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New Techniques in Relative RTK GPS Positioning Between Dynamic Platforms

Brent O'Meagher B.Surv (Otago)

Trimble Navigation
Westminster, Co

Abstract

This paper will discuss the latest advancement in Real Time Kinematic (RTK) GPS Positioning, *Moving Base RTK*. Developed by Trimble, Moving Base RTK differs from conventional RTK positioning, where the reference station remains stationary at a known location, while the rover moves, by allowing both the reference and rover receivers to be moving whilst calculating a centimeter accurate 3D vector between them.

The Moving Base RTK technique is ideal for applications where the precise relative offsets and closing velocities of two or more moving vessels is required, such as when a shuttle tanker is approaching an FPSO, FSRU, SPM or similar.

In its simplest form, the Moving Base RTK solution provides absolute vessel positioning, that is 'real-world' positions, accurate to autonomous GPS level (approximately 20m) but relative positioning between each vessel accurate to 1 - 2 centimeters. Enhanced Moving Base RTK allows for either shore or satellite broadcast DGPS or shore based RTK corrections to be included in the solution. If this option is implemented then the absolute 'real-world' positions are improved to either submeter, in the case of DGPS, or centimeter, in the case of RTK, levels. Regardless of whether Enhanced Moving Base RTK is used or not the relative positioning between each vessel remains at the high centimeter level.

Trimble's Moving Base RTK differs from currently available products by providing centimeter level relative accuracy's and update rates at up to 10hz.

This paper will present the Moving Base RTK technology with particular reference to the offshore oil & gas industry.

Moving Base RTK

In most RTK applications, the reference station remains stationary at a known location, while the rover moves. A new method of RTK positioning, called Moving Base RTK, is implemented in the Trimble MS Series receivers, the MS750 and MS860, in which both reference and rover receivers move. The Moving Base RTK technique is currently employed in the MS860 receiver for determining vessel orientation (see Figure 1). Precise tracking of the relative separation of two or more moving vessels is also possible using two or more MS750's or MS860's.

