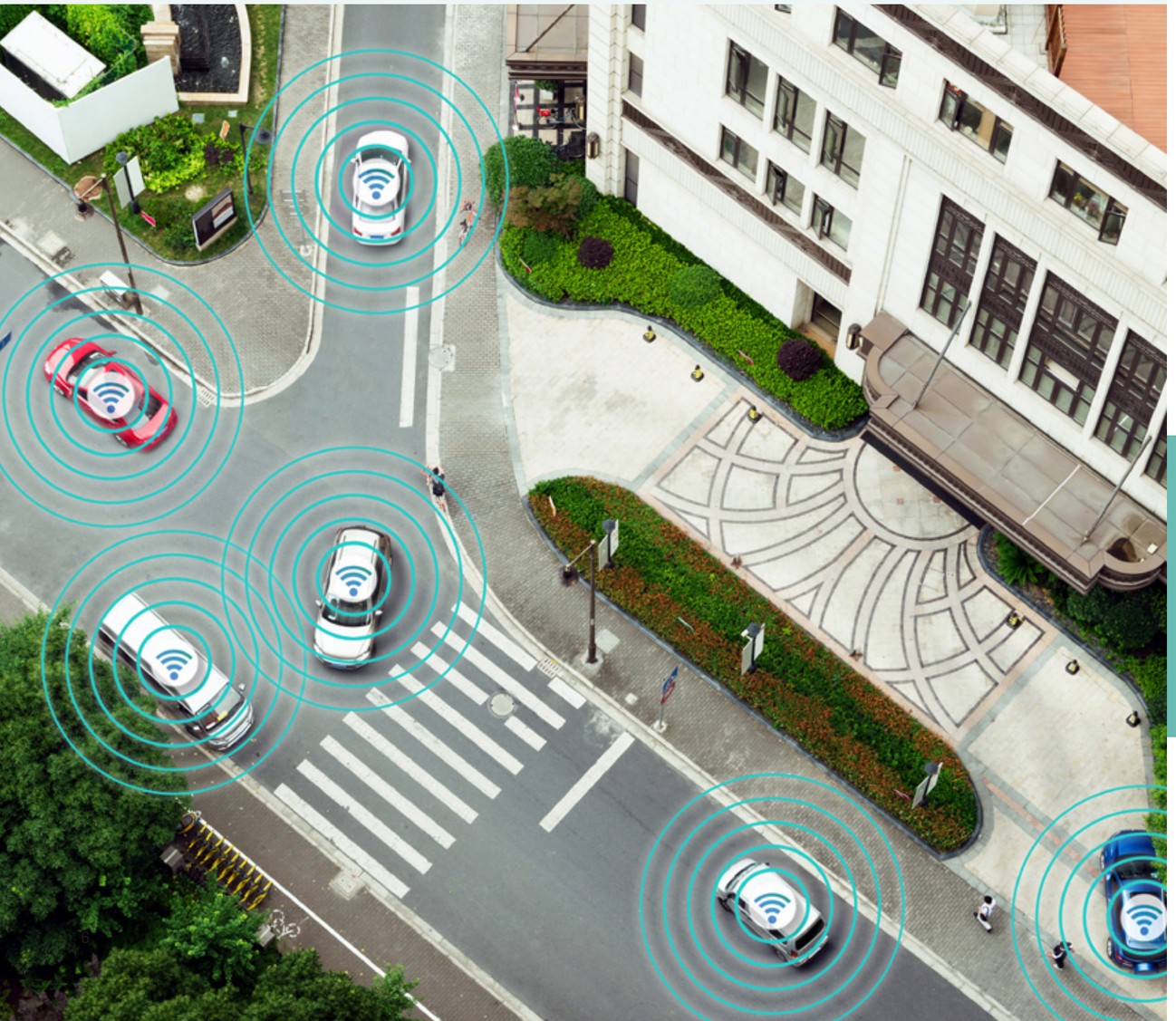
Fit to drive isn't a computer program or connectivity tool, but rather an approach to system design that delivers the best real-time solutions to imperfect road situations. It is based on the interaction with the driver and the environment as much as on the veracity of sensors or intelligent technology.

We must and will come to terms with improving safety in a world that can't and may never conform our idea of what it "should" be.

The Importance of V2X

This means that adoption of safety technologies will be a key area of focus for OEMs, challenging them to not only develop deeper connections between real-life data and understanding their customers but innovating ways to make those solutions more apparent and available, trustworthy, and easy-to-use. This is an education remit as much as it's one of development or sales.

