REPORT TO THE COMMITTEE ON COMMERCE, SCIENCE, AND TRANSPORTTION OF THE SENATE AND THE COMMITTEE ON ENERGY AND COMMERCE OF THE HOUSE OF REPRESENTATIVES

Summary:

This report provides a summary of the Commission's effort to "test[] the feasibility of partnering with Federal agencies that operate delivery fleet vehicles, including the United States Postal Service (USPS or Postal Service), to facilitate the collection and submission" of mobile wireless broadband data for the purposes of supplementing and verifying wireless broadband coverage maps collected by the Commission pursuant to the Broadband DATA Act.[1] The Commission has conducted a pilot feasibility study using USPS delivery vehicles in Longmont and Denver, Colorado, to explore the possible use of delivery fleet vehicles to verify and supplement mobile broadband coverage information submitted by wireless service providers. After receiving Congressional funding to implement the Broadband DATA Act, Commission staff purchased the equipment necessary to conduct a pilot project and entered into an agreement with USPS to conduct a study to test the feasibility of equipping USPS vehicles with 5G-capable handsets, as well as spectrum sensing equipment, to measure mobile broadband service. This report provides a summary of the design, engineering, and mechanical work done to establish the pilot program. The combination of smartphones and sensor equipment successfully collected a large amount of throughput and other network performance metrics data along the delivery routes traveled by the pilot vehicles. Although the Commission was able to collect a large amount of useful data, however, the pilot demonstrated that there are certain technical and logistical challenges and other limitations that would need to be resolved in order to make it feasible for USPS fleet vehicles to be used to supplement and verify mobile broadband coverage data collected by the Commission. For example, safety, space, and power limitations in delivery vehicles, and the imperative not to interfere with or impose burdens upon the postal carrier, place substantial restrictions on the size and amount of equipment that can be installed. As a result, we conclude that there are a number of barriers to establishing a scalable model to operate fleet vehicles to facilitate the collection and submission of coverage maps and data speeds submitted by mobile broadband providers as part of our Broadband Data Collection efforts.

Background:

The March 2020 Broadband DATA Act directs the Commission to make fundamental changes to its requirements, processes, and approach for the collection of data on the availability and quality of fixed and mobile broadband Internet access service throughout the United States.[2] As required by the Act,[3] the Commission issued rules in July 2020 and January 2021 to establish a new Broadband Data Collection[4] for collecting granular data from providers on the availability and quality of broadband Internet access service, creating publicly available coverage maps, establishing processes for members of the public and other entities to challenge and verify the coverage maps, and creating a common dataset (the Fabric) of all

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[1] Broadband Deployment Accuracy and Technological Availability Act, Pub. L. No. 116-130, § 804(b)(2)(B)-(C), 134 Stat. 228, 237 (2020) (codified at 47 U.S.C. § 644(b)(2)(B)-(C)) (Broadband DATA Act or Act).

[2] Broadband Deployment Accuracy and Technological Availability Act, Pub. L. No. 116-130, 134 Stat. 228 (2020) (codified at 47 U.S.C. §§ 641-646) (Broadband DATA Act or Act).

[3] 47 U.S.C. § 642.

[4] The Broadband Data Collection was formerly known as the Digital Opportunity Data Collection.

locations where fixed broadband Internet access service can be installed.[5]

As part of the Broadband DATA Act, Congress also directed the Commission to test the feasibility of partnering with federal agencies, including USPS, that operate delivery fleet vehicles to collect data that can be used to verify and supplement broadband coverage information.[6] The goal of such partnerships would be to "facilitate the collection and submission of information" about the actual availability of broadband service "on an ongoing basis so that the information may be used to verify and supplement information provided by providers of broadband [I]nternet access service for inclusion in the maps created" under the Act.[7] The Broadband DATA Act further requires that the Commission submit a report to Congress on its assessment.[8]

On December 27, 2020, Congress authorized funding for implementation of the Broadband DATA Act.[9] In the January 2021 Broadband Data Collection *Third Order*, the Commission directed the Office of Economics and Analytics (OEA) and the Wireless Telecommunications Bureau (WTB) to investigate a pilot program that tests the feasibility of partnering with USPS or other federal agencies to collect information to verify and supplement broadband information submitted by mobile providers.[10]

Discussion:

The pilot program. To begin the pilot testing as quickly as possible, and in view of the extensive USPS delivery network, the Commission focused on establishing a partnership with USPS. USPS is an independent establishment of the executive branch of the United States government and maintains a fleet of more than 230,000 delivery vehicles.[11] USPS delivers mail across the United States, providing service to over 160 million delivery points across a range of urban, suburban, and rural areas.[12]

The Commission and USPS completed negotiations and entered into an agreement to conduct a study to test the feasibility of equipping USPS vehicles with 5G-capable handsets, as well as spectrum sensing equipment, to measure mobile wireless broadband service. A central issue was ensuring that USPS mail

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[5] *See Establishing the Digital Opportunity Data Collection; Modernizing the FCC Form 477 Data Program*, WC Docket Nos. 19-195, 11-10, Third Report and Order, 36 FCC Rcd 1126 (2021); *Establishing the Digital Opportunity Data Collection; Modernizing the FCC Form 477 Data Program*, WC Docket Nos. 19-195, 11-10, Second Report and Order and Third Further Notice of Proposed Rulemaking, 35 FCC Rcd 7460 (2020); *see also Establishing the Digital Opportunity Data Collection; Modernizing the FCC Form 477 Data Program*, WC Docket Nos. 19-195, 11-10, Report and Order and Second Further Notice of Proposed Rulemaking, 34 FCC Rcd 7505, 7506, 7521, paras. 2, 3, 35 (2019).

