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March 31, 2021

Dr. Steven Cliff
Acting Administrator
National Highway Traffic Safety Administration
1200 New Jersey Avenue S.E., West Building
Washington D.C. 20590-0001

Subject: ANPRM - Part 571 – Framework for Automated Driving System Safety
Docket No. NHTSA-2020-0106

Dear Acting Administrator Steven Cliff:

On behalf of the BMW Group, BMW of North America, LLC (BMW) appreciates the opportunity to provide comments in response to the National Highway Traffic Safety Administration (NHTSA) request for comments regarding the creation of a Framework for Automated Driving System Safety.

Introduction

BMW applauds NHTSA's effort to create a framework that supports the mission to save lives and prevent injuries while balancing removing unnecessary regulatory barriers that might hinder the market introduction of ADS (automated driving system) technologies or prematurely creating new FMVSS that could result in unintended safety consequences. The ANPRM notes that the Agency is seeking to develop a safety framework of standards and/or guidance that manufacturers of ADS would (or, in the case of guidance, could) follow to evaluate and demonstrate the safety of their systems.

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BMW agrees with the Agency's assessment that premature establishment of regulations or new FMVSS without the appropriate knowledge base could hinder the development of ADS technology and result in unintended safety consequences. The Motor Vehicle Safety Act[1] establishes that the Secretary of Transportation shall prescribe motor vehicle safety standards that meet the need for motor vehicle safety; be practicable, both technologically and economically; and be stated in objective terms. Currently, there has been no significant deployment of ADS equipped vehicles for sale to the public or for commercial applications. Currently no safety need can be demonstrated based on real world traffic data.

As ADS technology is still in the development phase, Agency guidance, voluntary reporting by developers and NHTSA's authority to initiate defect investigations and influence recalls are appropriate mechanisms of oversight. In developing a framework for ADS safety, BMW encourages the Agency to consider voluntary mechanisms of oversight in the near term

[1] 49 USC 30111(a) - https://www.nhtsa.gov/sites/nhtsa.dot.gov/files/mvs01092008.pdf

and regulatory mechanisms of oversight looking forward. As ADS technology evolves and ADS equipped vehicles are deployed, NHTSA's oversight mechanisms may need to evolve to meet safety needs that can be demonstrated with real word data.

BMW supports the publication of guidance documents, such as the Federal Automotive Vehicle Policies (FAVP) given the current state of ADS technology. FAVP 2.0 highlights twelve priority safety design elements as guidance in the form of a (Vehicle Safety Self-Assessment) VSSA. The VSSA serves to educate and build confidence in ADS technology with the public, safety advocates, government officials and many other stakeholders. BMW published its first VSSA in early 2020 titled "Safety Assessment Report – SAE Level 3 Automated Driving System"[2]. In addition to focusing on dedicated SAE Level 4 automation, BMW strongly encourages the agency to also examine aspects related to SAE Level 3 and SAE Level 4 vehicles that are designed such that the Dynamic Driving Task (DDT) can be done manually by a human driver or by the ADS (i.e. dual use vehicles), e.g. HMI (Human Machine Interaction) and handovers.

The ANPRM describes some engineering and process measures that various developers and organizations are creating and also reviews standards that could be used to develop frameworks or portions of a framework. Well-known standards such as ISO 26262 (Functional Safety) and ISO/PAS 21448 (Road vehicles - Safety of the Intended Functionality) are also included in the discussions. BMW strongly recommends the Agency consider incorporating principles from ISO/TR 4804[3] in the development of a framework. The twelve safety and cybersecurity principles highlighted in this standard are to achieve a "Positive Risk Balance" and can be mapped to several publications including the ADS Safety Elements described in U.S. Department of Transportation (U.S. DOT), "Automated Driving Systems 2.0: A Vision for Safety (ADS 2.0)". The terminology Positive Risk Balance– also used in the medical field – provides a means to measure the safety benefit of ADS technology and will be discussed in more detail later in this document.

Engineering Measures

Core Elements of ADS Safety Performance

The ANPRM highlights four primary functions (or Core ADS Safety Functions) that are the current focus of the Agency's attention. These functions are: **Sensing, Perception, Planning;** and **Control**. BMW notes the terms "Primary Function" and "Core ADS Safety Functions" do not necessarily have the same meaning in the context of ADS functionality. **Sensing** (including perception), **planning** and **acting** are design paradigms commonly seen in robotics and other areas of automation. However, BMW does not necessarily view these "design paradigms" as primary or core safety functions. Rather these paradigms are a function of an ADS performing nominally and are not exclusive to safe system operation.