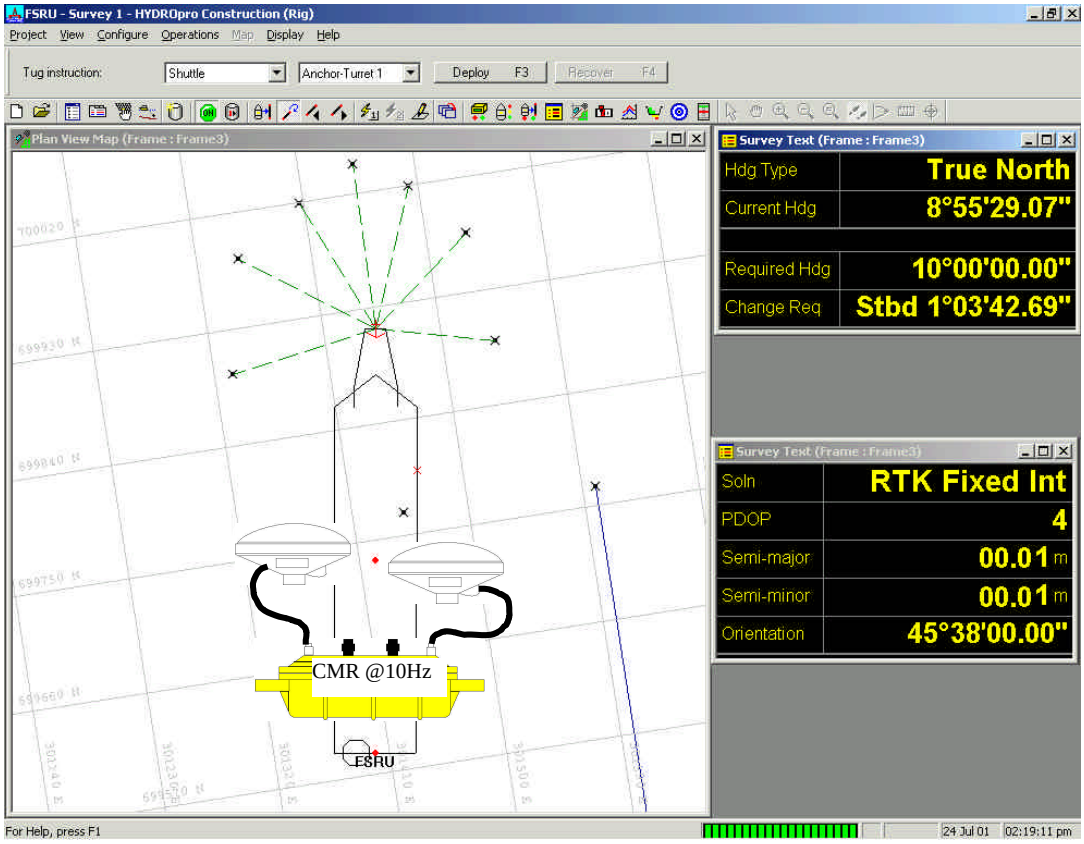

Figure 1: MS860 for vessel (FSRU) heading

With the Moving Base RTK technique, the reference receiver broadcasts CMR measurement and station location data every epoch and the rover receiver performs a synchronized Base[1] solution at 1, 5 or 10 Hz. The resultant Base solution is accurate to centimeter-level, while the absolute location of the reference — rover vector is only accurate to autonomous GPS levels, approximately 20 meters. Figure 2 illustrates the Moving Base RTK technique as applied to an SPM installation

[1] ***Synchronized Base*** - The rover receiver waits until the reference station measurements are received before computing a Base vector.

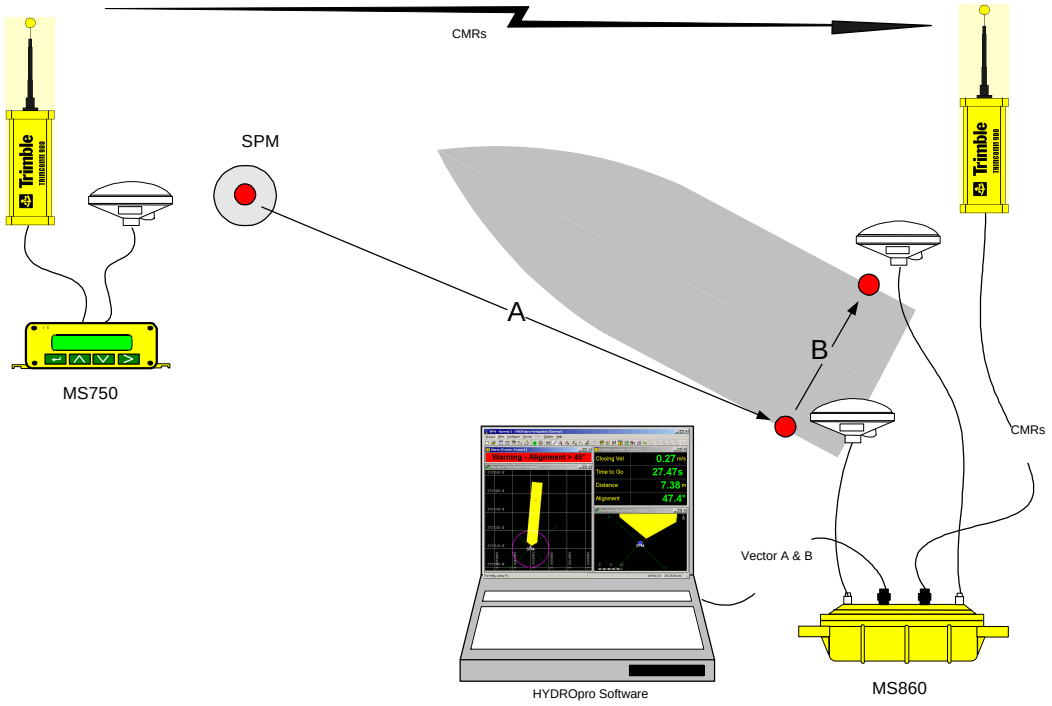

Figure 2: Example of Moving Base RTK for SPM installation

Enhanced Moving Base RTK

Although the Moving Base RTK mode provides centimeter-level vector components between moving reference and rover, the absolute coordinates of the reference and rover are only generally known to 20 meters. The MS Series receiver is capable of performing DGPS or RTK positioning while also acting as the moving base reference station relative to a fixed reference to submeter-level with DGPS, or centimeter-level with RTK.

This technique is best explained with an example.

