BMW GROUP

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Room W12-140, Washington
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Subject: Advanced Driver Assistance Systems Draft Research Test Procedures
Docket No. NHTSA-2019-0102

On behalf of The BMW Group, BMW of North America, LLC (BMW) appreciates the opportunity to provide comments in response to NHTSA's Request for Comments regarding the Advanced Driver Assistance Systems Draft Research Test Procedures.

As a general comment BMW would like to strongly recommend the agency consider international harmonization of Advanced Driver Assistance System (ADAS) testing. ADAS test procedures have been developed in working groups and collaborative approaches together with manufacturers, suppliers, NCAP programs and authorities in Europe and other countries. Alignment with existing test procedures would reduce manufacturers burdens in developing and testing advanced safety technologies and will enable a quicker introduction into the US-market.

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1. Traffic Jam Assist System Confirmation Test

1.1 Can the test procedures be expected to assess adequately for the purposes of research, within practical limitations, the performance of the underlying ADAS technologies? If not, please provide specific reasons why, and suggestions for how they may be improved.

Although a vehicle equipped with a Level 3 system should be able to navigate through a test configuration of a stopping vehicle, lead vehicle lane change stopping (LVLCB), and sudden revealed stopped vehicle (SRSV) collision free, there are some limitations. As an example, within the test procedure development consideration should be given to scenarios where the system may change lanes to avoid a collision in a critical situation instead of merely applying the brakes. This should also be acceptable criteria for dealing with the situation.

More importantly a Level 3 system should not be tested on a proving ground without special involvement of the manufacturer. Many systems are in place to ensure the safety of the customer. To name a few, the BMW system will ensure that the stretch is both mapped with HD quality as well as approved by the backend. Even if that is the case, the on-board sensors also check that the surroundings match the map including features such as guard rails and an absence of intersections.

1.2 Do any of the draft research test procedures contain elements that may potentially confound the system operation and/or test results (e.g., regarding test conduct)? If so, please indicate what those elements are and how they might be addressed and/or mitigated?

Traffic Jam Assist features describe a system developed to high safety standards while also delivering increased comfort to the driver. If the system is not available due to a situation, it does not decrease the safety. For example, the stopping car, 'lead vehicle lane change with braking' (LVLCB) and 'suddenly revealed stopped vehicle' (SRSV) demonstrate a wide range of situations ranging from comfort to safety critical. One of the key characteristics of a Level 2 system (as opposed to a Level 3 system) is that there are system limits and situations that the system cannot handle as the driver completes the Object and Event Detection and Response (OEDR) subtask (as defined by SAE J3016). For that reason, it would be incorrect to evaluate the systems under pass-fail criteria for all of the situations. Active safety systems, such as Traffic Jam Assist, utilise additional functions (e.g. lane keeping assist) to support certain situations, the test protocol needs to account for the use of combined systems.

In addition, systems may even offer reduced comfort if the driver is classified as inattentive which may reduce the chance that the vehicle resumes after being stationary. It is then necessary to include that the driver's face and eyes are clearly visible in the list of General Test Requirements (5.3.1). This is sometimes necessary to safely offer the full comfort features of this system which are also evaluated in this procedure.

1.3 Are the draft research test procedures clearly written, understandable, and executable? If not, please provide specific areas for which clarification is necessary, and suggestions for how they may be improved.

While it is appreciated that the lane markings are well defined, it is also important that the test area be free of additional markings which may confuse the system.

1.4 Are the ranges of test speeds, speed combinations, and/or speed increments specified within each draft research test procedure reasonable? If not, please provide any data or evidence to support any claim of unreasonableness from a research perspective.

In section 3.0 the speed of the function is limited to 40km/h, but the test speed in 5.3.5.2 is already 48km/h. For this reason, it is recommended to indicate that speeds of at least 40km/h can be attained by the system.
It also doesn't seem to be addressed if the subject vehicle (SV) is set to the same speed as the lead vehicle, it will not gain and therefore will never be actively in closed loop control. The footnote under Table 4 seems to try to address this, but it would be simpler if the secondary other vehicle (SOV) speed was nominally lower than the SV Speed. Also, the principal other vehicle (POV) speed was omitted from the test procedures in 5.3.5.1.

