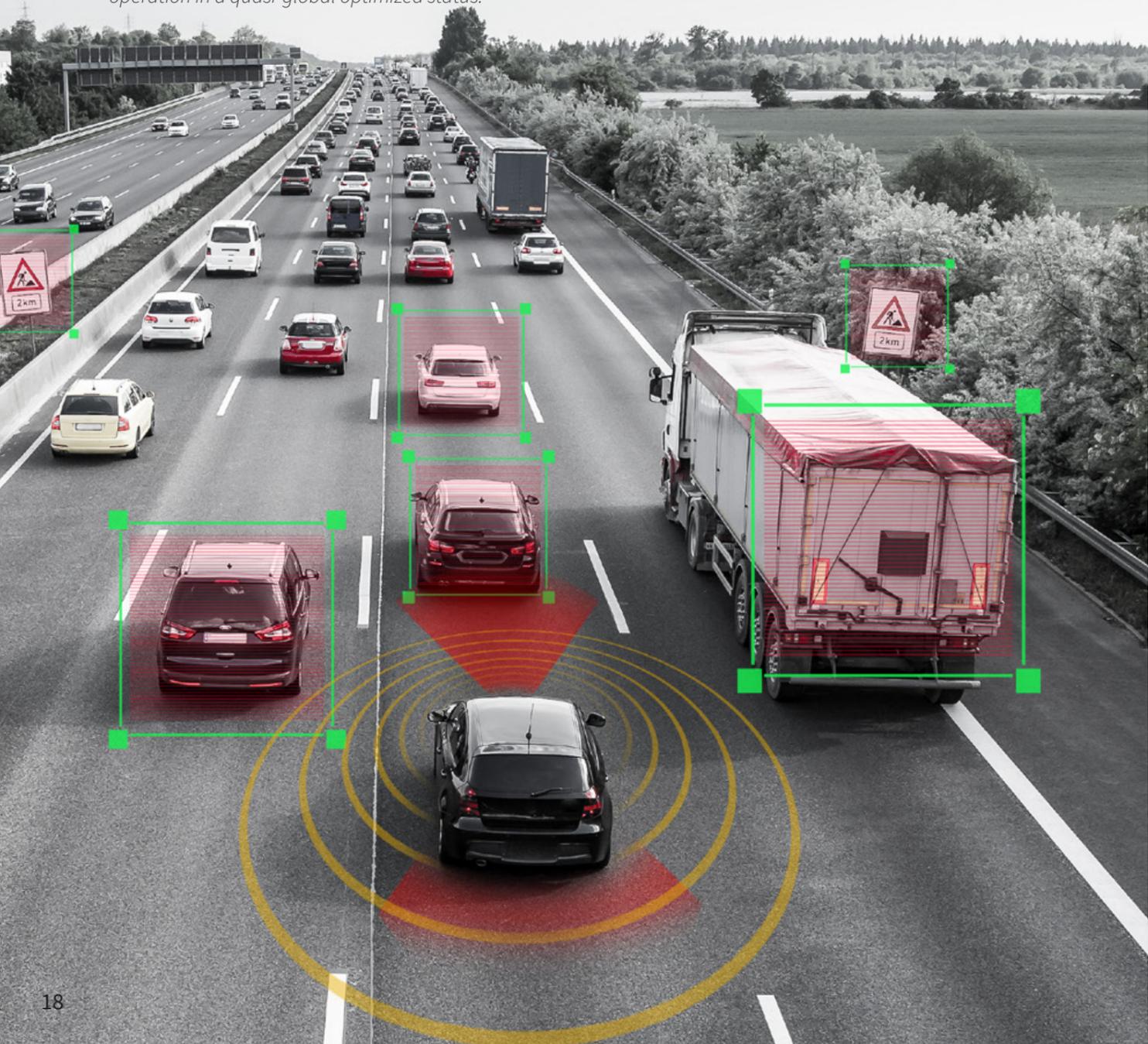**PREDICTIVE DRIVING**

ANTICIPATED DRIVING 2.0

DENSO AND FEV DEVELOP A PREDICTIVE OPERATING STRATEGY

Many of today's powertrain improvements target to improve the vehicle's operation strategy in terms of drivability, fuel consumption, emissions and NVH. These strategies are often rule-based and non-predictive using only current locally available parameters for situation interpretation and vehicle operation controls. These parameters include current driver's request, vehicle velocity, battery state of charge, etc. So far, computation does not consider information about future road profile, traffic and infrastructure as well as future driver's request to optimally control vehicle operations. This implies that pre-defined driving cycles are used to calibrate a set of operation rules by which the vehicle and powertrain is controlled. As a result, the vehicle controllers are in optimal state only, when the driving profile is very similar to the pre-defined driving cycles. An "electronic horizon" can be setup to predict the state of the vehicle for a specific future time span. Adapting the controllers based on predictive parameters enables vehicle operation in a quasi-global optimized status.

DENSO and FEV are currently developing a predictive operating strategy including an electronic horizon that not only achieves additional fuel consumption savings in the real driving scenarios, but also increases the drivability of the vehicle. The strategy is based on using a-priori knowledge of the road ahead from vehicle's navigation system in combination with data about provided street topography and traffic information, speed limits and traffic lights status by car-2-x technology. Utilizing this data, an optimized operating strategy for the powertrain as well as for the HVAC system is determined for a predicted period of time.

Predictive Hybrid Operation Strategy

"With the prediction of upcoming driving scenarios, the suitable parameters are pre-selected and applied to the hybrid controllers", explained Max Nakagawa, President and CTO at Denso International Europe. "The target is to achieve quasi-global optima within the predicted horizon." To investigate the improvement in drivability and fuel consumption through predictive operating strategies, a 3D vehicle simulation environment with real-world driving situations and traffic scenarios was setup for multiple test cases.

Predictive Cabin Thermal Management

