Airborne Multi-Pass Precise Point Positioning in GrafNav 8.10

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Executive Summary

New to GrafNav 7.80 was a Precise Point Positioning (PPP) engine. This engine uses dual frequency GPS measurements and precise orbit and clock files to achieve accuracy levels of 10-30 cm on typical airborne surveys without using a base station. This level of accuracy is sufficient for many applications such as large scale aerial mapping.

GrafNav 8.10 includes an improved version of this processor that has shown 20%-40% improvements for aerial surveys up to 4 hours in duration. This level of improvement is achievable on typical aerial flights collected with an unobstructed view of the sky, low multipath, good satellite geometry, and minimal loss of GPS signal lock. The level of improvement on surveys greater than 4 hours is less significant (0-20%).

The PPP processor in GrafNav 7.80 processes independent forward and reverse solutions. A final variance weighted trajectory is then produced from both directions. The Multi-Pass feature in GrafNav 8.10 will process data three times sequentially; forwards, reverse, and then forwards again. After each processing run, the converged Kalman Filter states (position, velocity tropospheric delay and satellite ambiguities) are preserved.

Introduction

This report shows PPP accuracies from five airborne surveys using both the PPP tool available in GrafNav 7.80 and the Multi-Pass function available in GrafNav 8.10. All flights are of typical duration for aerial surveys ranging from 1 hour 45 minutes to 4 hours 8 minutes.

All flights were processed with simple field procedures in mind. That is, in all flights other than flight 1 data processing began five minutes prior to aircraft taxing and ended five minutes after the aircraft came to a complete stop. Data collection began during flight for flight 1. All data was processed entirely in kinematic mode.

For each flight a differential trajectory was processed using a nearby base station. This trajectory is used as truth and any difference between this trajectory and a PPP solution is considered error in the PPP solution.

For each flight, the error in each PPP solution is plotted and the RMS of the horizontal and vertical error is summarized. All of this is done with GrafNav's own quality control tools which are available to any user wishing to compare differential and PPP solutions. A height profile is also included to show the flying elevation of each survey.