[6] Section 644(b)(2)(B) of the Broadband DATA Act requires the Commission, within one year of the Act's enactment, to "conclude a process that tests the feasibility of partnering with Federal agencies that operate delivery fleet vehicles, including the United States Postal Service, to facilitate the collection and submission" of data that can be used to verify and supplement broadband coverage information. 47 U.S.C. § 644(b)(2)(B).

[7] 47 U.S.C. § 644(b)(1).

[8] 47 U.S.C. § 644(b)(2)(C).

[9] Consolidated Appropriations Act, 2021, Pub. L. No. 116-260, H.R. 133, Div. E, Tit. V, Div. N, Tit. V, § 906(1) (Dec. 27, 2020).

[10] *Establishing the Digital Opportunity Data Collection; Modernizing the FCC Form 477 Data Program*, WC Docket Nos. 19-195, 11-10, Third Report and Order, 36 FCC Rcd 1126, 1154, para. 69 (2021) (*Third Order*).

[11] *See* Postal Facts, https://facts.usps.com/top-facts/.

[12] *See* "About the United States Postal Service," https://about.usps.com/who/profile/.

carriers did not need to be involved in the operation of the testing equipment. The Commission and USPS also determined the scope and duration of the pilot testing program. Under the terms of the agreement, the Commission and USPS agreed to equip each of seven Postal Service vehicles with a kit that contained several devices that would collect, among other things, uplink and downlink data-rate (throughput) measurements on wireless handsets and a sensor to measure wireless signal strength and signal quality data across multiple bands. These measurements were conducted as the vehicle traveled over established Postal Service delivery routes that were selected to contain a mix of urban, suburban, and rural areas with a variety of different terrains and building environments. The parties agreed to conduct the testing for the study near two post office locations in Colorado over the course of approximately three weeks. After executing the agreement, the Commission and USPS worked cooperatively to complete the design, engineering, and mechanical work needed to establish the pilot program and to select appropriate delivery routes.

Testing equipment design. Over the course of approximately four weeks, Commission staff completed the design for the kits that were used in the testing. Staff proceeded to build seven test kits, each of which would be placed in a separate USPS vehicle. Each kit would be comprised of a commercially available Pelican Case® containing three Google Pixel 5 Android smartphones (for a total of 21 smartphones deployed across the pilot), a spectrum sensor developed by the University of Notre Dame Wireless Institute,[13] a MiFi (mobile Wi-Fi) device wirelessly connected to the spectrum sensor and used by the sensor to transmit data back to servers managed by the University of Notre Dame, and power components sufficient to maintain a charge to the smartphones and to power the spectrum sensor and MiFi device (hereinafter "kit" or "equipment kit"). The power components included a DC converter (vehicle voltage to 5V) and Universal Serial Bus (USB) cables to provide power to each device in the kit. Each case had a lock to secure the equipment. For purposes of tracking and organization, staff assigned a unique identifier to each kit and to each device in the seven cases to help monitor activities on remote monitoring dashboards.

Smartphones. Staff included three smartphones in each kit to test the uplink and downlink throughputs associated with the broadband coverage maps of the three nationwide mobile providers – AT&T, T-Mobile, and Verizon. Each of the three smartphones contained a SIM card to receive the network of one of the three providers. While for kit size, power supply, equipment, and data transmission cost reasons, staff would have preferred to use one device within each vehicle to test all locally-available mobile broadband networks, staff could not identify a device with this functionality that would also measure carrier-specific uplink and downlink throughputs.[14] Unless such a device becomes available, each kit in each delivery fleet vehicle used for testing would need to include separate test devices for each locally-available mobile provider in order to test the availability of mobile broadband service in any area, and the Commission would need to subscribe to data plans for each such provider that would accommodate a huge amount of test data – factors that would necessarily impact both the size and safety limitations imposed on USPS delivery vehicles and the cost of such tests.

Staff chose the Google Pixel 5 Android smartphone for testing because of its ability to operate across all

[13] *See* https://wireless.nd.edu/research/radiohound-distributed-spectrum-sensing/.

