CARLSON VIKING
Technology White Paper

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Carlson Software, Inc.

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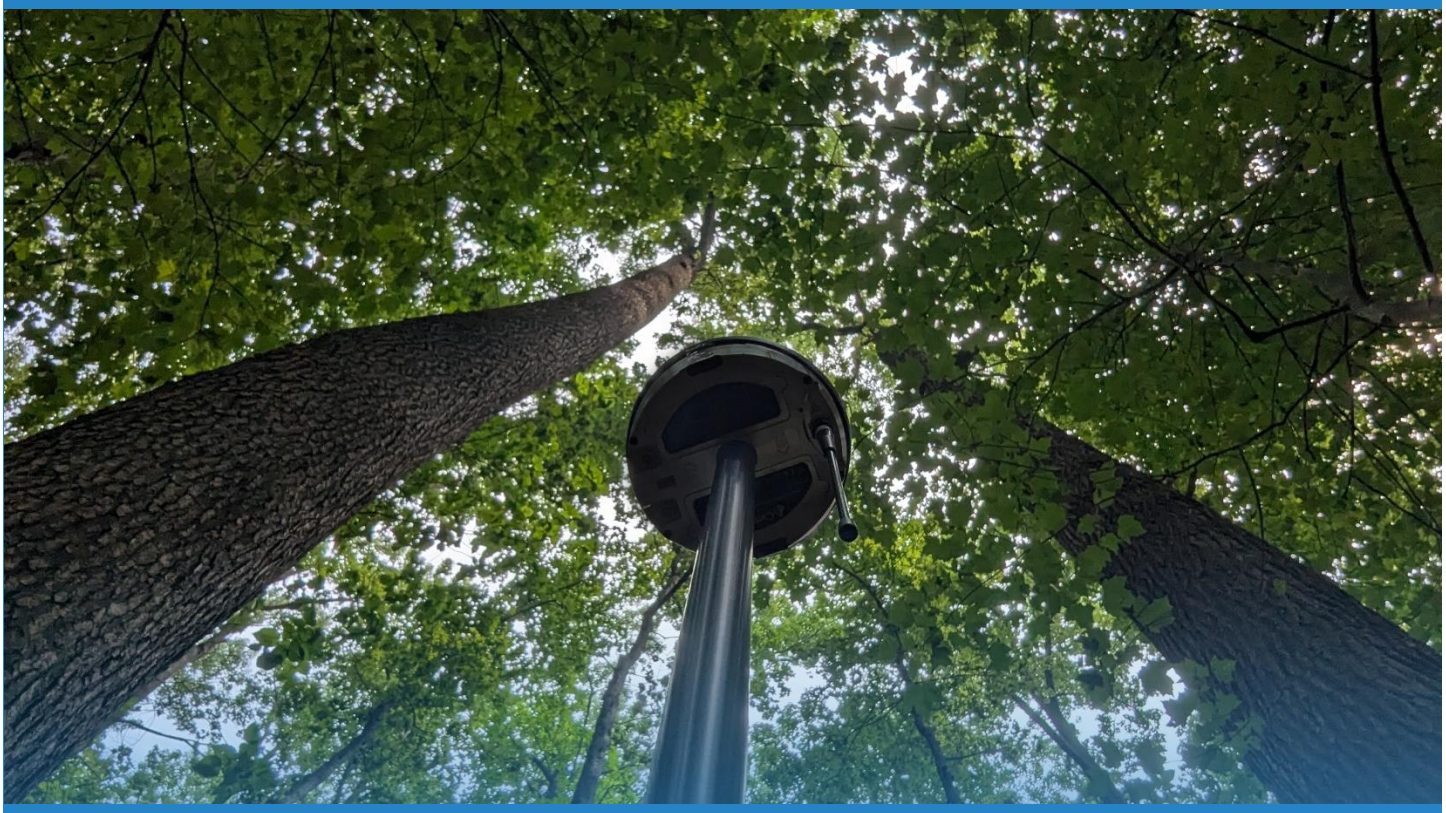


ABSTRACT

Carlson Software's Navigation Division is proud to present its next generation GNSS Smart Antenna product, the Viking RTK Receiver.

This paper provides an overview of the main technologies deployed in the new Viking RTK Receiver to deliver best-in-class performance as tested in the field. This paper also includes a summary report on competitive RTK performance testing of the Viking RTK Receiver.

EXECUTIVE BRIEF

The Carlson Viking RTK Receiver is our next-generation GNSS Smart Antenna, designed to deliver unmatched accuracy and reliability in every environment.

THE CHALLENGE

Surveyors, engineers, and GIS professionals face tough conditions: dense forests, urban canyons, multipath interference, and even intentional GNSS jamming. Traditional RTK receivers often lose accuracy, forcing costly delays and rework.

THE VIKING ADVANTAGE

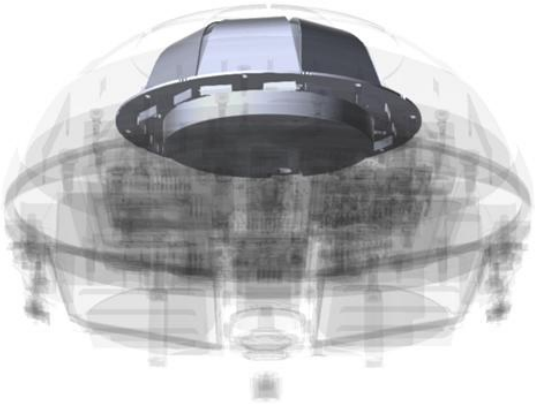
- ✓ Triple-Fixed RTK: Three independent RTK engines ensure reliable RTK accuracy in harsh conditions.
- ✓ Calibration-Free IMU Tilt Compensation: Work faster by measuring points without leveling the pole.
- ✓ Resilience to Disruptions: Advanced anti-jamming, anti-spoofing, and multipath mitigation.
- ✓ Seamless Connectivity: Operates as a base or rover with easy web-based management.
- ✓ With Carlson Hybrid+ (SurvPC/Layout) seamlessly integrate Viking GNSS, robotic laser total stations, and onboard inertial sensors for unmatched precision and reliability.

Metric	Viking RTK	Competitors (Avg.)	Advantage
RTK Fixed Availability*	95–100%	62–75%	+30–52%
RTK Fixed Error* (difficult environments)	3–5 cm	4–17 cm	25–70% lower
Tilt Compensation	Calibration-free, immune to magnetic fields	Limited, requires calibration	Faster, simpler
Resilience	Anti-jam, anti-spoof, multipath mitigation	Basic or none	Higher reliability

** in challenging environments depicted in this paper.*

THE BOTTOM LINE

The Carlson Viking RTK Receiver is built for professionals who demand accuracy without compromise. Whether surveying, mapping, or guiding construction, Viking lets you work with confidence, speed, and resilience.



UNLEASHING GAMA® RTK

Viking features best-in-class HW and unleashes, for the first time, the full potential of Carlson's proprietary GAMA® RTK engine, taking full advantage of Viking's best-in-class GNSS antenna, IMU and powerful multi-core CPU.

TRIPLE-FIXED RTK

For the first time in the industry, Viking integrates two GNSS chips with three independent RTK engines, delivering exceptional accuracy and reliability even in the most challenging environments.

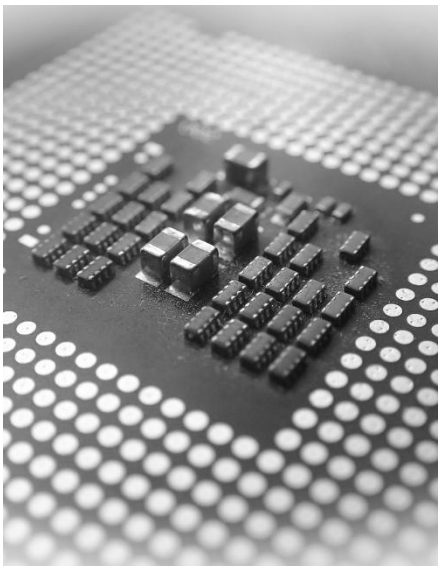
When the GAMA® RTK engine and one of the secondary OEM engines are in agreement, the Viking reports RTK Fixed+. When all three engines achieve RTK Fixed and align perfectly, it reports Triple-Fix (shown as Fixed3).

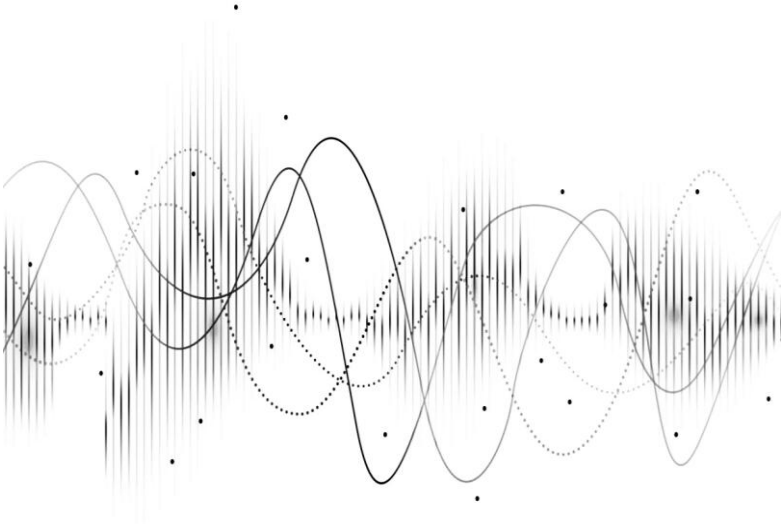
PRECISION, RELIABILITY AND VERSATILITY REDEFINED

Viking is Carlson Software's new ultimate solution for precision positioning. An all-new high-precision GNSS multi-frequency RTK smart antenna, designed to deliver reliable centimeter level positioning together with 3D orientation.

