GENERAL MOTORS LLC'S AUTOMOTIVE SPECTRUM USE CASE PRIORITIES DEVELOPMENT AND IMPLEMENTATION OF A NATIONAL SPECTRUM STRATEGY

NTIA Docket No. 230308–0068

I. INTRODUCTION.

General Motors LLC ("GM") welcomes the opportunity to meet with National Telecommunications and Information ("NTIA") staff to discuss the company's spectrum priorities for the National Spectrum Strategy (the "Strategy"). NTIA's ongoing development of the strategy comes at an important moment for GM and other automakers, with the industry undergoing major technological advancements that will bring increased connectivity and automation to today's era of vehicles. To realize the potential of these technological advancements, however, GM and other industry participants will require additional spectrum to ensure continued and future deployments of cutting-edge technologies.

As described in greater detail below, GM currently deploys a wide range of wireless technologies, and is interested in rolling out further use cases. These current and prospective wireless use cases rely on spectrum from the 80 Hz band up to frequencies exceeding 100 THz. Given this array of critical spectrum bands for automotive technologies, it is imperative that the Strategy encourage regulatory policies that ensure effective coexistence that avoids harmful interference, particularly in bands where additional Wi-Fi use cases are contemplated.

II. AUTOMOTIVE SPECTRUM USE CASE PRIORITIES

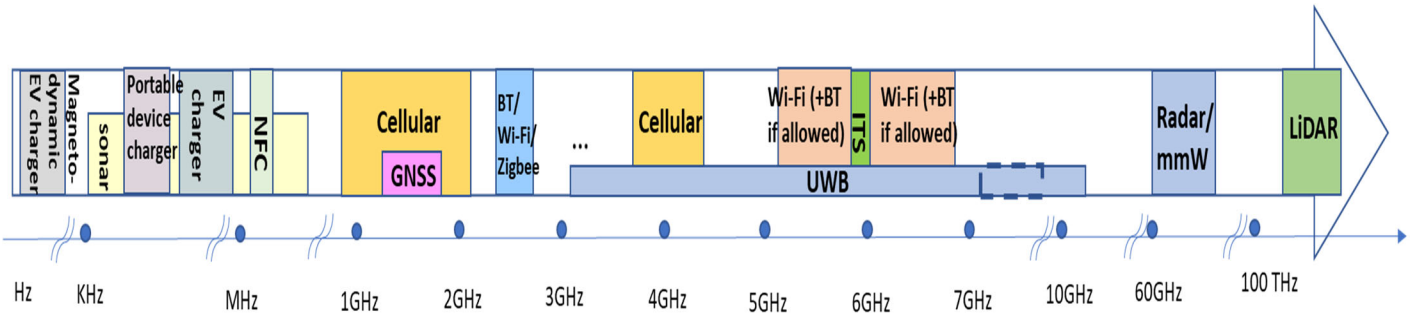

Figure 1- Spectrum utilized or considered for automotive applications in US (both licensed and unlicensed bands included)

1. General Motors currently deploys or is interested in deploying a wide range of wireless technologies, as shown in Figure 1. Note that the technologies currently in use within the industry are marked with an asterisk. Continued preservation of the spectrum allocated for these applications is critical to their undisrupted operation.

    a. **Sonar Sensors*:** Based on ultrasound range detection in 40 KHz-18 MHz spectrum, this technology may be used in vehicles for external obstacle detection, parking assistance, accident prevention and other use cases.

b. **Wireless Charging of Portable Devices*:** Wireless charging for onboard devices such as smart phones, based on inductive coupling in 87 kHz – 205 kHz range, can be used in vehicles for consumer convenience.

c. **Wireless Power Transfer for Electric Vehicles*:** Wireless charging for vehicle batteries can be based on resonant inductive coupling (at ~85kHz) or Magneto-dynamic coupling in the hertz range.

d. **NFC*:** Near Field Communication ("NFC") cards may be used for high-proximity applications including, but not limited to, vehicle unlocking at very close distances. They use very low frequency (13.56 MHz) which does not typically incur any risk of interference with other wireless technologies within and around the vehicle.

e. **Cellular Technology*:** Embedded in the vehicle is a telecommunications unit which provides cellular connectivity for vehicle-embedded applications as well as internet access to onboard devices within the vehicle by serving as a Wi-Fi hotspot.