[14] While each USPS delivery employee would also have a Mobile Delivery Device in their vehicle, these devices are subject to restrictions on use per USPS contracts with wireless service providers, do not measure 5G-NR services using the most recently deployed spectrum, and would measure only one provider network.

spectrum bands (including millimeter-wave, Citizens Broadband Radio Service (CBRS), and unlicensed spectrum bands) currently being used for 4G Long Term Evolution (LTE) and 5G New Radio (NR) deployments, and because of its compatibility with the applications needed to conduct the testing. The same model and type of smartphone was used for all tests to ensure consistency in measurements among the three providers and across all the test kits in order to reduce the potential performance variations that might occur by using different handset models, manufacturers, or chip sets. Use of a single handset model also helped reduce design and testing complexity by allowing staff to use a common set of chargers, common sizes for installation, and a common configuration between the smartphone and the testing applications. During the design process, staff conducted testing to ensure that prolonged exposure to cold temperatures would not significantly affect smartphone battery performance because the kits would be installed in vehicles left outside in cold temperatures. Staff also conducted testing to determine whether placing the smartphones inside a case would cause signal penetration losses. Staff compared the measured RF signal power of the smartphones with the case closed to the measured RF signal power of the smartphones with the case open. These tests were performed both indoors using Wi-Fi and in a stationary outdoor environment using cellular signals. The testing did not measure any perceptible losses through the case.

Staff planned to equip each smartphone used for the testing with an unlimited data plan and apps for speed testing as well as remote access software and software for app automation. Given the large volume of speed tests that staff planned to run during the pilot (one speed test every one to three minutes during the driving period for a daily USPS delivery route), it was essential that each handset had an unlimited data plan. It was difficult to subscribe to unlimited 5G plans, at least through available government procurement plans, and ultimately staff procured an unlimited 4G LTE plan for one of the providers because staff could not obtain a 5G NR unlimited plan for that provider.

***Spectrum sensors*.** In addition to the three smartphones, each kit was designed to include a spectrum sensor developed by the University of Notre Dame Wireless Institute. Those spectrum sensors are programmable software defined radios built for wide-band spectrum sensing in mobile applications for frequencies up to 6 GHz, which does not include millimeter wave bands that would have to be included as part of the equipment used within any longer term project. Each spectrum sensor was connected to a MiFi device to transmit data to servers managed by Notre Dame.

Although they do not measure throughput, the spectrum sensors measure signal strength as a function of frequency across most of the spectrum bands used by mobile broadband providers, and therefore are a significantly less expensive radio signal measurement tool than separate smartphones and data plans for individual mobile providers. Staff therefore included spectrum sensors in the pilot to test the usefulness of the sensors for helping to verify broadband coverage maps, as well as their suitability for wide scale deployment. Staff is analyzing the data obtained to assess the value of sensor test data to the Commission's goal to improve the data it collects and makes available to other agencies, state and local authorities and consumers. Sensor data alone will not enable the Commission to test the data speeds of any provider and is therefore not a substitute for testing by smartphones or other devices that can measure the throughput of individual carrier networks in order "to verify and supplement information provided by providers of broadband internet access service" as envisioned by the Broadband DATA Act. Sensor data would, however, enable the Commission to identify changes in the radio frequency environment that could then be used to identify areas that might require follow-up data speed testing.

***Power*.** A significant design and operational challenge in the pilot was determining how to maintain battery levels for the smartphones, sensor, and MiFi device in each kit during the testing. To prevent the need for USPS staff to take any action to charge the smartphones or power the sensor or MiFi in each kit, Commission staff designed the kits so the devices would charge automatically through a connection to the vehicle battery. Because USPS vehicles do not have charger ports (commonly referred to as 12V accessory ports) in the cabin, USPS provided power to the cabin area of the vehicle from the engine compartment. As specified by USPS, this power supply was engineered to be active only while the vehicle key was in the ignition and the vehicle turned "on" (generally meaning that the engine was running, although it could also be supplied when the vehicle key was in the "accessory" position). This arrangement prevented the measurement equipment from draining the vehicle battery overnight or across non-delivery days (primarily Sundays or holidays). However, as described below, the tests demonstrated that the USPS vehicles can be powered off for a considerable percentage of the day while deliveries are made along their routes. USPS policy requires that the vehicle be turned off and locked anytime the driver is out and away from the vehicle, such as when taking a package to a customer's door. It was quickly identified that the vehicle off periods were more prevalent than expected, meaning that the smartphone testing devices were unable to recharge sufficiently to power the tests.[15] Although Commission staff and USPS technicians developed a workaround power arrangement, the power supply problem would have to be resolved in order for any longer-term arrangement on a larger scale to be feasible, particularly since the drain on the vehicle battery could be increased if additional devices were added to test the data speeds of other mobile providers in the area.

[15] Initial observations from the downtown Denver vehicle indicates that the percentage of vehicle off time is less than observed in the more rural and suburban Longmont area.

Figure 1. A completed kit, open to show the contents, as installed in a USPS model delivery vehicle. The three smartphones as mounted in the lid are level with the window and windshield for maximum signal penetration when the case is closed. The spectrum sensor is located at the top left with a red LED, with the MiFi for sensor data communication below that. Both are positioned in the foam interior. A single monopole RF antenna for the spectrum sensor is visible at the top, on the outside of the box. A small GPS antenna for the spectrum sensor is also mounted at the top but is not fully visible in this image. The power cables for the smartphones and MiFi are shown. These cables fit cleanly in the space between the smartphones and the interior foam when the lid is closed.