Equipped with a best-in-class GNSS antenna element and an integrated IMU, the Viking provides exceptional flexibility, durability, and automatic pole tilt compensation – **completely calibration-free and immune to magnetic interference**.

The Viking is your ultimate solution for precision positioning, whether as a base station delivering RTK corrections to your existing rover network or as a lightweight, easy-to-use rover. Seamlessly connect the Viking to your base station via UHF radio or a cellular network, and manage every aspect of its functionality through the intuitive, built-in Web User Interface (Web UI).





FOR NEXT-GEN CPUs

Modern CPU architectures enable powerful multi-core computations in embedded and handheld devices.

GAMA® was designed to take full advantage of multi-threaded computation routines, unlocking new possibilities and computational performance.

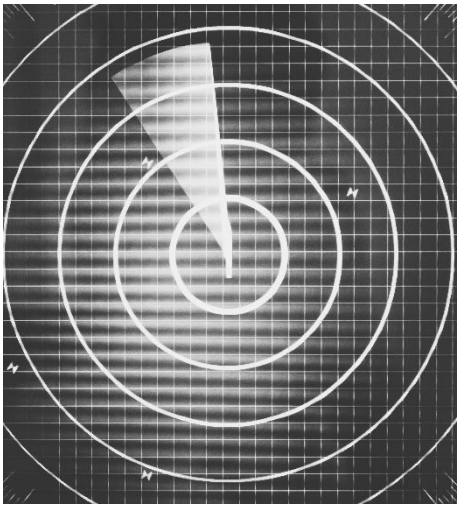
NEXT-GEN FILTERS

At its core GAMA® relies on multiple Extended Kalman Filters that estimate individual error components, for each individual GNSS signal. New CPU architectures enable, for the first time, the deployment of extended mathematical models eliminating approximations that were a necessity of the past. GAMA® can estimate more than 1000 parameters per second to ensure the highest accuracy in every environment.

GNSS SIGNAL AND FREQUENCY DIVERSITY

GAMA® was designed from the ground up to take maximum advantage of all GNSS signals available today as well as those that may become available in the future.

GAMA® implements a strict independent handling of all GNSS signals available in multiple frequencies, including different modulations that signals have available in common GNSS frequency bands. This means, for instance, GAMA® can fully use the legacy GPS L2P and the new L2C simultaneously, for RTK, side by side with GPS L1 and L5. GAMA® can also operate in single-frequency mode, or with any sub-set of frequencies, in case some signals are not available or become jammed. A similar logic applies to all GNSS constellations.



OUTLIER DETECTION AND HANDLING

Multiple protection layers apply a variety of techniques for outlier detection and handling that protect the main estimation process responsible for the high-accuracy PVT computations.

Iterative Robust Statistics and strict statistical analysis is employed to identify measurements that do not fit in the predefined model.

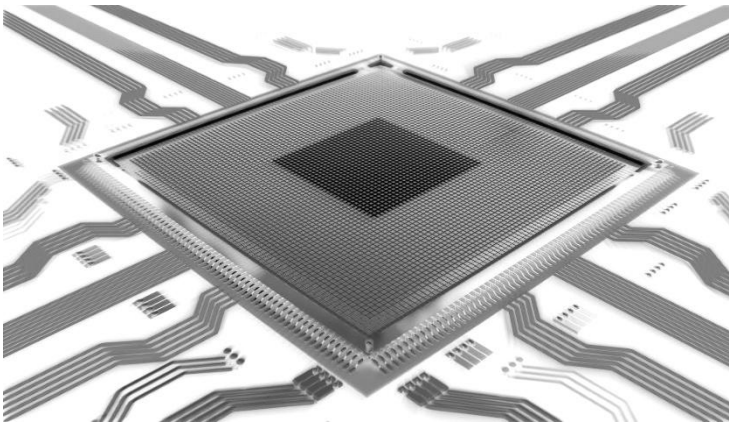
Outlier handling mechanisms respond by either adapting the error models in real-time, allowing use of the affected observation, or by fully rejecting faulty observations if the error is too large to be useful. This logic is applied in the multiple Extended Kalman Filters that comprise GAMA®, as well as at the level of a range of pre-processing filters.

REAL-TIME ADAPTIVE FILTERING

GAMA® employs multiple techniques to ensure all GNSS error models are as accurate as possible, regardless of the environmental conditions and dynamics.

Data-driven error models were carefully derived from a broad pool of real environment data, collected under controlled conditions, and provide a strong basis for all estimation processes within the GAMA® Engine.
To cope with changing conditions of the surrounding environment, a collection of pre-processing filters are used to monitor GNSS signal quality, not only in terms of magnitude of the errors but also its temporal behavior (how effects change over time windows), together with other signal characteristics such as the GNSS signal strength.

Different multi-frequency signal combinations are computed and filtered to isolate unique error sources (e.g., multipath, non-LOS signals, ionosphere) and interpret their magnitude and time behavioral characteristics.
All these metrics are combined to allow real-time adjustment of the GNSS observation models of the main Extended Kalman Filters.



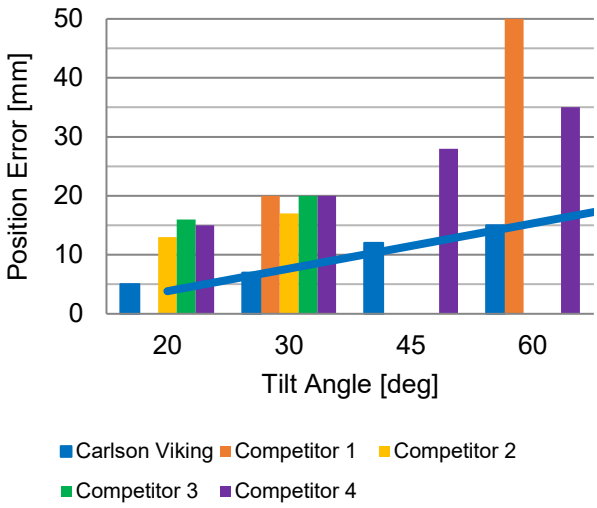
ADVANCED IMU INTEGRATION

Processes data from six-axis inertial sensors for high-accuracy position, velocity, tilt, and heading information

Completely calibration-free and immune to magnetic interference

Life cycle automatic IMU error calibration maximizes integration accuracy and maintains long-term reliability.

Best-in-class tilt compensation



ADVANCED GNSS DSP TECHNOLOGIES

Viking features a variety of technologies at the GNSS Digital Signal Processing level, improving acquisition, tracking but also accuracy and reliability of the GNSS raw measurements offering a first layer of protection for the Carlson GAMA® RTK engine.

Anti-jamming and anti-spoofing protection
Industry-leading interference monitoring and mitigation technology offers resistance against radio interference and protects against intentional GNSS jamming and spoofing.

Optimal tracking under high vibration
Maintaining high accuracy and ensuring resilience to heavy vibrations and shocks.

Resilience to space weather events
Mitigates adverse impact of both normally active and scintillating ionosphere providing stable operation during solar storms.

Multipath mitigation at signal level
Multipath mitigation technology for mitigation of reflected GNSS signals for higher accuracy and reliability. Extra correlators in each tracking channel to estimate the multipath error on the pseudorange and carrier phase measurements.

Competitors include the top-tier RTK smart antenna receivers from top 4 GNSS receiver brands in the USA. Identities were withheld for confidentiality.

More Accuracy

Higher Availability

Triple-Fixed

Carlson

COMPETITIVE TESTING RESULTS

As part of the internal RTK R&D processes, Carlson's internal test team continuously tests the latest version of the GAMA®RTK engine in a variety of diverse environments.

Overall statistics shown in the next sections were directly pulled from the Carlson Test Database which aggregates test results gathered over the last 5 years from the GAMA® RTK engine and real-time results produced by competitors.

Position error statistics were computed versus independent references constructed using a hybrid technique combining robotic total station and GNSS RTK, ensuring an accurate and independent reference even in the most challenging locations near wall and in dense foliage.

PERFORMANCE METRICS

Well defined performance metrics to objectively measure all main quality parameters.

CONTINUSLY TEST AND REPORT

Regular in-field testing to qualitatively test the system from a user perspective and collect data for our test database.

