

ASEP Vehicle Test Results:

Automatic Transmission & Hybrid/Electrical Vehicles

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Preface

This testing and analysis was conducted in support of the ASEP IG request for test data on the performance behavior of Automatic Transmission and Hybrid Vehicles.

The vehicles selected are all examples of technologies that are currently on the market, or will be on the market by the 2010 timeframe. In particular, the hybrid/electrical vehicles selected for test represent next generation technologies that are extensions of the 1st generation of hybrid and electrical vehicles. The operating behavior of such vehicles do not follow basic operating assumptions of traditional internal combustion (IC) vehicles with a manual gearbox.

Overview

- Various analysis methods proposed all have technical assumptions based on MT IC technologies.
 - This is a good starting point, but not complete.
- Vehicles tested that have the potential for nonlinear noise emission vs. engine rotational speed.
- Four vehicles presented as representative of technologies in use and planned for future use.
 1. 2 Automatic transmission vehicles with torque converter behavior representative of current AT vehicles.
 2. Electrical vehicle representative of 3rd generation Hybrid where all-electric propulsion mode is possible over an entire operating range.
 3. Plug-In Hybrid vehicle representative of an electrical vehicle with option of recharge by on-board IC engine.

Issues

Assumption: Political demand that all vehicles are subject to ASEP testing -> Implies all vehicle must have a valid test mode.

1. What are dB per (rpm, vehicle velocity) behaviors of AT and Hybrid vehicles?
2. What are the mechanisms that cause different dB/(rpm, velocity) behavior?
3. What are the possible ways to deal with test results to properly evaluate different vehicle technologies?

Example #1: AT vehicle A

Vehicle Data

S = 5600; Idle = 500

PMR= 144

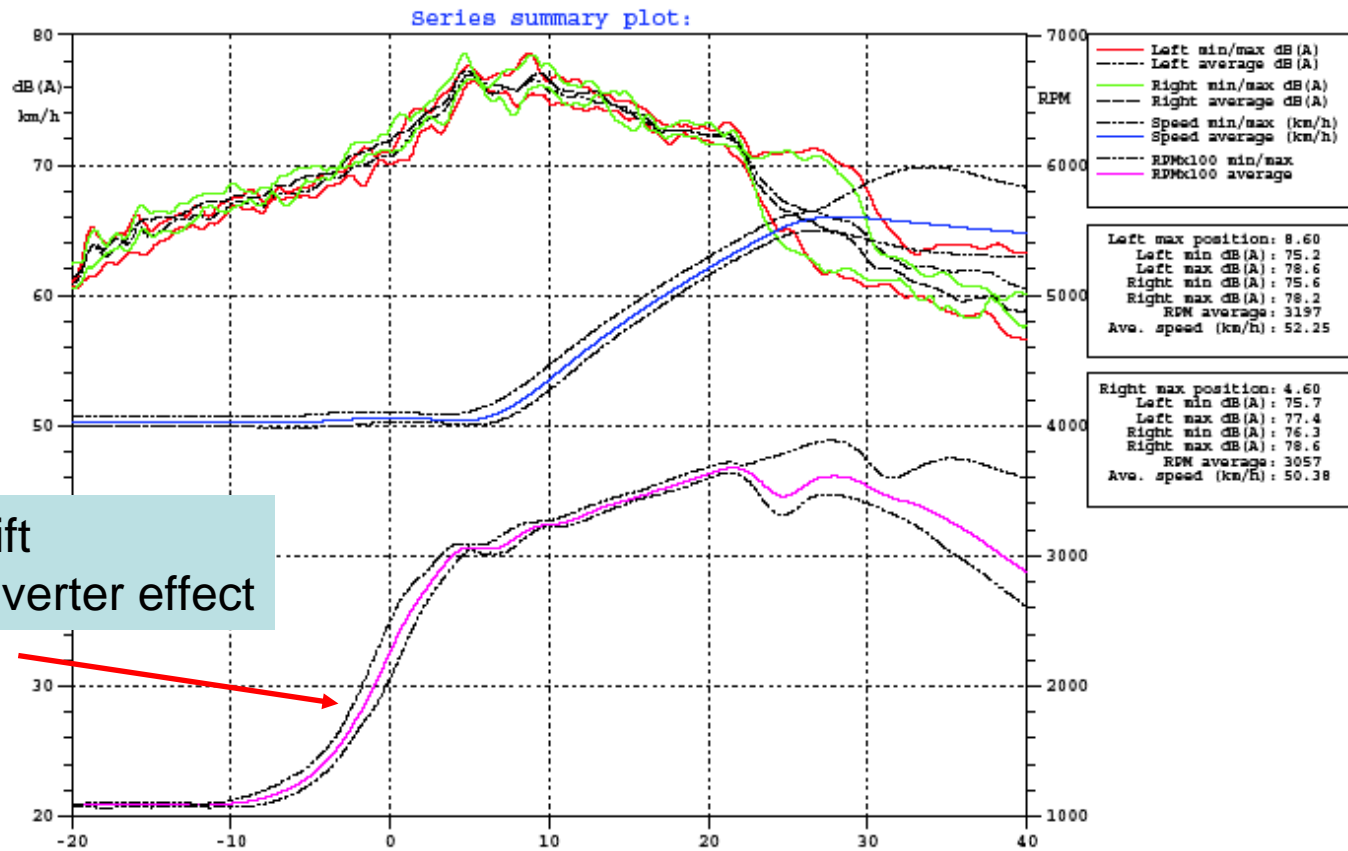
6 speed AT

R51.02* test result

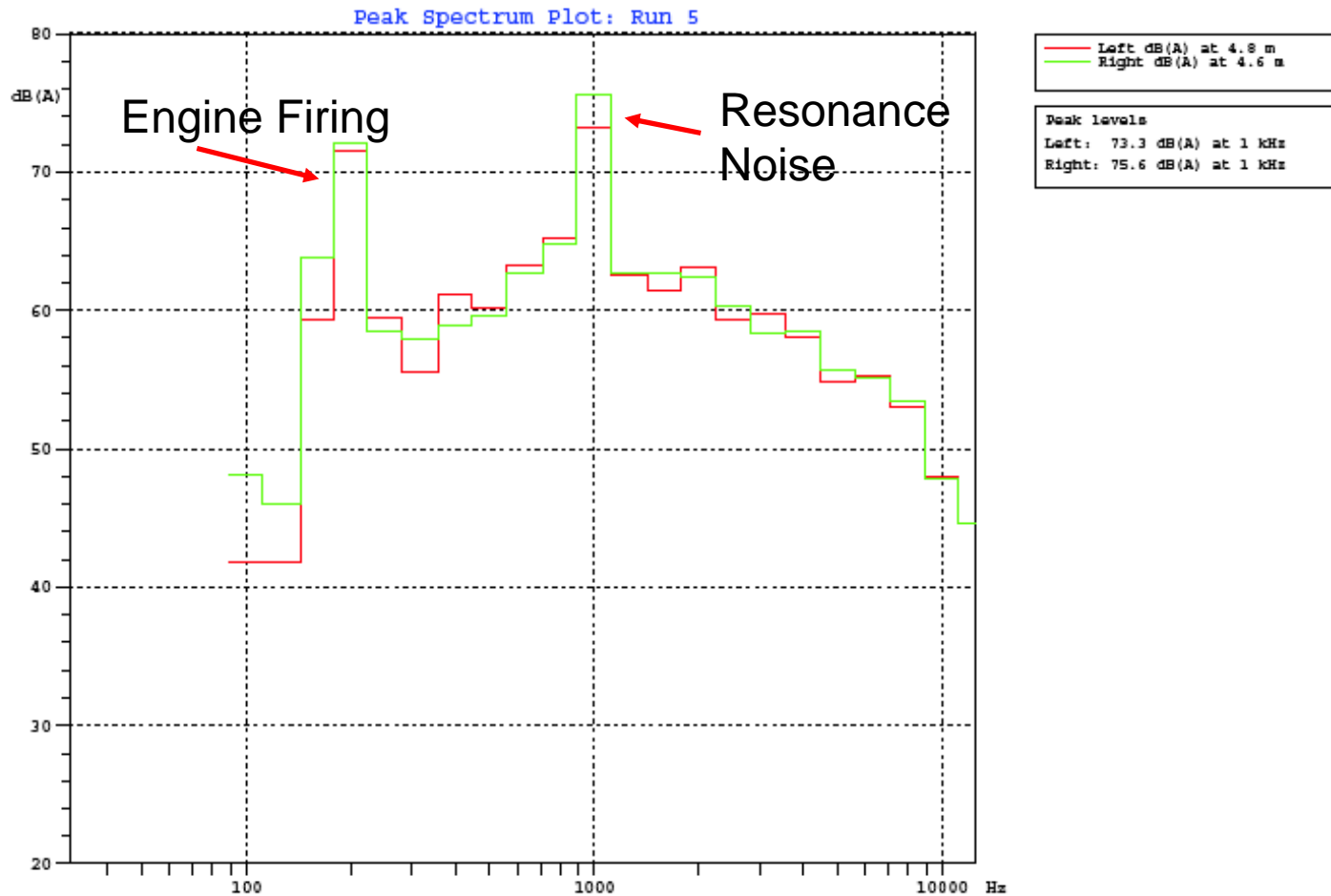
* ECE test is valid both ways

- Tested in Drive (2nd gear) = 77.7 (76)
 - N @ Lmax = 3200 (53%); N@AA = 1090
- Tested in 3rd = 73.3 (72)
 - N @ Lmax = 2350 (36%); N@AA = 1850