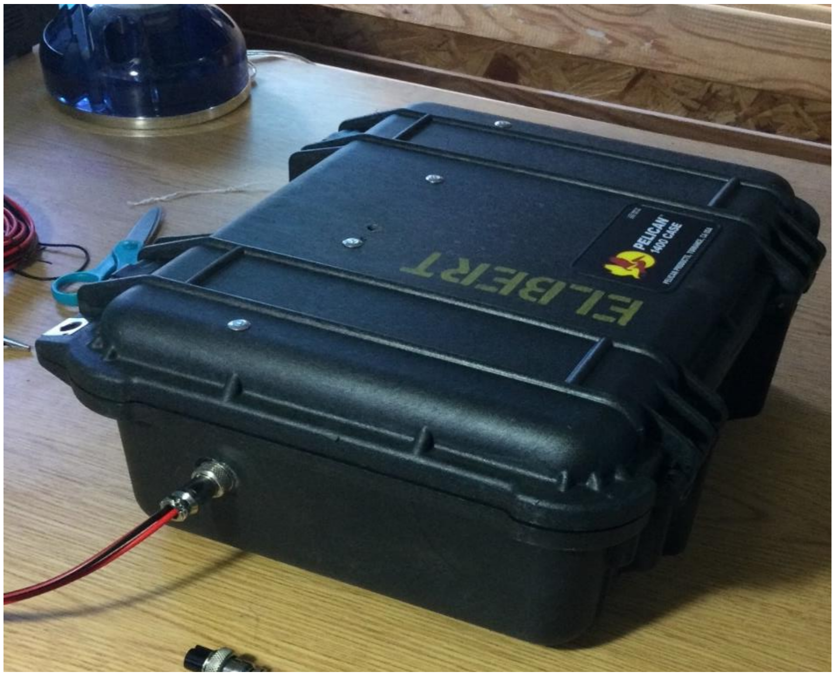

Figure 2. The completed kit, from the bottom, shows the 12V power connection to the USPS vehicle.

Procurement. After completing the design of the kits, Commission staff initiated the procurement process to obtain the smartphones, cases, and power accessory equipment. Staff conducted the required contracting market research, identified available equipment, and worked with providers to obtain smartphones and data plans. Staff entered into an agreement with the University of Notre Dame to obtain the most recent version of its RadioHound spectrum sensors to use in the testing.

Determining equipment placement. Over the course of several weeks, with the procurement process underway, the Commission staff worked with USPS to determine where and how to mount the kits in each USPS vehicle. USPS informed the Commission that Long-Life Vehicles (LLVs) and 2-Ton trucks would be used for the pilot testing and permitted access by staff to a USPS vehicle maintenance facility to coordinate and test possible mounting locations. The choice of possible locations was driven by safety and space limitations, as well as radio signal reception considerations.

For LLV vehicles, Commission staff considered several locations, including the passenger side bulkhead, underneath the mail tray table, and under and behind the driver's seat. Commission staff assessed how well each location would allow reception of radio signals and minimize signal penetration losses. For example, Commission staff analyzed whether each location would allow the testing equipment to not be greatly shielded by the vehicle body. Higher locations that were in view of windows were desirable. Staff also considered whether each location would interfere with operation of the vehicle or mail delivery activities. Staff needed to confirm that installation of the equipment would not block the driver's view out of the vehicle or block the ingress or egress out of the vehicle, and that the equipment would not occupy areas used to stack and store the mail within the vehicle. Staff also assessed the feasibility of securing the kit in each location so that there would be no danger of its becoming a dangerous projectile in the event of an accident or other sudden stop. Based on all these considerations, staff identified and then ranked possible mounting locations based on both the vehicle operational requirements as well as the need to optimize RF performance. Staff discussed the ranked proposed locations, and USPS engineering staff made the final selections.

It was determined that installation of the kits in the passenger side bulkhead was the preferred approach because it would place the radio sensors near the window of the vehicle, thereby ensuring good signal reception and minimizing signal penetration losses. The testing equipment could be mounted easily in the bulkhead location and installation in the bulkhead location did not interfere with operation of the vehicle or mail delivery activities. For the 2-Ton truck, the testing equipment was also mounted in the passenger side position and affixed to a handrail.

Figure 3. The USPS LLV.[16]

[16] Photographed by user Coolcaesar on December 24, 2005, CC BY-SA 3.0, https://commons.wikimedia.org/w/index.php?curid=1172110.

Figure 4. The USPS 2-Ton truck.

USPS engineering and safety inspection. Once Commission staff received the component parts for each kit, they began assembling the kits. When they completed assembly on the first kit, it was shipped to the USPS Engineering Facility in Merrifield, Virginia, for an engineering and safety inspection. During the inspection, USPS staff installed the assembled kit in a test vehicle in the Commission's preferred mounting location (i.e., the passenger side bulkhead). This installation consisted of mounting three bolts through the back of the protective case for the kit and then through the passenger side bulkhead in an LLV. Electrical power to the kit was provided by running an electrical wire from the vehicle's battery in the engine compartment through the firewall of the vehicle. This included installation of relay circuitry that enabled the electrical power to go on and off as the vehicle key was turned on and off. This ensured that the kit would not drain the vehicle battery when the vehicle was turned off. The connection was completed by applying the mating connector so that it could be attached properly to the equipment kit. The USPS engineering and safety inspection included an assessment of (1) whether the kit drained excessive battery power from the vehicle battery; (2) whether the mounting of the kit was secure enough to prevent it from loosening and becoming a projectile risk inside the vehicle; and (3) whether the kit was mounted in a manner that did not obstruct the driver's vision. USPS began its inspection and review on or about March 15, 2021, and approved the kits for installation on April 12, 2021.

