Future Mobility Systems

Challenges and Success Factors in Development and Validation

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Future Mobility as System-of-Systems

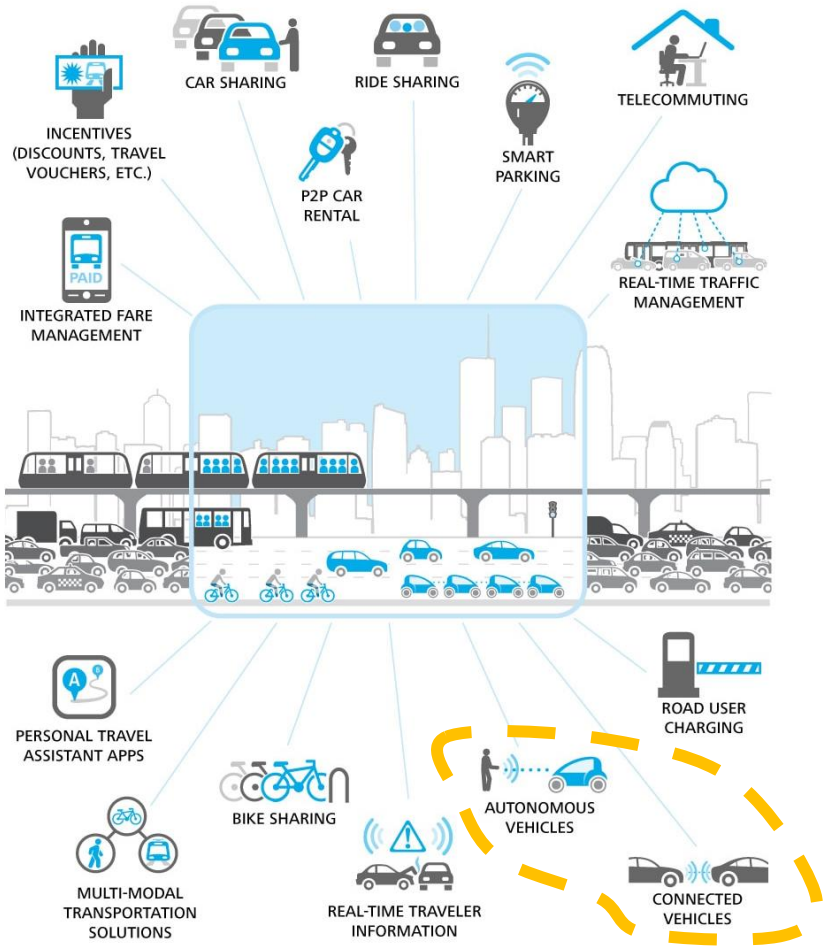
Vision of the city of the future

Autonomous systems act independently and communicate with people. They share common space, create new freedom and increase the quality of life.

Source: https://www.daimler.com/innovation/pioneering/

Source: https://www.daimler.com/magazine/sustainability/

Mobility of the Future as System-of-Systems



Source: https://www2.deloitte.com/us/en/insights/industry/automotive/digital-age-transportation.html

- Vehicles of the future are no single products anymore. They are embedded in the overall mobility system
- Mobility of the future will be a complex system-of-systems
- … it will be a CASE Mobility:
  - Connected
  - Autonomous
  - Shared
  - Electric

