Performance of an AUV Navigation System at Arctic Latitudes

DRAFT OUTLINE

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Abstract

In October of 2001 MBARI operated an AUV in the arctic at latitudes exceeding 80°. The navigation system included a ring-laser gyro INS coupled with a DVL and GPS, a separate fiber-optic based gyro-compass, and a traditional flux-gate AHRS system. This paper compares the performance of the three instruments.

1 Introduction *All*

1. Why is this important?
   (a) Accurate navigation is essential for arctic science.
   (b) Manned arctic submarine research program terminated. (SciSx)
   (c)
2. What has been done before?
   (a) Meridian/Kearfott (Don, you probably know about these)
   (b) Lockheed Dvl/Ins Precision Underwater Navigation System (PUNS)
   (c) AutoSub; Antarctic, with PHINS? With Seatex DTG?
   (d) ISE; Thesius
3. What is different or new here?
   (a) Small and low power, compared to traditional manned submarines.
   (b) Moving base alignment?
4. Brief description of the conditions aboard the Healy.

2 INS Moving-Base Alignment and Free-Inertial Propagation *Don & team*

1. Description of experimental process: On-deck alignment with GPS, followed by free-inertial propagation, then reconnected to GPS. (Hans)
2. Comparison to the Octans deck-test data?

3. Determine how well the INS aligns under the arctic conditions of high latitude and moving base.

4. How much longer does alignment take?

5. What is Northern-most limit?

6. More ...

3 Comparison of INS/DVL, Gyro-compass, and Magnetic Compass Heading Error *Rob & Hans*

1. Description of experimental process: In-water AUV runs, etc.

2. Relative errors between the magnetometer and the INS, and the gyro-compass and the INS.

3. Use more accurate INS AHRS to transform the raw magnetometer measurements to the Navigation frame? Must account for mechanical misalignment between instruments.

4. Compare with magnetic field model IGRF.

5. Compare data from the summer 2001 tests here. Discuss error magnitude and character.

6. Conclusion - how usable was the magnetometer at these latitudes?

7. Note: Octans oscillating w/ 34 min period $\pm 4^\circ$, Triangle run, 298.00. Schuler period is 84 minutes.

4 Dvl Ice-Tracking Performance *Rob & Hans*

1. Re-compute dead-reckoning plot from INS heading and DVL velocity. Compare against USBL data. Estimate ice drift from the ship drift as measured by GPS during the mission.

2. Compare against IPS??

3. Is water-tracking more accurate in the long term than ice-tracking? This depends on water currents versus ice drift and wind.

4. Is it possible to post-process the INS/DVL data to correct for the Dvl reference-frame flip? We would probably ask Don to parse out the slow test messages for us.

5 INS/DVL Water-Tracking Performance *Don & Team*

1. Comparison to the data taken here in the Monterey Bay.

2. What about distinguishing between water and ice for the upward-looking DVL? Can water reflections cause problems? An AUV on a long distance arctic mission will likely pass under open water from time to time.

3. Extrapolate results to long-distance missions?

4. More ...

6 Conclusions *All*

Summarize:

1. Heading errors, particularly those due to high latitude.

   (a) Was the magnetic compass usable?

2. Dvl velocity-aid errors due to tracking ice rather than ground.

3. Alignment errors, particularly those due to moving base and high latitude.

4. In-water performance of the INS/DVL with water-track aiding.

5. Relate all error sources to overall expected system performance.

Note: We probably should also discuss the limitations of our data (carefully worded here!):

1. INS/DVL never navigated off the ice due to the coordinate transformation problem.

2. The AUV never got a GPS fix while in the water.

3. All three navigation instruments were mechanically aligned only by eye. The magnetometer/AHRS was in a different body section than the other two, so the mechanical alignment changed each time the section was removed and reconnected. (No alignment key in roll).

4. Magnetometer calibration uncertain. The manual doesn't provide a way to read out the calibration data.

References

[1] Thor I. Fossen. *Guidance and Control of Ocean Vehicles*. Wiley & Sons, New York, 1994.

Figure 1: Ground Track