Figure 5. This picture shows the kit mounted in an LLV.

Speed testing and remote-control apps (Smartphones Only).

Commission staff tested several speed test applications, assessing how often each application performed speed tests, the metrics each application reported, the consistency of each application's performance, how well the application worked with macros and remote access software, and how the application allowed retrieval of test results.[17]

Based on its review, staff chose to download for use on the smartphone devices several speed test applications during the pilot testing: 1) the FCC Speed Test app, an active speed-test app that measures download and upload speeds; 2) Cell Audit, another active speed-test app developed by SamKnows (the FCC's Speed Test app vendor) to measure download and upload speeds; and 3) SigCap, a passive sensing app developed by researchers at the University of Chicago, that collects signal strength and frequency of operation and identifies the cellular and Wi-Fi signals the smartphone receives. Based on internal testing, staff chose to use both active speed-test apps and the passive sensing app to provide a complete picture of broadband coverage. The active speed-test apps provided consistent download and upload data rate measurements at regular time intervals. The passive sensing app recorded consistent measurements of the radio performance metrics through the Application Programming Interface on the smartphones every ten seconds, from which data staff could extract information about the signal strength of not only the primary spectrum channel but also all of the secondary and neighboring channels from the serving cell and other cells (including the bandwidths of channels being aggregated).

Staff also conducted extensive testing to choose a commercially available remote-control app to be able to

[17] Macros are programmed steps that were used to automate phone operation.

remotely control each smartphone. A critical implementation challenge for the pilot testing, as well as for being able to scale the pilot to a greater number of vehicles, was the imperative to run the testing apps without requiring any involvement from USPS employees. The objective for Commission staff was to be able to remotely control the operation of the smartphones in each kit to turn the testing apps on and off during the day and to monitor whether the smartphones were charging and transmitting data as the vehicles traveled over USPS delivery routes. During field operation, the intent was that staff would halt speed testing on evenings and weekends to reduce the power consumption so that the batteries in each smartphone would not fully discharge (and as noted below, even with these measures, the initial testing uncovered serious power supply problems that drained smartphone batteries and required manual restarts of selected devices by Commission staff).

The remote-control app allowed FCC staff to control the operation of the smartphones and to review and monitor performance of the smartphones and applications in real time. In addition to the remote-control app, staff installed software on the smartphones that enabled them to develop scripts to automatically turn on and off the testing apps on each smartphone based on time of day and similar criteria. The scripts would start and stop speed tests as a function of time and as a function of application of 5V charging power to the mobile device and would repeat speed test measurements at specific intervals. The scripts also checked the smartphones continuously to see that the applications were running and, if they were not running, to turn them back on. The software was an essential element of automating the testing process as staff used it to revise the apps' default settings to perform tests during defined periods each day. The spectrum sensors were programmed with their own scripts to take spectrum signal strength measurements at regular intervals.

Assembly of kits. Over the course of three weeks, staff completed the loading of the speed test and remote-control software on all of the test smartphones, and assembled the remaining kits. Five of the seven completed kits consisted of a protective case with three smartphones, a spectrum sensor, MiFi device, and power accessories, including a DC converter and USB cables, and a lock to secure the contents. The two remaining kits contained the same equipment except for the spectrum sensor due to unavailability of the Notre Dame sensors for these kits. Commission staff modified each protective case to house the equipment and to provide a means of connecting power wires to USPS vehicles. Staff also modified each case to attach antennas to allow operation of the spectrum sensor. While the kit's initial design had two RF antennas mounted on the top of the kit for the spectrum sensor, staff subsequently determined that the spectrum sensor needed only one RF antenna. The RF antenna and one Global Positioning System antenna were attached to the outside of each case for the spectrum sensor. Staff riveted a flat piece of metal to the top of each case and attached the antennas to each case via magnets. Additionally, to ensure that the testing equipment did not overheat in the case, staff drilled ventilation holes in each kit.

The radio transmitters in each case consist of the smartphones, the MiFi unit, and the Wi-Fi dongle that is attached to the spectrum sensor. The smartphones transmit and receive cellular signals as they measure the performance of each cellular network. The MiFi unit transmits and receives cellular signals and connects to the sensor device via a Wi-Fi data connection. The spectrum sensors use these MiFi units to transmit data back to servers at a predefined time interval. A DC converter in each kit produces a +5V DC output to the 4 USB (2 Amps each) connectors in each case. When the kit is turned on, the converter provides a slow charge rate for all connected battery-powered devices. The DC power is applied through a cannon connector socket that is fed through a 5-amp automotive slow blow fuse stored underneath the protective foam in the case. Following the fuse, the voltage is applied to the DC converter. From there, all connections to the internal devices are made via commercial USB cables and connectors. Based on this configuration, the devices in the kit only receive battery charge when the USPS vehicle ignition switch is turned on or in the accessory position.