TEST STATISTICS DATABASE

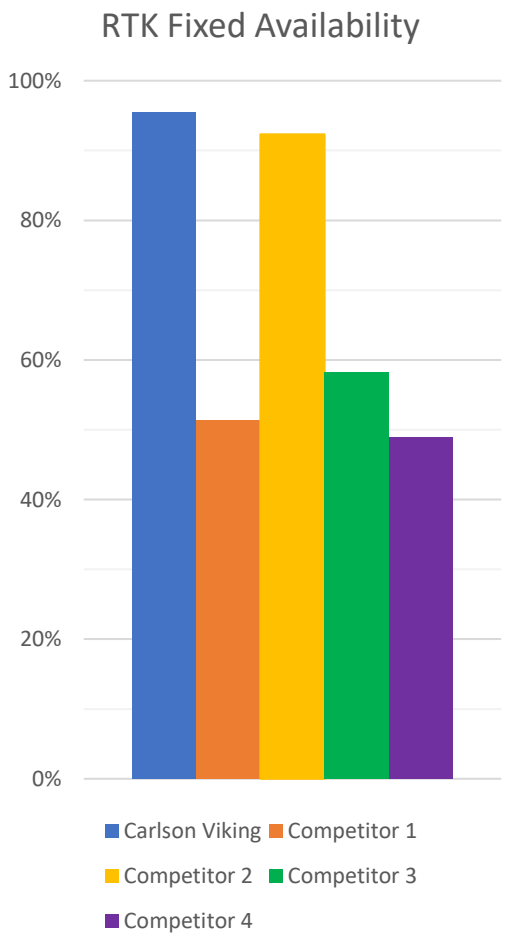
Compile all test results in a single database to monitor evaluation of performance and objectively measure and compare performance.

STOP-AND-GO TEST
PINE TREE FOREST

Competitive testing vs RTK industry leaders in stop-and-go test dynamics within a pine tree forest environment.

9 control points sequentially surveyed multiple times, collecting a total of 207 points for each unit, in stop and go dynamics (total 5 hours test duration).

The test track features a wide range of GNSS challenges with different level of difficulty. Control points were pre-surveyed using hybrid robotic total station and RTK with mm accuracy.

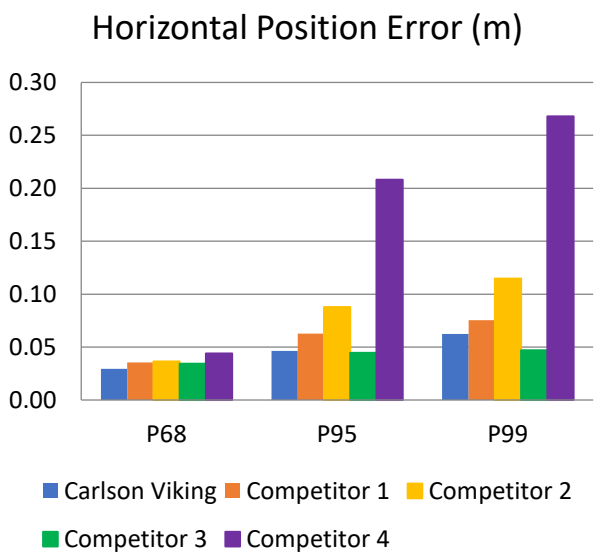


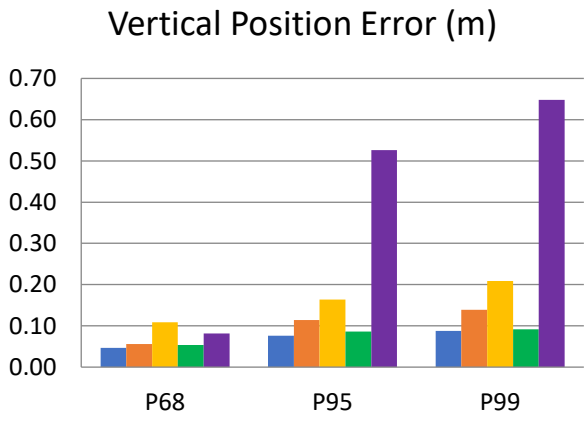
Competitors include the top-tier RTK smart antenna receivers from top 4 GNSS receiver brands in the USA. Identities were withheld for confidentiality.

POSITION ERROR STATISTICS

Viking outperforms competitors in all error percentiles, both for horizontal and vertical domains, while delivering unmatched RTK availability in the most difficult locations:

- P68: 68 percentile (1-sigma confidence)
- P95: 95 percentile (2-sigma confidence)
- P99: 99 percentile (3-sigma confidence)





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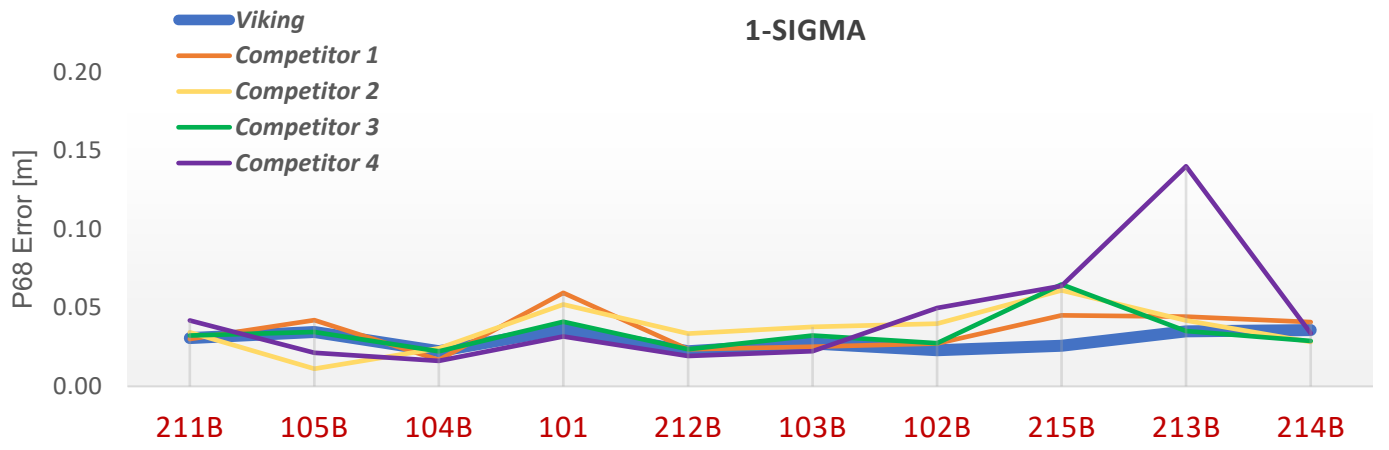
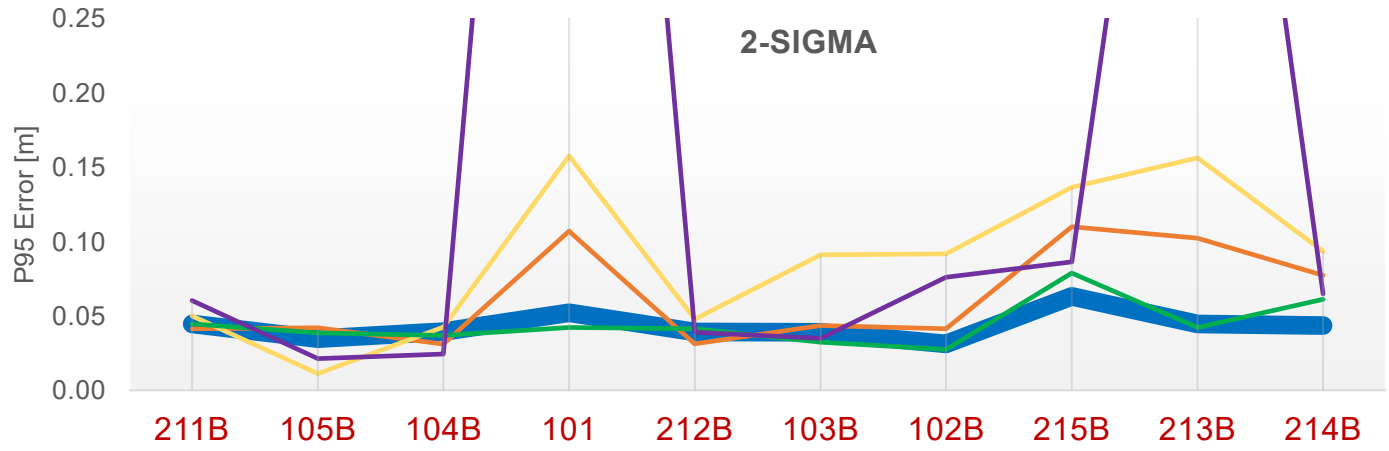
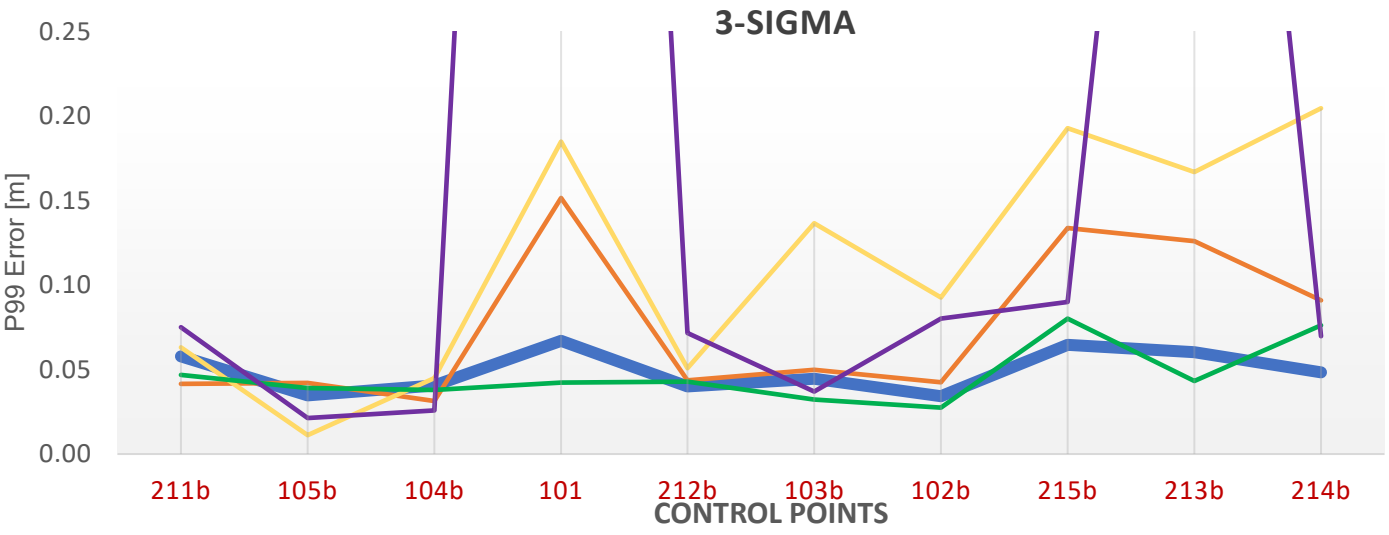
HORIZONTAL POSITION ERROR (M)

