GNSS Heading Systems

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Determining heading with GNSS has traditionally relied on dynamic movement to calculate direction from successive positions. On static or slow-moving platforms this technique will not provide adequate results. Trimble has adapted its RTK technology to provide an accurate vector between two receivers that are static or moving. RTK allows one to achieve centimeter accurate positions using the carrier phase measurements from GNSS satellites. In traditional RTK applications, a reference receiver remains stationary at a known location, and a rover receiver moves. However, it is also possible to operate the technique with both the reference and rover receivers moving. This is known as Moving Baseline RTK. The result is a centimeter accurate vector between the two units. From this vector a precise heading can be calculated. Moving Baseline RTK mode can be operated between two separated receivers or in the case of dual antenna receivers between two antennas connected to the same receiver. Applications for two separate receivers include:

- Vehicle convoy operations
- Aircraft landing on dynamic platforms
- Aircraft air refueling
- Marine docking systems
- Agricultural implement guidance

Applications for Moving Baseline RTK running on a single dual antenna receiver include:

- Platform heading determination:
  - Platform heading determination
  - Manned and unmanned aircraft
  - Construction dozers, excavators and graders
  - Mining shovels, drills and draglines
  - Autonomous vehicles
  - Marine vessels
- Antenna pointing

In addition to heading between the two antennas one can also calculate the pitch or roll of the platform. If the antennas are placed at the front and back of the platform, we get a pitch measurement. If the antennas are placed at the left and right of the platform, we get a roll measurement. For applications that require all three attitude components(heading, pitch and roll) then one can configure multiple receivers to achieve this. Alternatively, a single or dual-antenna GNSS/INS system can be used for 3D orientation. In the case of dual antenna GNSS/INS systems the Moving Base RTK technique is used to align the gyros. This allows for 3D orientation when static on startup. Single antenna GNSS/INS systems require vehicle movement to align the gyros and are better suited to more dynamic applications (> 5 kph).

The use of GNSS systems in attitude determination and orientation has its own set of error sources and mitigation techniques. Different factors that influence the accuracy of the system outputs are:

Baseline Length

Baseline length or the distance between antennas used in orientation is an important factor to be kept in mind while considering antenna placement and mounting on the vehicle body. The distance is inversely proportional to the error in the heading measurement and the accuracy of orientation is a nonlinear function of baseline length.

Choice of Antennas

Antenna selection will have an impact on the accuracy of measured parameters and the user will have to make a trade off based on antenna performance, size and weight, cost and other systems engineering metrics. Trimble recommends using an antenna ground plane in applications which are prone to multipath error sources. Some antennas may require a ground plane to properly track satellite signals.

Heading vs. Pitch or Roll Accuracy

The heading accuracy is superior to the pitch or roll values calculated. This is due to the inherent geometrical limitation of a satellite navigation system where a receiver only sees ranging satellites above it and cannot track anything below the horizon.

Position Latency

Moving Baseline RTK uses a synchronized RTK technique. This requires the measurements made at both antennas to be synchronized before a vector can be calculated. For separated receivers using radio communications this can add significant latency into the output values. For dual antenna receivers the latency is considerably less as there is no over the air transmission.

Absolute Accuracy

Moving Base RTK delivers a centimeter accurate vector between the two antennas. However, the absolute position accuracy is only as good as the positioning mode of the moving base receiver. If this receiver is in autonomous mode, then the positions are at the meter level accuracy. If centimeter absolute accuracies are required for the application then the moving base can simultaneously receive corrections from a static RTK base, placing it in a known accurate coordinate system.