Once the remaining kits were fully assembled, they were shipped to USPS facilities in Colorado for installation in USPS vehicles. USPS and Commission staff completed installation of the kits in seven LLV vehicles.

Data collection route plan. The Commission and USPS coordinated to develop a data-collection plan for the pilot. Teams from each agency reviewed mapping and demographic data to focus testing on delivery routes covering a variety of urban, suburban, and rural areas, households with a range of income levels, and varying terrains. Based on their review of available delivery routes, the teams created a data-collection plan under which USPS would collect data over the course of three weeks from 28 routes in Longmont, CO, and one route in Denver, CO. The plan provided for installation of the kits in seven USPS LLV delivery vehicles. Those vehicles rotated through the 28 routes in the Longmont CO, area until data were collected for each route. For each route, data was being collected for approximately three days. After collecting data in the Longmont area for two weeks, one kit was shipped to Denver, CO, for installation in a 2-Ton delivery truck for data collection in the downtown Denver area. The data-collection plan included procedures for retrieving the testing equipment after the testing was completed.

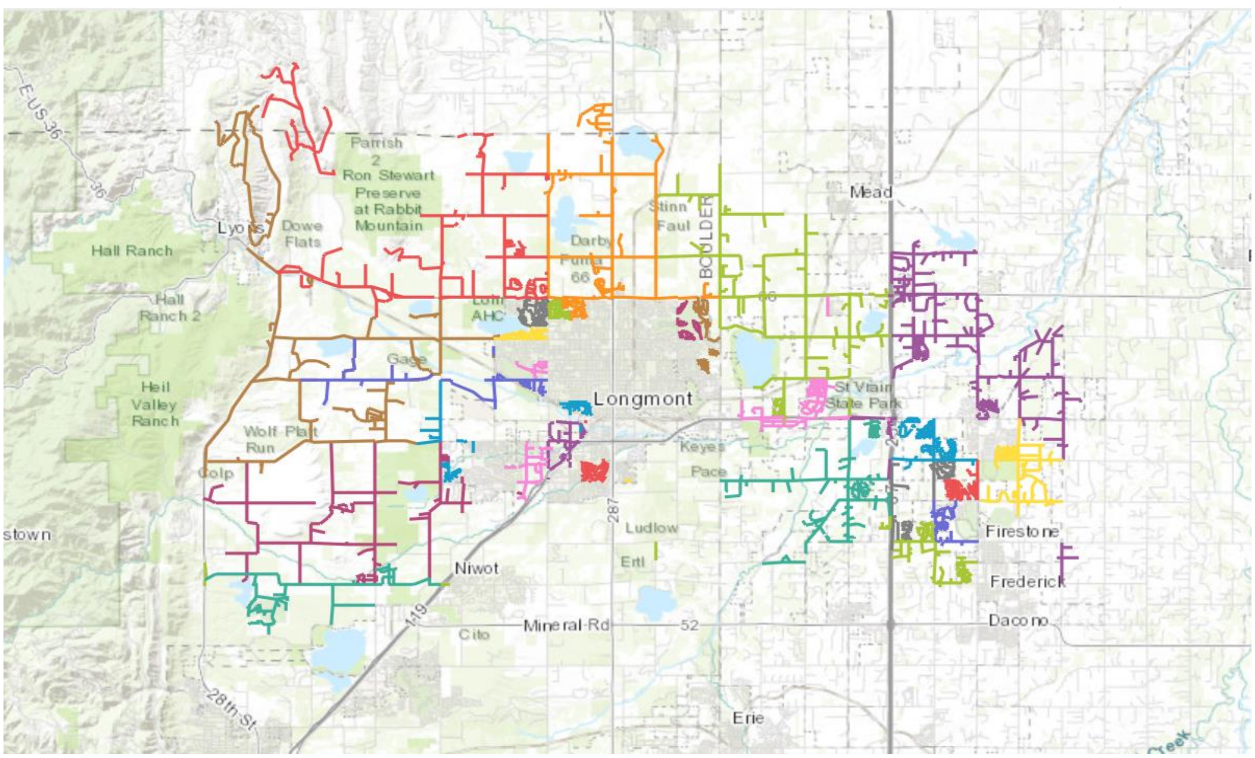

Figure 5. Longmont Routes.