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1.5 To reduce test burden for the assessment of some technologies for research purposes, the number of repeated trials per test condition is proposed to be less than or equal to seven based on our experience from past test procedure design work. Is this adequate, or should another number of repeated trials be performed for all technology/condition combinations to support an assessment of whether differences in the test results, for a given condition, are statistically significant?

No comment.

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2. Pedestrian Automatic Emergency Brake System Confirmation Test

2.1 Can the test procedures be expected to assess adequately for the purposes of research, within practical limitations, the performance of the underlying ADAS technologies? If not, please provide specific reasons why, and suggestions for how they may be improved.

In section 6.1 the test equipment position and nominal weight is defined. BMW recommends defining only the maximum load or maximum axle load (like in Euro NCAP). This allows roadsters or other non-five-seaters to be tested adequately to the same protocol.

In section 9.1.3 S1f the S1f misuse scenario the pedestrian leads to standstill at TTC=1.08s and at 0.5m from the SV. BMW considers this as a critical situation where a warning is justified. BMW suggests doubling these values as a typical driver's reaction brake time would still be higher and therefor a warning is still comprehensible for the driver.

In section 9.1.3 S1g the described S1g misuse scenario incorporates a pedestrian that leaves the SV path 0.36s before the SV reaches the pedestrian path. Like in S1f BMW considers this also as a critical situation where warning is justified. In addition, as long as the pedestrian is in the vehicle's drive path a warning and braking has to be triggered due to the high agility of a pedestrian. To not initiate a warning sequence and an emergency braking maneuver at all, BMW suggests significantly higher time-to-collision (TTC), as a warning and a corresponding braking maneuver would already be applied while the pedestrian is still crossing the vehicle's driving path.

BMW supports the introduction of near miss / false positive tests. However, it is important to consider the OEM's desired system reaction depending on the situation.

BMW emphasizes the use of an articulated dummy (section 4.3.2) instead of a non-articulated dummy. An articulated dummy corresponds more to the behavior of a real pedestrian. For that reason, the articulated dummy was introduced by all NCAPs with Pedestrian Automatic Emergency Brake (PAEB) requirements in the past.

2.2 Do any of the draft research test procedures contain elements that may potentially confound the system operation and/or test results (e.g., regarding test conduct)? If so, please indicate what those elements are and how they might be addressed and/or mitigated?

No comment.

2.3 Are the draft research test procedures clearly written, understandable, and executable? If not, please provide specific areas for which clarification is necessary, and suggestions for how they may be improved.

No comment.

2.4 Are the ranges of test speeds, speed combinations, and/or speed increments specified within each draft research test procedure reasonable? If not, please provide any data or evidence to support any claim of unreasonableness from a research perspective.

BMW supports the proposal of several test trials. For an assessment BMW recommends establishing a sliding scale evaluation considering impact speed mitigation (like Euro NCAP or IIHS) rather than a simple pass-/fail-criteria.

2.5 To reduce test burden for the assessment of some technologies for research purposes, the number of repeated trials per test condition is proposed to be less than or equal to seven based on our experience from past test procedure design work. Is this adequate, or should another number of repeated trials be performed for all technology/condition combinations to support an assessment of whether differences in the test results, for a given condition, are statistically significant?

The described procedure to ensure the initial brake temperature in section 8.2 is expected to generate a high measurement effort. BMW is of the opinion that a standard pre brake procedure at the onset of each test without brake temperature check like in Euro NCAP is sufficient.

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3. Intersection Safety Assist System Confirmation Test

BMW is of the opinion that due to the complexity of the described intersection scenarios reproducibility and repeatability will be a challenging task, especially for scenarios S2-C and S3-B0. BMW recommends performing all described scenarios with appropriate pedal- and steering robots only.

3.1 Can the test procedures be expected to assess adequately for the purposes of research, within practical limitations, the performance of the underlying ADAS technologies? If not, please provide specific reasons why, and suggestions for how they may be improved.