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[2] https://www.bmwusa.com/content/dam/bmwusa/innovation-campaign/autonomous/BMW-Safety-Assessment-Report.pdf

[3] ISO/TR 4804 - https://www.iso.org/standard/80363.html

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BMW agrees that the four functions noted in the ANPRM have a role in ADS development. However, BMW encourages the Agency to consider the following elements and structure:

1. Perception of relevant static and dynamic objects
2. Prediction of the future behaviour of relevant objects
3. Determination of location
4. Creation of a collision-free and lawful driving plan
5. Correct execution and actuation of the driving plan
6. Communication and interaction with other road users

ISO/TR 4804[4] "Road vehicles – Safety and cybersecurity for automated driving systems" released at the end of 2020 is focused on developing and validating safe automated driving for SAE Level 3 / 4 ADS systems, however, does not exclude Level 5 system. The standard takes into consideration vehicles having both manual and automated driving modes.

ISO/TR 4804 is based on the whitepaper "Safety First for Automated Driving"[5] which BMW was one of the founding authors. The technical report is meant to be a living document that will need to evolve as ADS technology evolves. As such, activities are underway for the next iteration to result in upcoming ISO/TS 5083 containing normative requirements for design and validation and verification.

ISO/TR 4804 is designed to supplement existing publications and standards[6] on various aspects related to the safety and cybersecurity of automated driving. This standard presents a technical overview of the specifications required for the development of systems to avoid safety-related hazards and it also emphasizes the importance of safety by design. Furthermore, this standard aims to provide a sound discussion of the verification and validation of such systems. Two key aspects in ISO/TR 4804 are Positive risk balance and avoidance of unreasonable risk. Positive risk balance is discussed in more detail in the section titled "Positive Risk Balance" later is this document.

[4] ISO/TR 4804 - https://www.iso.org/standard/80363.html
[5] https://www.press.bmwgroup.com/global/article/attachment/T0298103EN/434404
[6] ISO 26262, ISO/PAS 21448, and ISO/SAE 21434

Other Safety Functions:

The ANPRM also describes eight other functions that could impact the ability of an ADS to carry out its intended plans in a safe and reliable manner including:

1. Identifying reduced system performance and/or ODD in the presence of failure;
2. Operating in a degraded mode within reduced system constraints;
3. Performing the essential task of transporting occupants or goods from starting point to the chosen destination;
4. Recognizing and reacting appropriately to communications from first responders, including fire, EMS, and law enforcement;
5. Receiving, loading, and following over-the-air software updates;
6. Performing system maintenance and calibration;
7. Addressing safety related cybersecurity risks; and
8. System redundancies.

BMW believes these eight additional functions described in the ANPRM can be mapped and structured with some of the twelve principles noted in ISO/TR 4804. The twelve principles are identified below and can be categorized into three groupings.

The first group of principles, **"automated vehicle and related aspects"**, includes the following elements:

1. Cybersecurity (PSC_01)
2. Data recording (PSC_02)
3. Passive safety (PSC_03)
4. Safety assessment (PSC_04)

These principles address overarching aspects on the vehicle level including the automated driving system and human factors. These aspects are essential to achieving overall safety and cybersecurity. This covers technical features as well as process related aspects.

The second group of principles, **"automated driving system"** includes the following elements:

5. Safe operation (PSC_05)
6. Safety layer (PSC_06)
7. Behaviour in traffic (PSC_07)
8. Operational design domain handling (PSC_08)

These principles focus on the main technical aspects of the system. These principles constitute functionality related to safety and cybersecurity of the automated driving system itself.

The third group of principles, **"human factors"** includes the following elements:

9. Role of user (PSC_09)
10. Driver initiated takeover (PSC_10)
11. Vehicle initiated takeover request (PSC_11)
12. Interdependency between driver and automated driving system (PSC_12)

These principles address all safety and secure interaction aspects of the ADS and the user. This includes the role of user, clear distinction between the role of the user and the ADS, as well as takeover scenarios in both directions.

