



August 3, 2018

Via ECFS

Marlene H. Dortch
Secretary
Federal Communications Commission
445 12th Street, SW
Washington, DC 20554

Re: Wireless E-9-1-1 Location Accuracy Requirements (PS Docket No. 07-114)
Submission of Z-axis Metric and Report (47 C.F.R. § 20.18(i)(2)(ii)(B))

Dear Ms. Dortch:

The wireless industry is committed to working with stakeholders across the 9-1-1 ecosystem to enhance wireless 9-1-1 location accuracy, particularly indoors. On behalf of the nationwide wireless carriers (AT&T Mobility, Sprint, T-Mobile USA, and Verizon) (Carriers), CTIA hereby submits a vertical (Z-axis) accuracy metric, validated by a test bed report (Report),¹ as required by the Commission's *Fourth Report & Order*.² The Report describes the independently administered test bed process used to assess vertical location solutions (Stage Z) and provides the results of the testing. Overall, CTIA and the carriers appreciate the participation of the two vendors who offered their potential Z-axis solutions for evaluation to help inform the proposed Z-axis metric and looks forward to further opportunities to evaluate these and other evolving Z-axis technology solutions.

The Test Bed and Stage Z Testing

Since 2015, CTIA and the carriers have expended significant time and resources to enhance indoor 9-1-1 location accuracy consistent with the *Fourth Report & Order*. On behalf of the carriers, CTIA established a non-profit entity, 9-1-1 Location Technologies Test Bed, LLC (Test Bed LLC), to independently administer testing operations, pursuant to the Commission's requirement of an independently administered and transparent test bed process.³ The Alliance

¹ 911 Location Test Bed, LLC Report on Stage Z, attached hereto (Report).

² *Wireless E911 Location Accuracy Requirements*, Fourth Report and Order, 30 FCC Rcd 1259, ¶ 116 (2015) (*Fourth Report & Order*); 47 C.F.R. § 20.18(i)(2)(ii)(B).

³ 47 C.F.R. § 20.18(i)(3)(i) (CMRS providers must establish a test bed to validate indoor location technologies "through an independently administered and transparent test bed process").



for Telecommunications Industry Solutions' (ATIS) Emergency Services Interconnection Forum (ESIF) timely established standards for testing, including Stage Z, and served as the independent Program Manager of the Stage Z testing process, while Further Enterprise Solutions (FES) served as the independent Administrator/Executor.

In accordance with the *Fourth Report & Order* and applicable testing standards and protocols, Test Bed LLC has executed numerous stages of testing with many different technologies, throughout multiple test regions covering four different geographical areas (i.e., morphologies), and dozens of building types with hundreds of test points. Even after submission of this Report, Test Bed LLC will remain an independently administered resource to continue evaluating indoor wireless 9-1-1 location accuracy technologies.

The objective of Stage Z testing was to provide a rigorous, transparent framework to test emerging vertical location technology solutions and to develop a proposed Z-axis metric. Stage Z is the only test campaign specifically designed to evaluate the performance of Z-axis technologies for this purpose.

After an open call to any Z-axis technology vendors, two technology vendors, NextNav and Polaris Wireless, elected to participate in Stage Z. NextNav's location technology solution uses its Metropolitan Beacon System (MBS), a wireless network that is deployed using Part 90 Multilateration Location and Monitoring Service (MLMS) licenses. NextNav beacons, where deployed, broadcast information required for the 9-1-1 caller's device to compute a more precise location estimate. Polaris Wireless's Hybrid Location Engine (HLE) location technology is a software-based solution that collects data from the 9-1-1 caller's device and applies proprietary algorithms to generate a Z-axis location estimate.

