vGIS UTILITIES ACCURACY GUIDE

Accuracy Guide

vGIS Utilities is a cloud-based app that displays BIM and GIS data using mixed and augmented reality.

vGIS is incredibly easy to learn and use. To offer the best experience in the broadest range of applications, vGIS is optimized for work in different conditions and using different equipment.

This guide provides information about the options available in vGIS for ensuring accurate positioning, about the use cases for each option, and about how to optimize each setup to achieve the best results.

Please follow us on **LinkedIn**, **Twitter**, **Facebook**, **Instagram** and **YouTube** to stay on top of the latest developments.

Have questions? Let us know – **support@vGIS.io** or **@vGIS_Map**.

Accuracy and Stability

Many factors affect the accuracy and stability of any augmented reality (AR) system, including vGIS. These factors are often mutually exclusive. Higher accuracy and better precision require additional equipment; whereas greater convenience often comes at the expense of guaranteed positioning.

vGIS is designed to satisfy the broadest range of possible use cases and to provide the best experience possible in each category. To help you balance the cost, convenience, and experience, this guide explains the specifics, the use cases, and the pros and cons of each method.

Available Positioning Options

vGIS offers five positioning options:

- Smartphones and Tablets
- Microsoft HoloLens
- Low-precision GNSS
- High-precision GNSS
- Superior accuracy

	Phones and Tablets	MS HoloLens	External GNSS Low-Precision	External GNSS High-Precision	Superior Accuracy
Positioning accuracy					
Best case	Up to 10 cm	Up to 10 cm	Up to 10 cm	Up to 5 cm	Up to 1 cm
Real-life	Sub-50 cm	Sub-50 cm	Sub-50 cm	5 cm-20 cm	2 cm-5 cm
Heading accuracy					
Best case	Up to 0.1°	Sub-0.1°	Up to 0.1°	Up to 0.1°	Sub-0.1°
Real-life	0.2°-0.4°	0.1°-0.3°	0.2°-0.4°	0.2°-0.4°	0.05°-0.3°
Guaranteed					
Positioning	No	No	Assisted	Yes	Yes
Heading	No	No	No	Yes	Yes
Manual adjustments					
Positioning	Required	Infrequent	Required	No	No
Heading	Required	Infrequent	Required	Infrequent	No
Accumulated error					
Positioning	1%-4%	0%-1%	N/A	N/A	N/A
Heading	1%-4%	0%-1%	1%-4%	N/A	N/A
Hardware					
Additional hardware	No	No	Yes	Yes	Yes
Fixed hardware setup	No	No	No	No	Yes

Details

Phones/Tablets

vGIS comes with a patented vGIS calibration method set as the default. The vGIS calibration compensates for the shortcomings of the internal GPS and compass, which may otherwise result in a positioning error of up to 30 meters (100 feet) or more and a directional error of 45° or more.

Under typical conditions, due the low accuracy of built-in GPS and compass, consumer-grade smartphones and tablets are unsuitable for the utility-grade AR. However, vGIS calibration can render the positioning accurate to within 20-30 centimeters (8-12 inches) and the direction accurate to within 0.1°.

Use Cases

- General situational awareness.
- Maintenance of utilities.
- Construction work and design review.
- Utility-grade work such as asset locating.
- Other utility and construction tasks where tolerances of 30 cm to 50 cm are acceptable.

Not Ideal For

- Jobs involving long walks; e.g., walks of 150 m (450 ft) or more.
- Tasks requiring extensive movement around the job site.
- High-accuracy work.
- Locations with frequently changing landscapes (e.g., forests, open fields, etc.) and areas with no man-made landmarks.

Advantages

- No additional hardware.
- Fast launch sequence.
- Simple to use.

Considerations

vGIS calibration relies on accurate aerial maps and optical object tracking. It compensates for the shortcomings of the built-in compass and GPS by using aerial base maps for the initial positioning and optical tracking for managing the device location and heading. Since most consumer-grade phones and tablets use only a single camera for optical tracking, absolute accuracy and precision are not currently possible, so that the system will exhibit occasional jumps and locational drift.

- **Accurate aerial maps.** To achieve the best initial positioning, accurate maps are required—i.e., accurately geolocated maps that have little or no horizontal shift and that have high-resolution, non-oblique imagery with surfaces unobstructed by foliage. The accuracy of the positioning is directly correlated with the accuracy of the underlying base map.

