6. Research Project

Is this authorization to be used for providing communications essential to a research project? (The radio communication is not the objective of the research project)? If "YES", include as an exhibit the following information:

1. **A description of the nature of the research project being conducted.**
2. **A showing that the communications facilities requested are necessary for the research project involved.**
3. **A showing that existing communications facilities are inadequate.**

Yes

1. Glydways is a leading innovator in autonomous mobility, dedicated to transforming urban transportation through advanced technology. The company specializes in developing high-capacity, on-demand transit networks that utilize autonomous electric vehicles on dedicated infrastructure. By focusing on scalability and operational efficiency, Glydways aims to create seamless mobility solutions that address the growing demands of modern metropolitan environments.

The research project that will be supported by this experimental authorization is the Atlanta Airport Community Improvement Districts' (AACIDS) ATN Pilot Project, which is a mass transit, autonomous, personal rapid transit (PRT) demonstration system that will showcase Glydways' technology to the City of College Park, GA.

The ATN Demonstration Pilot is a free, on-demand transit demonstration that will connect the ATL SkyTrain at the Georgia International Convention Center to the Gateway Center Arena using dedicated lanes called fixed guideways. The ATN will operate five autonomous vehicles operating along a 0.49-mile long dedicated guideway, running four days a week for up to eight hours per day. The ATN Demonstration Pilot is a test project to show how an ATN system can work in real-life using Glydways technology, and will demonstrate the user experience of the ATN and illustrate how the system can grow over time, in real-world environments. This research project has a short-term, 16 month, duration (4 months for installation, testing, and commissioning plus 12 months of operation).

A 2019 transit feasibility study identified the ATL airport area as a 24/7 mobility district, where both travelers and workers require reliable transportation around the clock. The study identified two primary gaps in existing transit service: inadequate first- and last-mile connectivity and the presence of unserved or underserved populations. The ATN was developed to address these gaps, with the goal of demonstrating that the Glydways personal rapid transit technology can be used at scale to achieve high people per hour per direction (pphd) throughput with an autonomous system. Under this project, Glydways will conduct a full test plan containing a variety of scenarios that AACIDS is interested in witnessing. End-to-end system operations will be executed in order to prove that the technology is viable and meets AACIDS' criteria.

Additional background on the research project can be found at ***https://aacids.com/automated-transit-network***; and more information on Glydways can be found at ***https://www.glydways.com/***.

2. In order for vehicles to maintain a safe separation distance from one another, each vehicle must know its precise position within the system map. Vehicle-to-Infrastructure (V2I) Ultra Wideband (UWB) ranging is necessary to obtain localization information per vehicle as the vehicles move through the system, while Vehicle-to-Vehicle (V2V) UWB ranging allows vehicles to measure their distance relative to each other to ensure the vehicles maintain a safe separation distance.

Glydways uses UWB Channels 5 (6240 - 6739.2 MHz) and 9 (7737.6 - 8236.8 MHz). These channels were selected for the following reasons.

- The commercial-off-the-self FCC pre-certified Qorvo DWM3001C units that will be used with this experiment only support Channels 5 and 9.
- Glydways is not customizing the module or its frequencies
- Glydways believes that these frequencies will not overlap or interfere with radar altimeter, safety bands, or other sensitive frequencies, including governmental frequencies.

3. The autonomous vehicle system takes several inputs into its localization algorithm in order to determine its state. UWB is a necessary input for safety, even though fiducials, perception data, and GPS may also be used to improve the positioning integrity. In this Glydways system, headways will be 3.2 seconds. Therefore, vehicles will be separated by approximately 22.4 m while traveling at a maximum velocity of 7 m/s. In order to reduce the risk of collision, high accuracy position information is required.