In point 5 under section 5.3.1 the operation of the SV in automation Level 2 and 3 is described. BMW wants to point out that depending on the design of the Level 3 system the Operational Design Domain (ODD) could prevent the usage of Level 3 functions within the described test setup.

3.2 Do any of the draft research test procedures contain elements that may potentially confound the system operation and/or test results (e.g., regarding test conduct)? If so, please indicate what those elements are and how they might be addressed and/or mitigated?

Throughout the document there is a mix of units of measure for velocity (i.e. Mix km/h and mph).

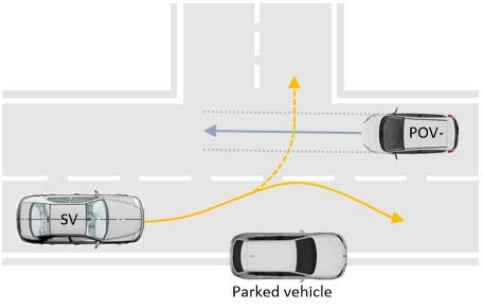
In section 5.3.5 a near-miss scenario is described with an SV and POV speed of 25mph. At this speed the SV enters the POV path only 0.09s after the POV has passed 2 meters. BMW considers this as a critical situation where a warning and brake intervention is acceptable. As mentioned in the comments to the Pedestrian Automatic Emergency Brake System Confirmation Test, BMW recommends considering the driver's brake reaction time.

In section 5.3.5.1 C the use of GVT revision F as POV is suggested. BMW recommends using the GVT revision G. The GVT revision G was validated especially for oncoming and intersection scenarios (turning and crossing) at several workshops by CLEPA and ACEA in 2019.

In BMW's opinion the short-term change from straight driving to a constant radius described in section 5.3.7.1 does not correspond to a realistic driver manoeuvre. Furthermore, the described turning manoeuvre is not feasible by an autonomous platform. BMW recommends that more realistic turning trajectories should be used as e.g. for Euro NCAP Car-to-Car Front Turn-Across-Path (CCFtap) and Car-to-Pedestrian Turning Adult (CPTA).Moreover, turning at a speed of 25mph and a radius of 8.59m the lateral acceleration of 5,2m/s² will most probably be too high for the GVT. Likely the GVT will not adhere on the autonomous platform while the turning.

Section 5.3.8 describes the test of an AV performing a left turn across the POV's path. BMW suggests activating the turning signal before turning. The turning signal

is a significant indicator for the drivers turning intention and helps to distinguish a turning intention from an in-lane steering.



3.3 Are the draft research test procedures clearly written, understandable, and executable? If not, please provide specific areas for which clarification is necessary, and suggestions for how they may be improved.

No comment.

3.4 Are the ranges of test speeds, speed combinations, and/or speed increments specified within each draft research test procedure reasonable? If not, please provide any data or evidence to support any claim of unreasonableness from a research perspective.

No comment.

3.5 To reduce test burden for the assessment of some technologies for research purposes, the number of repeated trials per test condition is proposed to be less than or equal to seven based on our experience from past test procedure design work. Is this adequate, or should another number of repeated trials be performed for all technology/condition combinations to support an assessment of whether differences in the test results, for a given condition, are statistically significant?

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4. Blind Spot Detection System Confirmation Test

4.1 Can the test procedures be expected to assess adequately for the purposes of research, within practical limitations, the performance of the underlying ADAS technologies? If not, please provide specific reasons why, and suggestions for how they may be improved.

Blind spot detection systems are often adjustable in order to set the time of a blind spot warning. The test procedure does not specify, in which setting the tests will be conducted. BMW suggests using a requirement comparable to NHTSA's Lane Departure Warning (LDW) test for NCAP ("If the Lane Departure Warning system provides a warning-time adjustment for the driver, at least one setting must meet the criterion of the test procedure.")

4.2 Do any of the draft research test procedures contain elements that may potentially confound the system operation and/or test results (e.g., regarding test conduct)? If so, please indicate what those elements are and how they might be addressed and/or mitigated?

The test procedure describes when the blind spot detection system issues a warning at the latest. As earlier warnings can provide more safety BMW suggests that the procedure should explicitly allow earlier warnings.