- **Dark places and bright light.** Optical tracking relies on the processing of a live video feed in real time by the camera of the device. When the camera is blinded by direct or reflected light or is unable to capture enough light in dark places, it may lose tracking ability, causing a visible drift in the position.
- **Even surfaces.** Even surfaces without recognizable features (e.g., plain walls or floors) do not provide enough detail to enable the optical tracking to establish accurate tracking points, causing the system to jump or drift.
- **Tracking error.** Under normal conditions, optical tracking on single-camera devices has an inherent tracking error of 1% to 4%. As you take 100 steps around the job site, for example, the system may miscalculate the total distance you covered by a few steps. The same drift applies to the heading tracking. As you move the device from side to side or turn around, the directional accuracy of the system may deteriorate, and you will need to readjust it.
- **AR framework anomalies.** Rarely, the underlying AR frameworks may misidentify a surface or a location, instantly causing all objects in the scene to jump. The jump may be horizontal, vertical, or rotational, and it will move all objects out of alignment.

Hardware

Using vGIS Calibration requires no additional hardware.

Microsoft HoloLens (No GNSS)

The Microsoft HoloLens relies on the same patented method of vGIS Calibration for positioning. However, unlike most phones and tablets, which track position using a single camera, the Microsoft HoloLens uses an array of cameras. This array results in positional tracking that is more accurate than the positional tracking of traditional phones and tablets. In typical conditions, the Microsoft HoloLens will maintain accurate positioning without noticeable drift.

Use Cases

- All tasks suitable for phones and tablets.
- Complex infrastructure reviews.
- Tasks requiring highly stable visuals.
- Jobs requiring that both hands remain free.
- Engineering tasks.
- BIM-related activities.

Not Ideal

- Jobs involving long walks—e.g., 150 m (450 ft) or more.
- High-accuracy work.
- Locations with frequently changing landscapes (e.g., forests, open fields, etc.).

Advantages

Due to its array of internal cameras, the Microsoft HoloLens offers a spatial tracking experience superior to that of mobile devices. The vGIS method of calibration used in phone and tablet deployments produces better results in a HoloLens because of its inherently more accurate spatial tracking.

Moreover, since it enables the user to remain hands-free while operating it, the HoloLens is especially useful for jobs that require the use of both hands.

Finally, the stereoscopic nature of visuals produced by the HoloLens makes it an indispensable tool for reviewing complex infrastructure and BIM data when instant understanding of 3D data is of paramount importance.

Considerations

The similarities in spatial tracking used by the Microsoft HoloLens and mobile devices result in similar considerations when deploying the device. They include:

- Accurate aerial maps.
- Dark places and bright light.
- Even surfaces.
- Tracking error.
- AR framework anomalies.

Although similar considerations apply to both the HoloLens and mobile devices, there are also a few differences. The Microsoft HoloLens performs significantly better in dim and bright light or when used with even surfaces. Under normal conditions, it exhibits no positional drift or almost no positional drift. AR anomalies that result in visual jumps are extremely rare.

Hardware

Using vGIS calibration on Microsoft HoloLens requires no additional hardware.

Low-Precision GNSS

Occasionally, vGIS is deployed in conjunction with external GNSS devices that provide sub-meter accuracy, including the EOS Arrow 100 and the Trimble R1. The relatively low precision of sub-meter positioning devices does not permit using the data that they produce for utilities-grade AR. However, vGIS has developed a method of using their positioning data to provide assurances to the user that these GNSS devices remain within acceptable positioning tolerances.

Low-precision GNSS tracking relies on the same vGIS calibration for the initial positioning. During usage, vGIS calibration can also detect significant positional drifts and alert the user to them.

Use Cases

- All tasks suitable for phones and tablets.
- Tasks requiring long walks.

- Utility jobs requiring that accuracy remain within tolerances achievable by sub-meter GNSS.
- Locations with poor aerial-map coverage.
- Locations with frequently changing landscapes (e.g., forests, open fields, etc.).

Advantages

Using sub-meter GNSS with vGIS offers guarantees that the positioning accuracy remains within the accuracy of GNSS. It extends the use of vGIS to jobs where users are required to perform long walks or remain within a certain distance from the target location. Whether optical tracking will be susceptible to accuracy drift, low-precision GNSS will maintain acceptable positioning accuracy.

