SAE J3016

Fifty shades of gray from L2 to L3

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Among the many duties of The Society of Automotive Engineers (SAE International) is to provide a forum for engineers, governments, and other stakeholders to develop technical standards and best practices for the automotive sector. The SAE today houses over 9,900 documents that are the fruits of collaboration between some 15,000 experts and engineers worldwide. Among these standards, perhaps the most referenced and influential today is standard J3016.

To most, J3016 is better known as the standard for referencing vehicle autonomy levels. It is the source for the six levels of autonomy from L0 through to L5 that have entered the popular discourse since their creation in 2014. However, while being very influential the standard has provided consternation for the industry, governments, and insurance companies alike.

Much of the consternation centers on how nebulous the standard is in its treatment on the move from L2 to L3 and the point at which an L3 system must transfer to the human driver in an emergency. So knotty has this problem proven that the industry has adopted L2+ as a destination in itself, with many shying away from L3 and others concentrating efforts directly on L4. In particular, the industry in China is moving quickly to expand use cases in L2+ and building on the foundational 'Navigate on Autopilot' feature that keeps drivers engaged with hands on the wheel.

This latest issue of Talking Heads gathers the views of S&P Global Mobility subject matter experts in the autonomy and software domains on the thorny SAE J3016 theme.

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If you read the SAE definitions, there is a clear statement about L0 through L2. The driver is always, and unquestionably, in charge regardless of the technology that is onboard. This is patently true. Without the driver's control, the vehicle will crash. Users and OEMs bought into this before developing and purchasing the technology. The clear distinction also allows the technology to have standard use cases. What is more the cost of development will decrease due to mass adoption.

When it comes to L2 the situation becomes a bit murky, but with L3 J3016 is opaque. The SAE standard on L3 is vague and abstract. It fails to guide what is the role of the driver when technology is in action – i.e., what is it permissible for a driver to do when a vehicle is in automation mode or, more explicitly, what should drivers not do in an automated journey. There are a whole series of questions here. What should drivers' attention rate to driving be? How is the attention rate

measured? Or what is a safe time lapse between the technology warning the driver and the driver taking over? There is also the conundrum or paradox that the better an automated system is that the less attentive an operator is likely to be.

Also, there is no clear guidance or stipulation on a parametric definition of what constitutes a successful handover between technology and driver or vice-versa. Similarly, there is no definition of what makes for an unsuccessful handover. For me, SAE is just a description of automation, not guidelines. This is confusing both national legislators and OEMs and they are interpreting J3016 to the best of their ability.

The point is that the technology is so serious that the industry should have clear guidance on all use cases and what drivers should or should not do when vehicles are in automation mode. What is more, understanding where the vehicle's or system's responsibility boundaries begin and end, together with clear guidance on where liability lies in the event of failure, is vital.

For example, Mercedes-Benz declared that they would take responsibility if the Drive Pilot fails but they will not accept if the driver failed duty of care. But what does the duty of care in L3 mean? How and who will determine liability in the event of an insurance claim? There is no guidance. If these issues were covered through regulation we would avoid the localization of L3 use cases and move faster toward mass adoption, impacting volumes and reducing development costs.

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It is true that J3016 is not a comprehensive regulatory asset, and elements are undefined or otherwise left for inference. But J3016 is not meant to be regulation, only a means to establish common terminology and put structure to what was previously entirely undefined in every way.

J3016 is not perfect, and we are seeing how some national regulatory bodies are referring to other methods to govern this development and certification by using UNECE efforts under WP.29 including R157 ALKS (Automated Lane Keeping Systems). That approach still requires much additional technical detail to assess compliant versus non-compliant system design and operation, but the work is well underway and continues.

Liability is a key topic with J3016. A clear line from L0-2 and L3-5 is inferred with the standard. The fact that some OEMs (Volvo and Mercedes most vocally) have publicly assumed liability endorses that line inherent in J3016. But a "duty of care" argument still makes any eventual judgment of liability much more difficult, and courts will certainly play a role.

The timeline of the handover of control from vehicle to driver is also a huge problem. Human factors research studies would suggest that there is no reasonable time interval for a driver to assume control and take appropriate action, especially since transition of control is likely to happen in the most dynamic of driving environments. That fundamental human factors challenge is unlikely to ever be resolved satisfactorily, and this is essentially why L2+ has become so popular amongst automakers around the world. It is the reason L2+ is 15x the share of L3 volumes by the end of the decade in the S&P Global Mobility Autonomy Forecasts. It is also why L4—in purpose-built vehicles without the possibility of driver control—is the focus of companies like Waymo and Cruise who faced the handover problem early in their research and quickly removed the uncertainty from their roadmaps.