	Automated vehicle and related				Automated driving system				Human factors			
	PSC_01	PSC_02	PSC_03	PSC_04	PSC_05	PSC_06	PSC_07	PSC_08	PSC_09	PSC_10	PSC_11	PSC_12
(1) identifying reduced system performance and/or ODD in the presence of failure					x	x		x				
(2) operating in a degraded mode within reduced system constraints					x							
(3) performing the essential task of transporting occupants or goods from starting point to the chosen destination					x		x	x				
(4) recognizing and reacting appropriately to communications from first responders, including fire, EMS, and law enforcement							x	x				
(5) receiving, loading, and following over-the-air software updates	Not explicitly mentioned as a guidline but mentioned as a neceassary boundary											
(6) performing system maintenance and calibration					x	x		x				
(7) addressing safety related cybersecurity risks	x											
(8) system redundancies					x							

The ANPRM appropriately acknowledges that "Communication" is an important safety aspect that is not encompassed in the four "Core ADS Safety Functions". BMW agrees with the Agency's assessment that the vehicle's ability to communicate with vehicle occupants, other vehicles and other road users are important considerations. HMI (Human Machine Interaction) design is important to the operational safety of ADS equipped vehicles and public acceptance. BMW also notes that communication with other road users must be developed with caution. It should not motivate other road users to abuse their interaction with ADS or to have too much trust in the abilities of ADS vehicles.

Federal Engineering Measure Development Efforts

This section of the ANPRM describes four focus areas of ADS research:

1. Identifying methods, metrics, and tools to assess how well the ADS-equipped vehicle performs both normal driving tasks as well as crash avoidance capabilities, including:
   a. system performance and behavior relative to the system's stated ODD and object and event detection and response (OEDR) capabilities
   b. fail-safe capabilities if/when it is confronted with conditions outside its ODD.

2. Functional safety and ADS subsystem performance.

3. Cybersecurity of vehicles and systems, including ADS.

4. Human factors issues that may accompany vehicles equipped with ADS.

The Safety Act defines a motor vehicle safety standard as the minimum standard for motor vehicle or motor vehicle equipment performance. Each FMVSS regulates one or more identified aspects of vehicle or equipment performance and specifies a minimum performance criteria for each. The criteria define a clear separation of compliant versus noncompliant products."

For ADS, defining a clear threshold may not be possible. For example, even if an ADS can pass 100 pre-defined performance tests, the 101st test could result in a failure. New methods of evaluation, such as Positive Risk Balance are necessary.

Positive Risk Balance

Deployment of ADS has the potential to significantly improve road traffic safety. Relatively limited testing in the public domain poses a challenge in providing an evidentiary basis to confirm that ADS technologies can be deployed in a safe manner. New methods are necessary to measure the safety of ADS.

In various reports[7] of Commissions, standards, and regulatory authorities the need for a positive risk balance has been emphasized. These reports propose the approval of ADS is justifiable only if it achieves a "positive risk balance" as compared to human driving performance. A comparative review of different methods from various publications revealed that existing drug licensing procedures show a sufficient level of similarity when considering the safety of an ADS.

"PrOACT-URL"[8] (Problem, Outcomes, Alternatives, Consequence and Tradeoffs Uncertainty Risk and Linked decisions) has been identified as a methodology of interest. PrOACT-URL, a framework for assessing problems with multiple criteria, was developed as part of the European Medicines Agency (EMA) Benefit-Risk project. This framework is consistent with existing European legislation for drug certification and is accepted as a guide for the process of evaluating the benefit-risk balance (or positive risk balance) in the development of new medicinal products. BMW believes this method can be a suitable basis to validate automated driving systems.

Designing an ADS to be safe is a balancing act of risk and availability of the application. Being too risk adverse leads to a system that is overly conservative, and the system availability becomes too low, which in turn will not provide the benefits of a safer and more comfortable customer experience. On the contrary, if the system safety design is too liberal, it will have the effect of a system that is not safe enough but may be highly available.