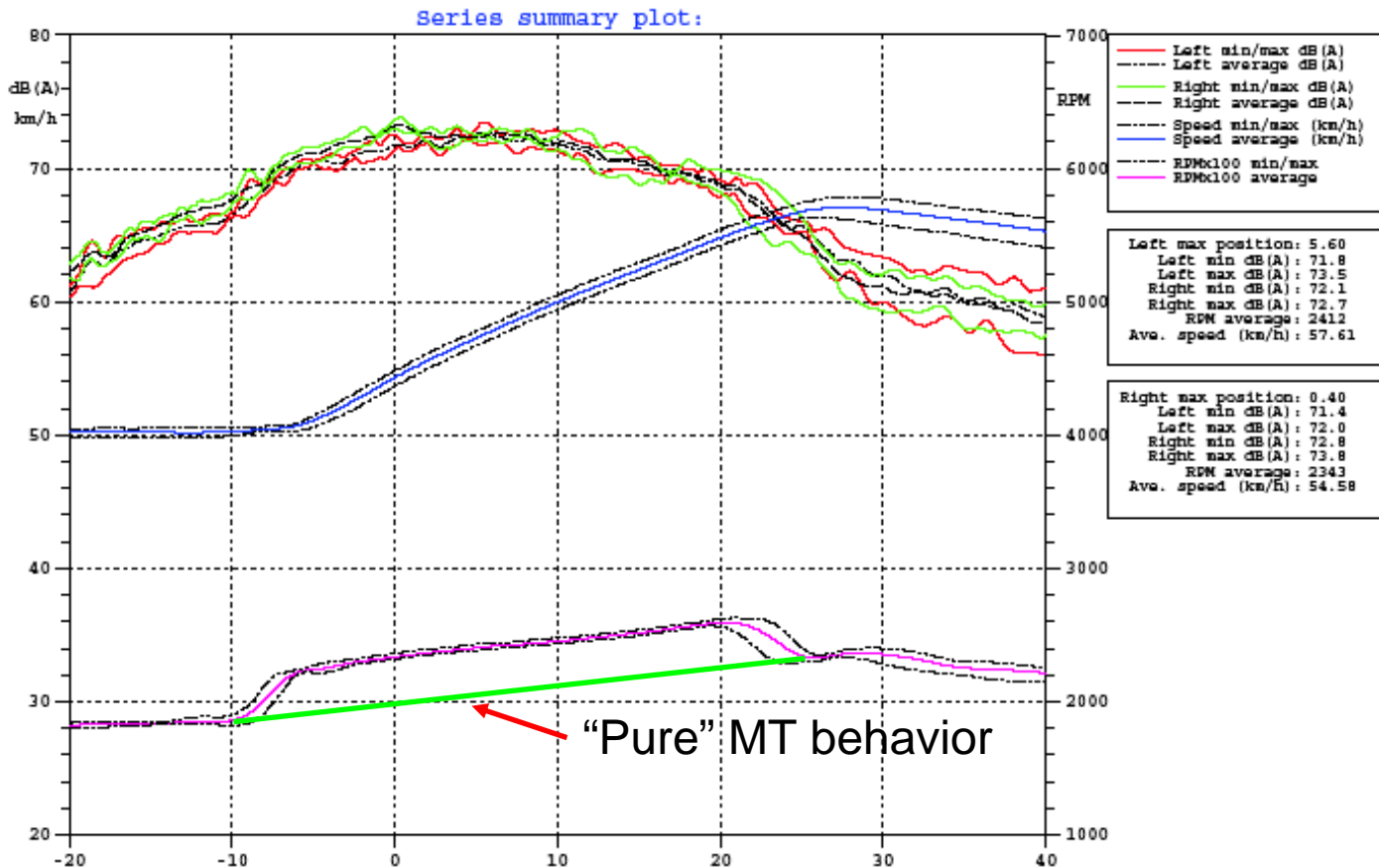
AT Behavior Unlocked



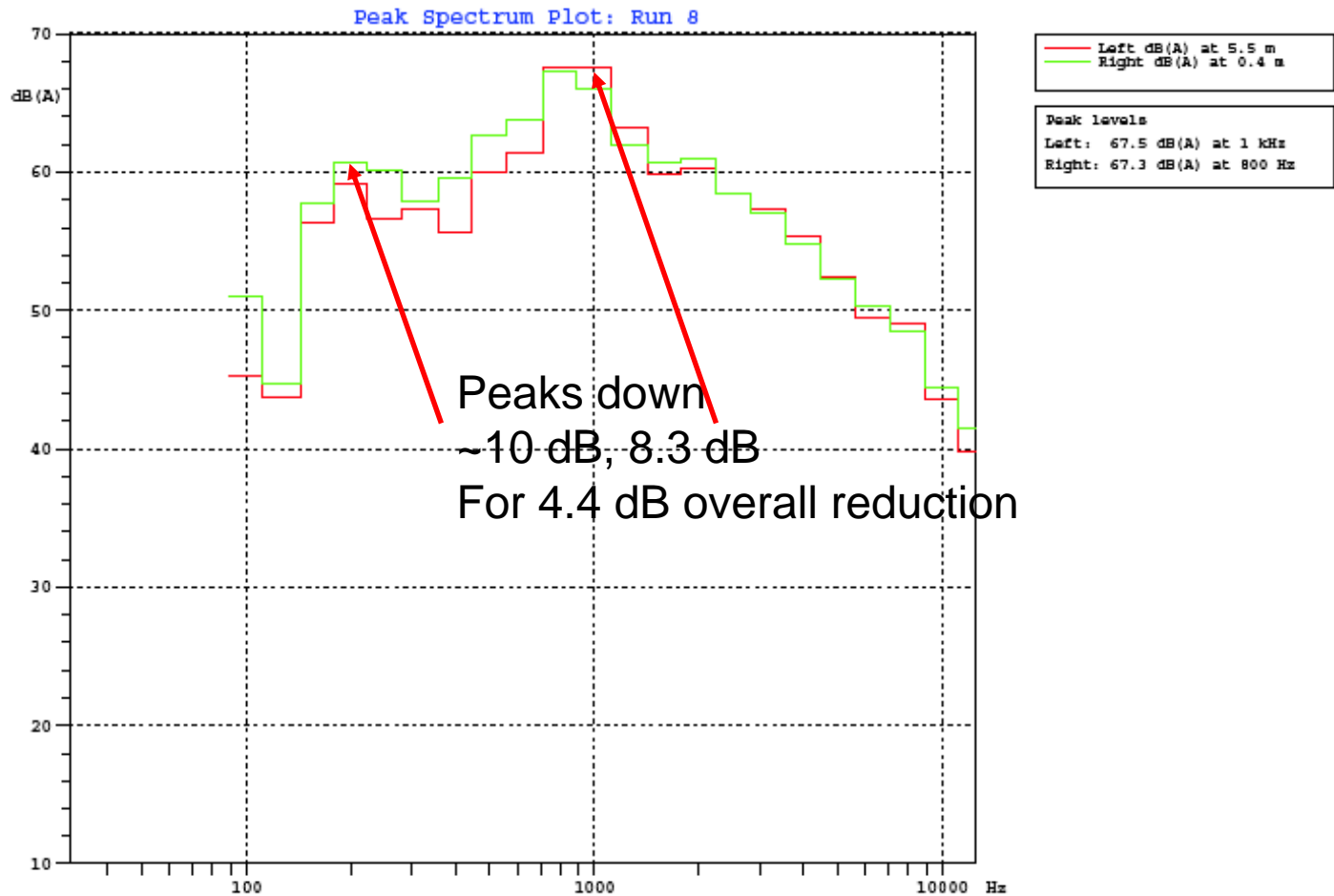
Noise Result



AT Behavior "Locked"

