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Development of a Low-cost Positioning System Using OEM GPS Receivers and Usability in Surveying Applications

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Overview

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- ***Introduction***
- ***Motivation***
- ***Developed Low-cost Positioning System***
- ***Static Field Trials***
- ***Data Processing And Analysis*** -Evaluation of the Measurements
- ***Conclusion***

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Introduction

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As a result of the improvement on the GPS over the last decade, it enables positioning with the accuracy **from a few tens of meters down to centimeters**.

However, the more accurate results are desired, the more complicated methods, hardware and software are needed and the more the cost of the system becomes.

FIG SYDNEY

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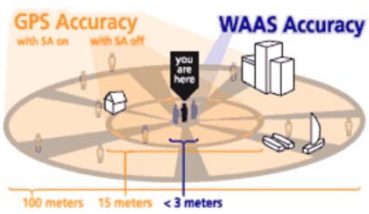
For instance after removing of the SA in 2000, it is possible to obtain 10 meters or even better stand-alone positioning accuracy with a hand held GPS receivers of a few hundred US dollars.



This positioning accuracy can be increased to a few meters level by using various regional augmentation systems such as WAAS.

FIG SYDNEY

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Such an accuracy is not enought for geodetic and surveying applications. To provide high-accuracy requirements, differential positioning techniques and the use of carrier-phase data should be used. This, however, requires the availability of expensive geodetic-grade single or dual frequency GPS receivers.

Such a receiver can be provided at about US$5,000-7,500 and US$15,000-20,000 for single and dual-frequency units, respectively.

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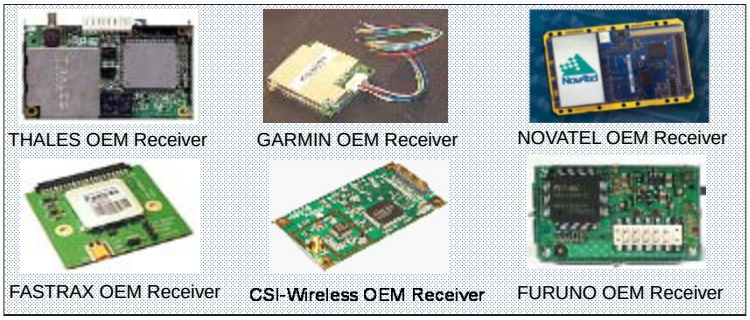
In recent years OEM type low-cost (less than US $1,000) single frequency receivers/boards that can output carrier phase data have begun to be used as an alternative to the geodetic grades, in surveying applications.



Using such a system may significantly reduce the positioning equipment cost.

Motivation

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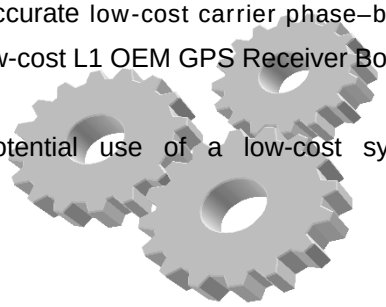
The objective of this study is;

to constitute an accurate low-cost carrier phase–based GPS positioning system using a low-cost L1 OEM GPS Receiver Boards,

AND

examines the potential use of a low-cost system for surveying applications.



Developed System

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In this study, **Garmin GPS 25-HVS** and **Thales Navigation AC12** single frequency OEM Boards were selected as GPS receivers.

Developed System

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Garmin GPS 25-HVS

Performance

Frequency: L1
Receiver: Differential-ready 12 parallel channel receiver tracks and uses up to twelve satellites to compute and update a position.
Update Rate: 1 second, continuous (programmable from 1 second to 15 minutes)
Interfaces:

- Dual-channel RS-232 compatible with user-selectable baud rate
- NMEA 0183 version 2.0 ASCII output

Outputs:

- Raw measurement output for both pseudorange and phase data (i.e. code&carrier phase on L1)
- Position, velocity, and time
- Receiver and satellite status
- Differential reference station ID and RTCM data age
- Geometry and error estimates
- PPS (pulse per second) output

Physical

Size: 1.83" (w) x 2.75" (l) x 0.45" (h) (46.5 mm x 69.9 mm x 11.4 mm)
Weight: 1.3 oz., (38 g), not including interface cable or remote antenna

Developed System

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Thales Navigation AC12

Item	Specification
General	12-channel continuous tracking OEM GPS receiver board
GPS parameters	L1 frequency, C/A code (SPS) and carrier
Update rate	1 Hz
Accuracy	
Horizontal 95%	Autonomous 5.0 m, SBAS 3.0 m, DGPS 1.5 m
Carrier Phase Meas. Accuracy	3 mm (RMS)
Speed (max)	514 m/s (1,000 knots)
WAAS/EGNOS Support	Yes
Communication interface	NMEA 0183 V3.0 using standard Ashtech command set
Message types	RTCM V2.2 differential remote message types 1, 3, 9
Serial ports	One TTL full duplex for primary I/O One TTL half duplex for RTCM
Baud rate	Selectable 1200 to 115,200 bps (except 2400 and 38400 bps.)
Size/Weight Board	Bare board: 39 x 60 x 10 mm 20 gr (with mechanical shield case: 45.4 gr)
Input voltage/current consumption	3.3 to 5 VDC/55 to 70 mA typical

Static Field Trial

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In order to test the developed system's accuracy and performance as a function of occupation time and baseline lengths, three static test measurements were conducted in University Campus in different days.