ISO/TR 4804 describes metrics, the **leading measure** and the **lagging measure** in sections 3.28 and 3.27 respectively that relate to positive risk balance. The leading

[7] Report of the German Ethic commission on automated driving {Fabio et al. 2017}, Report of the European Commission on "Ethics of Connected and Automated Vehicles" [Bonnefon et al. 2020; UNECE 20209], UN ECE ALKS Regulations [UNECE 2020], and ISO/TR 4804
[8] https://www.benefit-risk-assessment.com/proact-url/

measure describes metrics that are derived from data that is assessed prior to deployment of an automated driving system indicating that the ADS conforms with safety-by-design techniques to achieve a positive risk balance and avoidance of unreasonable risk. The lagging measure describes metrics that are assessed after deployment of an ADS and provide confirmation that the positive risk balance as well as the conformance with the safety-by-design techniques have been achieved.

Other Notable Efforts Under Consideration as Engineering Measures

BMW appreciates the Agency's recognition of the efforts involved in the publication of the white paper "Safety First for Automated Driving" which was the basis for ISO/TR 4804. BMW was one of the 11 companies that contributed to the publication of the document.

In this section the Agency notes that the twelve principles used to guide safety efforts are "expressed to be relevant to ADS, and most of them, except those relating to handover to a human operator, are indicated to be relevant to SAE Level 4 and above." Handover aspects are also relevant for SAE Level 4 ADS equipped vehicles which can also be manually driven by a human driver (dual-use vehicles). BMW believes that consumers will continue to value the option to manually drive vehicles well into the future. Dual use vehicles may compose a significant part of the market share of Level 4 ADS equipped vehicles and should be considered in the development of an AV framework for ADS safety.

Process Measures—Safety Risk Minimization in the Design, Development, and Refinement of ADS

In this section of the ANPRM three standards: ISO 26262 (Functional Safety), ISO/PAS 21448 (Road vehicles — Safety of the Intended Functionality), and UL 4600 (Safety for the Evaluation of Autonomous Products) are discussed in detail regarding safety risk minimization. BMW references ISO 26262 and ISO/PAS 21448 in its VSSA as standards that are useful in development of ADS.

UL 4600 is similar in scope to ISO/PAS 21448 that provides guidance on the design, verification, and validation measures that developers can apply to achieve the SOTIF (Safety of the Intended Functionality) in their automated mobility products. However, UL4600 is primarily focused on Level 4/Level 5 ADS without any traditional manual controls (dedicated ADS). The scope of the standard does not account for dual-use vehicles and the resultant human factors consideration of ADS. Also, Level 3 and higher levels of ADS may encounter unknown hazards within its specific ODD. ISO/PAS 21448 describes a methodology to minimize the unknown hazardous events and lists all necessary processes and work products. BMW is concerned that UL4600 provided checklists may not adequately address all unknown hazards.

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Voluntary Mechanisms

Safety Self-Assessment and Other Disclosure/Reporting

BMW agrees with the agency that FMVSS is premature as ADS technology is still in in the development and testing phases and to date there has been no significant deployment of ADS equipped vehicles in the US.

ADS technology is at a critical phase in development. As the industry looks forward to deployment of ADS equipped vehicles, safe and successful deployment of this technology is predicated on building public trust. The VSSA guidance published in Federal Automated Vehicle Policy (FAVP) 2.0 is both a reasonable and an appropriate approach. FAVP 2.0[9] highlights twelve priority safety design elements as guidance to the industry that would serve both to educate and build confidence in ADS technology with the public, safety advocates, government officials and other stakeholders. As of early March 2021, more than 25 ADS developers have published VSSAs. These publications have allowed ADS developers to describe in detail how they are exercising due diligence in the design and development of ADS systems.

BMW appreciates the Agency publishing a VSSA template[10] for the Crashworthiness safety element. In future iterations, BMW recommends the Agency consider refining its guidance by providing a recommended structure and recommended level of detail. This would allow interested stake holders to read and evaluate published VSSA by ADS developers with more consistency.

The ANPRM also seeks comment regarding voluntary reporting by ADS developers of some or all of its safety case. A safety use case describes a use case/item with potential safety risks and derives measures considering controllability, severity and exposure and includes test cases to verify the derived requirements and measures. Disclosing some identified hazardous events as defined in ISO 26262 could considered as a means of transparency. However, a disclosure of potentially hazardous scenarios does not guarantee a complete description of all safety as described in ISO/PAS 21448.