Results

Flight 01

Length of Survey: 1 Hour 55 Minutes

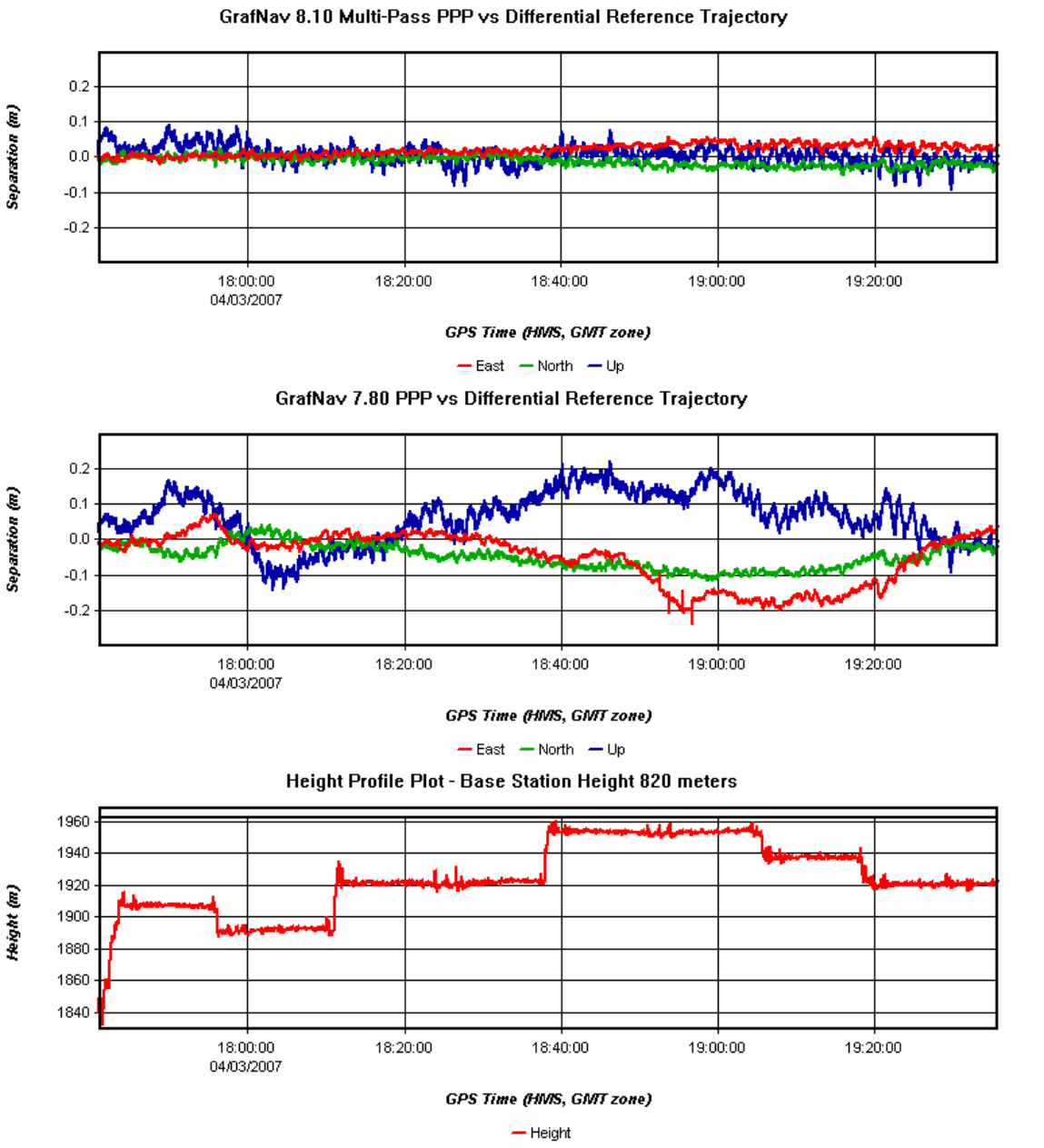
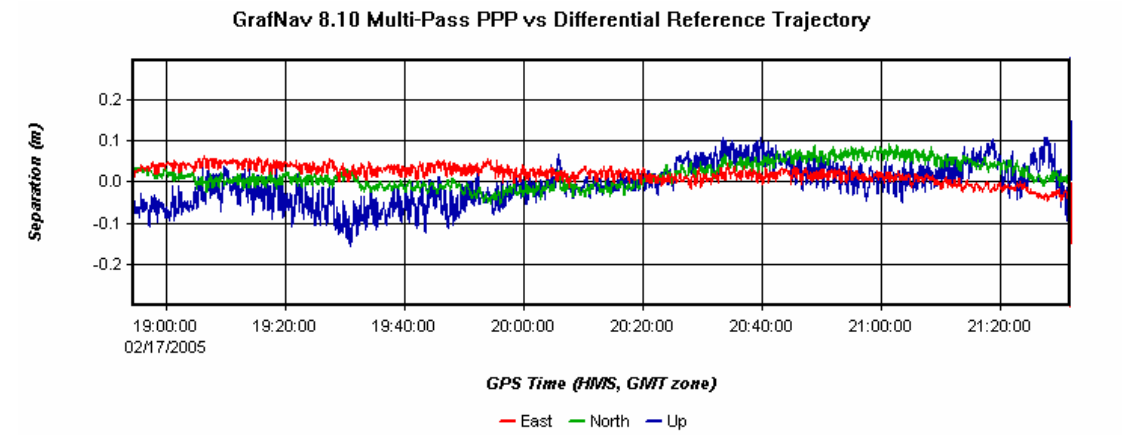