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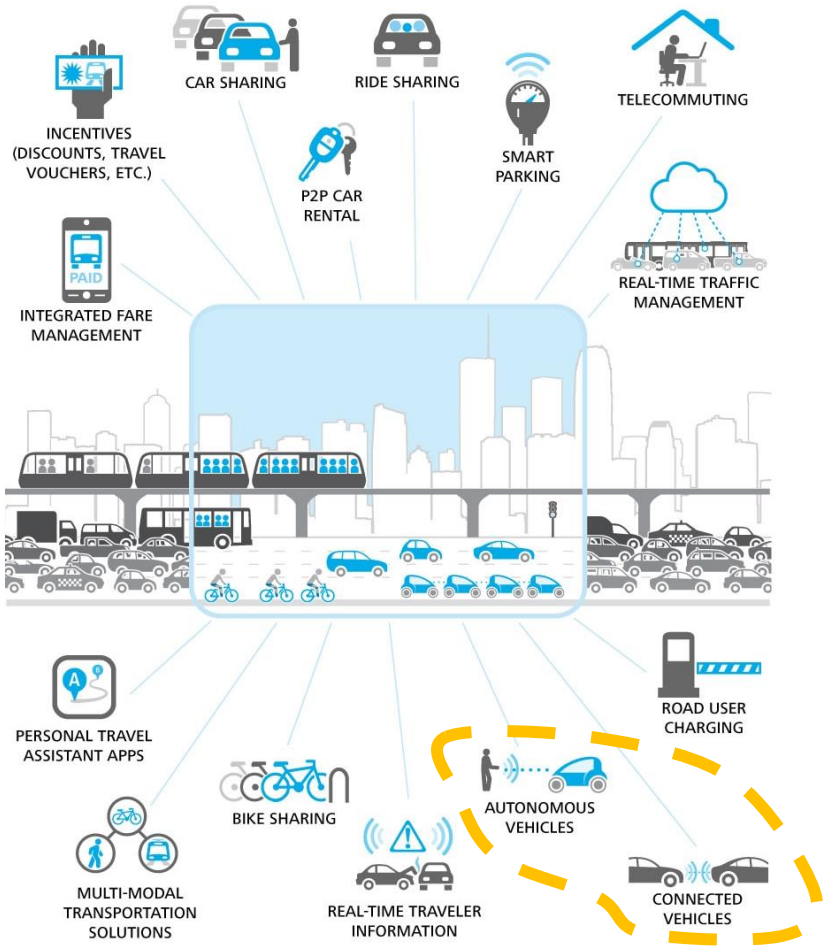

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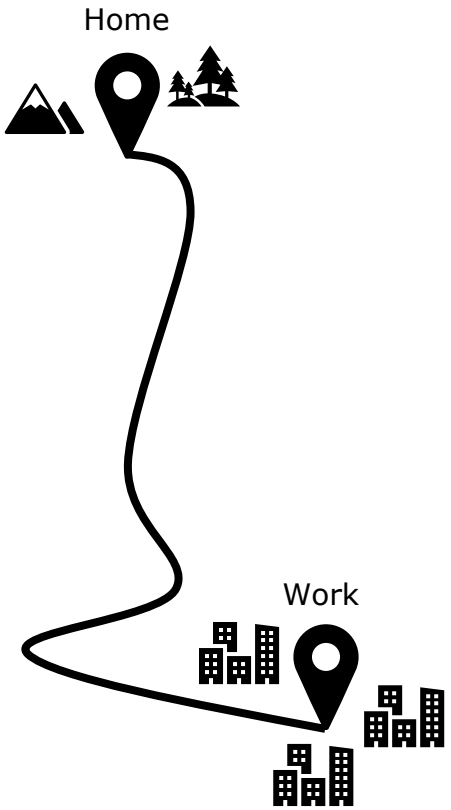
But what will be the exact use cases for vehicles of the future?

The exact use cases will evolve and are volatile today!

How could the daily ride to work look like? (Examples)



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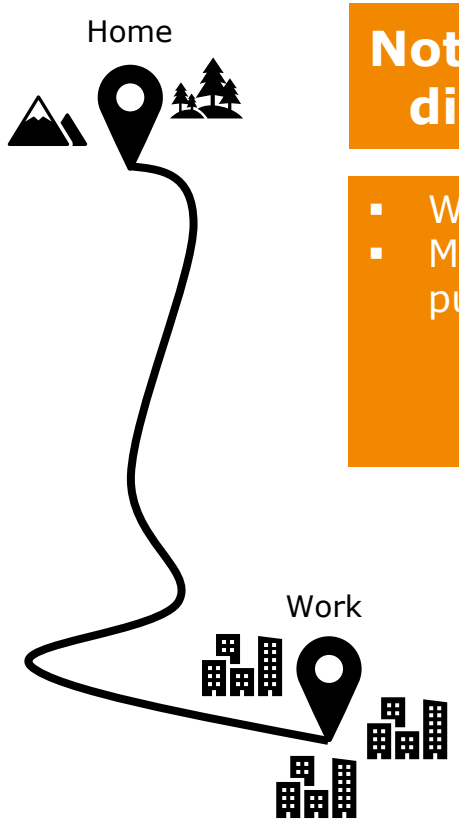