Considerations

Optical tracking remains central to the low-precision GNSS method. Although it is guaranteed that positioning accuracy will remain within tolerance levels, directional accuracy is susceptible to the same conditions that govern a phone or tablet. Dim or bright light, even surfaces, and anomalies in the AR framework may push the system out of sync with the physical world. Although the system will maintain positioning accuracy, manual adjustment may be necessary to validate and restore directional accuracy.

Hardware

Sub-meter GNSS such as the EOS Arrow 100, BadElf Surveyor or the Trimble R1.

High-Precision GNSS

Some tasks demand high-accuracy placement of augmented reality visuals. vGIS natively integrates with multiple centimeter-grade devices such as the Leica GG04 Plus and EOS Arrow Gold to achieve required levels of accuracy. This integration simplifies the initial calibration and eliminates the need to adjust the positioning during operations, which makes this method preferable for high-intensity and high-accuracy jobs that leave no room for error.

Use Cases

- All tasks suitable for phones and tablets.
- Tasks requiring guaranteed positioning quality.
- Tasks requiring long walks or extensive movement around job sites.
- High-accuracy construction and engineering jobs.
- Situations requiring high-accuracy—i.e., 5-20 cm (2-8 in) positioning.

Advantages

Integration with high-precision GNSS devices enables vGIS to offer verifiable accuracy for the most demanding tasks. The flexibility of the antenna placement makes it an ideal solution for situations where it is advisable to carry the device’s antenna in a backpack or on a long pole.

In addition to offering verifiable accuracy, this type of integration eliminates the need for manual calibration and correction while introducing such advanced features as vGIS's patent-pending automated heading correction.

Considerations

The flexibility of the antenna placement enables near-survey-grade accuracy. However, if the distance between the antenna and the device changes, this will cause slight inaccuracies. For instance, when the antenna is carried in a backpack, by extending his or her hands the user may increase or decrease the distance between the antenna and the device and thereby introduce an error of 10 cm-15 cm (4 in-6 in). Similarly, when carrying the antenna on a long pole, by tilting the pole the user may move the antenna a few centimeters or inches away from or toward the device, causing a slight misalignment in positioning.

Although this method can take advantage of automated heading correction, if the device satisfies only minimal requirements the system may exhibit a heading error of up to 1.5°, moving virtual objects out of alignment.

Hardware

A high-precision GNSS device meets the following requirements:

- **Minimal**: sub-10 cm (sub-4 in) accuracy, 1 Hz refresh rate;
- **Recommended**: 5 cm (2 in) or higher horizontal accuracy, 5 Hz or higher refresh rate.

Superior Accuracy

Survey-grade accuracy relies on the same integration as the high-precision GNSS setup. The main difference is that the antenna remains affixed near the visualization device, which helps reduce or eliminate the small inaccuracies that can arise from flexible antenna placement.

Use Cases

- Tasks suitable for high-precision GNSS integration.
- Tasks requiring visuals to be extremely accurate.

Advantages

Survey-grade GNSS integration maintains the best possible integration with current technology.

Considerations

The antenna must be rigidly fixed as close to the visualization device as possible.

Hardware

Survey-grade integration requires a high-precision GNSS device that meets the following criteria:

- **Minimal**: 5 cm (sub-2 in) accuracy, 5 Hz refresh rate;
- **Recommended**: 1-2 cm (0.5-1 in) or higher horizontal accuracy, 10 Hz or higher refresh rate.