Especially less powerful vehicles are prone to a deterioration of both drivability and fuel consumption caused by the energy consumption of the Air Conditioning (AC). This effect is even stronger in particularly demanding driving cycles or extreme hot weather conditions. Using an advanced and predictive thermal management system in combination with a thermal storage device enables to optimally schedule the additional load from the AC compressor. This reduces the fuel consumption while the cabin temperature is kept within the comfortable zone.

Result and Outlook

According to simulation results, the predictive hybrid operational strategy and predictive HCAV not only decrease fuel consumption and CO_2 emission, but also improve drivability of the vehicle. Since these predictive strategies are based on already existing vehicle and hardware, applying them will reduce the fuel consumption and improve drivability of the vehicle with nearly zero additional cost. Therefore, these strategies are promising candidates for implementation in future advanced powertrains.

To exploit all the potentials of predictive strategies, DENSO and FEV will continue the development and setup demonstrator vehicles for road testing

Simulation environment for predictive strategy

Three questions to
Masato (Max) Nakagawa,
President and CTO at
DENSO INTERNATIONAL EUROPE

What is DENSO's strategy and vision for the EU market?

DENSO is a leading supplier of advanced automotive technology, systems and components for major automakers in Europe. The predictive operating strategy will improve the values of our products at any challenging areas.

What is City-e's role and why is it key to implement predictive strategies?

DENSO has advocated a new concept of City-e (Connected Intelligence for Mobility and Society in Europe) with FEV since 2013. It is very important to show new concepts and discuss them with European parties in order to address social issues such as CO_2 reduction of road transportation in the real driving circumstances etc.

Why did DENSO choose FEV and FEV Consulting as partners?

FEV and FEV Consulting are professional automotive R&D partners of the automotive industry. FEV can provide turn-key solution from the trend analysis to evaluation and verification with actual vehicles. DENSO and FEV have monthly steering meetings, and specific technical meetings are held in a timely manner. DENSO is confident that we can work with FEV to develop ideas shaping our future society.

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