Typical standalone GPS positioning can be both unreliable and lacks the required accuracy for an autonomous vehicle system that supports high passenger throughput and low headways. For instance, typical GPS accuracy is expected to be approximately 3-10 m depending on the quality of the GPS signal (https://archive.gps.gov/systems/gps/performance/accuracy/). On the other hand, UWB ranging offers +/- 10 cm accuracy. The standard GPS update rate for car navigation is 1 Hz (once per second) as per the NMEA 0183 Standard. Conversely, once a UWB ranging session is established, the ranging measurements occur within approximately 12 ms.

With respect to perception and sensing, the UWB is required for corroboration of sensor data. Without the UWB input, the perception information cannot be adequately cross-checked. Further, when a vehicle is within range of a UWB tower, the UWB positioning/ranging information can also be communicated almost instantaneously. Whereas the perception system's processing of sensor inputs leads to a more latent

determination of location and range. Finally, while there are no anticipated tunnels on this exact system, UWB works with both open sky and tunnels (as compared to the GPS requirement for open sky) and therefore is a better fit for the Glydways product. The below offers supporting diagrams and related exhibits as to how the UWB will be used.

UWB units with integrated antennas are only 4.2672 m above ground level and installed into plastic enclosures. The Glydways autonomous vehicle system is located on 2 sides of the GICC building. The GICC building, Marriott and Renaissance Hotels, the elevated Atlanta Skytrain and MARTA train systems, and surrounding trees and geographical features provide obstructions between the Glydways system and the Hartsfeld-Jackson Atlanta International Airport. The airport terminals also provide obstructions. For the 6-8 GHz frequencies that we are proposing to use, these obstructions will greatly limit the transmission distance of the signals. At these frequencies, the UWB signals will naturally experience fast free-space attenuation and will not be capable of penetrating dense obstacles. Even in the absence of obstructions, the UWB power is distributed over a 500 MHz bandwidth, the signals are always expected to degrade rapidly with respect to distance.

A simple free-space path loss calculation using the formula below can be used to calculate the loss at various distances.

$$FSPL = 20\,log_{10}(d) + 20\,log_{10}(f) + 20log_{10}\left(\frac{4\pi}{c}\right) - G_{Tx} - G_{Rx}$$

At a distance of 1000 m (the approximate distance to the airport), one can see for a Channel 5 frequency of 6240 MHz, peak antenna gain (G_{Tx}) of 2.5 dBi, and receive antenna gain (G_{Tx}) of 0 dBi, the FSPL will be 105.844 dB. If the TX Power of -41.3 dBm/MHz is considered, then the signal level, not including effects of obstructions, is expected to be -147.144 dBm/MHz.

For the Channel 9 frequency of 7737 MHz, the signal level would be -107.711 dBm.

For comparison's sake, even at a close distance of 100 m, the Channel 5 and 9 signal levels would be -127.144 and -129.011 dBm, respectively.

In terms of interference, according to the UWB radio manufacturer, Qorvo Inc (***https://www.qorvo.com/design-hub/blog/unlocking-the-future-how-uwb-is-reshaping-secure-access-in-the-connected-world***), the transmit power of the radios is below the noise floor. Qorvo states, "its pulsed nature allows it to operate at extremely low power levels, minimizing interference by keeping the transmitted power below the noise floor." UWB is designed to be technology that can coexist in the spectrum with other technologies.

In addition to limited propagation due to low transmit power, path loss, and obstructions, the Glydways UWB modules are PoE-based and can be quickly powered off via remote control. When the experiment is not running, Glydways will power off

the UWB radio units based on a network policy. For example, when operations end for a given day, the UWBs will power down and will not transmit. As discussed herein, Glydways selected the proposed frequencies to minimize the chances of harmful interference, however, in the unlikely event of any complaint, Glydways can immediately issue the remote power off commands to shut down the UWB.

Also, note that the fixed infrastructure UWBs only send low throughput beacon messages at a rate of 10 Hz. The beacon rate is adjustable and can be lowered if requested. Active distance ranging (bursty packet transmissions) only occurs when a vehicle is within range of the fixed radio.