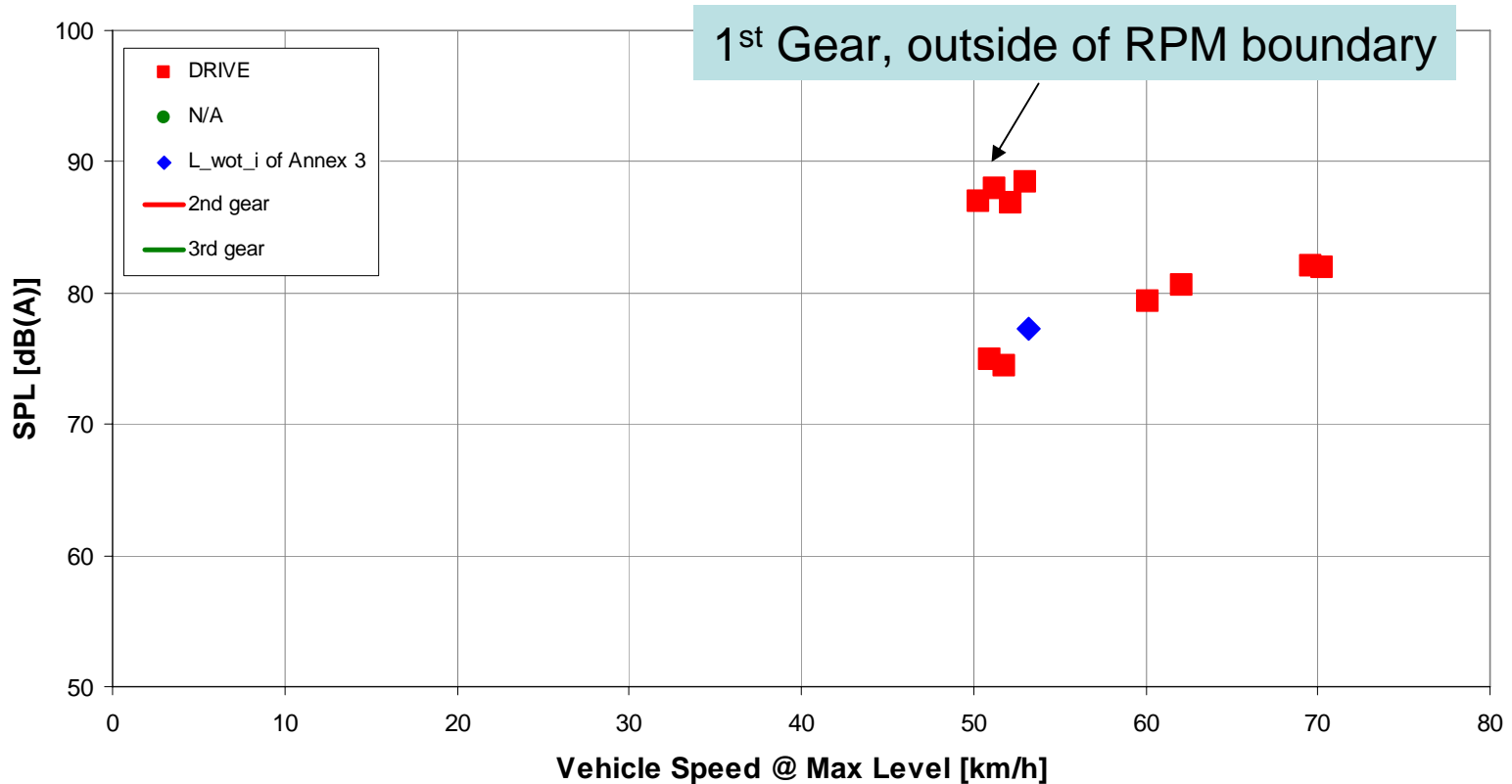


Noise Result



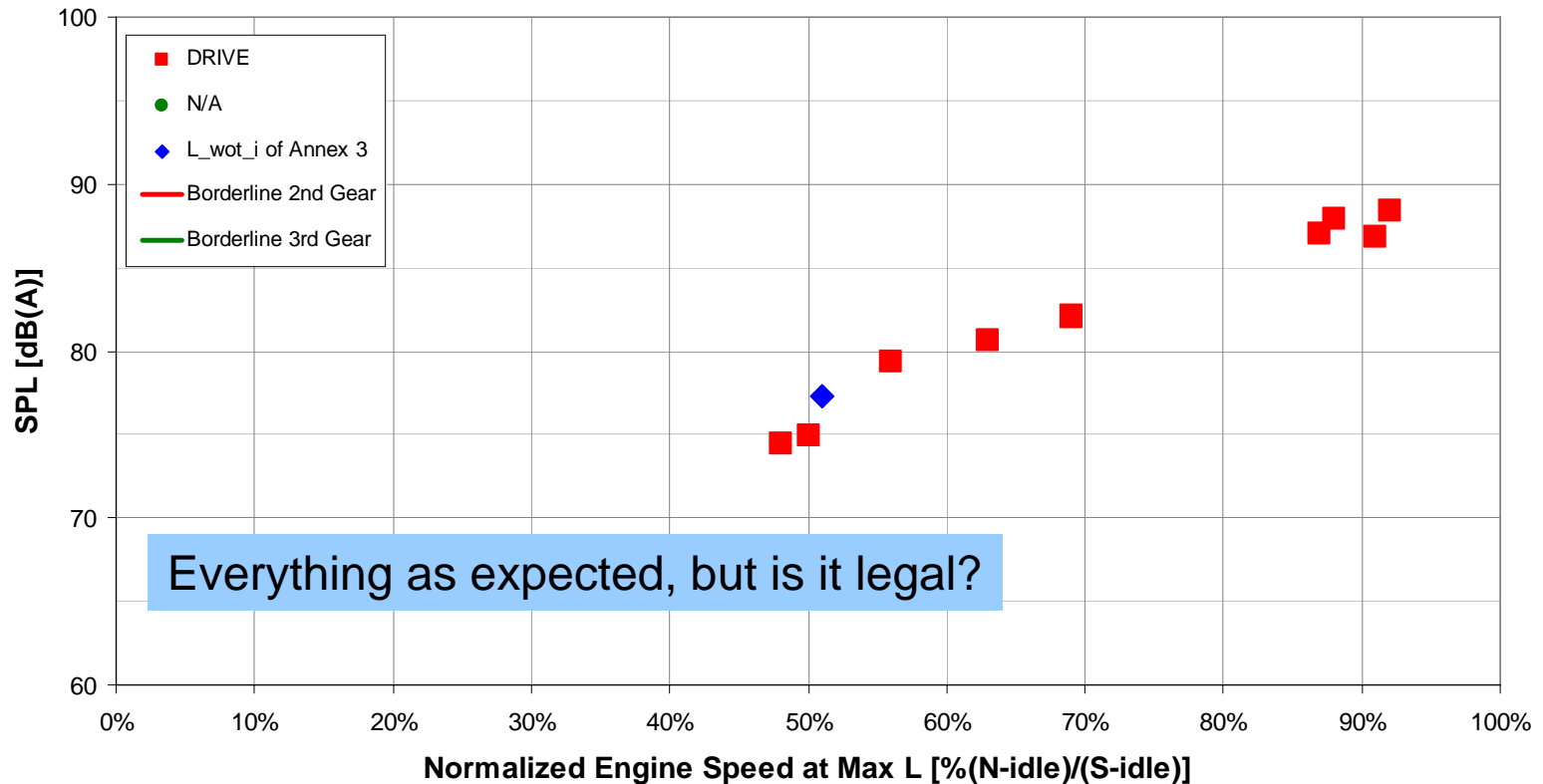
ASEP Results, Drive

French-German-Japanese Proposal (Reference to N@Lmax)