(-) DIFFICULTY (+)



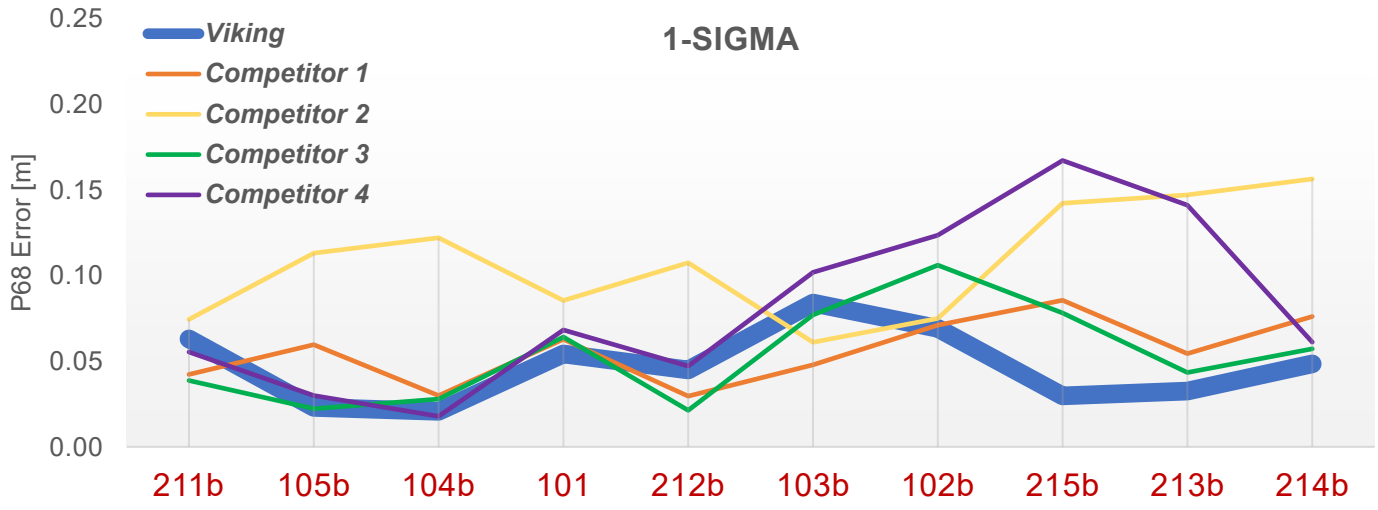


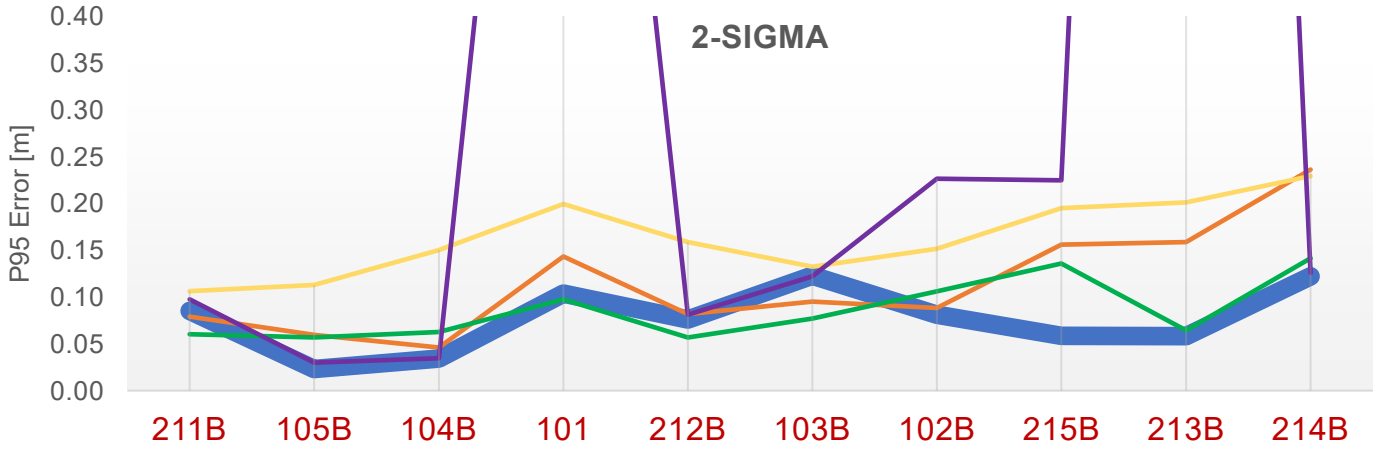


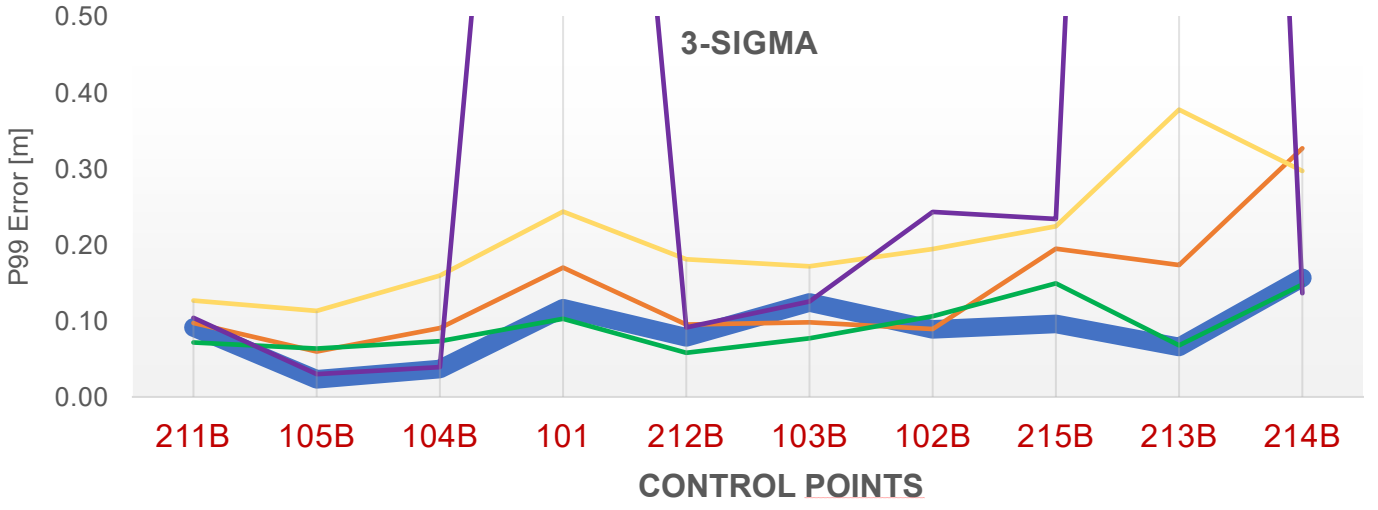
(-) DIFFICULTY (+)

VERTICAL POSITION ERROR (M)

(-) DIFFICULTY (+)



