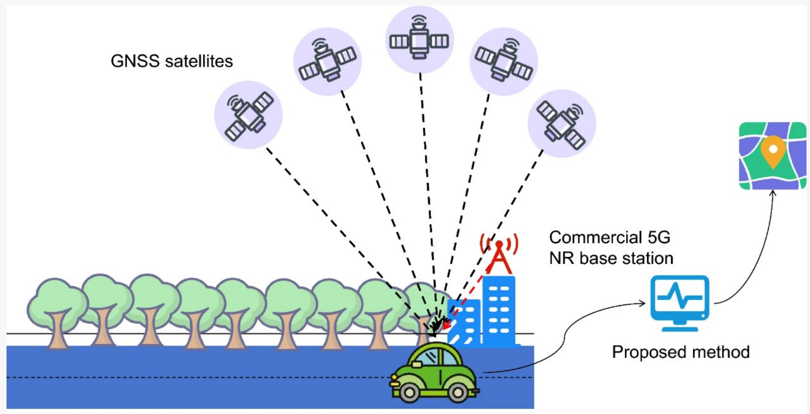
When satellites fall short: how 5G and GNSS team up for reliable urban positioning

GA, UNITED STATES, December 27, 2025 /EINPresswire.com/ -- Finding accurate locations in dense cities has long challenged satellite-based navigation, where tall buildings and signal blockage often lead to large errors or complete service loss. A new study presents a deeply integrated positioning approach that combines commercial 5G New Radio (NR) signals with Global Navigation Satellite Systems (GNSS) to overcome these limitations. By strengthening 5G signal tracking and deeply fusing it with satellite measurements, the method significantly improves both ranging stability and positioning accuracy. Real-world tests show that the system maintains reliable performance even in heavily obstructed environments and when only a few satellites are available, offering a promising solution for robust urban navigation.



Deeply integrated fusion of commercial 5G NR multi-beam signals and GNSS.

GNSS technologies underpin modern navigation, from smartphones to autonomous vehicles, but their reliability drops sharply in urban canyons, shaded streets, and complex outdoor environments. Traditional solutions often rely on inertial sensors or vision-based systems, which add cost, computational burden, or sensitivity to environmental conditions. Meanwhile, commercial 5G networks are rapidly expanding worldwide, providing dense infrastructure and wide bandwidth that are attractive for positioning. However, practical challenges—including multipath interference, clock bias, and complex multi-beam transmissions—have limited their real-world use for navigation. Based on these challenges, there is a clear need for an integrated approach that can fully exploit 5G signals while compensating for the weaknesses of satellite navigation.

In a study published (DOI: 10.1186/s43020-025-00183-8) in Satellite Navigation in 2025, researchers from Wuhan University, The Chinese University of Hong Kong (Shenzhen), and Shandong University of Science and Technology report a new positioning framework that tightly integrates commercial 5G NR signals with GNSS. The approach is designed to improve navigation reliability in urban environments where satellite signals are frequently degraded. By combining advanced 5G signal tracking with real-time fusion of satellite and cellular measurements, the system delivers more accurate and stable positioning under real-world conditions.

The research introduces a deep fusion strategy that enhances both signal tracking and positioning estimation. At the signal level, the team developed a method that jointly uses 5G synchronization and reference signals to stabilize tracking in environments affected by multipath interference. This design substantially reduces ranging errors compared with conventional 5G-only approaches. To further improve performance under weak signal conditions, a phase-stabilized Kalman filter was incorporated into the tracking loop, helping maintain accurate carrier phase estimates even when signal quality drops.

Beyond signal processing, the study applies an extended Kalman filter to deeply fuse 5G and GNSS measurements. Unlike loosely and tightly coupled methods, the fused position and clock estimates are fed back to correct the 5G tracking process in real time. Field experiments conducted in complex outdoor environments show that this deep integration significantly improves positioning accuracy in both horizontal and vertical directions. Importantly, the system continues to deliver reliable positioning when satellite visibility is severely limited—conditions under which conventional GNSS solutions often fail. These results demonstrate the practical value of combining 5G and satellite navigation in real urban settings.

“This work shows that commercial 5G signals can do much more than support communication,” an author of the study said. “By deeply integrating 5G with GNSS and addressing real-world challenges such as multipath and clock errors, we demonstrate a practical pathway toward reliable urban positioning. The key advantage is robustness—our system continues to work when satellite-only solutions struggle. This opens new possibilities for navigation in cities, where reliable positioning is often the hardest to achieve.”

The findings point to a wide range of applications in urban navigation and location-based services. Autonomous vehicles, delivery robots, smart transportation systems, and connected infrastructure could all benefit from more reliable positioning in challenging environments. Because the method leverages existing commercial 5G networks, it can be deployed without major changes to current infrastructure. As cities become more connected and navigation demands increase, deeply integrated 5G–GNSS solutions like this one may play a key role in enabling safe, accurate, and continuous positioning for next-generation intelligent systems.

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