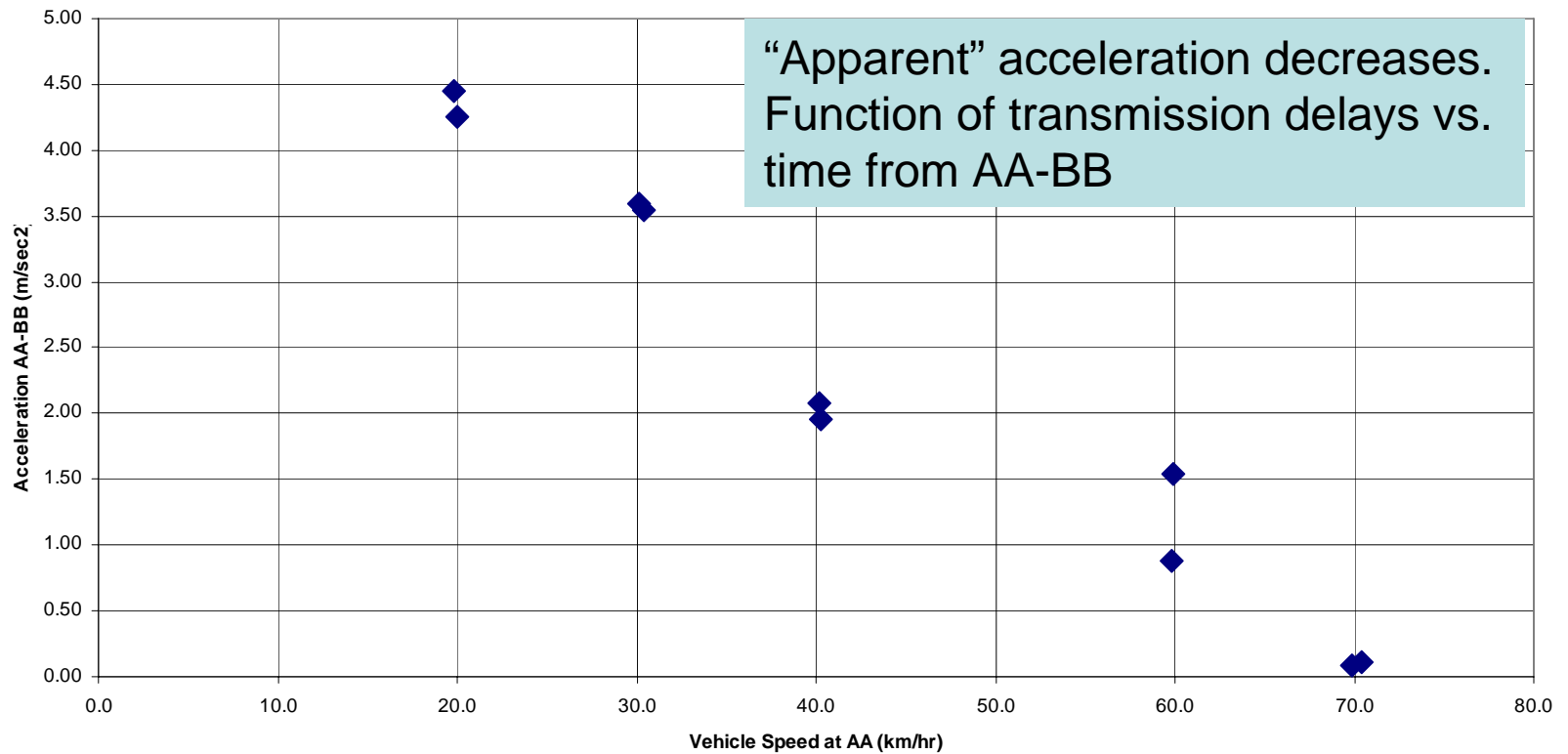
ASEP Results vs. RPM

French-German-Japanese Proposal (Reference to N@Lmax)



Acceleration Behavior

Acceleration vs. Entry Speed
G8 V8 Drive



Example #2: AT vehicle B

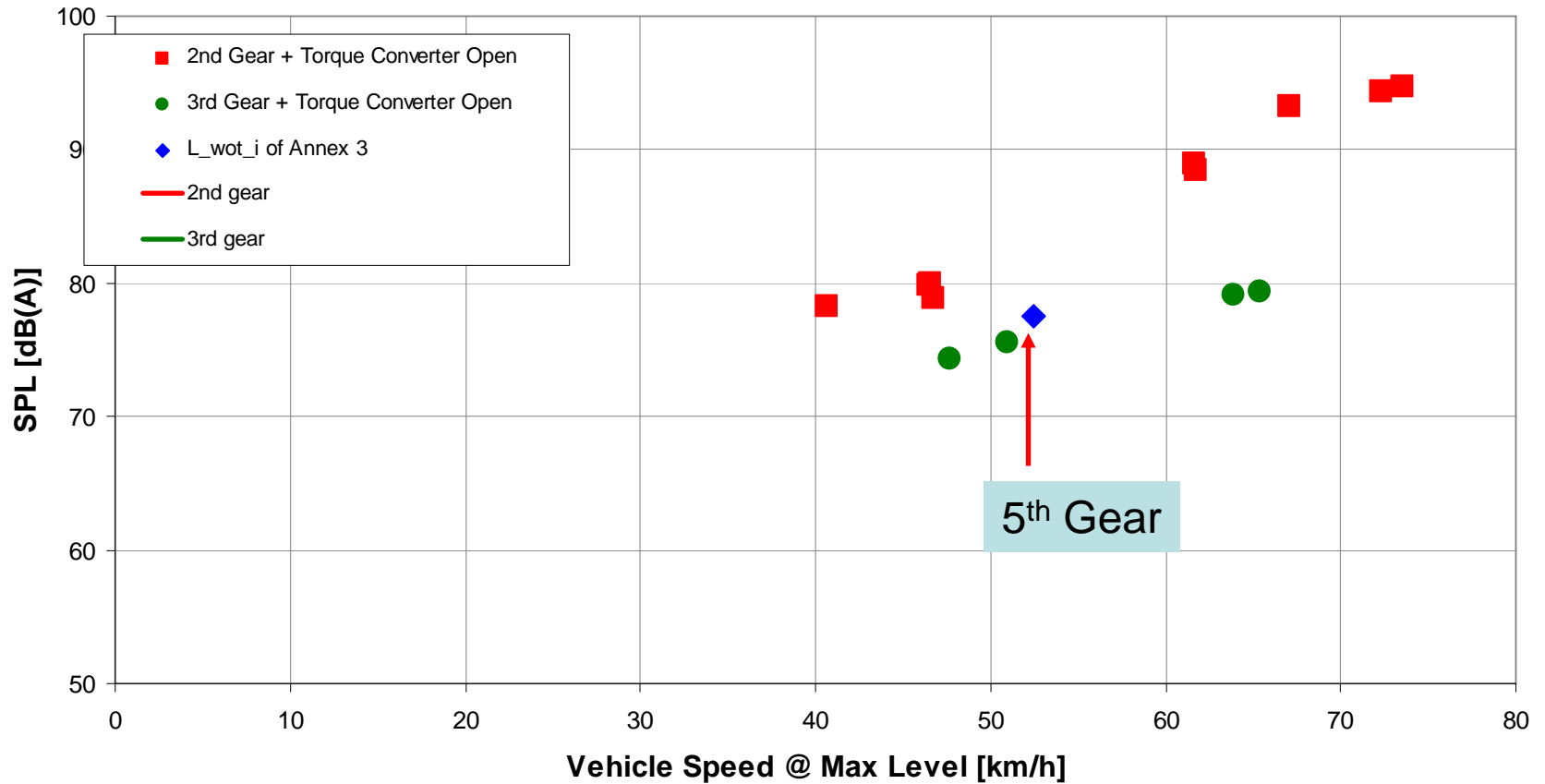
Vehicle Data

- S = 6000; Idle = 500
- PMR= 211
- 6 speed AT
- Tires – P285/35ZR19

- Annex 3 Result
 - L_urban = 76.4, 5th gear
- R51.02 test result
 - Tested in 3rd = 76.9 (75)
 - N @ Lmax = 1830 (24%); N@AA = 1665