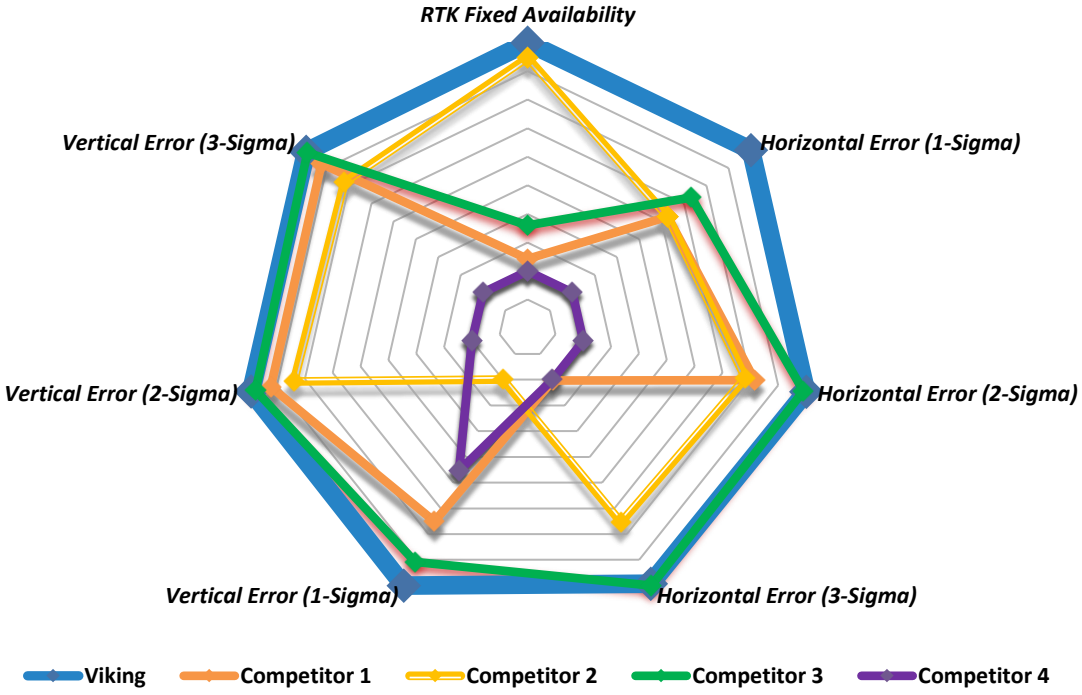




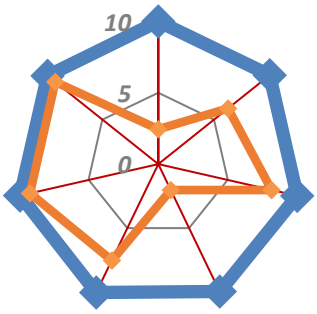
(-) DIFFICULTY (+)

NORMALIZED QUALITY COMPARISON - PINE TREE FOREST

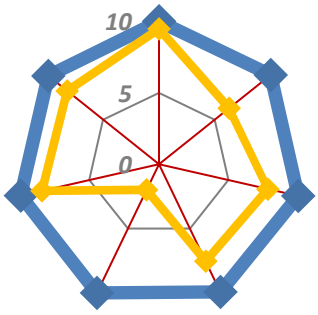
Viking outperforms competitors on every metric



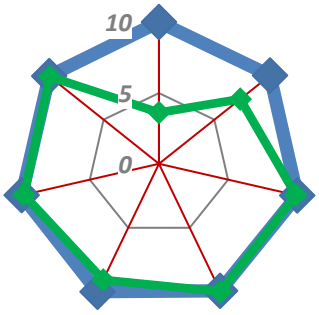
Viking vs Competitor 1



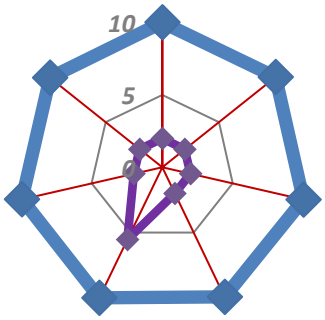
Viking vs Competitor 2



Viking vs Competitor 3



Viking vs Competitor 4



Competitors include the top-tier RTK smart antenna receivers from top 4 GNSS receiver brands in the USA. Identities were withheld for confidentiality.

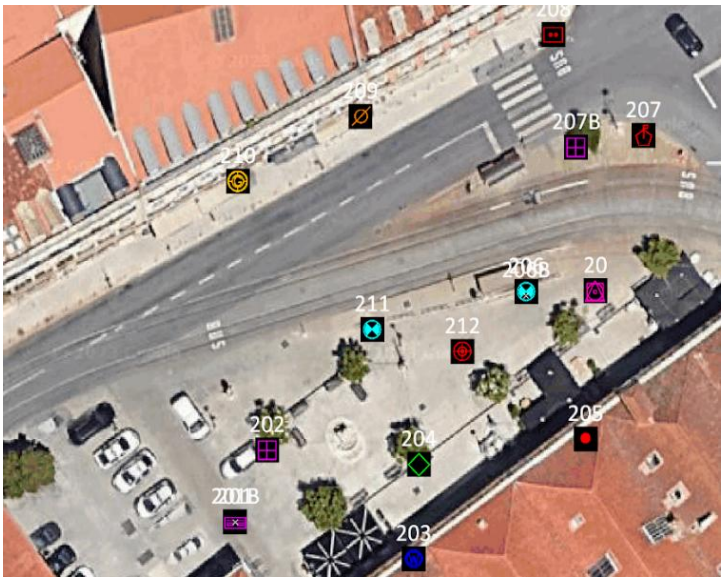
Robust against the elements

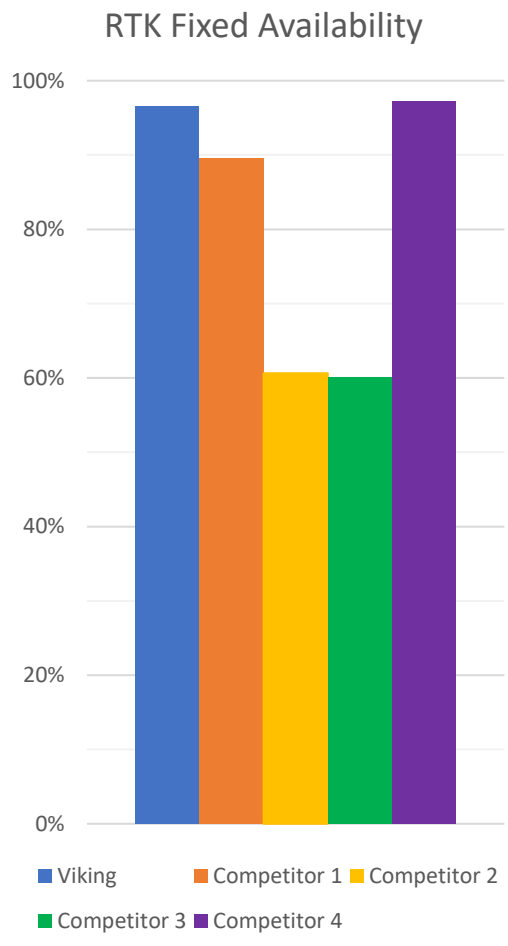
STOP-AND-GO TEST URBAN ENVIRONMENT

Competitive testing vs RTK industry leaders in stop-and-go test dynamics within an urban environment.

12 control points sequentially surveyed multiple times, collecting a total of 144 points for each unit, in stop and go dynamics (total 3 hours test duration).

The test track features a wide range of GNSS challenges with different level of difficulty. Control points were pre-surveyed using hybrid robotic total station and RTK with mm accuracy.





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POSITION ERROR STATISTICS

Viking delivers best-in-class RTK Fixed availability while delivering best accuracy metrics even in the most difficult locations:

- P68: 68 percentile (1-sigma confidence)
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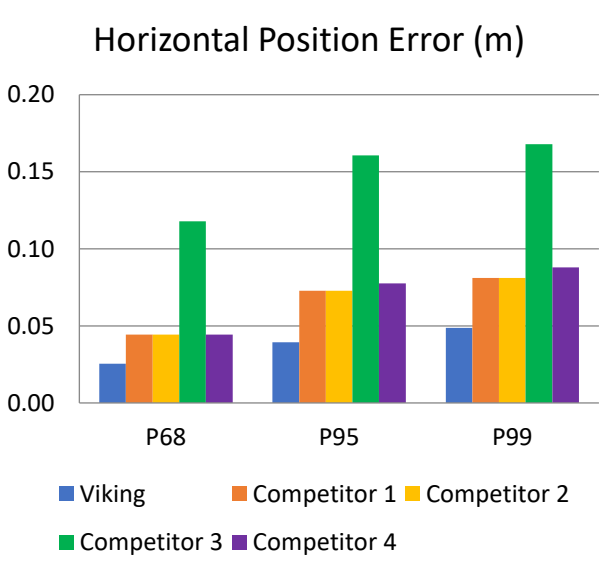
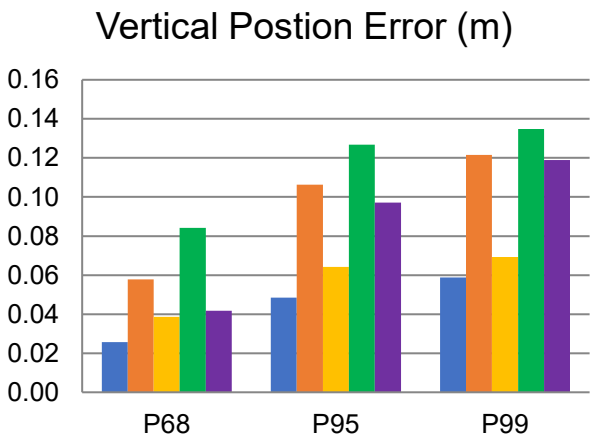
- P99: 99 percentile (3-sigma confidence)





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HORIZONTAL POSITION ERROR (M)

