

A Re-certification Credit Allocation Method for OTA Software Updates in Software-Defined Vehicles

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1. Introduction

Software-defined vehicles (SDVs) deliver type-approval-relevant function changes via over-the-air (OTA) software updates, yet how much of the required re-assessment can be discharged virtually rather than physically remains under-specified. Type-approval simulation-credibility provisions (EU 2022/1426; UNECE NATM) and software-update management (UN-R156 SUMS, RXSWIN) exist as separate instruments, with no method connecting them by accounting for virtual-evidence reuse across an OTA change. This paper proposes such a credit-allocation method and illustrates it on a deployed Level-3 ALKS (UN-R157).

2. Method

The method has three components. Change Impact Classification (CIC) maps an OTA change, identified via the RXSWIN delta, onto a per-pillar damage score $d \in [0,1]$ along safety-case and cyber-relevance axes over the five NATM pillars (Simulation, Test-Track, Real-World, Audit/Assessment, ISMR). The Virtual-Evidence Credibility Tier (VECT) aggregates the EU 2022/1426 five-factor credibility into credibility $\in [0,1]$ by a weakest-link min-pool. The allocation matrix partitions each pillar's initial evidence $E_{0,p}$ into three components through the carry-over coefficient $c_p = s_p \cdot \text{credibility}$, where s_p is the pillar's intrinsic virtualisability:

$$\begin{aligned} C_{p,a} &= E_{0,p} \cdot (1 - d_{p,a}) && \text{(Reuse credit)} \\ V_{p,a} &= E_{0,p} \cdot d_{p,a} \cdot c_p && \text{(Virtual substitution)} \quad \dots(1) \\ P_{p,a} &= E_{0,p} \cdot d_{p,a} \cdot (1 - c_p) && \text{(Physical residual)} \end{aligned}$$

Equation (1) conserves evidence, $C_{p,a} + V_{p,a} + P_{p,a} = E_{0,p}$, by construction.

3. Application and Results

The method is illustrated on the OTA-delivered ODD speed extension of a deployed L3 ALKS (UN-R157, 60 → 95 km/h; Mercedes-Benz Drive Pilot, KBA type-approval extension, December 2024). Substituting the CIC outputs into (1) yields the 4-category × 5-pillar allocation of Fig. 1: physical residual concentrates on the Real-World and Test-Track pillars under functional safety and HARA, whereas Simulation and Audit/Assessment retain most evidence as reuse credit and the cybersecurity category discharges almost entirely through reuse and audit. Under ±20% Monte-Carlo perturbation of the input assumptions (N = 5000), the physical-residual top-2 pillars {Real-World, Test-Track} remain invariant in all draws, so the qualitative allocation structure is robust to the assumed values.

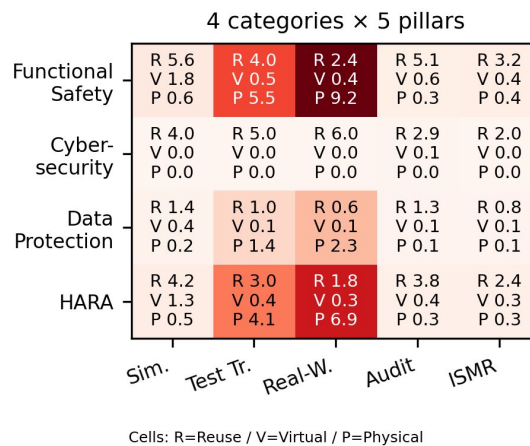


Fig. 1 Credit allocation heatmap for the L3 ALKS (UN-R157) 60 → 95 km/h ODD extension (4 categories × 5 pillars).

4. Conclusion

The method connects the NATM multi-pillar evaluation with UN-R156 software-update management at the granularity of an individual OTA change, producing an auditable reuse / virtual-substitution / physical-residual allocation that is qualitatively stable under perturbation. It is a proposed accounting framework rather than a validated regulatory artefact; future work addresses cross-case validity, sub-pillar discrimination, and retrospective anchoring against approval-authority outcomes.

References

- (1) UN Regulation No. 156, UNECE, E/ECE/TRANS/505/Rev.3/Add.155, EIF 2021-01-22.
- (2) Commission Implementing Regulation (EU) 2022/1426, OJ L 221, 2022-08-26.
- (3) UNECE WP.29/GRVA, NATM Master Document (2nd iteration), ECE/TRANS/WP.29/2022/57, 2022-06.
- (4) UN Regulation No. 157, UNECE, E/ECE/TRANS/505/Rev.3/Add.156, 01-series EIF 2023-01-04.