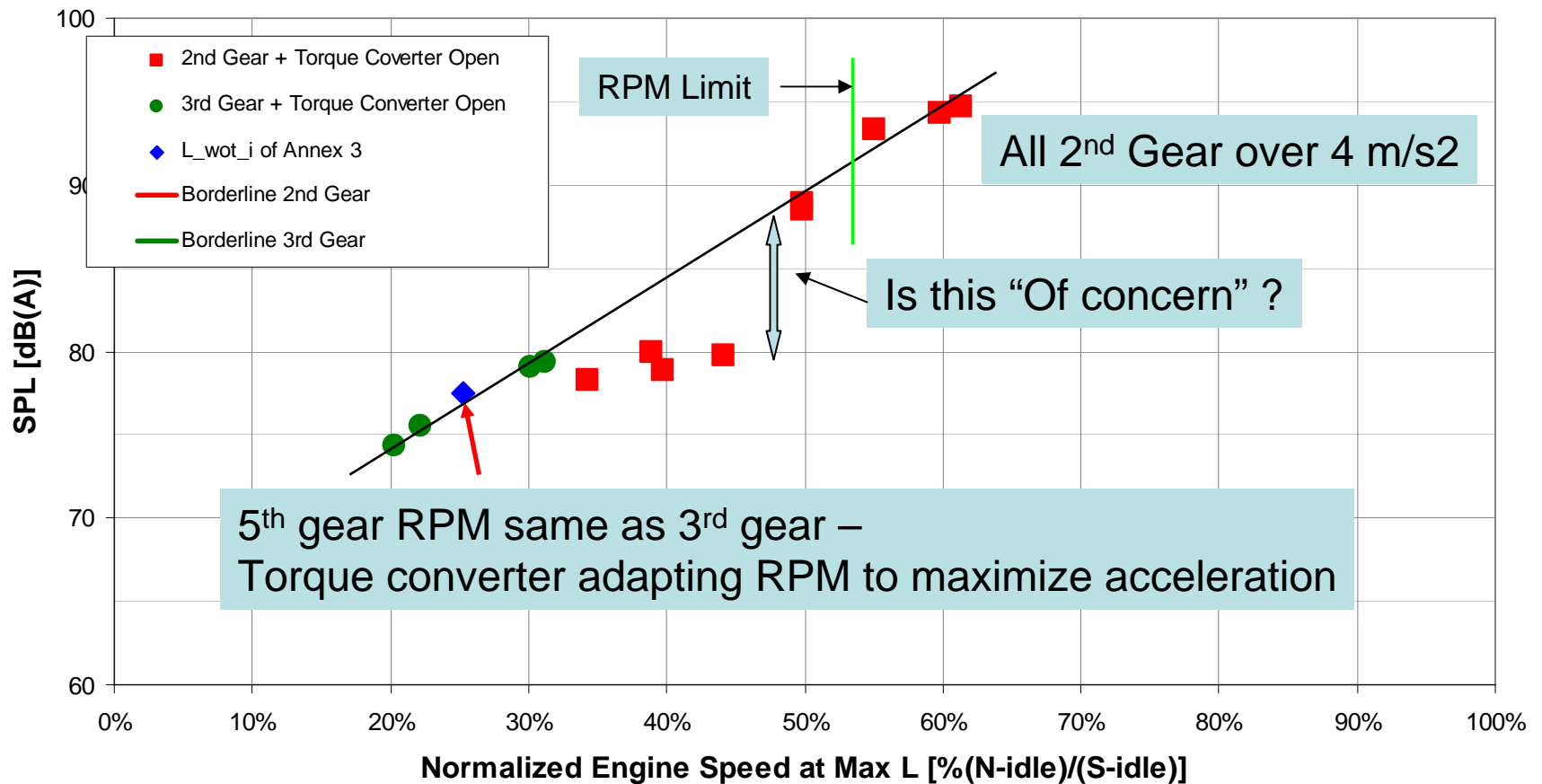
ASEP Results

French-German-Japanese Proposal (Reference to N@Lmax)



ASEP Results, RPM

French-German-Japanese Proposal (Reference to N@Lmax)



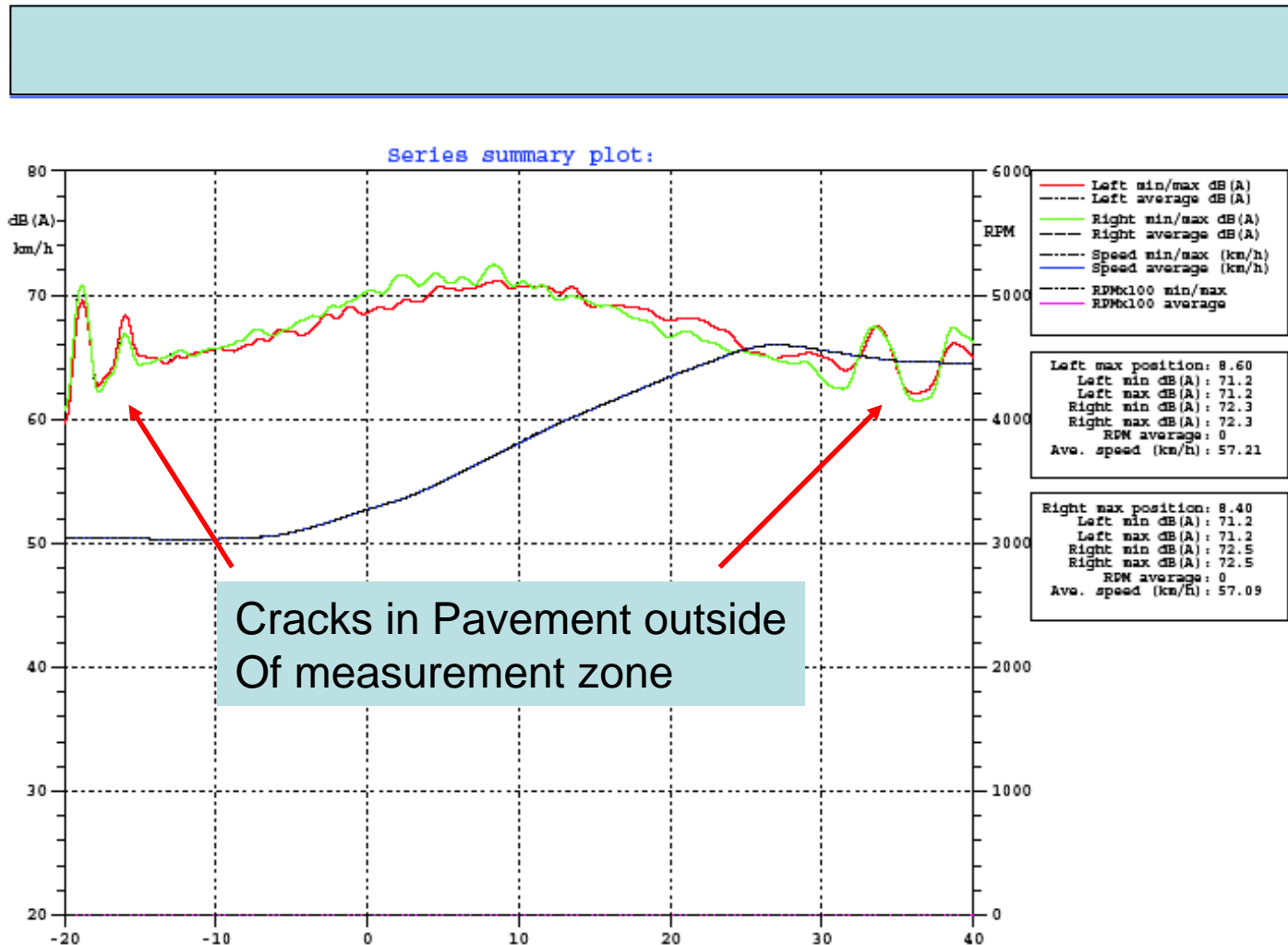
ASEP AT Technical Issues

- Requirements vs. vehicle velocity and/or acceleration must consider real torque converter/shift behavior – it provides nonlinear RPM/accel vs. entry vehicle velocity behavior.
 - Unlocked AT behave between a manual and CVT.
 - “Locked” AT have RPM delta to manual for same vehicle speed.
 - Shifting to lower gears may not lower test RPM.
 - Lower entry speeds give lower (1st) gear
- In this case, dB/RPM is sensible evaluation.
 - Limited RPM range due to BB velocity limit.
 - Political/Technical issue of accounting for higher AT RPM vs. MT at same vehicle speed.
 - Analysis method must account for AT characteristics.