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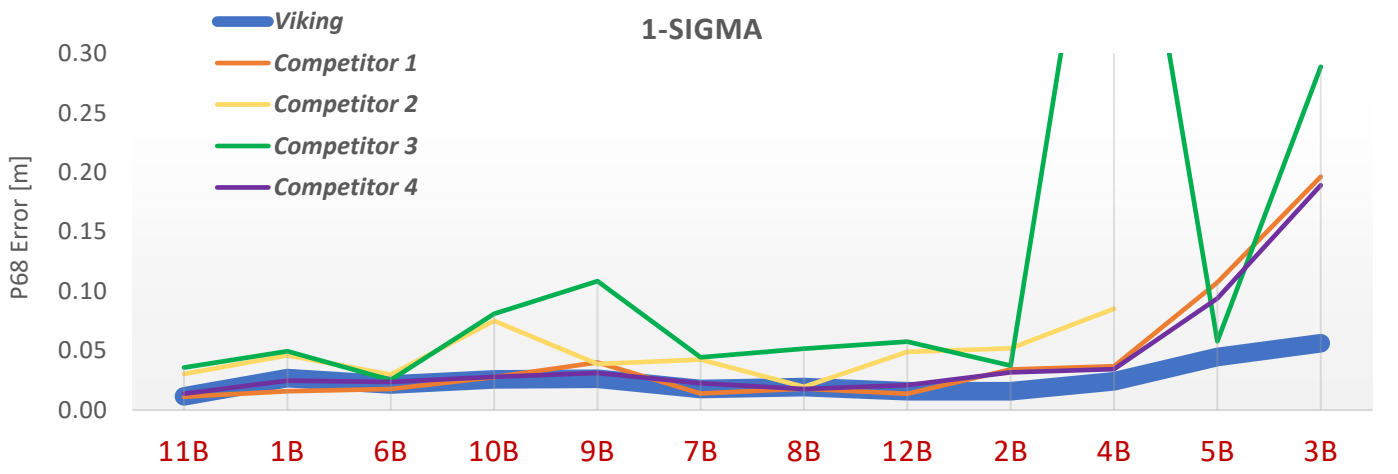
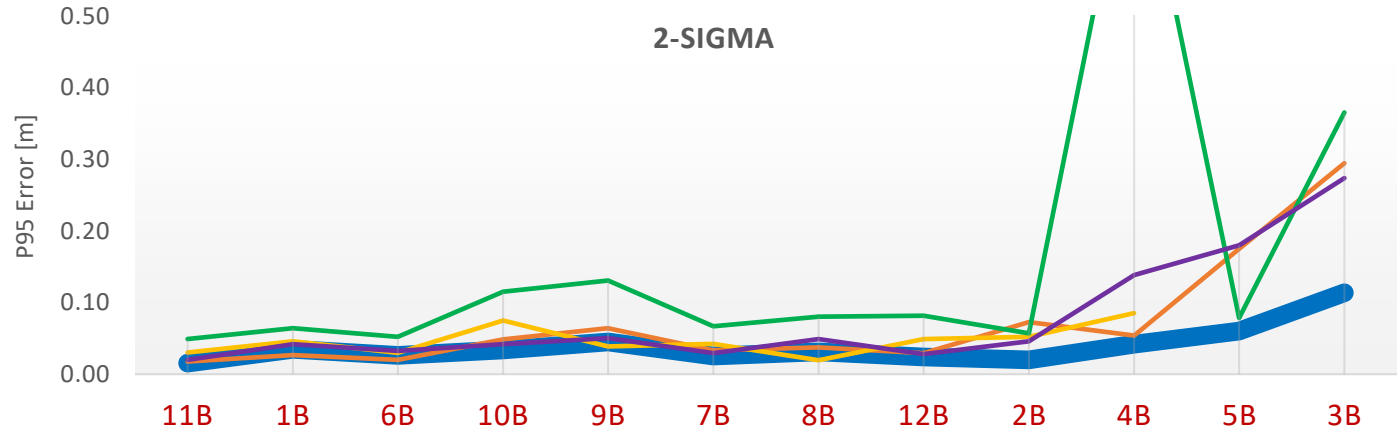
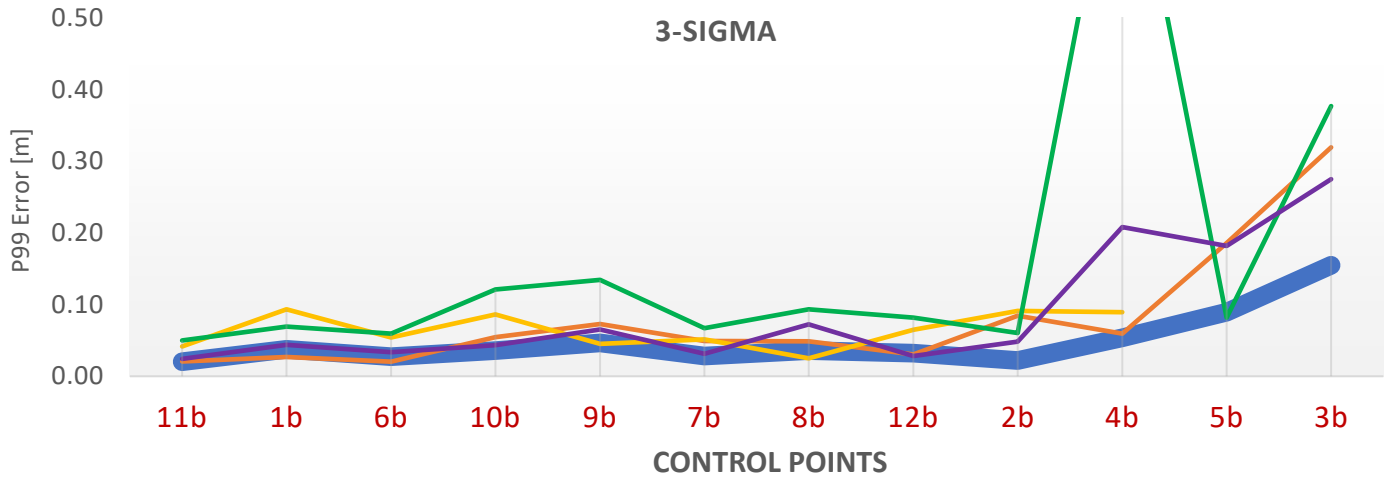