4.3 Are the draft research test procedures clearly written, understandable, and executable? If not, please provide specific areas for which clarification is necessary, and suggestions for how they may be improved.

Subchapter 4.1 is different to the same section in the Blind Spot Intervention System confirmation test. BMW recommends that the road test surface conditions should be the same in both test procedures.

4.4 Are the ranges of test speeds, speed combinations, and/or speed increments specified within each draft research test procedure reasonable? If not, please provide any data or evidence to support any claim of unreasonableness from a research perspective.

No comment.

4.5 To reduce test burden for the assessment of some technologies for research purposes, the number of repeated trials per test condition is proposed to be less than or equal to seven based on our experience from past test procedure design work. Is this adequate, or should another number of repeated trials be performed for all technology/condition combinations to support an assessment of whether differences in the test results, for a given condition, are statistically significant?

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5. Blind Spot Intervention System Confirmation Test

5.1 Can the test procedures be expected to assess adequately for the purposes of research, within practical limitations, the performance of the underlying ADAS technologies? If not, please provide specific reasons why, and suggestions for how they may be improved.

The test procedure describes the operation of the SV in automation Level 2 and 3. BMW wants to point out that depending on the design of the Level 3 system the ODD could prevent the usage of Level 3 functions within the described test setup.

5.2 Do any of the draft research test procedures contain elements that may potentially confound the system operation and/or test results (e.g., regarding test conduct)? If so, please indicate what those elements are and how they might be addressed and/or mitigated?

There is a conversion error in chapter 5.3.7.3: 0.8ft is not equivalent to 0.5m

5.3 Are the draft research test procedures clearly written, understandable, and executable? If not, please provide specific areas for which clarification is necessary, and suggestions for how they may be improved.

No comment.

5.4 Are the ranges of test speeds, speed combinations, and/or speed increments specified within each draft research test procedure reasonable? If not, please provide any data or evidence to support any claim of unreasonableness from a research perspective.

No comment.

5.5 To reduce test burden for the assessment of some technologies for research purposes, the number of repeated trials per test condition is proposed to be less than or equal to seven based on our experience from past test procedure design work. Is this adequate, or should another number of repeated trials be performed for all technology/condition combinations to support an assessment of whether differences in the test results, for a given condition, are statistically significant?

No comment.

6. Opposing Traffic Safety Assist System Confirmation Test

From BMW's perspective, this test procedure describes an extraordinarily complex driver assistance scenario for state-of-the-art sensor configurations due to the restriction of the detection range by the lead vehicle in front and given speeds. Therefore BMW would like to give additional comments after further investigation, which might exceed the actual commenting period.

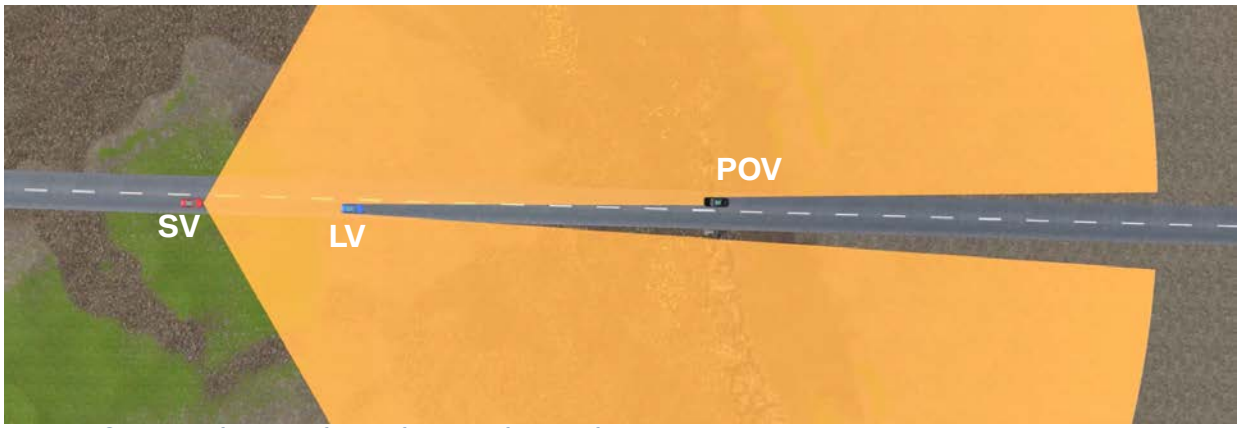

Figure 1: Simulation for Field of view of a state-of-the-art fusion sensor system (camera/radar)

6.1 Can the test procedures be expected to assess adequately for the purposes of research, within practical limitations, the performance of the underlying ADAS technologies? If not, please provide specific reasons why, and suggestions for how they may be improved.