In Figure 3, a shore-based (fixed) reference station sends either RTCM or CMR data to the moving reference station on the SPM. The moving reference station (the MS750 on the SPM) receives corrections from the shore-based reference station and generates position solutions.

The moving reference station can be operated in either Low Latency[2] mode or Synchronized mode. CMR data is output by the moving reference station to the rover at either 1, 5 or 10 Hz by using the Standard or Fast CMR output modes, respectively.

[2] The Low Latency positioning mode delivers 20 Hz position fixes with around 20 millisecond latency with a precision that is only slightly less accurate than Synchronized RTK positioning. Based upon the predictability of the reference station phase data.

The rover accepts CMR data from the moving reference station and generates an RTK vector solution at the same rate as moving reference CMR transmissions.

When the roving reference station is differentially corrected, both the vector displacement and absolute location of the moving Base are calculated to DGPS levels.

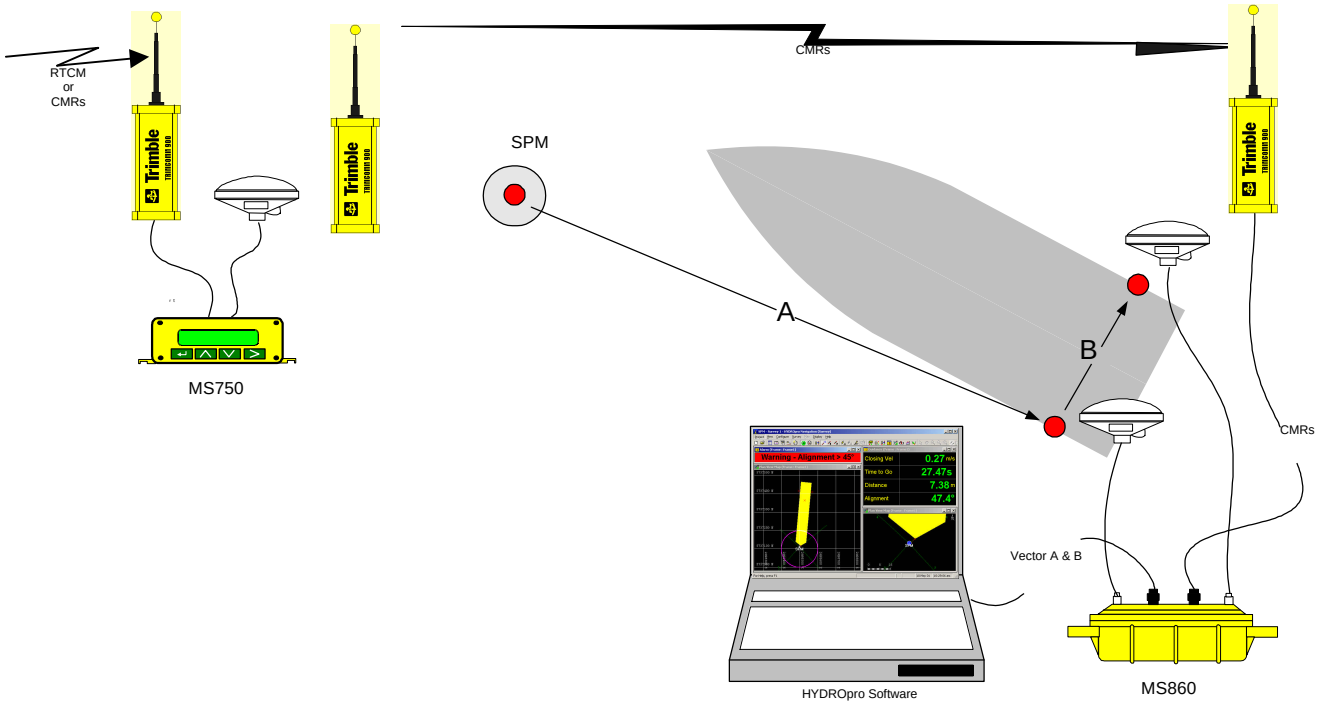

Figure 3: Example of Enhanced Moving Base RTK for SPM installation

Chained Moving Base RTK

The moving Base RTK mode can chain together multiple moving reference receivers. Chained-RTK is best explained with an example. Consider the case of a lightering operation where a shuttle tanker is approaching a Very Large Crude Carrier (VLCC). In this example the heading and position of both vessels is required on the shuttle which is coming alongside the VLCC

Either two MS750 or one MS860 receiver is installed on each vessel. In the case of two MS750's one receiver on each vessel is designated the 'Base' Station, although all receivers are moving. The Base station on each vessel transmits CMR corrections to the rover receiver on each vessel at 10Hz allowing the heading of each vessel to be very

accurately determined[3]. Because the receivers would be both installed on the bridge, the receivers are cabled together, thus radios are not required for this part of an install.

