Positioning Issues

Positioning issues are absolutely the most common issue to address with an INS for submersible systems. As the positioning solution is the most constructed solution in an INS and least directly measured, there are numerous error paths and many are a result of errors in other state channels. Heading errors contribute substantially to positioning issues such that even small heading errors can result in very large positioning errors.

INS position is not the same as USBL position when aided with a DVL. In many subsea configurations using a DVL and USBL, the USBL position may not be included in the INS navigation solution because the noise and error associated with the USBL may actually corrupt the solution for delicate functions such as station-keeping, dynamic positioning, and route following. Because the DVL+inertial solution will drift over time, it is not uncommon for the position to differ from the USBL position. Greensea provides the option of fusing the USBL measurements in the solution or not. Additionally, Greensea allows manual USBL inclusion for position updates when the operator considers the USBL stable.

- **Position stops updating.** IMUs commonly used in subsea navigation systems are not adequate for extended periods of free-inertial drift. When unaided by other sensors, the position solution due solely to the IMU can easily drift more than 4 meters per minute when stable and much more when dynamic. Greensea often allows free-inertial drift for only short periods of time if there are no aiding sensors. This will cause the position to stop updating if there are no aiding sensors. Should the IMU itself stop working or enter an error state, the INS will not be able to update the position either.

- **The INS rejects most USBL fliers but will accept some if they are near each other.** Each sensor has a software prefilter that is used to filter data prior to putting it into the Kalman. These filters typically do logical tests on the data and filter for basic sanity: "Could this be real data?" Greensea uses a sanity filter on USBL data prior to allowing the data into the Kalman. This prefilter checks to see if the USBL update is possible based on the vehicle's dynamics and current position of the vehicle. The INS rejects data that is illogical and accepts logical data it into the solution. Many fliers are rejected because they are physically impossible and not logical. If fliers start clustering, the period of time between the last feasible USBL update and the last flier may be long enough such that it is physically possible the new USBL update may be correct. These logical prefilters are conservative because it is impossible for a filter to "know" what the vehicle is really doing. Often, it is simply a function of the stochastic processes inside the state estimation filter governing when the solution starts to merge with USBL data.

- **The position tracks well when the vehicle is stable, but does not track well when the vehicle is transiting.** The primary culprits are vehicle noise, vehicle attitude, and environmental factors. Noise due to the vehicle's thrusters can often interfere with acoustic sensors, including both DVL and USBL. This is commonly seen as poor data from the sensor which corrupts the INS. DVLs require orthogonality with the bottom and can tolerate deviations within about 20 degrees. If the vehicle pitches and rolls when transiting more than about 20 degrees with respect to the bottom, it will cause the DVL to lose bottom lock. Just the before the DVL loses bottom lock, it typically outputs degraded data that is difficult to filter. This can cause the INS solution to significantly degrade. Analyzing logged data will show the vehicle attitude during transit and the DVL's attitude with respect to the bottom can be computed from the beam data. When using a DVL as an aiding sensor, it is very important all four beams of the DVL are able to reach the bottom and that the bottom is normal to the DVL face. If the vehicle is transiting over uneven bottom, the degraded DVL data will corrupt the position solution.

- **Forward is not forward.** When a DVL is used with the INS, the DVL has to be aligned to the IMU exactly for good tracking. If the navigation solution differs from the actual motion during transit, it is likely due to an error in the DVL or IMU configuration. Adjusting the transforms of either sensor allows operators to align the sensor frames in software, but the best solution is properly mounting the sensors so that their frames are well aligned.

- **The vehicle transits out in a steady direction, returns on the reciprocal heading, and the paths do not align.** This is actually a very good test to ensure INS function on a vehicle. If the reciprocal path does not align with the outbound path, the heading solution is most likely the problem. For magnetic systems, this is a good indicator that the heading sensor requires calibration.

- **The vehicle transits out in a steady direction, returns on the reciprocal heading to visual fiducial, and one leg is shorter than the other.** This is usually an indicator that the velocity solution of the vehicle is inaccurate.

- **Testing at the dock is not going very well.** Almost any aiding position sensor, DVL or USBL, will have troubles at the dock. Ports and harbors are very difficult environments for acoustic sensors because of interferences from harbor walls, pylons, ships, and debris on the bottom. Further, port and harbor environments are rich with ferrous materials, which significantly challenge magnetic sensors.

- **The position solution jumps when the vehicle lands on, or gets very close to, the bottom.** DVLs require a minimum height off of bottom; under that minimum height, they do not work and will not provide a velocity solution. Some DVLs have trouble during the transition from high enough to not high enough. During this period, the velocity measurements from the DVL can get erratic and pollute the INS solution.

- **Tracking is poor while flying close to the bottom.** This is common with DVL-aided solutions. DVLs require a minimum height off of bottom to sense velocity. If they are operated lower then the minimum required height, they will not have bottom lock and will not output velocity data. If the DVL is the only aiding sensor, the INS may stop updating the solution when the DVL stops providing a velocity measurement.

Article ID: 218

Source URL: http://localhost:8888/kb2017/positioning-issues