Not required anymore, distributed working

- Working from everywhere
- Mobility only for special purpose and business trips

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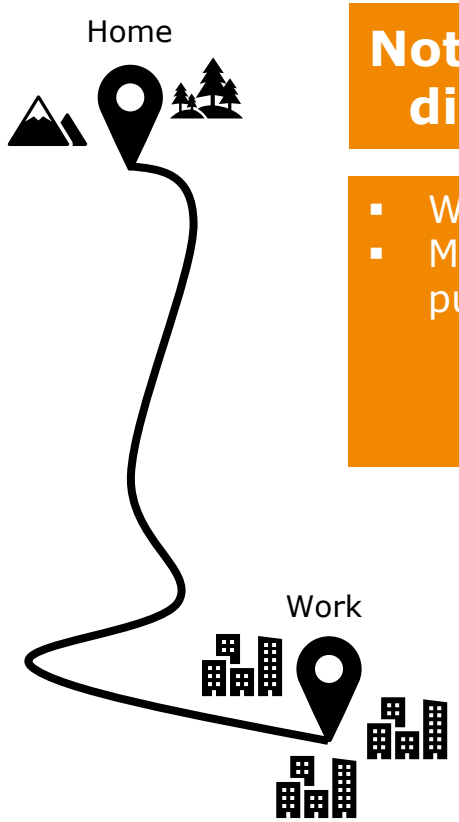

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Multimodal Transportation

- **Robotaxis for the last mile**
- Train for long distances
- Tram or a micro mobility solution in cities

- Rural areas
- Road gradient
- Narrow roads
- Bad infrastructure
- Etc.

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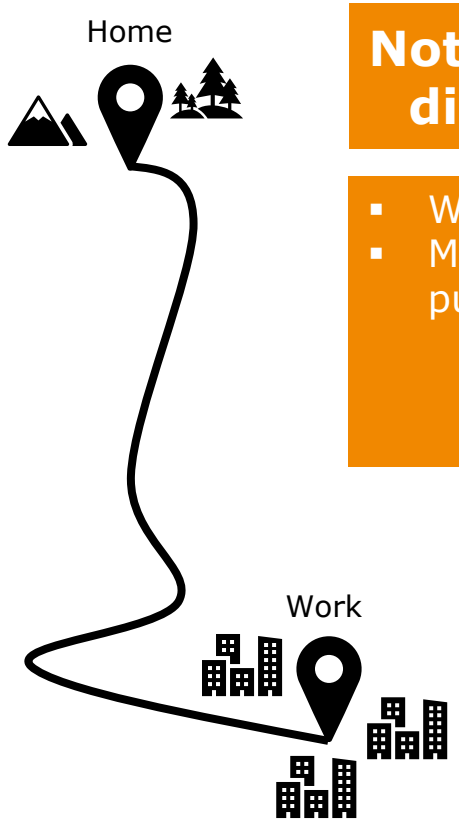