The required lateral speeds are rather high (0.5m/s without indicator, 0.7m/s with indicator, each with tolerance of 0.1m/s). To BMW's experience a typical unintentional lane departure corresponds to a lateral speed of 0.3m/s or less, an intended lane change typically occurs at a lateral speed of 0.5m/s.

BMW wants to point out that depending on the design of the Level 3 system the ODD could prevent the usage of Level 3 functions within the described test setup. Moreover, as mentioned before, Level 3 systems cannot be tested on a proving ground without special involvement of the manufacturer.

6.2 Do any of the draft research test procedures contain elements that may potentially confound the system operation and/or test results (e.g., regarding test conduct)? If so, please indicate what those elements are and how they might be addressed and/or mitigated?

As BMW would consider such a System as part of a Lane Keeping Support System (LKSS), it is recommended to not switch off the LKS system during the described test procedures. .

In various sections the SV's lateral position from the POV has to be less than 1.5ft (0.46m) for a valid result. BMW recommends harmonizing this value with Euro NCAP LKS procedures where this distance is 0.3m.

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6.3 Are the draft research test procedures clearly written, understandable, and executable? If not, please provide specific areas for which clarification is necessary, and suggestions for how they may be improved.

Sections 4.7.1.5 and 4.7.1.7 are identical.

The given lane width defined in section 4.3 is between 3.7m and 4.3m. In combination with a possible maximum vehicle-to-lane marking distance (D2) of 1.88 m defined in tables 2 and 3 in section 5.3.6.2 and an estimated vehicle width of 2m or more, the vehicle may protrude beyond the lane marking in a 3.7m-wide lane.

6.4 Are the ranges of test speeds, speed combinations, and/or speed increments specified within each draft research test procedure reasonable? If not, please provide any data or evidence to support any claim of unreasonableness from a research perspective.

No comment.

6.5 To reduce test burden for the assessment of some technologies for research purposes, the number of repeated trials per test condition is proposed to be less than or equal to seven based on our experience from past test procedure design work. Is this adequate, or should another number of repeated trials be performed for all technology/condition combinations to support an assessment of whether differences in the test results, for a given condition, are statistically significant?

No comment.

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7. Active Park Assist System Confirmation Test

7.1 Can the test procedures be expected to assess adequately for the purposes of research, within practical limitations, the performance of the underlying ADAS technologies? If not, please provide specific reasons why, and suggestions for how they may be improved.

BMW is of the opinion that an Active Park Assist (APA) system should be designed as a cooperative assistance system which reacts sensitively to driver input. Therefore the system override assessment described in chapter 5.6. should be reviewed. BMW agrees with the defined system override criteria – except braking – but recommends not to define specific sequences along with fixed wording as it may not fit appropriately into the OEM's own holistic warning and information strategy.

BMW suggests not to assess a brake pedal override as described in chapter 5.6.3.1. As pointed out above automated parking is a cooperative task that shall respect the driver's wish to slow down the automatic parking procedure. BMW's experience is that, this comes naturally for the driver, as the driver is stays responsible to overview and control the parking procedure. An early termination as described in the procedure, through brake pedal override will force the driver to reinitiate the whole process or to finish parking manually. BMW believes this will result in less customer usage/acceptance of this feature.

Moreover, the override assessments do not consider critical situations where the driver needs to escape the scene for any reason. In this case a need to use the brake pedal first to be able to drive away is not recommended. BMW suggests that if the vehicle's gear is in D, it should be possible to accelerate immediately after the vehicle has been automatically brought to a standstill.