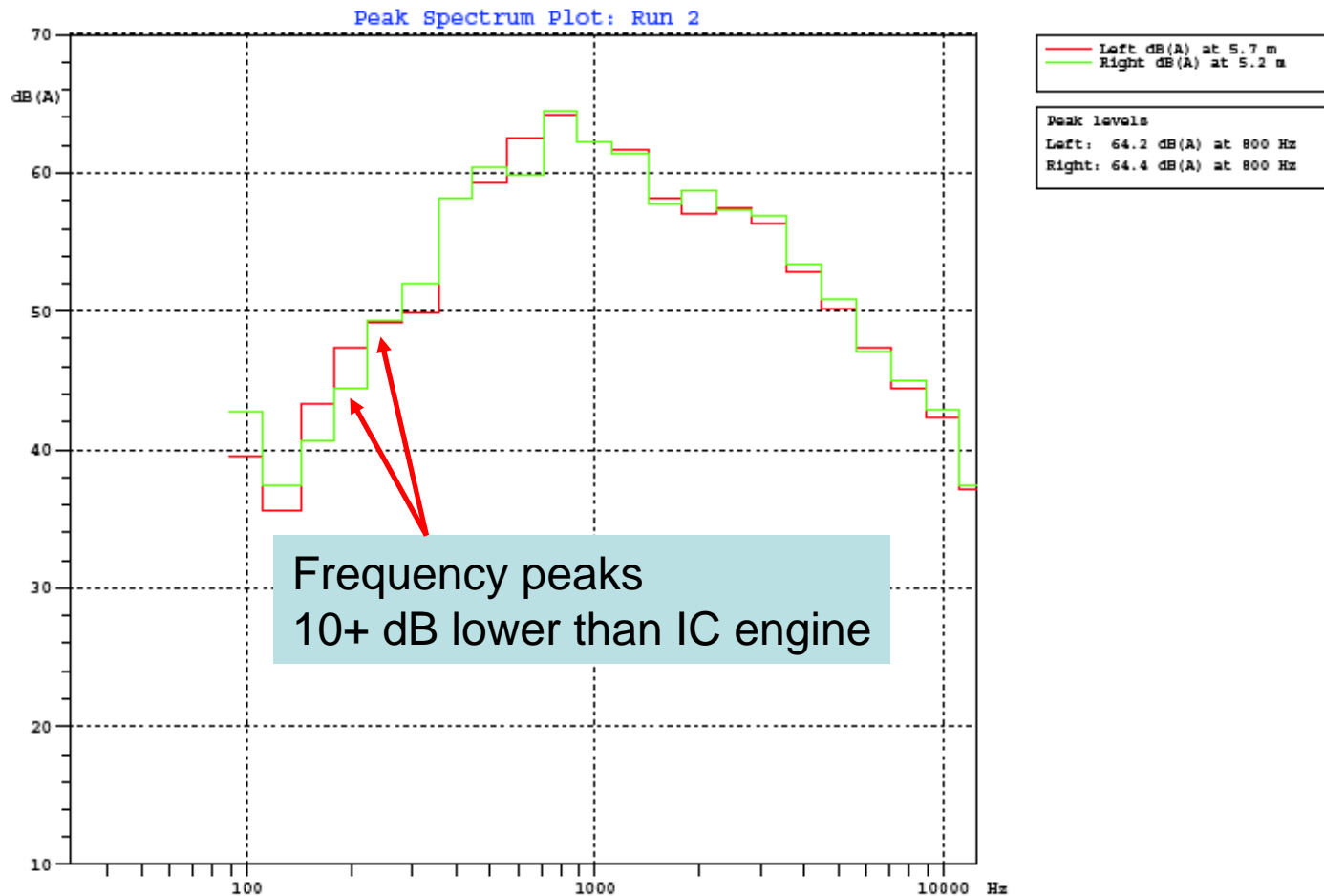
Example #3: Fuel Cell Vehicle

- Vehicle Data:
 - $S = \text{NA}$; Idle = 0
 - PMR= 42 (Power is the kW rating of the Fuel Cell)
 - Fuel Cell with Regenerative Braking and Battery Pack
- R51.02 test result
 - Tested in Drive = 71.2 (70)