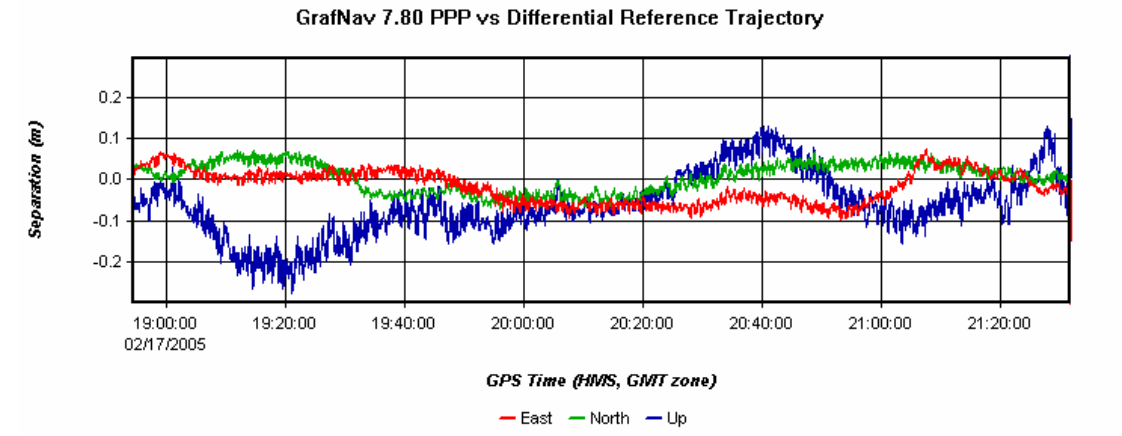
Table 1: RMS PPP Errors on Flight 01

	8.10 Multi-Pass PPP	7.80 Combined PPP
RMS 2D Error (cm)	3.1	10.6
RMS Height Error (cm)	2.7	9.7

Flight 02

Length of Survey: 2 Hours 38 Minutes





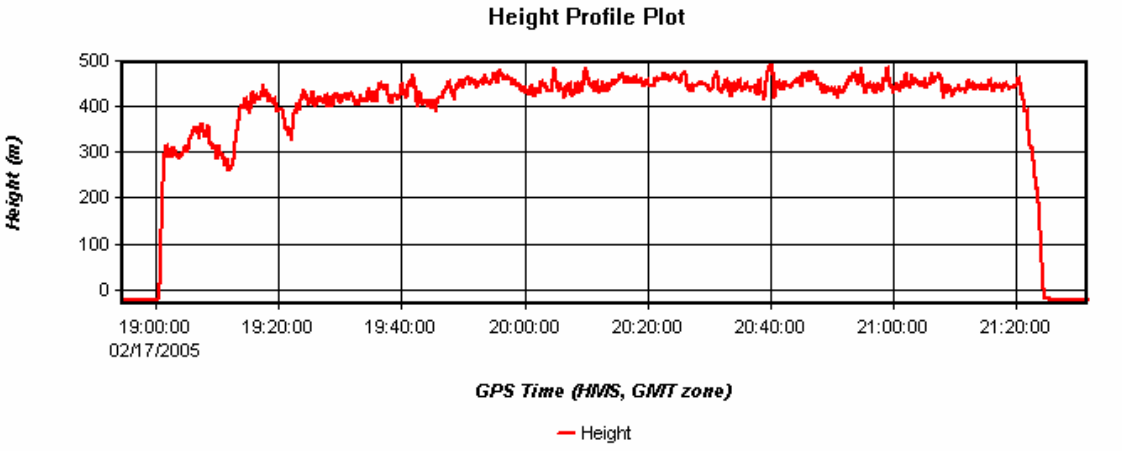