One of the vessels is now designated the Base Vessel and the 'rover' receiver on this vessel becomes the Moving Base RTK Base Station, which transmits, via radio, CMR corrections to the vessel that has been designated the Rover Vessel. In order to conserve radio frequencies, the Rover receiver on the Base Vessel (the Moving Base RTK Base Station) also transmits its position and the heading of the Base Vessel at the same time. Thus the Base Vessel is transmitting to the Rover vessel its position, heading and RTK GPS corrections, allowing the Rover vessel to display the position and heading of the Base Vessel and determine its 3D vector from the Base vessel to centimeter level accuracy.

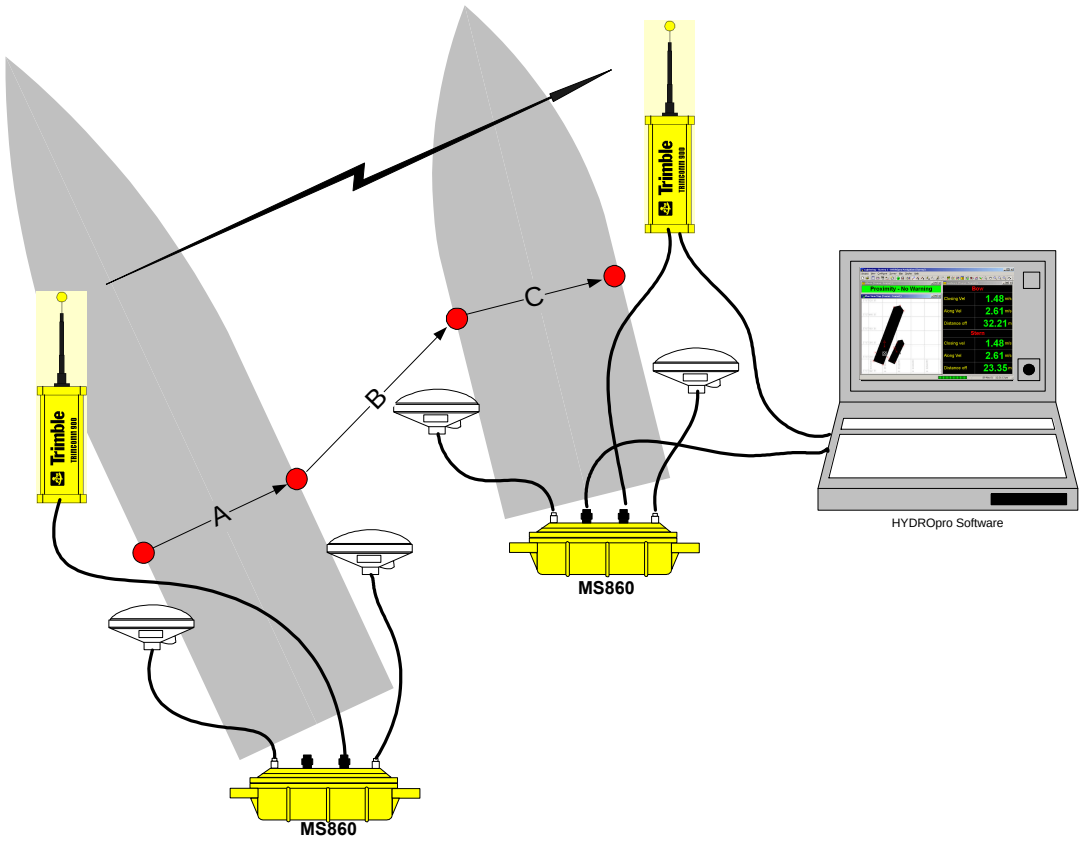

Figure 4: Example of Chained Moving Base RTK using MS860's for a Lightering installation

[3] The heading accuracy is dependant upon the base line separation of the two antennas. Trials in high multipath environments show that with a 10mseperation,heading accuracy's of 0.03° can be achieved.