Operating Behavior

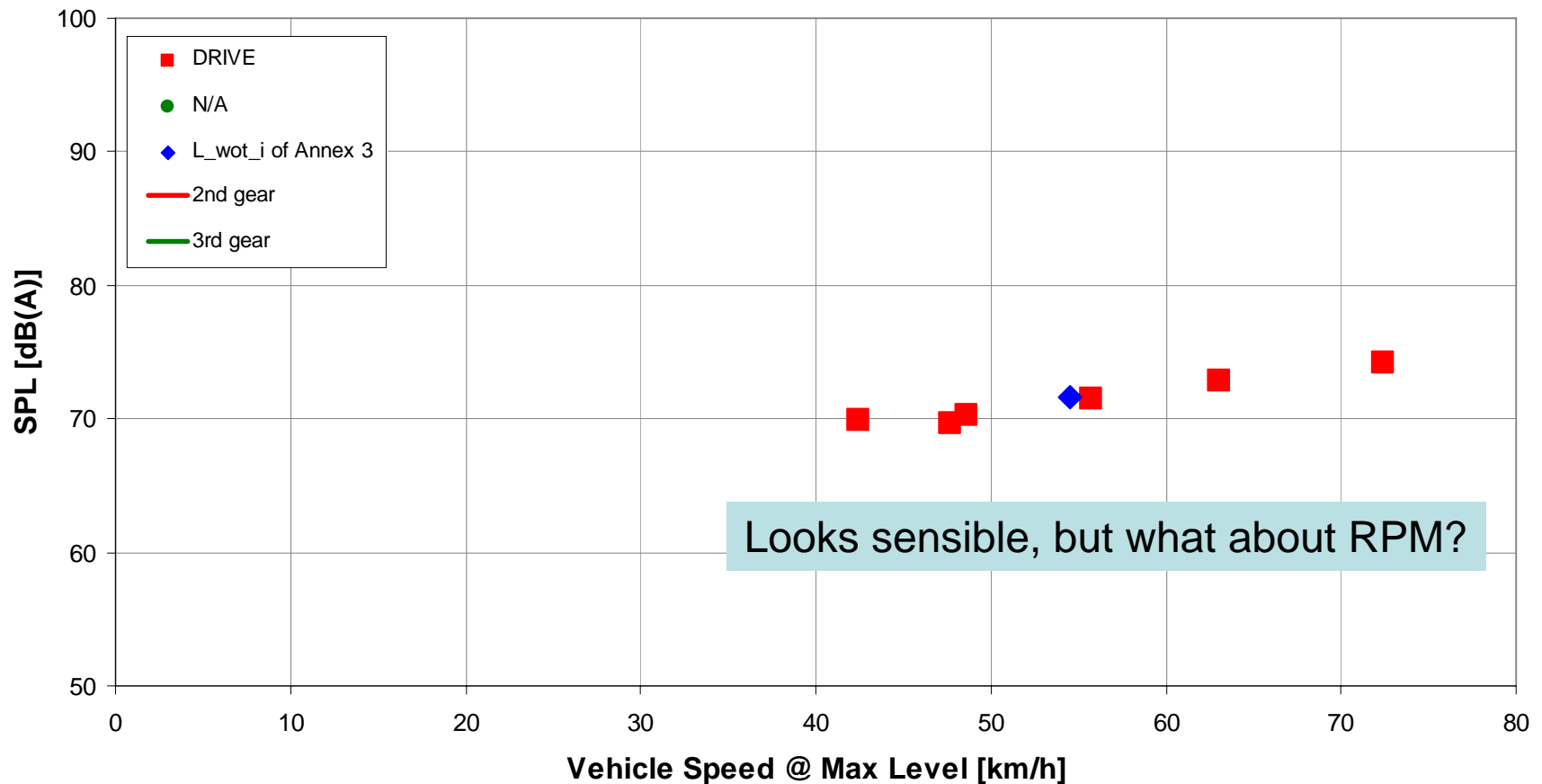


Noise Result



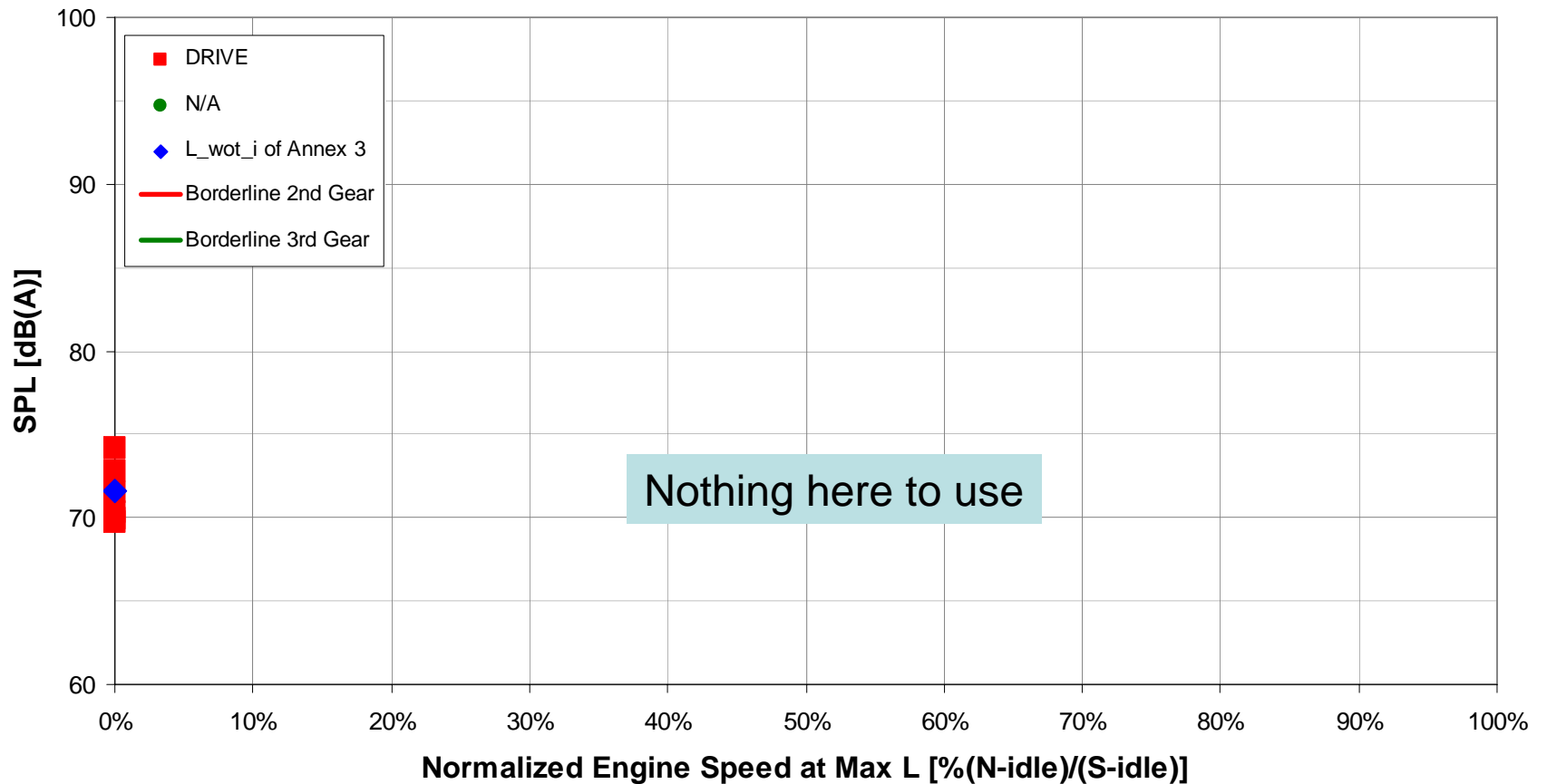
ASEP results, vehicle velocity

French-German-Japanese Proposal (Reference to N@Lmax)



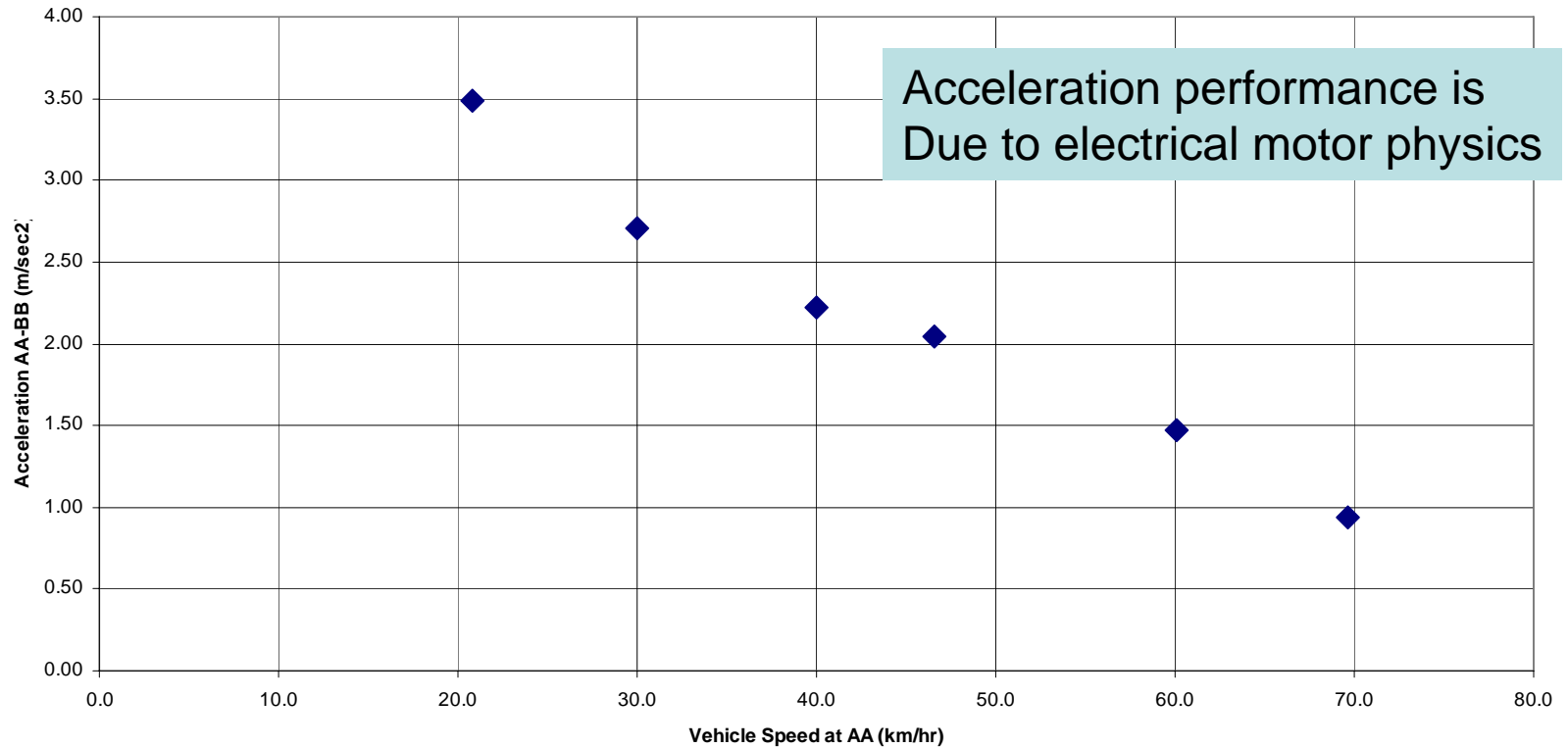
ASEP results, RPM

French-German-Japanese Proposal (Reference to N@Lmax)



