Critical factors affecting RTK accuracy

The following sections present system limitations and potential problems that could be encountered during RTK operation.

Base station receiver type

CAUTION – Trimble recommends that you always use a Trimble base station with a BD9xx roving receiver. Using a non-Trimble base receiver can result in suboptimal initialization reliability and RTK performance.

The receiver uses a state-of-the-art tracking scheme to collect satellite measurements. The receiver is compatible with all other Trimble RTK-capable systems.

Base station coordinate accuracy

The base station coordinates should be known to within 10 m in the WGS-84 datum for optimal system operation. Incorrect or inaccurate base station coordinates degrade the rover position solution. It is estimated that every 10 m of error in the base station coordinates introduces one part per million error in the baseline vector. This means that if the base station coordinates have a height error of 50 m, and the baseline vector is 10 km, then the additional error in the rover location is approximately 5 cm, in addition to the typical specified error. One second of latitude represents approximately 31 m on the earth surface; therefore, a latitude error of 0.3 seconds equals a 10 m error on the earth's surface. The same part per million errors apply to inaccuracies of the base station's latitude and longitude coordinates.

Number of visible satellites

A GNSS position fix is similar to a distance resection. Satellite geometry directly impacts on the quality of the position solution estimated by the receiver. The Global Positioning System is designed so that at least 5 satellites are above the local horizon at all times. For many times throughout the day, as many as 8 or more satellites might be above the horizon. Because the satellites are orbiting, satellite geometry changes during the day, but repeats from day-to-day.

A minimum of 4 satellites are required to estimate user location and time. If more than 4 satellites are tracked, then an over-determined solution is performed and the solution reliability can be measured. The more satellites used, the greater the solution quality and integrity.

The Position Dilution Of Precision (PDOP) provides a measure of the prevailing satellite geometry. Low PDOP values, in the range of 4.0 or less, indicate good satellite geometry, whereas a PDOP greater than 7.0 indicates that satellite geometry is weak.

Even though only 4 satellites are needed to form a three-dimensional position fix, RTK initialization demands that at least 5 common satellites must be tracked at base and rover sites. Furthermore, L1 and L2 carrier phase data must be tracked on the 5 common satellites for successful RTK initialization. Once initialization has been gained, a minimum of 4 continuously tracked satellites must be maintained to produce an RTK solution.

When additional constellations such as GLONASS are tracked, one of the satellites will be used to resolve the timing offsets between that constellation and the GPS constellation. Tracking additional satellites will aid in the RTK solution.

Elevation mask

The elevation mask stops the receiver from using satellites that are low on the horizon. Atmospheric errors and signal multipath are largest for low elevation satellites. Rather than attempting to use all satellites in view, the receiver uses a default elevation mask of 10 degrees. By using a lower elevation mask, system performance may be degraded.

Environmental factors

Environmental factors that impact GPS measurement quality include:

- Ionospheric activity
- Tropospheric activity
- Signal obstructions
- Multipath
- Radio interference

High ionospheric activity can cause rapid changes in the GPS signal delay, even between receivers a few kilometers apart. Equatorial and polar regions of the earth can be affected by ionospheric activity. Periods of high solar activity can therefore have a significant effect on RTK initialization times and RTK availability.

The region of the atmosphere up to about 50 km is called the troposphere. The troposphere causes a delay in the GPS signals which varies with height above sea level, prevailing weather conditions, and satellite elevation angle. The receiver includes a tropospheric model which attempts to reduce the impact of the tropospheric error. If possible, try to locate the base station at approximately the same elevation as the rover.

Signal obstructions limit the number of visible satellites and can also induce signal multipath. Flat metallic objects located near the antenna can cause signal reflection before reception at the GPS antenna. For phase measurements and RTK positioning, multipath errors are about 1 to 5 cm. Multipath errors tend to average out when the roving antenna is moving while a static base station may experience very slowly changing biases. If possible, locate the base station in a clear environment with an open view of the sky. If possible use an antenna with a ground plane to help minimize multipath.

The receiver provides good radio interference rejection. However, a radio or radar emission directed at the GPS antenna can cause serious degradation in signal quality or complete loss of signal tracking. Do not locate the base station in an area where radio transmission interference can become a problem.

Operating range

Operating range refers to the maximum separation between base and rover sites. Often the characteristics of the data link determine the RTK operating range. There is no maximum limit on the baseline length for RTK with the receiver, but accuracy degrades and initialization time increases with range from the base. Specifications given for receivers specify the distance within which those specifications are valid, and specifications are not given beyond that range.