We also know from conversations with OEMs that many have L3 systems that are deployable up to 130km/h (in line with updates to ALKS regulations that began at low speeds only up to 60 km/h. But because most national regulators have yet to clarify the liability situation, some OEMs are unwilling to place products on the market. New vehicle architectures also afford the ability to upgrade from L2+ to L3 in the future via software updates so many automakers are taking advantage of this potential amid the uncertainty.

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Since 2020 the Chinese sector has placed much less emphasis on following J3016. This can be traced back to NOA (Navigate on Autopilot) – originally the Tesla system – being passed as safe to deploy on China's highways in 2019. Now, NOA is regarded as the flagship intelligent driving system in the market and is analogous to L2+.

J3016 is also less important for the Chinese market because, due to local legal requirements, hands-off driving is not permitted within the L2 category. This leads to different L2+ definitions in the market. The local L2+ is NOA, while L2+ Global is hands-off driving and this explains why NOA is central to AD development in China and not J3016.

Initial NOA was for on-highway applications, where the system allowed the vehicle to drive without human input point-to-point. During a journey, obstacles and situations such as construction zones, toll stations, lane merging, overtakes, and lane changes are all initiated by the system.

NOA on-highway system availability was the key trend in AD technology for the 2020-2022 period. Now, and up to 2025, the emphasis is shifting to NOA for urban scenarios. Here the system can navigate roundabouts, right turns, U-turns, unprotected left turns, traffic lights, and VRU (vulnerable road user) avoidance. NOA for urban scenarios is similar in capability to Tesla's FSD suite. Among Chinese OEMs, Xpeng is leading the way with Xpilot 3.5/4.0, with other Chinese OEMs as fast followers. The main deployment has been in the cities of Guangzhou, Shenzhen, and Shanghai.

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The April 2021 revision to the standard - J3016_202104 – did try and guide the nebulous position of human handover in its initial drafts. Specifically, it mentions "clarifying the role of the (human) driver, if any, during driving automation system engagement." However, the revision still does not allow for a nuanced framework for the driver's status under automated driving. In reality, a driver's engagement status is much more diverse and complex. ADAS/ADS functions are designed to provide driver comfort and safety making the driver's engagement behavior worthy of a deeper and more detailed categorization. In this respect, SAE levels are almost irrelevant when developing ADAS systems, as the driver's experience is more important. This is why Chinese OEMs have eschewed J3016. Incidentally, Mobileye – also the first to conceive of L2+ - has established a framework that seeks to enhance the driver's role under automated driving. In their framework, there is a four-axis evaluation: (i) eyes-on/hands-on (ii)) eyes-on/hands-off (iii) eye-off/hands-off and (iv) no driver. The first three elements are related to the driver's status. For the latter two, the framework stipulates a full MRM (minimum risk maneuver) capability – whereby under system failure the vehicle stops safely on the shoulder of the road – is present.

With this background, Chinese OEMs have developed L2+ (or NOA) on a continuous basis and there is an expectation that the automation level will jump straight to L4, virtually bypassing L3, in the future. Today on Chinese open roads, Xpeng and Huawei have already delivered NOA urban. Late last year Xpeng launched XNGP on Xpeng P7i and G9, with more vehicles to follow with the sensor set this year. Just this April, Huawei – the Chinese tech giant – released its "ADS 2.0" system on the new Aito M5. Aito, standing for "Adding Intelligence to Auto" is a brand of Seres, the former SF Motor.

Both Xpeng and Huawei are developing their AD tech stack to focus on 'light map, heavy perception.' That means relying on stronger perception ability and AI, based on BEV (bird's eye view) perception and transformer modeling; the same basis Tesla uses for FSD. This loses dependency on the HD map step-by-step and makes use of the navigation map instead.

While Xpeng and Huawei lead the way, Chinese EV OEMs – including IM, NIO, Lixiang, and Zeekr - plan to deploy NOA urban features either later this year (NIO NAD, Lixiang AD Max3.0) or, we estimate, next year (Zeekr ZAD, IM AD NOA). Of the mainstream Chinese OEMs, Great Wall will introduce an NOA urban Mocha later this year. Haomo AI is the supplier of Great Wall's system called Hpilot3.0.

In the words of Huawei's Yu Chengdong, the Huawei ADS system - and the similar systems outlined above - will provide customers with an L2.9999 experience. This is the path we expect more Chinese OEMs to follow, continually build L2+ capability, and expand operational design domains (ODDs) to more cities.

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