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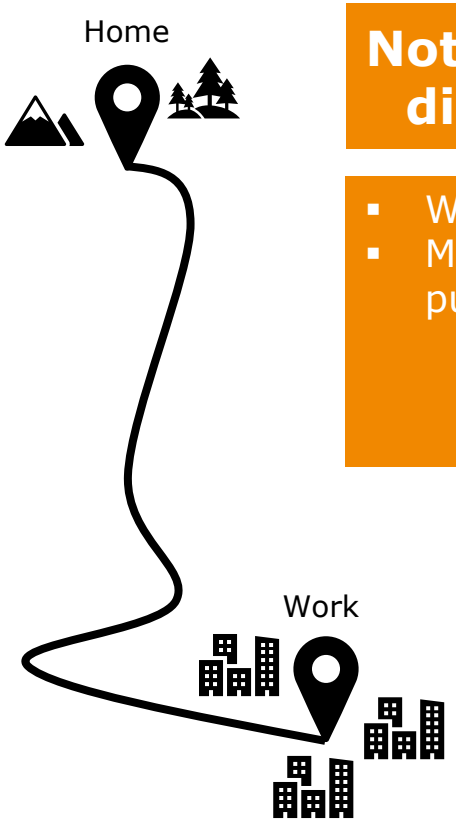

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The requirements will evolve according the use cases!

What kind of powertrain concept?

KLIMA & NACHHALTIGKEIT ❯

ZYLINDER-MOTOR

Toyota rüstet konventionelle Benziner auf grü-nen Wasserstoff um

Das Triebwerk hilet de extreme Belastung eines 24-Stunden-Rennens durch.

© Toyota / PR

Fernziel ist die Umrüstung des Fahrzeugsbestandes

Technisch ist vor allem interessant, dass kein spezielles Triebwerk entwickelt wurde, sondern ein bestehender Benziner auf Wasserstoff getrimmt werden konnte. Der leitende Ingenieur Naoaki Ito sagte allerdings, dass die Umrüstung des 1600-ccm-Dreizylinder-Turbomotors nicht ganz einfach war. "Wir denken, dass die Umrüstung bestehender Automotoren auf Wasserstoff, ein mächtiges Werkzeug im Streben nach CO2-Neutralität darstellt", so Ito. Toyota verfolgt die Vision, zu erforschen, ob es möglich ist, bestehende Fahrzeuge mit vertretbarem Aufwand klimaneutral umzurüsten.

Source: https://www.stern.de/auto/news/toyota-ruestet-konventionelle-benziner-auf-gruenen-wasserstoff-um-30552630.html

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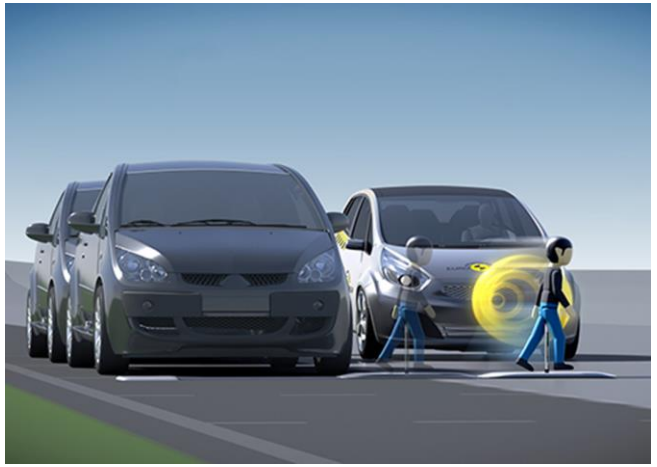
Future vehicles will receive not only software updates!

Validation as Core Enabler for Future Mobility

How safe is safe enough?
What needs to be considered during the validation activity?



Source: https://www.euroncap.com/

Source: https://www.ka-news.de/

Source: https://www.welt.de/vermischtes/article147368368/Die-Nervenprobe-am-Ende-der-Golden-Week.html

Source: AVL

Source: https://efahrer.chip.de/news/tesla-besitzer-erlebt-skurrile-situation-model-3-reagiert-auf-den-mond_105485

Source: https://www.bz-berlin.de/berlin/von-der-seltsamen-lust-ein-eichhoernchen-zu-sein

Validation as critical path in the approval of Automated Driving?

"... the functionality of autonomous vehicles might need to be limited to fit the constraints of feasible validation techniques.

Relaxing those constraints will require advances in areas such as characterizing the coverage of machine learning training data compared to the expected operational environment, gaining confidence in safety requirements with regard to exceptional driving conditions, and being able to validate the independence of failures inredundant inductive-based systems."