Table 2: RMS PPP Errors on Flight 02

	8.10 Multi-Pass PPP	7.80 Combined PPP
RMS 2D Error (cm)	4.7	5.7
RMS Height Error (cm)	5.0	10.0

Flight 03

Length of survey: 2 Hours 17 minutes

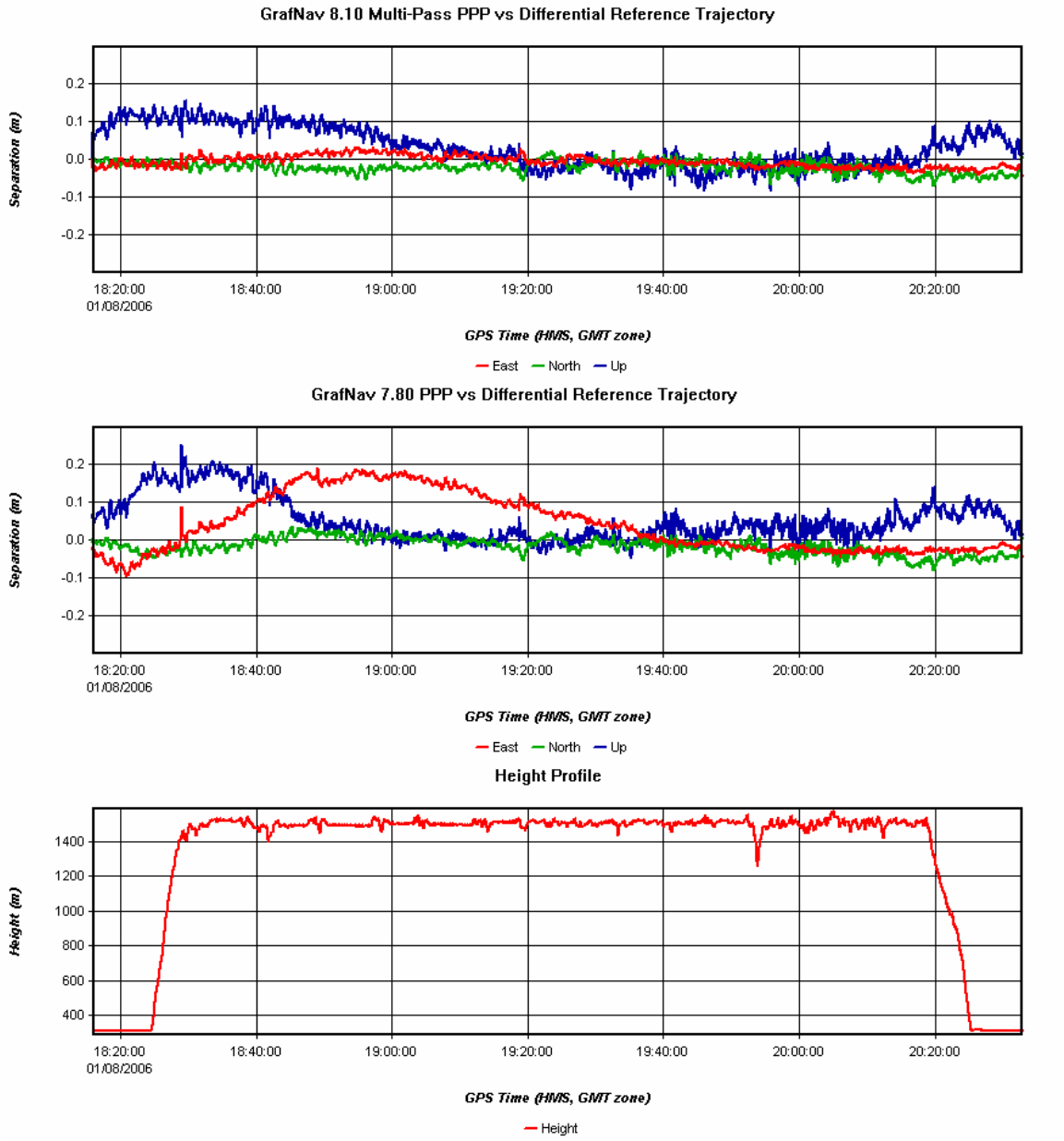
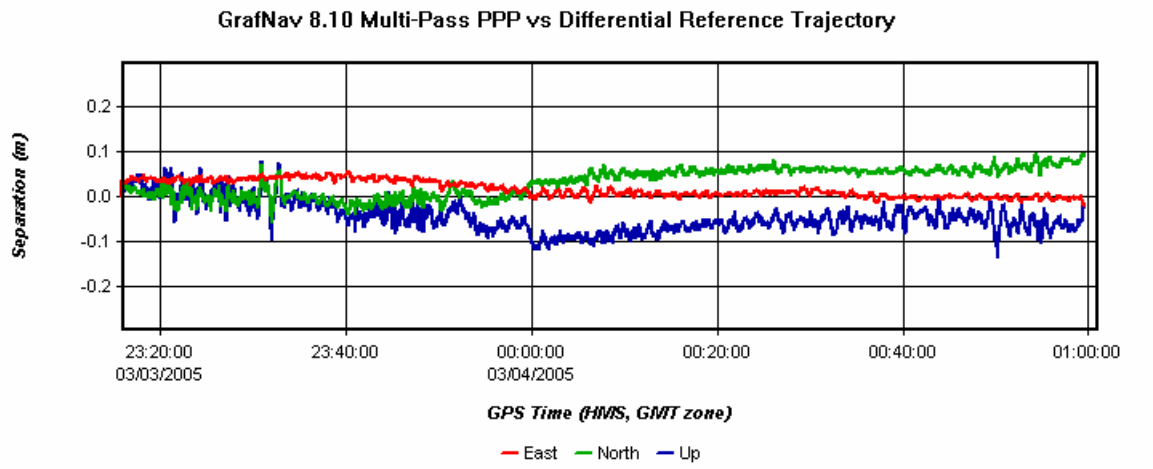