f. **GNSS*:** Most automated driving systems and many active safety systems rely on broadcast Global Navigation Satellite Signals ("GNSS") in the L-band (1-2 GHz) which have weak transmission levels and are susceptible to both unintentional and international RF interference. This critical spectrum must continue to be protected against encroachment.

g. Satellite-Based Communication for Internet and Voice Connection: Vehicles may be equipped with satellite modems for downlink and uplink communications over L-band (1-2 GHz) and/or S-band (2-4 GHz) frequencies.

h. **Satellite Radio*:** Many vehicle consumers are used to satellite radio-based entertainment channels in the 2.32-2.345 GHz range.

i. ZigBee: Zigbee technology, popular in IoT applications, may be used in the vehicle for inter-connecting embedded and/or onboard devices alongside or instead of applications relying on Bluetooth Low Energy ("BLE").

j. **Bluetooth/Bluetooth Low Energy*:** Bluetooth ("BT")/BLE may provide hands-free calls, onboard device projection, BT headphones, vehicle sensors monitoring systems, listening to music from a brough-in device on embedded stereo system, positioning, and others.

k. **Wi-Fi*:** One or more electronic units within the vehicle utilize Wi-Fi connections, as an Access Point ("AP"), station ("STA"), or in Wi-Fi-direct applications. For example, as an AP, an embedded electronic control unit ("ECU") enables data connectivity among embedded or onboard devices, and internet access by serving as a hotspot. In the STA mode, applications include, but are not limited to, receiving media streams from an onboard or embedded device, internet connection over Wi-Fi to download latest software or upload diagnostic and operational data to a remote server. The Wi-Fi-direct mode applications also comprise of, *inter alia*, docking applications and mirroring.

l. **V2X*:** Intelligent Transportation Systems ("ITS") utilizes vehicle-to-everything ("V2X") technology, which offers side-link connectivity between the vehicle, surrounding vehicles, as well as proximate Road-Side-Units which may be part of smart intersection infrastructures. Messages exchanged through V2X technology enhance situational awareness and can help mitigate or eliminate crash risks in dangerous non-line-of-sight scenarios which could not be addressed by other technologies such as other onboard sensors.

m. UWB: To provide customers the ability to use their smart phones as key-fobs to access their vehicles, ultra-wideband ("UWB") technology may be utilized to enable accurate localization even in challenging scenarios such as underground garages. While the nominal range spans 3.1-10.5 GHz, many stakeholders favor the 7.7-9.3 GHz portion of the band.

n. Internal Radar: Radar detection technologies operating in the 60-64 GHz band can reduce the risk of leaving children in the back of the vehicle unattended. This very low power technology has sensing capabilities in ranges even as small as the dimensions of the vehicle cabin.

o. **External Radar Applications*:** Currently, external radar solutions operating in 77-81 GHz band are used for obstacle sensing and detection in numerous automotive use cases such as assisted driving and parking features.

p. Wi-Gig: High-bandwidth short-range Wi-Fi use cases in the 60 GHz band can enable automotive applications such as Wi-Fi docking/serial bus.

q. **External LiDAR Applications*:** Based on RF frequency in the Terahertz range, this technology is used for obstacle sensing and situational awareness for assisted driving, as well as autonomous

driving technologies.

III. COEXISTENCE AMONG MULTIPLE TECHNOLOGIES

1. To best promote consumer welfare, the Strategy should encourage regulatory policies that ensure coexistence among the different technologies operating within a frequency band, including those mentioned in the use cases listed above. Such coexistence measures can help avoid harmful interference and device malfunction. Such policies may for example include enforcement of in-band power/EIRP emission limits and Out-of-Band Emission ("OOBE") restrictions/masks.

2. More specifically, the use of UWB (e.g., for keyless entry) and Wi-Fi in the 6 GHz band should assure that one does not impair the operation of the other. Also, in 2.4 GHz band, the Strategy should encourage coexistence mechanisms among various operating technologies including, but not limited to, Wi-Fi, BT, and Zigbee. When adjacent bands are utilized for applications for intra- and inter-vehicle connectivity, such as the proposal for 6G cellular use of the 6 GHz band, in-band and OOBEs should be contained via enforcement of power limits and proper masks to assure that Wi-Fi, cellular V2X, and other technologies using 5.9 GHz are not impacted.