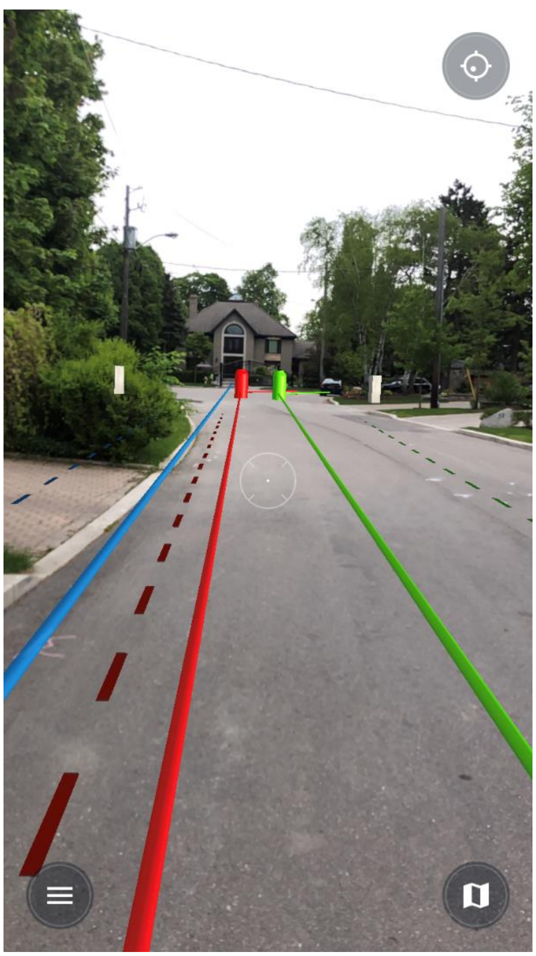
Visual Accuracy Tips

Vertical object placement (the elevation) affects the quality of visuals. Even if an object is perfectly aligned horizontally, a vertical misalignment will make it appear out of place. This effect is explained in our educational video at youtube.com/watch?v=D14KVAN4IM8.

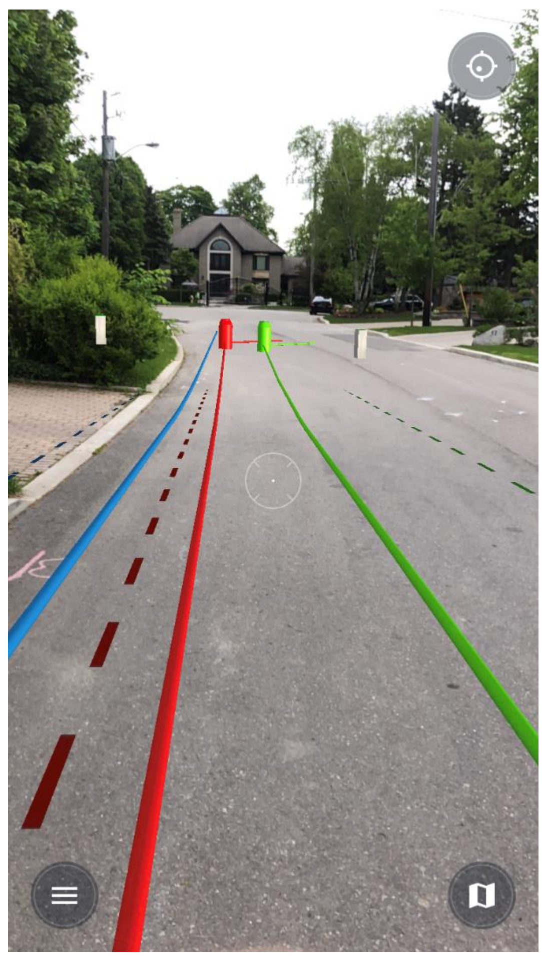
Although accurate vertical placement will not affect positioning accuracy, it improves the user's experience by minimizing visual distortions.

In some cases, enabling Topography in the main menu will adjust objects for the available topography and improve the visuals. This option is turned off by default, since the rough topological models available for most regions of the world may cause more problems than they solve.

Customized surface models enhance the topological correction because they rely on custom-surveyed environments that usually produce much more refined surface maps. To improve accuracy, you can add a customized surface model from the Admin Portal.



Topology Correction Disabled



Topology Correction Enabled

High-precision GNSS

To ensure the best possible experience with high-precision GNSS, it is recommended that all objects displayed in AR have a z value (elevation). For such datasets, the user can enable the option for using GNSS elevation (Main Menu > Options > GNSS). Doing so will ensure that the objects around the user are tracked accurately along the z axis (the vertical placement) as well as in the x-y plane.

If the GNSS-based elevation option is disabled or the dataset does not have z-values for all objects, the system will still maintain highly accurate x-y positioning. However, when viewing distant objects—e.g., objects that are 20 m (60 ft) away or more—some misalignment may occur in AR, with objects appearing to be farther away or closer than they are in fact. The objects will slide into the correct positions as the user approaches them.

You can attain optimal visuals by using up-to-date customized surface models in conjunction with z-values.