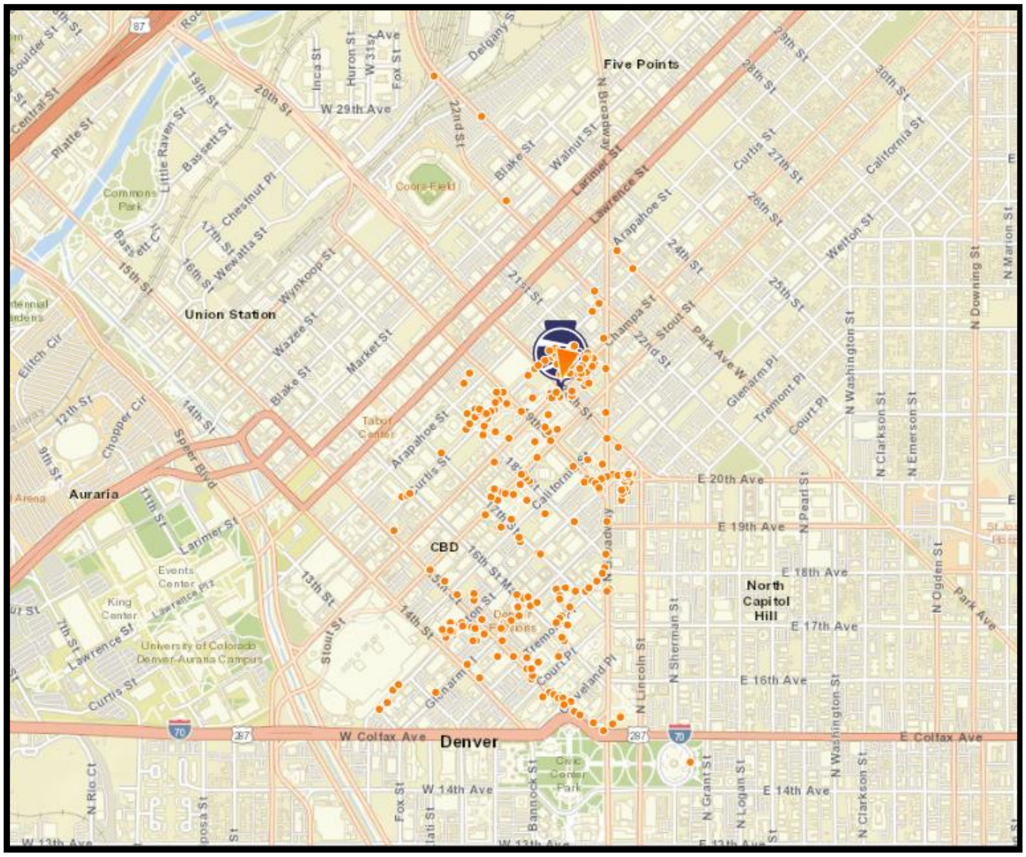

Figure 6. Denver Collection Area as shown by the orange dots.

Initial testing. Data collection began on April 22, 2021. The plan was for the 21 smartphones and 5 spectrum sensors to collect data from 8:45 a.m. to 6:15 p.m. MDT, with speed tests running at one-minute intervals. A serious technical implementation issue arose on the first day of testing when, although the smartphones were connected to the vehicle battery through the vehicle ignition switch and charged continuously while the vehicle ignition switch was turned on or in the accessory position, the batteries on several devices completely drained during travel over USPS delivery routes by the end of the day, thereby preventing those devices from collecting measurements. (Given that the spectrum sensors did not include a battery, they only collected data while the vehicle was turned on and did not have the same power issues as the smartphones.)

As part of the process to understand why the phone batteries were not maintaining a charge, Commission staff worked with USPS staff at the testing location to reexamine the kits. Staff focused on examining the connections between the wire running from the vehicle's battery and the power cables in the kits, and the connections in the kits between the USB cables and the smartphones. Staff also examined the amount of power that was available from each vehicle's battery.

After investigation, Commission staff determined that the fundamental issue was that the delivery vehicles were turned off for longer amounts of time than was anticipated. After the first day of testing, it was learned that, at some times during the day, USPS vehicles were turned on for just a few minutes before being turned off for a longer period, such as 20 minutes, throughout the day while the carrier makes deliveries to multiple addresses within walking distance or to a cluster of mailboxes in the same area. The tests suggested that vehicles could be off as much as 75% of time during the delivery process.

During those times the devices were being drained but not charging. The first day of the pilot demonstrated that such “park and loop” delivery stops along the route were long enough to prevent the smartphones’ from maintaining the charge needed to take nearly continuous speed test measurements throughout the day. Moreover, because the smartphones powered off when the battery drained they needed to be manually restarted by a Commission staff member before they could resume testing.

Staff worked to remedy the situation first by investigating methods to reduce device power consumption. Staff determined that the remote-control software on the smartphones was drawing excessive battery power and preventing the phones from charging effectively, even though the smartphones were connected to the vehicle battery and the vehicle ignition was tuned on. To address the issue, staff worked with the vendor and downloaded a software patch to change the settings to optimize battery performance. This provided some improvement but there were still power deficits at the end of each day such that a fully charged smartphone would only last a few days of normal operation before running out of power. To further address the issue, Commission staff worked with USPS to test the feasibility of rewiring one of the vehicles so that the kit was connected directly to the vehicle battery instead of connecting to the battery through the vehicle ignition switch. This configuration allowed the smartphones to charge continuously rather than charging only when the vehicle ignition switch was turned on or turned to the accessory position. To help limit the current draw, staff halted the data collection during nighttime hours so that the smartphones were idle and using little current. The testing on one vehicle established that rewiring the kits in this manner did not drain the vehicle battery through an overnight period. The remaining LLVs were rewired to provide continuous power to the kit.