In accordance with ATIS standards, Stage Z testing was conducted in the dense urban, urban, suburban, and rural morphologies of the Atlanta, San Francisco, and Chicago regions. Testing was conducted in 48 buildings of a wide variety, using 312 test points. Testing involved 30 smartphone devices, including 12 different handset models, and produced over 100,000 location estimates (i.e., fixes). (Report at § 11.1) However, as explained further below, only one vendor participated in all of the regions and morphologies. Comprehensive testing of Z-axis solutions in all regions and morphologies is necessary to confirm performance in live 9-1-1 calling environments.

Stage Z Results and Outstanding Questions

The Report finds that the Stage Z results provide helpful data, but it also notes that significant questions remain about performance and scalability for live 9-1-1 call environments. While the Report is not intended to support a comparison of the tested solutions, each of the



two vendors' solutions stopped short of testing in a comprehensive manner. Thus, key questions remain as to how and whether the results can be replicated and deployed ubiquitously in real-world production and live 9-1-1 call environments, including:

- **NextNav Testing Did Not Include the Stage Z-specific Chicago Region or Rural Areas:**
 - NextNav has not deployed its MBS network in Chicago. Notably, according to recommendations from ATIS, the Chicago test region was selected for the purpose of providing a more extreme weather environment to evaluate Z-axis technologies, including fluctuating indoor-outdoor temperature and pressure differences on barometric pressure sensor-based technologies. (Report at § 1) Therefore, NextNav's solution could not be tested with more extreme weather conditions.
 - In addition, NextNav "is not deployed in rural areas and therefore was not tested in Rural morphologies." (Report at § 9.2.5)
- **Polaris Wireless Testing Did Not Include Apple's iPhone:** Stage Z testing on Polaris Wireless' solution included six different device models but no iPhone. (Report at § 8.5.2.1)
- **Active Calibration of Unique Device Barometric Sensor Bias:** Stage Z results reflect that sensor bias is the dominant error source for estimating altitude.⁴ The test results also showed that each individual mobile device is subject to its own unique sensor bias and thus requires individualized active barometric sensor bias calibration. Adjusting for sensor bias on an individualized device-by-device basis proved manageable when dealing with dedicated application software (apps) running on six test handsets, but this calibration capability would need to be built into live production solutions, with signaling based on standards, and retested at scale to fully assess performance. (Report at § 1) It is, therefore, unclear whether the Stage Z performance results would be replicated in a live 9-1-1 calling environment.
- **Testing Did Not Include a Variety of Device Types or Extreme Weather:**
 - Barometer manufacturers have indicated that accuracy degrades as the sensors age. However, because older devices could not support the apps provided by NextNav and Polaris Wireless, only relatively new handsets – released more recently than mid-2016 – were tested. (Report at §§ 7.2, 7.4.5, 11.3) Among other

⁴ Sensor bias refers to the potential for measurement variability of the barometric pressure sensor within an individual handset over time, such as noise, drift, temperature and age. (Report at § 11.4.1)



reasons, the Report recommends further testing of sensor performance with a variety of device types and functionality.

- Although Polaris Wireless tested in Chicago in the winter, the lack of extreme weather conditions at the time of testing leaves open questions about the reliability of compensated barometric-pressure-based solutions in such conditions. (Report at §§ 9.4.4, 11.1.1)
- **Commercial Availability:** The Report observes that, “to evaluate these two technologies, some artificial steps and accommodations had to be taken to produce the location estimates in the test campaign.” (Report at § 11.3) Indeed, Stage Z testing “essentially perform[ed] a ‘proof of concept’ test.” (Report at § 11.1.1.) No actual calls were placed to produce any Z-axis fixes, and standardized 9-1-1 signaling was not used. Each vendor used its own dedicated app with “all permission requests allowed” (i.e., the app had unrestricted access to the barometric pressure sensor), which is not consistent with commercial practice. (Report at §§ 8.5.1.2, 8.5.2.2) For these reasons, barometric pressure sensor-based Z-axis solutions require further development, potentially including further standardization efforts, implementation into wireless network systems and production mobile devices, and then re-testing in a production configuration to determine whether the Stage Z results can be replicated and deployed ubiquitously in real-world production and live wireless 9-1-1 call environments. Further, additional factors are likely to limit the availability of barometric pressure sensor based Z-axis solutions, including lack of support for existing mobile wireless devices.

