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The Ever-Changing Powertrain - How OTA Makes Powertrains Change Over Vehicle Lifetime

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Abstract

Until about 2015 the design and calibration of a powertrain were considered fixed after the vehicle left the production plant. The developers considered efficiency and performance degradation due to wear and added the required procedures to follow when replacing components. The technology advancements and increasing share of SW-based functionality have led to the point that since around 2020 Over-The-Air SW updates during the life of the vehicle have become a common practice. The customers of the OEMs have started to request this functionality as well. When an SW update is possible also Upgrades by means of SW are a possibility. For the powertrain, this can vary from performance gains to trailer towing efficiency. The UN regulation R156 for Software Update Management System defines conditions to implement such upgrades while still complying with the type approval. The codification makes them clear for both OEM and Technical services. This regulation on one side means an extra effort for OEMs to ensure every SW update is covered by existing or updated type approval; on the other side, it has given a clear direction on how SW Upgrades that affect the type approval can be applied during vehicle lifetime. Some of the aspects of type approval, in such cases, require more detailed analysis, especially in the scope of durability assumptions, emission performance, or range evaluation. In this paper, the content of the UNECE R156 regulation is explained. In addition, a traditional powertrain type approval setup and timeline are compared against how such a setup and timeline can be when the SW Upgrades are used during the vehicle lifetime. The paper will consider Gasoline combustion-engined powertrains and Battery Electric powertrains.

Introduction and History

In 2021 the UNECE published a new regulation: R156 [1]. This regulation was introduced to address concerns amongst type approval bodies and governments alike on how to ensure SW updates to vehicles would not cause vehicles to deviate from their type approval status. Originally regulations were created based on the assumption that manufacturers would bring a vehicle to market identical to how it was type-approved (for some regulations checked by Conformity-of-Production). After production the vehicle would remain compliant as long as it was ensured (e.g. by means of periodic inspection) that the vehicle owner would not modify the vehicle without manufacturer consent; or that it was ensured the vehicle would only be maintained or repaired with components and software that met the manufacturer specifications. However, an industry trend started to develop within which manufacturers would learn from "field" experience by means of customer feedback or warranty reports and would release improvements. Typically these improvements did not alter the vehicle characteristics at all or were only minor. Usually these improvements that would be a minor change on the vehicle characteristic would focus on parts of the vehicle that were not under type approval (e.g. navigation maps).

As vehicles became more connected (e.g. Software update over the air - OTA [2]) the rate of improvements roll-out started to increase. The available research mostly concentrates on cyber security aspect of OTA, discussing technical solutions [3] rather than lifecycle regulation consequences. Acceleration of lifecycle stages and prolongation of support and possibilities yielding from wide SW and telecommunication usage in vehicle is characterized by Danger and Zamazal [4], however the type approval consideration was not taken into account. The transformation of vehicle lifecycle has led to the situation that the type approval bodies lost the confidence that the vehicles that are on the road for a few years are still a representation of the type approval state. The fact that UNECE R155 [5] Cyber Security Management regulation requires OEMs to keep supporting vehicles with updates in the form of Cyber Security Patches. These patches are expected to increase both the number of updates and the number of years an OEM may be rolling-out updates [6]. With the increased roll-out frequency and duration the concern is

therefore has to keep the battery durability in mind for performance releases.

Summary/Conclusions

With the arrival of the new R156 the process of applying Type approval relevant changes to vehicles via SW updates was described and regulated. This opens an opportunity to make use of new business models and distribution strategies including:

- Produce one Type approved vehicle and distribute to dealerships or warehouses around the world, only when selling to final client the cars SW is updated to desired version. What is more the SW versions might not be existent yet, in the stage of car production.
- The OEM can offer vehicle upgrades to vehicles that are already in possession of end clients.
- The OEM can offer time restricted or monthly paid based upgrades.

What is most important all of the above can be offered for features that are type approval relevant. On the other hand type approval relevant upgrades can manifest in violating emission standards or range degradation of BEVs which is part of "In-use compliance" testing scheme. Thus it is essential to design base variant with significant emissions and battery performance margins ("package protected") to avoid later costs.

Concluding the benefits and challenges of such an ever-changing powertrain are the following:

Benefits:

- The OEM can act on customer demands even well after the development was ended but before a next facelift or model year refresh is released.
- The OEM can support different business models
- The Build-to-stock model is easier to achieve
- Under the scrutiny of the R156 process the OEM has clarity if the updates or upgrades they intend to offer are approved by regulators
- The OEM is able to take away mistrust from regulators whether vehicles are operating on the road in a compliant state - in other words take away the regulator fear that a defeat device is installed by OTA update and can be removed by OTA update as well which would destroy the evidence

Challenges:

- The OEM must have a strong grip on change management. Any update, even a simple bugfix, that bypassed the R156 process is a compliance risk.
- The OEM change management must connect well with supplier change management to prevent any supplier made change is missed by the R156 process
- As many powertrain parameters and performance data are part of vehicle registration the changes in SW need to be accompanied by an update of the vehicle registration. This step introduces a dependency on the vehicle registration holder and limits the frequency of change such as in e.g. the monthly subscription model
- Updates can affect aging and wear processes which can lead to non-compliance (e.g. RDE/PEMS with aftertreatment aging) or increased warranty costs (e.g. with EV battery warranty).
- Even with the updates the vehicle must still comply to regulations. If there is not enough build-in reserve (package-protect) the update considered may not be feasible. The original development must therefore consider some extra reserves. The SW updates are therefore not a pure afterthought

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Definitions/Abbreviations

NVH - Noise, Vibration, Harshness

UNECE - United Nations Economic Council for Europe

AECD - Auxiliary Emissions Control Device (US term).

AES - Auxiliary Emissions Strategy (EU term)

OTA - Over The Air (software) update

RxSWIN - RX Software identification number

CoP - Conformity of Production

OEM - Original Equipment Manufacturer - in this case Car manufacturer brand

RDE/PEMS - Real Driving Emissions/Portable Emission Measurement System

BEV - Battery Electric Vehicle

PHEV - Plug-In (hybrid) electric Vehicle. Vehicle with small battery pack, electric motor and combustion engine. It is possible to charge it from external power source.

L4, L5 vehicle - L4 - autonomous but with restricted route, L5- fully autonomous vehicle

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