Source: Koopman, P, Wagner, M.: Challenges in Autonomous Vehicle Testing and Validation, SAE International Journal of Transportation Safety 4(1):15-24, April 2016

Source: https://www.youtube.com/watch?v=QS_NuVsiWfU

Main Challenges in Validation of Automated Driving





Main Challenges in Validation of Automated Driving

What to test?

- Critical scenarios
- Specific traffic rules
- Regional specific environmental conditions
- "Understanding human behavior is the key problem in building a capable and safe self-driving car." (Dmitri Dolgov, CTO Waymo)
- Etc.

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How to test

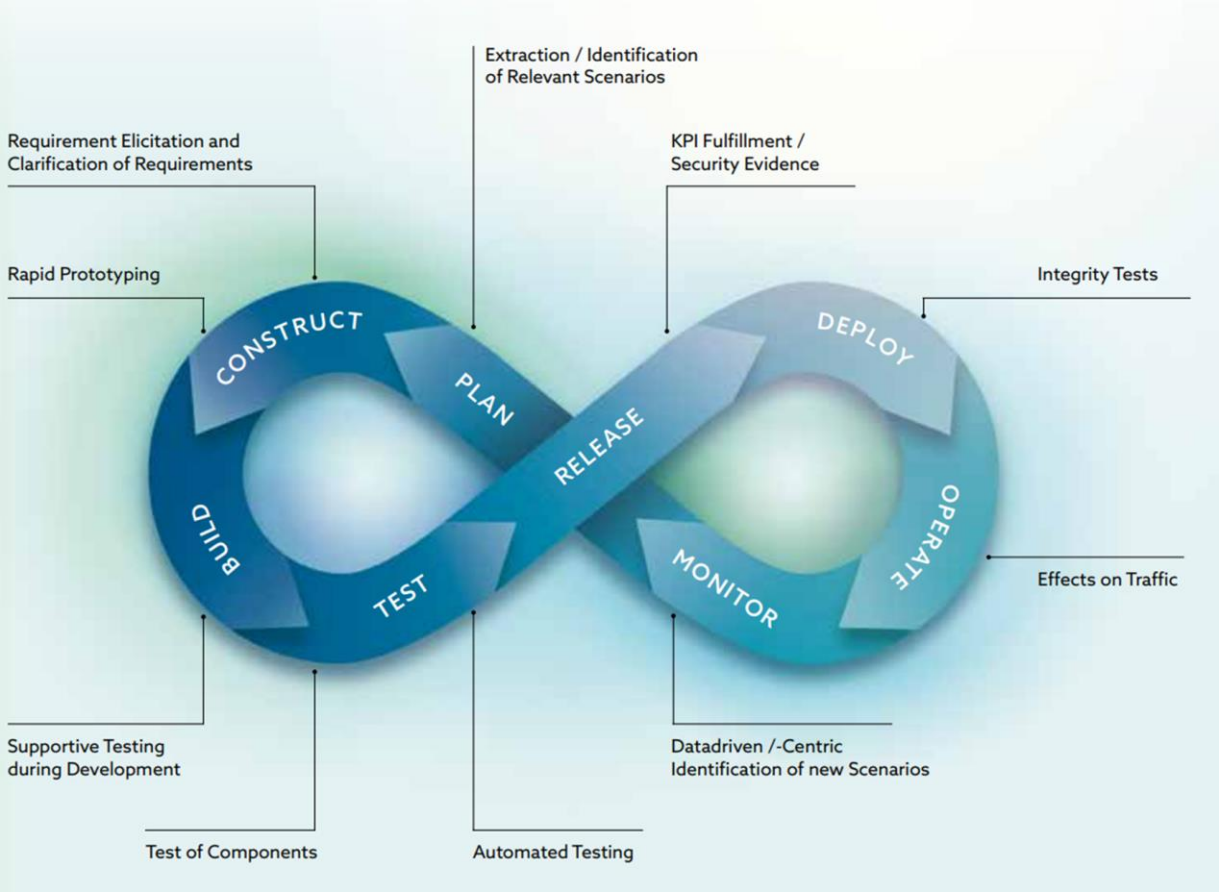
- Robustness validation
- Cover a high number of corner cases and critical scenarios
- Deal with vehicle variants and scenario variants
- Use virtual testing methods like X-in-the-Loop approaches