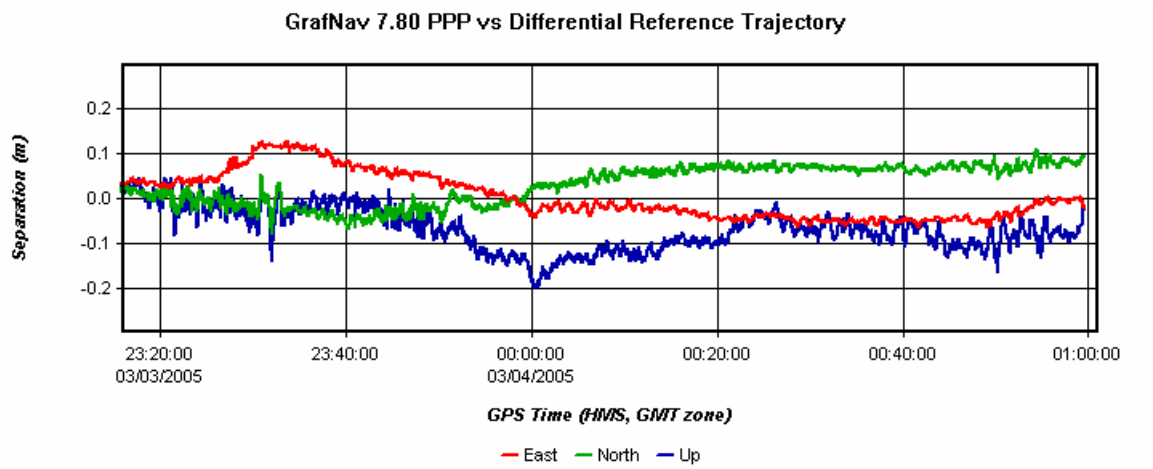
Table 3: RMS PPP Errors on Flight 03

	8.10 Multi-Pass PPP	7.80 Combined PPP
RMS 2D Error (cm)	3.1	9.0
RMS Height Error (cm)	6.2	7.8

Flight 04

Length of survey: 1 Hour 45 minutes





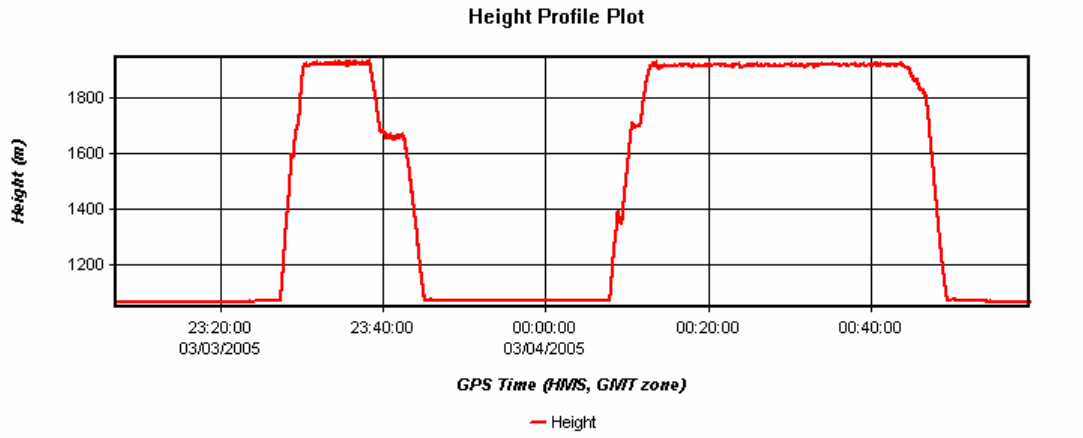


Table 4: RMS PPP Errors on Flight 04

	8.10 Multi-Pass PPP	7.80 Combined PPP
RMS 2D Error (cm)	5.0	7.3
RMS Height Error (cm)	5.8	8.5

Flight 05

Length of Survey: 4 Hours 8 Minutes

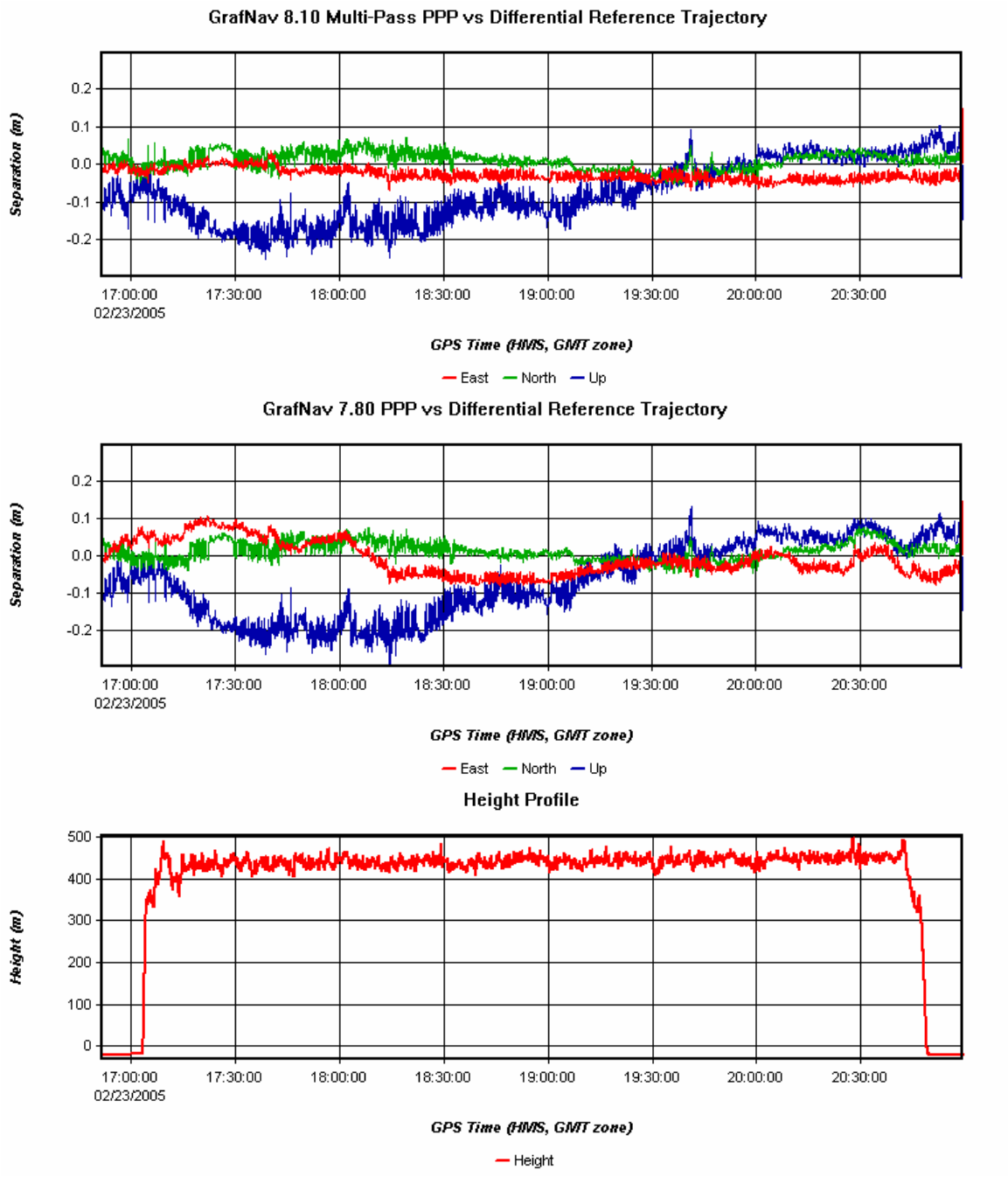
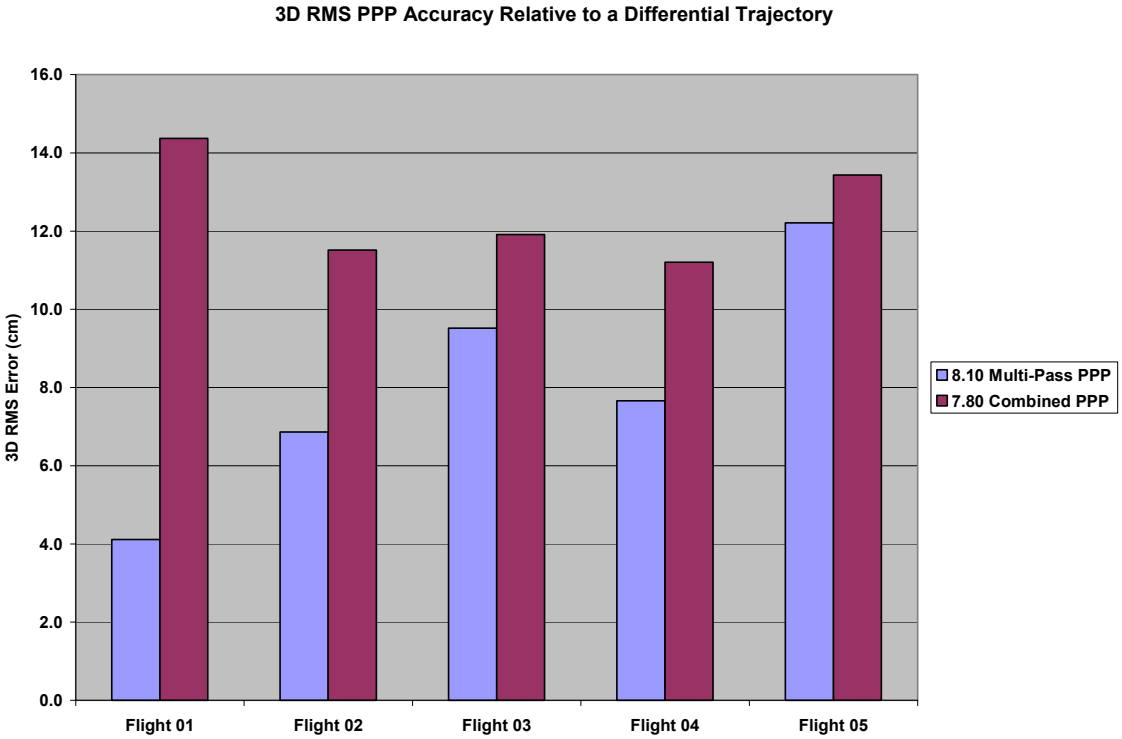


Table 5: RMS PPP Errors on Flight 05

	8.10 Multi-Pass PPP	7.80 Combined PPP
RMS 2D Error (cm)	4.1	5.4
RMS Height Error (cm)	11.5	12.3

Summary



Remarks

Multi-Pass PPP improved the 3D RMS of all five flights. An average improvement of 40% was obtained on Flights 1 through 4 when using Multi-Pass PPP over the independent forward and reverse PPP solutions.

Flight 5 showed only a 9% improvement when using Multi-Pass which was the least of any flight. Flight 5 was the longest flight at 4 hours and 8 minutes. By design, both types of PPP solutions are expected to produce similar results on long flights (4-5+ hours).

Although the Multi-Pass technique sequentially processes data forwards, reverse, and then forwards again; final results are combined from the reverse processing run and the final forward processing run. This is done in order to minimize error should a complete loss of lock occur. Losses of lock in airborne environments can occur if the aircraft banks too steeply during turns.

GrafNav 8.10 supports both Multi-Pass and independent forward and reverse PPP solutions. Multi-Pass PPP should be used as a tool in order to maximize PPP accuracies for open sky or aerial surveys. Significant savings can be achieved through the use of PPP for many applications such as large scale aerial mapping.