7.2 Do any of the draft research test procedures contain elements that may potentially confound the system operation and/or test results (e.g., regarding test conduct)? If so, please indicate what those elements are and how they might be addressed and/or mitigated?

In chapter 5.4.1. "the SV driver shall release the accelerator pedal and brake the SV to a complete stop within 5 seconds of receiving the parking space detection notification." Subsequently, the parking manoeuvre is initiated and the parking manoeuvre. should be executed within 45s (5.4.3.) while the time measurement starts in the moment the car starts to move backwards.

Considering the tolerances of the SV's speed (9.7 ± 1.6 km/h), the defined time range of 5s can result in a longitudinal travel path of up to 12m after detecting the parking space. The Active Park Assist System has to travel this distance backwards before starting the actual parking manoeuvre while the defined allowed overall time of 45s already counts down.

BMW recommends starting the time measurement after the SV travelled back to the actual start of the parking procedure itself. This can be defined as the moment of the first steering, to avoid high tolerances in the test.

Another suggestion is to change the time specification into a distance specification, for example "the SV driver shall release the accelerator pedal and brake the SV to a complete stop within 5 meters after receiving the parking space detection notification."

In 5.4.4. the APA's maneuvering area is limited. BMW is of the opinion that a limitation of the maneuvering area is not useful to assess an APA system, as the basic feature of an APA system is the ability to detect and avoid collisions with obstacles in the immediate vicinity of the vehicle. BMW agrees that the assessment of a final parking position considers specific borders of the parking spot, but as far as there are no obstacles the vehicle should be allowed to cross those borders more than the defined distance during the automatic parking process.

7.3 Are the draft research test procedures clearly written, understandable, and executable? If not, please provide specific areas for which clarification is necessary, and suggestions for how they may be improved.

No comment.

7.4 Are the ranges of test speeds, speed combinations, and/or speed increments specified within each draft research test procedure reasonable? If not, please provide any data or evidence to support any claim of unreasonableness from a research perspective.

No comment.

7.5 To reduce test burden for the assessment of some technologies for research purposes, the number of repeated trials per test condition is proposed to be less than or equal to seven based on our experience from past test procedure design work. Is this adequate, or should another number of repeated trials be performed for all technology/condition combinations to support an assessment of whether differences in the test results, for a given condition, are statistically significant?

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8. Rear Automatic Braking Feature Confirmation Test

8.1 Can the test procedures be expected to assess adequately for the purposes of research, within practical limitations, the performance of the underlying ADAS technologies? If not, please provide specific reasons why, and suggestions for how they may be improved.

No comment.

8.2 Do any of the draft research test procedures contain elements that may potentially confound the system operation and/or test results (e.g., regarding test conduct)? If so, please indicate what those elements are and how they might be addressed and/or mitigated?

No comment.

8.3 Are the draft research test procedures clearly written, understandable, and executable? If not, please provide specific areas for which clarification is necessary, and suggestions for how they may be improved.

No comment.

8.4 Are the ranges of test speeds, speed combinations, and/or speed increments specified within each draft research test procedure reasonable? If not, please provide any data or evidence to support any claim of unreasonableness from a research perspective.

BMW is of the opinion that the tested vehicles are not representative regarding rear coasting speeds.

BMW's experience is, that rearward rolling speed is highly dependent on the vehicles type of driveline (e.g. Engine Type, 4WD, Wheel Size, etc.). Rearward rolling speeds can reach a speed of up to 8mph/13kph over a distance of 20 feet. In a real-world parking maneuver, a driver would naturally regulate the speed by braking.

BMW recommends defining a specific test speed of 3 mph which corresponds to a convenient rearward parking maneuver speed.

8.5 To reduce test burden for the assessment of some technologies for research purposes, the number of repeated trials per test condition is proposed to be less than or equal to seven based on our experience from past test procedure design work. Is this adequate, or should another number of repeated trials be performed for all technology/condition combinations to support an assessment of whether differences in the test results, for a given condition, are statistically significant?

No comment.

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BMW appreciates the agency's consideration of the foregoing comments. 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
Vice President of Engineering
US BMW of North America, LLC