Product-Production-Codesign is another core enabler…

The development of future products is software-driven

New processes and shorter development cycles will arise

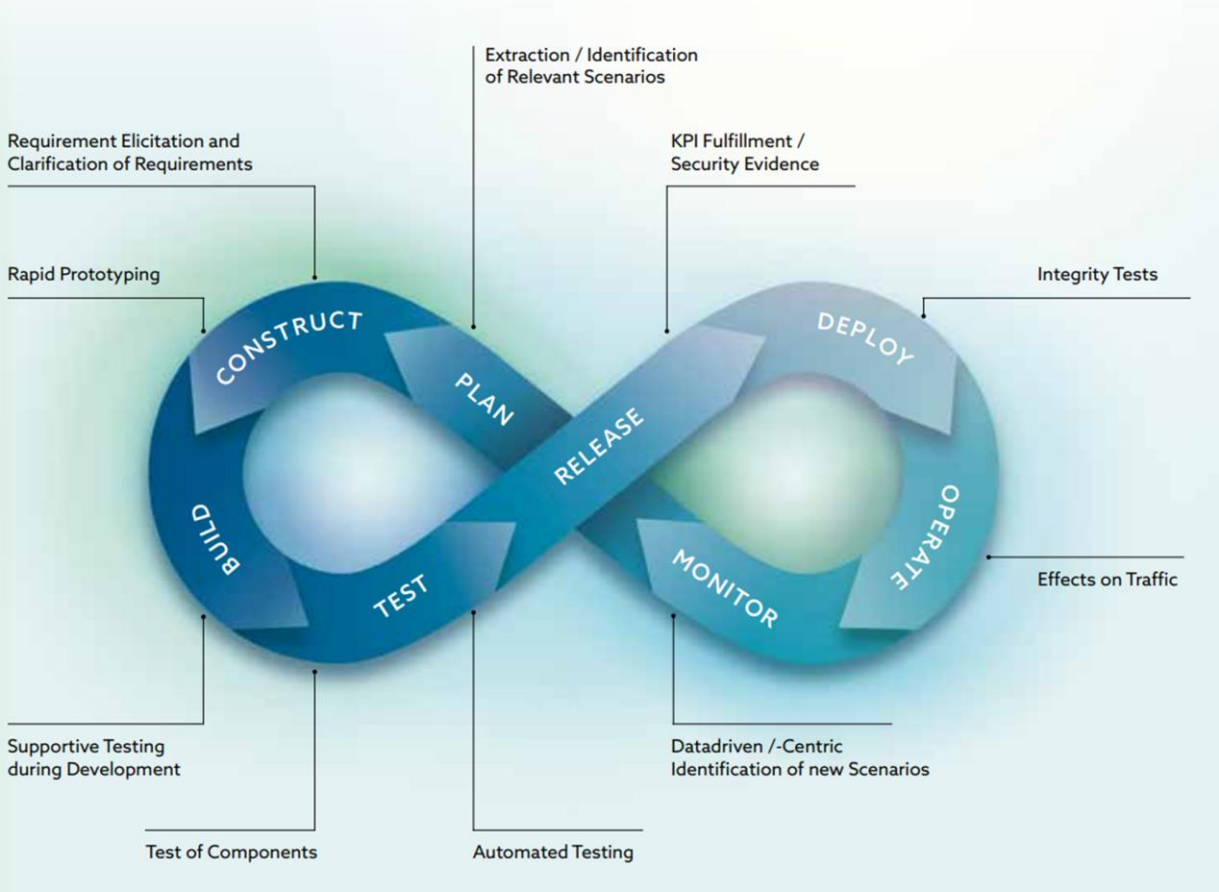
New processes and shorter development cycles