To further ensure that the testing equipment did not drain the vehicles’ batteries over weekends during the testing, from the end of deliveries on Saturday until the start of deliveries on Monday, staff decided to remotely turn the spectrum sensors off, as well as making phones idle, during this period. Although the sensors could be turned off remotely, they could only be restarted manually. Therefore, Commission staff had to visit the equipment kits and manually restart the spectrum sensors on Monday morning before the vehicles departed. The power supply solutions that were undertaken to enable testing to continue would need to be resolved in order to establish such a measurement methodology on a broader scale. A reliable power supply that would assure that vehicle batteries would not be adversely impacted would need to be developed and approved by USPS, and the shut down and manual restart of devices over weekends would ideally be eliminated through automation. The cost of personnel time of having to restart devices after a weekend would not be conducive to wide scale deployment with the testing configuration deployed for this trial.

Staff also discovered that a few smartphones were turning themselves off because they were overheating on warmer days. To address this problem, staff drilled additional ventilation holes in each kit and removed some of the interior foam so as to enable better airflow through the box. These changes were largely successful at preventing overheating, and enabled data collection to continue with only an occasional heating related shutdown on very warm days. Thermal analysis and associated design changes along with further testing across a range of regions would need to be conducted in order to deploy electronic equipment in vehicles for extended periods. Despite the challenges, staff collected data measuring mobile wireless broadband coverage along the planned USPS delivery routes.

<u>Conclusion</u>:

The Commission and USPS worked collaboratively to establish the pilot, completing the design, engineering, and mechanical work needed to equip seven USPS delivery vehicles with speed-test appequipped smartphones and spectrum sensing equipment and begin the autonomous data collection process. Data collection began on April 22, 2021 and was completed on May 15, 2021. Notwithstanding the limitations imposed in the pilot study by the power supply and other constraints, the data collection effort delivered a large amount of throughput and other network performance metrics data for three service providers whose networks were tested. We are carefully analyzing the collected data to assess whether it is possible to design a program with a more limited range of testing hardware that would address the identified equipment and power issues but could nevertheless obtain valuable data for purposes of verifying certain of the data collected pursuant to the Broadband DATA Act and possibly for other Commission programs and enforcement purposes.

In carefully analyzing the data, the Commission is continuing to gain insights about how to structure efficient drive testing using USPS vehicles, including how many speed test measurements and other network performance metrics are needed over a particular time or distance to accurately measure coverage and validate carrier-provided maps. In addition, we anticipate that the data analysis will provide quantifiable insight on the value of repeating speed tests on a defined route over time as an effective means of assessing coverage.

As described above, however, there are several significant technical and logistical challenges that must be overcome before the Commission can implement a nationwide drive testing program with USPS. These include:

- Unless a device is identified or becomes available in the future that would enable the Commission to test the throughput of multiple local providers, each kit in each delivery fleet vehicle used for testing would need to include separate smartphone test devices for each locally-available mobile provider, and subscribe to data plans for each such provider that would accommodate a huge amount of test data and therefore entail significant up front and ongoing costs per unit. Having multiple devices would also impact the size of the testing kit and therefore implicate the important vehicle safety limitations imposed by USPS and the imperative not to impinge on the limited work space available for the mail being delivered, the amount of power needed to recharge the units, required ventilation for the kits, and the equipment costs of each kit. Needing to have a separate device for each mobile provider also likely limits the number of providers that can reasonably be tested. There may be ways to address these issues. For example, it may be possible to rotate devices among vehicles, or to change providers on a given device (e.g., by changing out SIM cards), although this would imply not measuring each provider's performance on each route every day and require additional personnel resources to manage the rotations and make the equipment changes. Such approaches would increase operational complexity substantially and thus increase operational cost.
- The tests demonstrated that the USPS vehicles can be powered off for a considerable percentage of the day while deliveries are made along their routes, meaning that the smartphone testing devices were unable to recharge sufficiently to power the tests on an ongoing basis. Although Commission staff and USPS technicians developed a workaround power arrangement by enabling the phones to charge on the vehicle batteries even while the vehicle is not running, turning off the devices over weekends (which required manual restarts by Commission personnel), collecting data only when the vehicle is running, and decreasing the number of tests (and therefore collecting less data), the power supply problem would have to be resolved in order for any longer-term arrangement to be feasible. Beyond the power supply issue, the Commission would

need to determine whether frequent starts and stops associated with driving along “park and loop” delivery routes would affect the quality and probative value of the measurement data.

- Additional implementation issues implicated by a broader program should such threshold issues be resolved include, among others, how much testing equipment would be required, whether testing equipment could be rotated among vehicles, and the costs to procure, manage, obtain data plans, and place testing devices on USPS vehicles. We note that USPS relies on contractors’ vehicles in some instances, like an individual’s personal car. To the extent that such contract vehicles are in use in areas that are of more interest to the Broadband Data Collection, for example in more rural or remote areas, there may be additional logistical challenges that the Commission and USPS would need to address.

In sum, at this time, the challenges detailed above are the known obstacles to partnering with USPS or other Federal agencies that operate fleet vehicles to facilitate the collection and submission of coverage data. The Commission is continuing to explore possible solutions to the issues set forth herein and if they can be addressed, the Commission will be in a position to assess the scalability of the pilot framework and evaluate the costs and benefits of undertaking such an effort on a national basis.