For infrastructure, it means closer integration and real-time engagement with vehicles, whether under the control of people or AI, and requires investments in wireless connectivity and the uniform models of roads, vehicles, people, and environments that will inform that communication. Infrastructure will evolve to become an active collaborator in delivering safer driving outcomes.



The Wheels of Fit to Drive

There are four wheels underpinning the Fit to Drive approach:

1. **Functionality** — For a vehicle to be fit to drive in any circumstance, there must be a reliable platform of functional attributes. These attributes need to empower both the human driver and vehicle technology to be aware and therefore anticipate which and how the next action will be taken. This also means that the people and technology systems together in any given vehicle must possess a clear understanding of their joint capabilities. The aviation industry's experience with implementing automated tech is illustrative of this opportunity.

   When manufacturers, carriers, and airport operators started automating tasks, they discovered that peoples' skills decreased when they were longer required to perform those activities. This phenomenon, known as "skill degradation", was seen as a major impediment to rolling out new autonomous functions, as it reduced peoples' abilities to recognize and/or deliver the tasks that, quite literally, could potentially be required to keep planes in the air.

   Acceleration, positioning, and braking are the most important ways vehicles communicate with drivers and passengers.

   It turned out that human performance held a crucial role in implementing automation, as well as a crucial part of the overall success of safety systems. Accordingly, both the Federal Aviation Administration and EASA encourage carriers to provide manual flying opportunities, so pilots did not lose their skills, sometimes via simulators, and in some countries making it a requirement that they fly manually for a certain number of hours to keep their skills level up. There is no reason to believe this will not also hold true for driving.

2. **Trust** — Intriguingly, trust is two-way: it's not unreasonable to think that not only does a driver need to trust automation to perform its tasks, but that automation must trust the driver to perform his or her tasks. Otherwise, the system may be perceived as overriding the driver's intentions.

   Personalization is key.

   For the driver to trust the vehicle, it needs to communicate its capacity, often in real-time. For instance, a vehicle needs to be clear about its capabilities to protect vulnerable road users and the occupants of the vehicle, but visual communication, haptics, and even sound are not enough to communicate it; the function of the vehicle itself – positioning, accelerating, and braking – convey just as much and often different or more information to drivers and other road users.

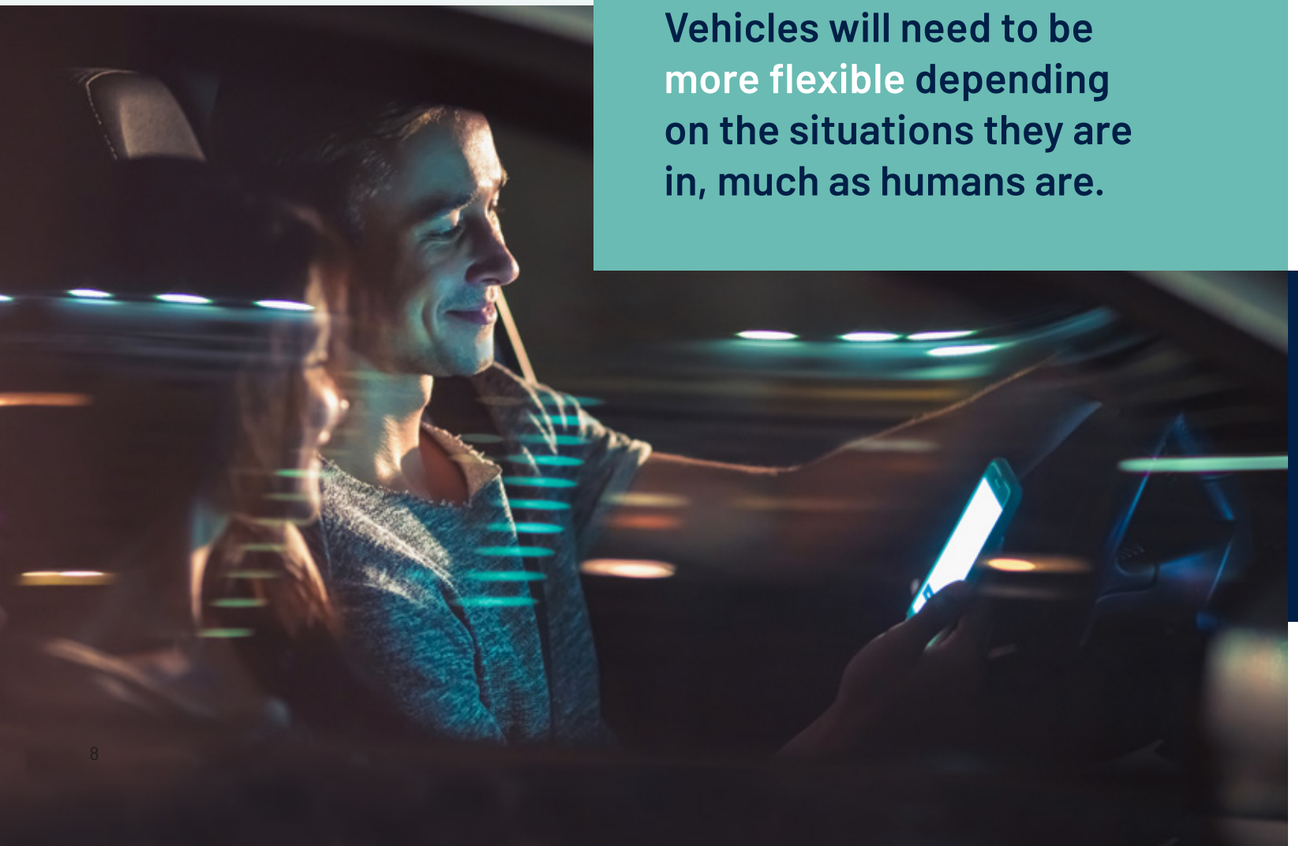
   Both assistance systems and autonomous vehicles will need to communicate through what they do, not just how they announce or indicate those functions. For the vehicle to trust the driver, it needs to understand and answer to