Proposed Metric Based on Stage Z Testing

The *Fourth Report & Order* directed the Carriers to use a “test bed process to develop a proposed Z-axis accuracy metric.”⁵ Section 20.18 of the Commission’s rules requires that the proposed metric be “validated” by the test bed, and that the Carriers submit the metric “supported by a report of the results of such development and testing.”⁶

Applying the results from Stage Z, CTIA on behalf of the Carriers submits a Z-axis metric of +/- 5 meters for 80% of fixes from mobile devices capable of delivering barometric pressure sensor-based altitude estimates. As noted, NextNav, whose testing produced 80% of fixes at 1.8 meters or less, did not test in one of the three test regions or in any rural morphologies. Polaris Wireless, whose testing covered all three test regions and all

⁵ *Fourth Report & Order* ¶ 116.

⁶ 47 CFR § 20.18(i)(2)(ii)(B).



morphologies, produced 80% of fixes at 4.8 meters or less. Stage Z testing did not demonstrate that more accurate results can be consistently achieved across all testing regions, morphologies, weather conditions, and devices by the August 3rd, 2018 filing deadline in the *Fourth Report & Order*.

The Test Bed invited NextNav and Polaris Wireless to submit accompanying statements to the Report, and each vendor offered results obtained outside of Stage Z testing. As such results were not obtained through Stage Z testing, the nationwide wireless carriers cannot rely upon those results to inform a recommended Z-axis metric.⁷ As explained below, Stage Z demonstrates that further testing is needed to validate performance and scalability of barometric-pressure sensor based Z-axis solutions for the commercial environment and, importantly, live wireless 9-1-1 calling.

Recommendations and Next Steps

In sum, the Report finds that the Stage Z results provide helpful insight to the state of barometric-pressure sensor based Z-axis technologies, but it also demonstrates that significant questions remain about performance and scalability in live wireless 9-1-1 calling environments. The vendors' accompanying statements to the Report diverge on key findings and, of relevance to next steps, they do not agree on the primary source of vertical error. Polaris Wireless concurs with the Report, observing that "[o]ne of the most significant sources of error for barometric sensor-based location solutions ... is bias in the device barometric sensors."⁸ But NextNav disagrees, questioning the Report's "assertion that the dominant source of error was sensor bias calibration" and asserting instead that "[w]eather is the dominant source of altitude measurement error and variability."⁹ The vendors' conflicting views regarding the results of the Stage Z testing underscore the need for additional testing to develop a more common understanding of the capabilities of existing and forthcoming Z-axis technologies.

For example, other approaches to Z-axis location estimates are emerging that rely primarily on enhanced Wi-Fi positioning technologies, and only secondarily on compensated barometric pressure (where available). These solutions may address some of the issues inherent to barometric pressure sensor-based systems, such as backward compatibility to existing handsets. A few vendors of the enhanced Wi-Fi positioning technologies have indicated the likely availability of their solutions for testing within the next calendar year.

⁷ *See id.*

⁸ Polaris Wireless Commentary on Stage Z Testing and Report at 1.

⁹ NextNav Comments on Z-Axis Test Bed Results/Recommendations at 3.



For these reasons, further testing is needed to validate and confirm performance expectations of Z-axis solutions for live wireless 9-1-1 calling environments. While Stage Z results provide support for a metric of +/- 5 meters for 80% of fixes, additional testing may yield results that validate adoption of a more accurate metric. CTIA and the Carriers encourage the Commission to support additional Stage Z testing within the next calendar year, covering these technologies and other approaches including enhanced Wi-Fi positioning technologies, prior to adopting a final Z-axis metric.

Sincerely,

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