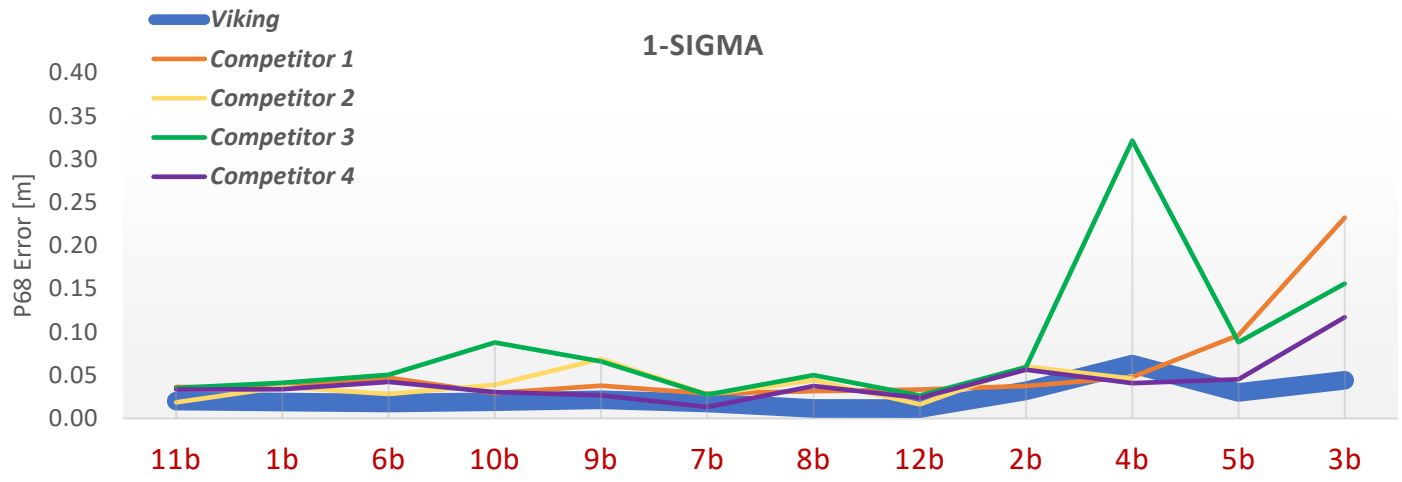


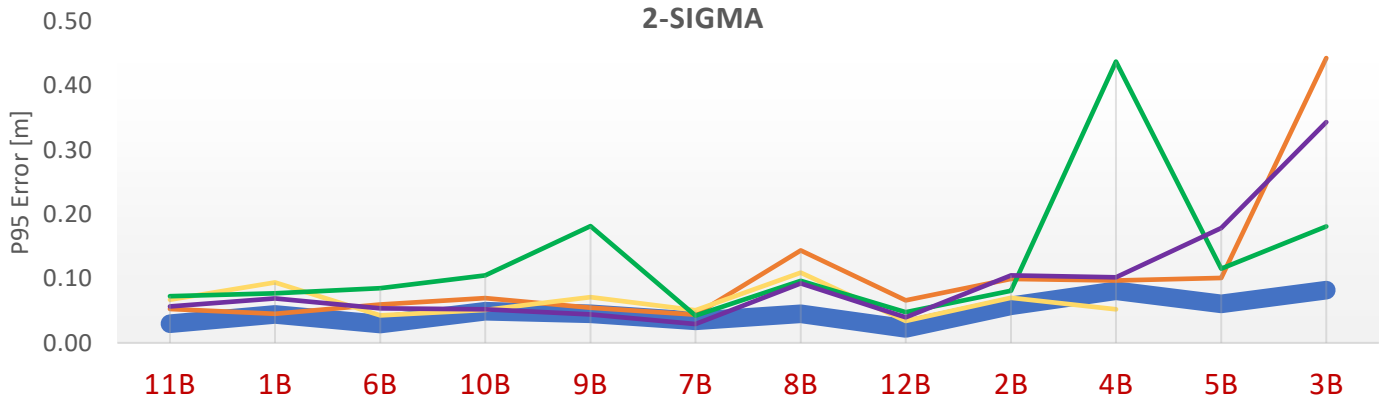


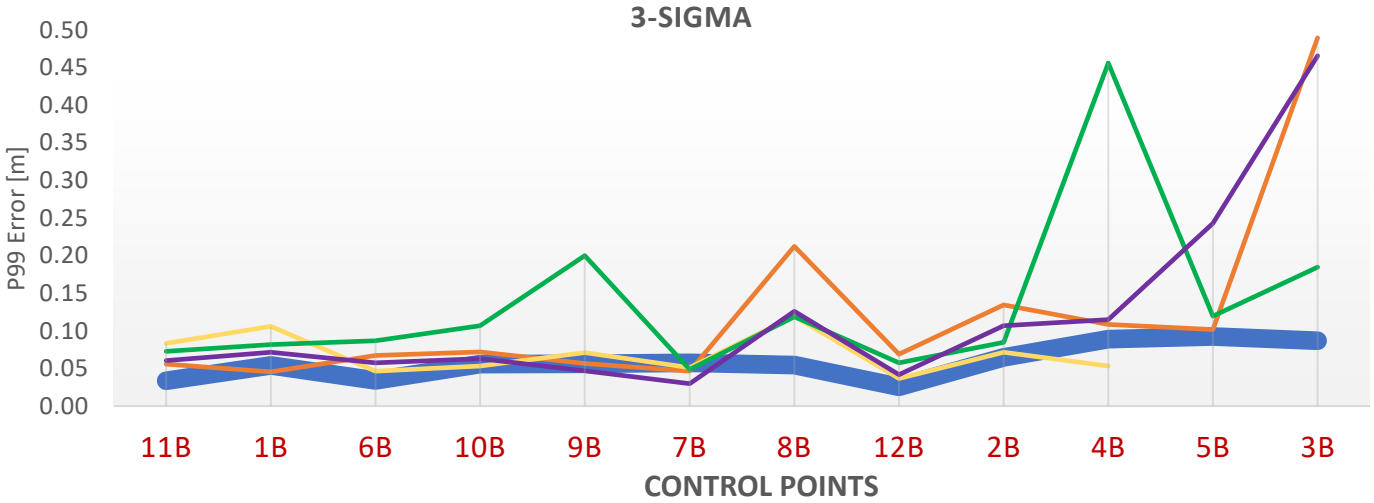
(-) DIFFICULTY (+)

VERTICAL POSITION ERROR (M)

(-) DIFFICULTY (+)



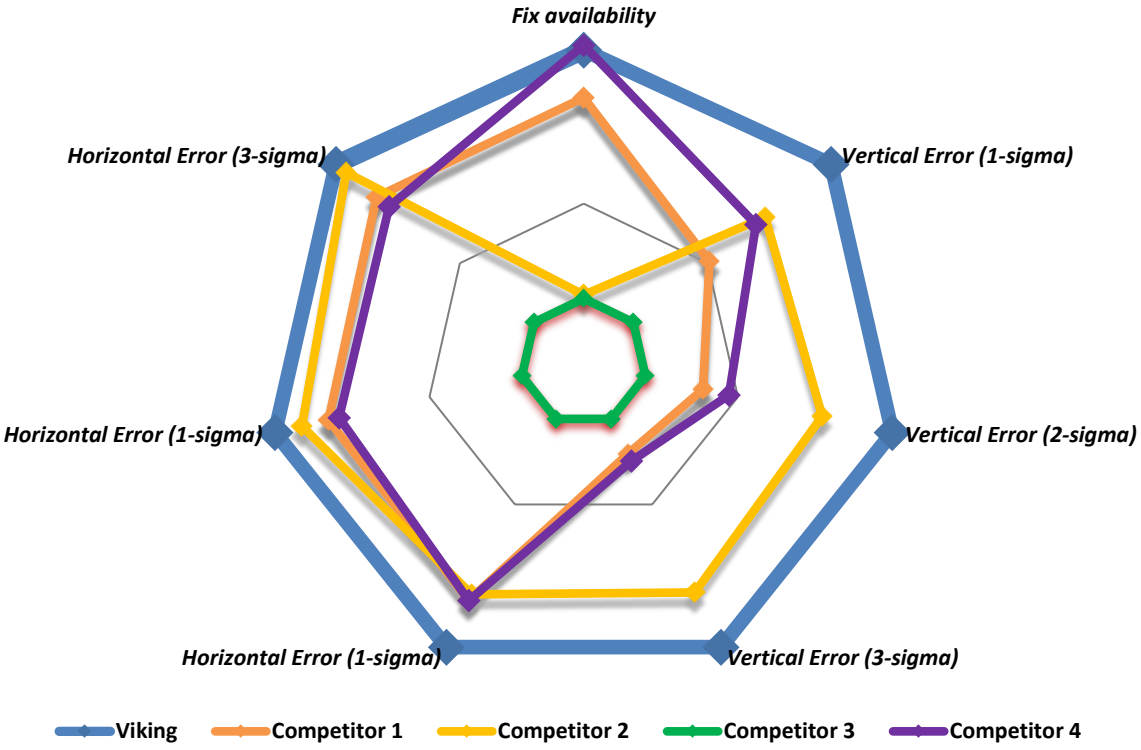




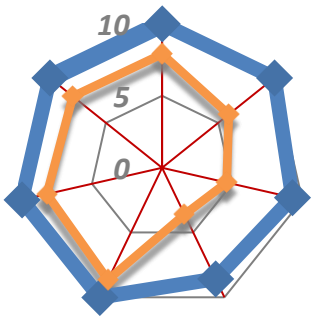
(-) DIFFICULTY (+)

NORMALIZED QUALITY COMPARISON – URBAN ENVIRONMENT

Viking delivers best-in-class RTK Fixed availability and best accuracy metrics



Viking vs Competitor 1



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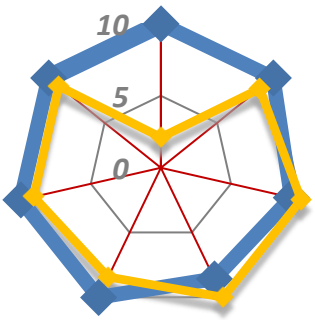
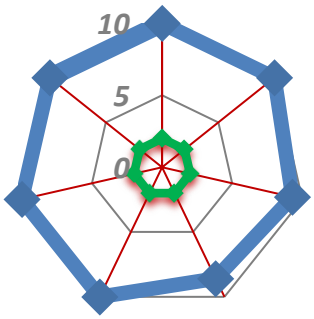


Viking vs Competitor 3



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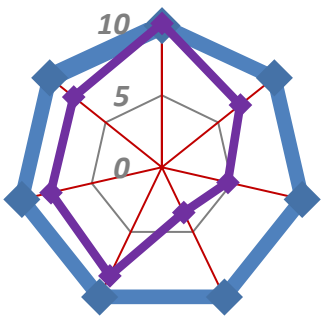

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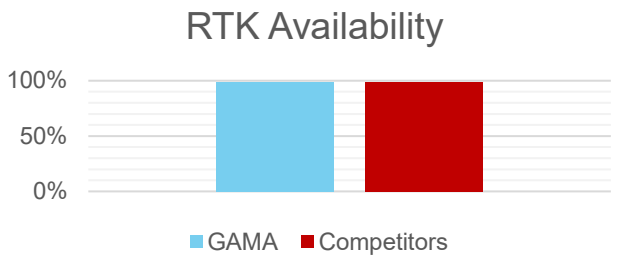
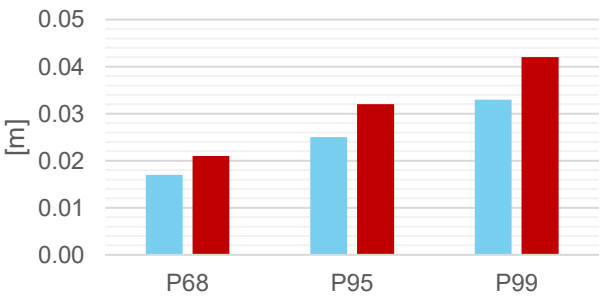
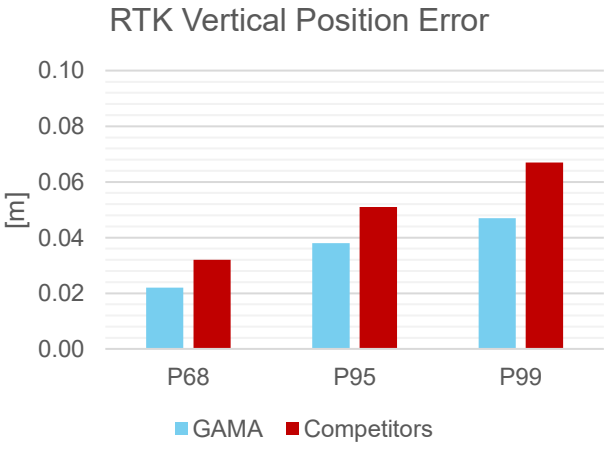
OVERALL STATISTICS