Source: ASAM SIM:Guide – Standardization for highly Automated Driving, ASAM e.V, 20213

- Waterfall – Agile – DevOps
- Validation is THE key knowledge provider during development and in-use of products (especially with volatile use cases and volatile boundary conditions)
- "Hardware Is Hard" (Sundar Pichai, CEO Google LLC) but needs to be considered in a similar way

New processes and shorter development cycles



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In early stages of the development, production systems and technologies are required to enable a fast "build"-process

As DevOps is providing increments directly to customers, the production system needs a certain level of fidelity and quality

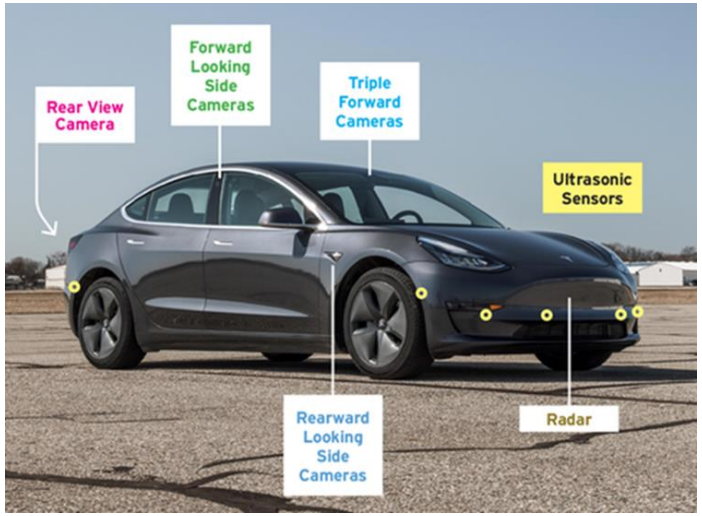
Safety is one of the most important topics for Autonomous Systems

Continuous Validation and Improvements are required to improve safety

Continuous Validation and Improvements to improve safety

Source: https://www.futurezone.at

"In-Use-Validation"



Source: https://www.caranddriver.com/

- Because of the complexity and the volatile environment future products will be updated during their lifecycle continuously
- Updates are required as they are related to safety

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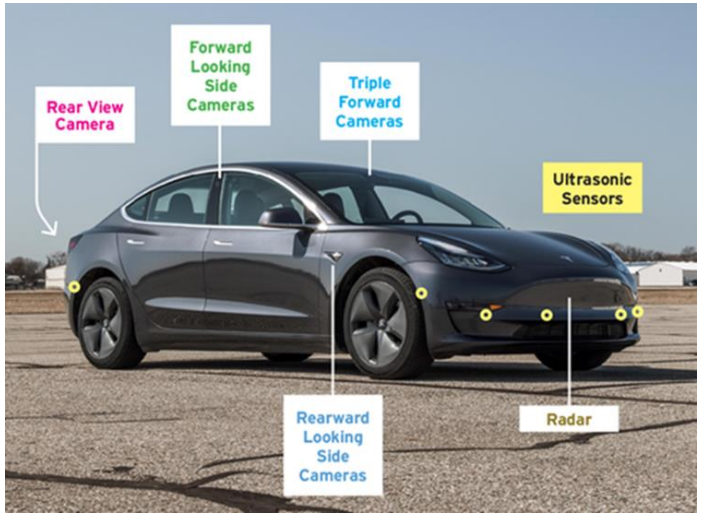

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Incidents during in-use operation will be fed back and results in system updates and/or requirements for future approval tests

Updates are not only related to software it could be also adding additional sensors. This requires the adaption of chassis parts. This requires flexible production systems