BMW generally agrees with NHTSA's assessment that information provided in voluntary reporting can:

1. Assist the Agency's flexibility to take proactive measures such as revising guidance more rapidly than through a protracted rulemaking process. This will also assist with facilitating the development of innovative technologies to their full safety potential.
2. Help the Agency avoid taking action that hampers safety innovation or otherwise adversely affect safety; and
3. Support the Agency's existing programs by helping the Agency become more responsive to new technologies.

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[9] https://www.nhtsa.gov/sites/nhtsa.dot.gov/files/documents/13069a-ads2.0_090617_v9a_tag.pdf
[10] https://www.nhtsa.gov/sites/nhtsa.dot.gov/files/documents/voluntary_safety_self-assessment_for_web_101117_v1.pdf

Voluntary reporting to the Agency and the public may also encourage competing ADS developers to place greater emphasis on safety and improve transparency. The twelve principles provided by NHTSA in FAVP 2.0 provided the industry key focus areas for the publication of a VSSA. BMW's VSSA published in early 2020 provide a detailed overview of how BMW ensures safety for all road users based on the recommended twelve principles. The document intended to strike a balance that provided technical details as well as being easy enough to read and comprehend by the public.

In addition to voluntary reporting, NHTSA has broad regulatory enforcement authority to conduct defect investigations and influence safety recalls for defects or for noncompliant vehicles or equipment that poses an unreasonable risk to motor vehicle safety. In fact, most recalls are issued for safety related defects and not for non-compliance to FMVSS.

New Car Assessment Program (NCAP)

A portion of this section describes in general terms that the information provided via a NCAP program empowers consumers to compare the relative safety of new vehicles as they are considering new vehicles purchases. The ANPRM also notes that the information provided via the NCAP program has encouraged automakers to compete based on improved safety – encouraging safety advancements and swift adoption of performance improvements that improve the safety of motor vehicles.

As related to ADS technology, the Agency notes that a "FMVSS obstacle-course performance test, would likely be inadequate to evaluate ADS competence, however such a test might form a useful foundation for consumer information under the NCAP program. A test of ADS-equipped vehicles could be expected to avoid collisions (including avoid causing collisions), while adhering to a driving model that minimizes the risks of getting into crash-imminent situations and observing operational limitations.

BMW notes the Agency generally examines four prerequisites when considering including technologies for rating in NCAP:

1. The technology addresses a safety need;
2. System designs exist that can mitigate the safety problem;
3. The technology provides the potential for safety benefits; and
4. A performance-based objective test procedure exists that can assess system performance.

Some of these prerequisites are not met as more research is necessary before considering ADS performance tests in NCAP or another similar consumer information program.

Regarding NCAP crash avoidance, testing of critical driving situations are targeted towards situations that could end in a crash. The test scenarios are developed based on drivers' behaviors and represent situations such as lane departure or forward collisions. Now with an ADS performing the driving tasks, performance tests would only be a valid tool for the evaluation of edge cases or system boundaries and not nominal driving. With this in mind, creation of an NCAP rating based in part on an ADS performance test, performance ratings of ADS would not be easily comparable or understood by consumers.

Furthermore, as ADS will be optional equipment for many OEM vehicles for the foreseeable future, in part due to the necessity of more sophisticated sensor technology (and the need for redundancy), an ADS performance test should be considered at this point for continued research purposes. Currently, BMW views incorporation of an ADS performance test in NCAP as premature.

Operational Data

The ANPRM also notes, operational data relating to crash avoidance performance, as well as "nominal" driving behaviors (e.g., lane-keeping ability), could be collected during "on-road driving" and could be used to contribute to an overall safety performance assessment method. BMW encourages the Agency to consider that data of nominal driving performance is not a measure to prove safety, as safety critical situations may not be encountered during the data collection. The exposure of critical situations (e.g. per operating hour / per mileage) within the field of functional application (fofa) could be considered as a valid measure.

Regulatory Mechanisms

NHTSA typically begins the process of creating a FMVSS by identifying the aspect of performance that may need regulation. NHTSA analyses real-world crash data and other available information to identify safety issues and to quantify the size of the safety problem. The Agency researches potential countermeasures that have been identified, and then develops practicable performance requirements intended to either resolve or mitigate the crash or injury risk. As there has been no large-scale deployment of ADS equipped vehicles there cannot be any analysis of real-world crash data. This reinforces the point that new FMVSS are premature.