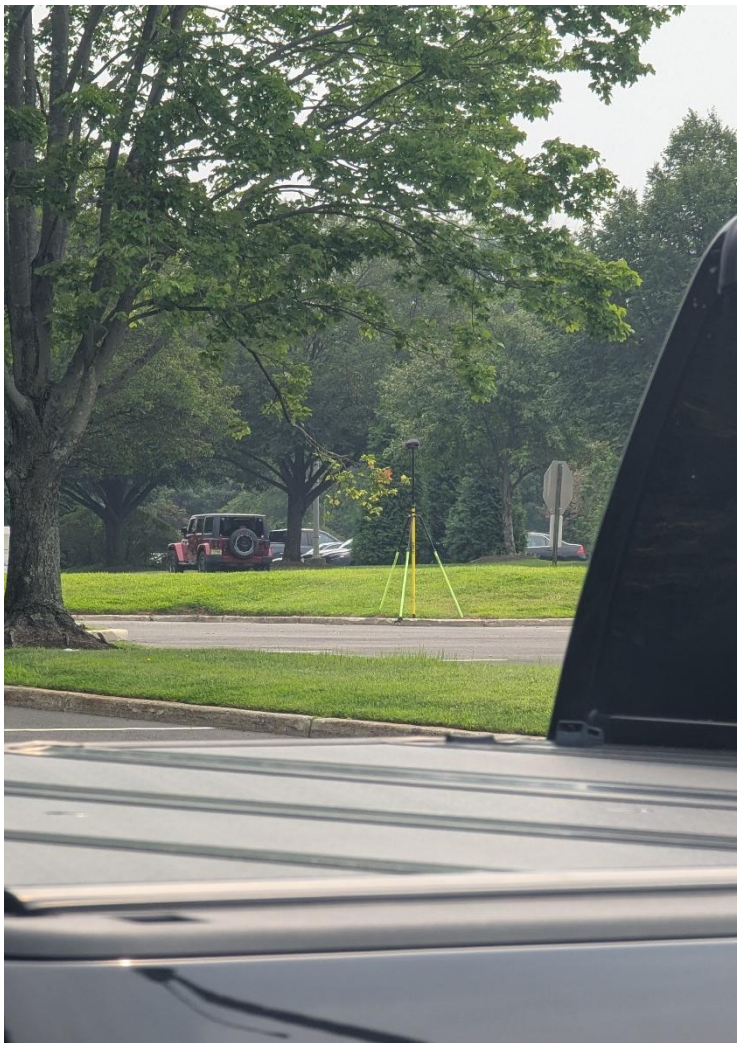
SEMI URBAN

Based on a total of 251 hours of data from 63 different data sets recorded at different locations.





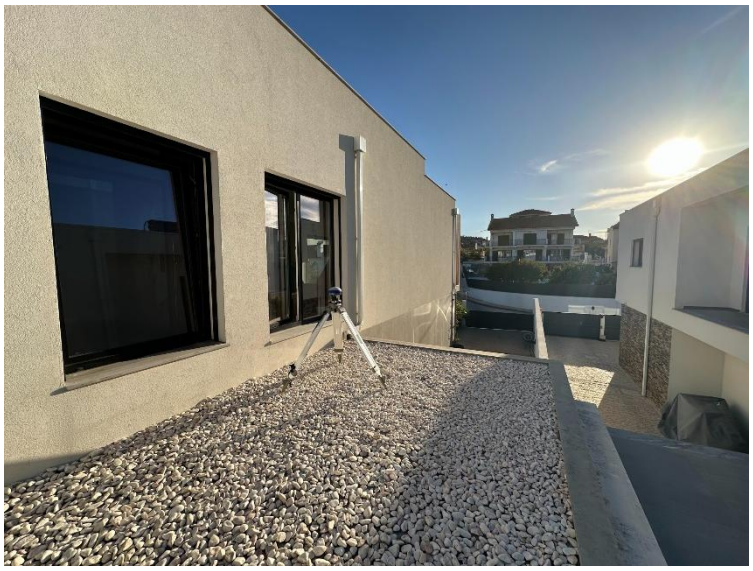


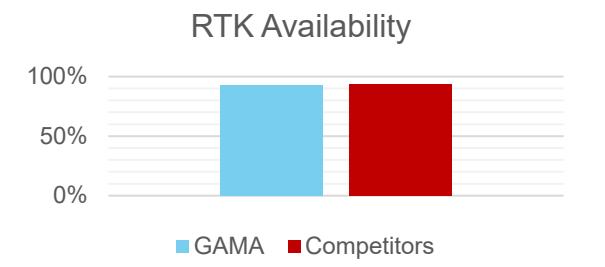


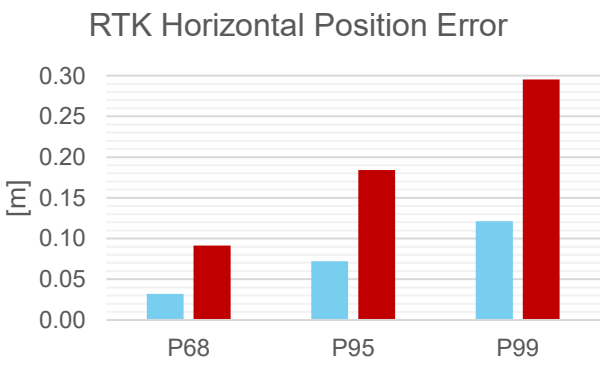
OVERALL STATISTICS

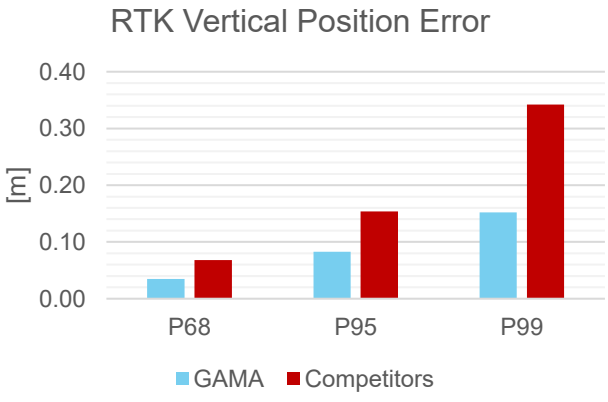
NEXT TO WALL

Based on a total of 132 hours of data from 107 different data sets recorded at different locations.





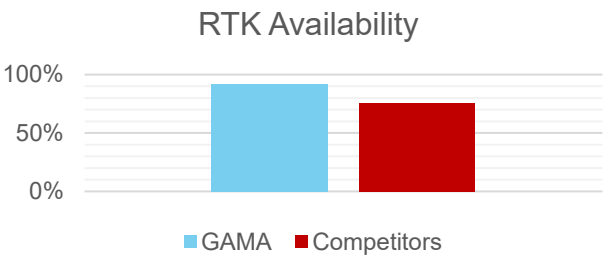


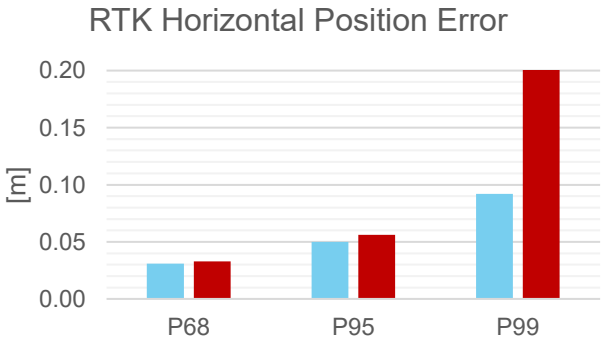


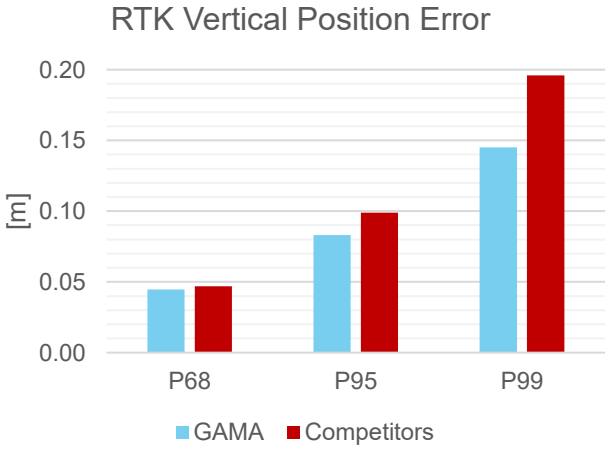
OVERALL STATISTICS

DENSE FOLIAGE

Based on a total of 84 hours of data from 41 different data sets recorded at different locations.







CONCLUSION

Carlson Software's next generation GNSS Smart Antenna, the Viking RTK Receiver, engine deploys a range of new technologies to deliver best-in-class performance.

Viking supersedes all performance metrics in every environment under test when compared to established RTK industry leaders, as assessed from performance test reports gathered over the last 5 years and supported by a large statistical pool of data presented in this report.

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