a driver's expectations. Its behavior needs to be understandable (especially when it comes to danger thresholds), but the system should also adjust in response to driver skills, state, or habits. Personalization is key.

3. **Collaboration** — Trust is put to test in "moments of truth" when control responsibility needs to be understood in the heat of tense and possibly dangerous situations. Any forced hand-off will be made increasingly difficult over the next decade as those situations become more complex due to improved safety technologies and more diversity in how the involved vehicles utilize them.

   That means a vehicle system will need to keep the driver engaged in the driving task by collaborating. That way, the driver will not be made to suddenly have automation interfere in a potentially surprising situation but will have learned during normal driving that they and the vehicle need to cooperate. Such driver-vehicle collaboration constitutes establishing a safeguard and perimeter of protection where automation, rather than human, does the monitoring. To realise this, a vehicle needs to build a model of the driver, personalizing itself depending on the situation as well. Only then can drivers of all skill sets and capacities — careful, uncertain, aggressive, distracted, even expert — all be supported. Automation, after all, can monitor tirelessly for extended periods of time. Consider a situation in which a child in the back draws the driver's attention away from the road: both technology and driver need to have a nearly intuitive sense of collaboration to ensure that the vehicle and driver together are seamlessly kept fit to drive.

Vehicles will need to be more flexible depending on the situations they are in, much as humans are.



The driver and vehicle will be empowered to learn, together.

4. **Context** — Finally, Fit to Drive relies on the continuous improvement of the context assessment in which vehicles operate — a shared knowledge or awareness — to best inform driving behavior (i.e., personalization). Just think about it: The miles of road you and others drive are experiences that improve your driving skills. Your vehicle can also learn from where you drive and how you perform together, such as:

- In what circumstances did you rely on a driver assist technology, and how did it function?
- When did you switch off an assist technology, and what were the conditions (which may lead to insights as to why)?
- What is a robust way to distinguish situations in which an existing or planned driver assist technology could have been applied, and what are their characteristics?

Our approach to automotive safety includes providing this 'fleet view' and using it to continually innovate and improve the way a driver and her vehicle collaborate. It can then be applied broadly to other vehicles, and their learnings used to improve your safety profile, resulting in improved collaboration between drivers and vehicles that evolves over time.

The Next Decade's Opportunity

The collaborative driving that will yield vehicles that are Fit to Drive will rely on bringing together technology, controls, and external environments into real-world models of experience and learning. This will enable situational adaptation, which will be far more important than the functional capabilities of any single safety-related technology. It will allow vehicle systems to adjust to sensor and/or driver problems, and it will use connectivity technology not just to share information but engage and inspire its recipients.

The more we empower vehicles and drivers, the more they will be fit to drive...and therefore make our roads safer for all.

We are committed to achieving the greatest possible safety benefits for the largest number of drivers, passengers, and pedestrians as soon as possible.

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Creating **Trust in Mobility**