Acceleration Behavior

Acceleration vs. Entry Speed
GMT101X Fuel Cell



ASEP Electrical Vehicle Technical Issues

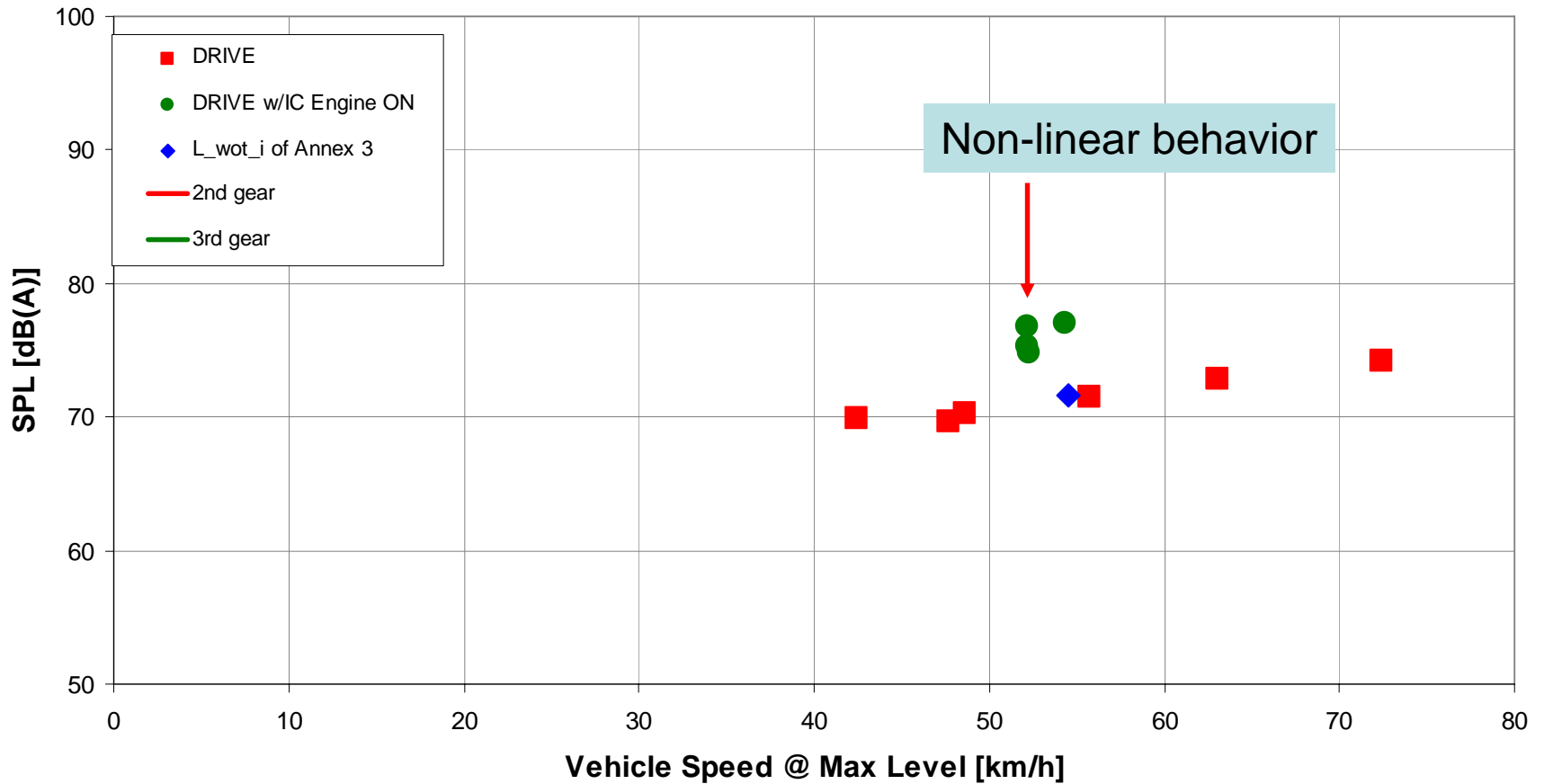
- Engine RPM is not applicable parameter for analysis of results.
 - Any regulatory scheme using RPM is invalid for these vehicles.
 - Acceleration vs. AA speed looks similar to unlocked AT vehicles, but this is due to a different physical mechanism.
1. Propose such vehicles be evaluated based on vehicle speed, OR:
 2. Such vehicles shall be excluded from ASEP as there is no technical reason for concern.

Example #4: Plug-In Hybrid

- Vehicle Data:
 - $S = 0$ (vehicle) 6450 (generator); Idle = 0.
 - PMR= 50 (Power is the kW rating of the Battery).
 - Electrically driven vehicle with on-board IC engine electrical generator.
 - IC engine operation independent of vehicle speed and throttle position.
 - IC engine operation ONLY dependent on battery state.
- R51.02* test result
 - Tested in Drive = 71.2 (70) - Generator Off
 - Tested in Drive = 77.2 (76) – Generator On

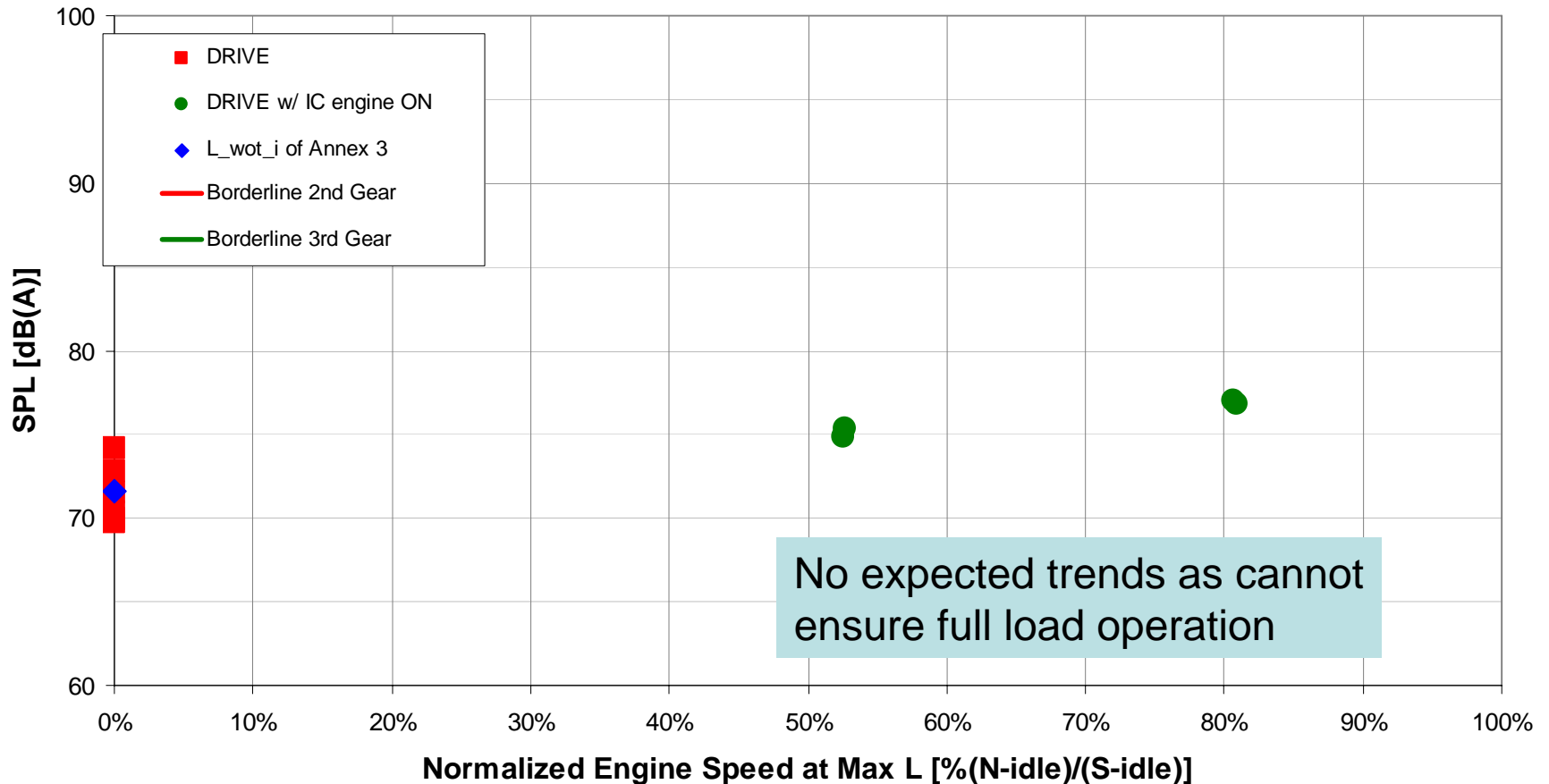
ASEP Results, vehicle velocity

French-German-Japanese Proposal (Reference to N@Lmax)



ASEP Results, RPM

French-German-Japanese Proposal (Reference to N@Lmax)



ASEP Issues with Plug-In Hybrids

- Have same lack of RPM information as electrical vehicles.
- Additional issue of non-linear dB vs. vehicle speed.
- IC Engine operation independent of driver commands.
- These vehicles can be dealt with in the following manner:
 1. Exclude from ASEP as not a vehicle of concern.
 2. Another method for analysis?

Summary

1. Non MT vehicles each have their own potential technical issues with ASEP.
2. If these vehicles will remain subject to ASEP, multiple analysis options are a solution.
 - a. RPM based analysis option
 - b. Vehicle speed based analysis option
 - c. Other mutually agreed method between manufacturer and approval authority.
3. If a vehicle can be shown to have expected/acceptable behavior in ANY analysis scheme, it shall satisfy ASEP.
 - Solves problem of having to force all vehicles to make sense in one analysis framework.
 - Maintains scope of ASEP as a “A test for Test Detection” in Annex 3
4. Allowing options for ASEP analysis provides both the technical tools necessary to properly treat different technologies and provides regulatory certainty for manufacturers and approval authorities.

Thank You

- Questions?