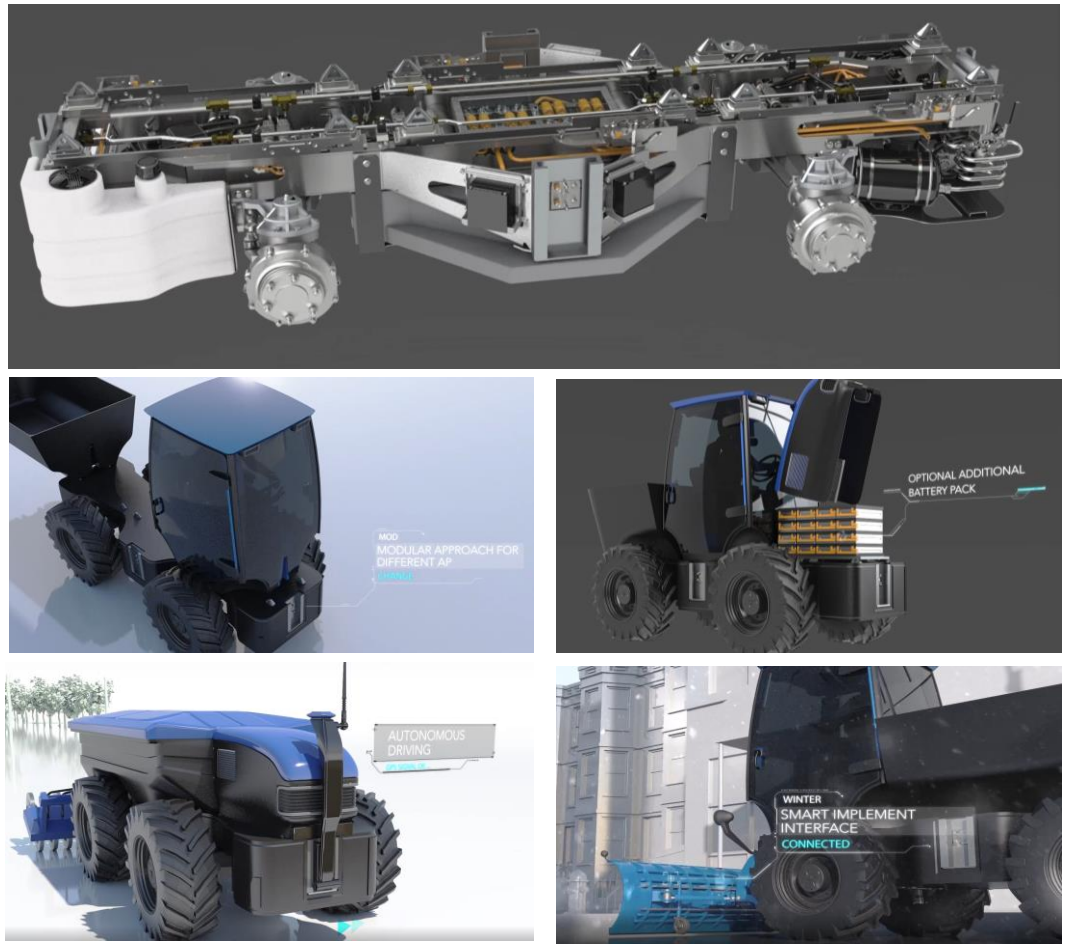
Mobility is Changing

The use cases are volatile and modular, flexible concepts are required

Modular, flexible concepts are required

- Use Cases will change will be extended or even evolve during the lifecycle
- Use Cases cannot be foreseen easily due to the complex interactions in systems-of-systems

Modular, flexible concepts are required



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Innovative upgrade concepts will help to deal with evolving use cases

Beyond a modular and flexible product architecture with a good platform for the product, a modular and flexible architecture with a good platform for the production system is required

Summary

- Future Products are software-driven but not only consisting of software
- Hardware will still be an important brick in future products
- Software has the strength that updates and upgrades can be easily made
- A competitive product will be characterized to deal with updates and upgrades also on the hardware side efficiently
- Extended continuous validation and extended continuous improvement are required for Systems-of-Systems, beyond that the deployment of improvements is crucial
- Product and Production System Designers needs to team up to provide competitive products in the future

Thank you

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