Applying the Established FMVSS Framework to ADS Safety Principles

In this section the ANPRM contemplates that in the future authorities may establish new rules of the road to address ADS-equipped vehicles specifically. The Agency could require that ADS be designed such that they must follow all applicable traffic laws in the areas of operation, thereby supporting state and local efforts to ensure their traffic laws are observed.

BMW recommends the Agency consider the consequences, of unique but not necessarily infrequent cases where the ADS may need to be non-compliant to a traffic rule. For example, if a vehicle is blocked by a double-parked car and is not able to pass the car because it would require crossing a solid or double line. As a practical matter, the ADS should follow traffic rules, however scenarios where crossing a solid line may be necessary to continue traffic flow or to avoid a possible collision by other road users performing unsafe traffic maneuvers might be a necessary exemption to the rule.

FMVSS Requiring Obstacle Course-Based Validation in Variable Scenarios and Conditions

The ANPRM notes that performance-based safety standards could require manufacturers to use test methods, such as sophisticated obstacle-course-based test regimes, sufficient to validate that their ADS-equipped vehicles can reliably handle the normal range of everyday driving scenarios as well as unusual and unpredictable scenarios. The ANPRM further notes that standards could be designed to account for factors such as variations in weather, traffic, and roadway conditions within a given system's ODD, as well as sudden and unpredictable actions by other road users.

BMW believes that creation of an obstacle course-based test is not a reasonable way to evaluate the safety of ADS equipped vehicles. These vehicles may use non-deterministic control algorithms which could have implications on test criteria. Special situations in real world traffic will be difficult to replicate in an obstacle course like environment. A more appropriate consideration would be a defined set of acceptable test outcomes versus limiting performance criteria to only one acceptable outcome.

An obstacle course-based test may be applicable for safety edge cases and/or a subset of randomly selected scenarios from an ODD "catalogue". A more comprehensive verification of safety is accomplished through combining simulation, test track tests, and real traffic scenarios.

FMVSS Requiring Vehicles to Be Programmed to Drive Defensively in a Risk-Minimizing Manner in Any Scenario Within Their ODD

In this section the ANPRM contemplates an FMVSS that might require that the planning and control functions of an ADS be programmed to adhere to a defensive driving model so as to minimize the likelihood of getting into a crash similar to the driving policies and metrics described in Mobileye's RSS, NVIDIA's Safety Force Field, and NHTSA's MPrISM. The ADS equipped vehicle may also be restricted to automated operation within its ODD.

Successful creation of a practical FMVSS using this approach would depend on the defensive driving model, and the efficacy of implementation of the model.

Appropriate definition of the defensive driving model is critical. For example, using a RSS model with a non-dynamic parameter set in mixed traffic scenarios will end up in a safe state, however the vehicle would no longer perform the driving task. A compromise of defensive driving and functionality needs to be sought. Otherwise, the new technology may not be accepted by customers, will impede traffic flow and the potential safety benefit may be minimized.

Timing and Phasing of FMVSS Development and Implementation

BMW agrees with the Agency's approach in this section. Issuing new FMVSS for ADS performance remains premature as ADS technology still lacks maturity and widespread deployment of ADS equipped vehicles is likely years away. It is in the interest of the industry and the public that the Agency carefully and strategically decided which aspects of ADS safety performance may require the most attention. This approach affords the Agency the time to perform the necessary research and validation to ensure that any new FMVSS regulates appropriate areas of performance while not unnecessarily hindering developers' ability to develop and introduce further safety improvements and capabilities.

BMW appreciates the Agency's consideration of the foregoing comments. BMW encourages the Agency to continue pursuing non-regulatory but meaningful mechanisms of oversight in the near term as described in previous comments in this document. Promulgation of new FMVSS should be considered once a safety need is identified and ADS technology has reached a significant level of maturation of deployment. BMW also encourages the Agency to include SAE Level 3 ADS systems in any decisions and consideration in an AV framework.

Should you have any questions on any of the above comments, please do not hesitate to contact Derek Rinehardt of my staff at (202) 393-6799.

Sincerely,

Adam McNeill Digitally signed by Adam McNeill Date: 2021.03.30 09:18:46 -04'00'

Adam McNeill
Vice President of Engineering
US BMW of North America, LLC