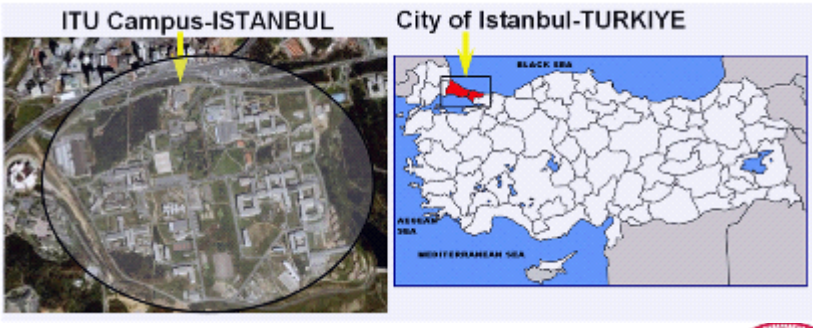

FIG SYDNEY

Static Field Trial

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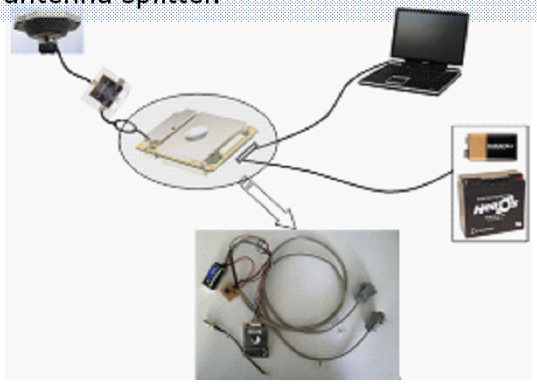
In the first trial, the **GARMIN GPS25** and **Ashtech Z-Xtreme** dual frequency geodetic-grade receivers are connected to a **Ashtech's single-frequency geodetic GPS antenna** via an antenna splitter.



The system then is set up on a point located on the roof of our faculty building and data were collected.

FIG SYDNEY

Static Field Trial

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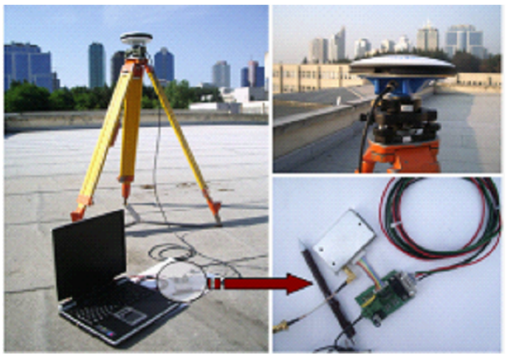
Thales AC12 GPS OEM Board and Ashtech Z-Xtreme dual geodetic receiver were connected to Ashtech Dual frequency GPS antenna via an antenna splitter and data were collected.



In this way, GPS data were collected by the OEM and geodetic receivers under the same conditions, which allows for precise assessment of the low-cost system.

Static Field Trial

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Throughout the studies, IGS and/or continuously operating GPS reference stations TUBI, BAD1 and KANDILLI-KANT were used as reference.

Trial Number &Date	Reference Station-Marker Name	Rover Station Name	Baseline Length (km)	Occupation Time (minutes)	Rover Receivers/ Antenna Type
Trial-1 November 25, 2006	- TUBI - KANDILLI (KANT)	CP-1	~ 50.6 ~ 6.0	30, 60 (2 parts) and 120	Garmin GPS25& Ashtech Z-Xtreme / L1 Geodetic Antenna
Trial-2 December 07, 2006	- TUBI - BAD1 - KANDILLI (KANT)	CP-1	~ 50.6 ~ 29.2 ~ 6.0	30, 60 and 120	Magellan AC12 OEM&Ashtech Z-Xtreme / L1&L2 Geodetic Antenna
Trial-3 December 08, 2006	- TUBI - BAD1 - KANDILLI (KANT)	CP-1	~ 50.6 ~ 29.2 ~ 6.0	30 (2 parts), 60 and 120	

Processing of the Collected Data

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All the collected data are converted to the RINEX format with the software and then imported to Leica Geo Office (LGO) commercial software for processing.

The coordinates of the rover antenna connected to the OEM and geodetic receivers are estimated using baselines referenced to the 'Reference Stations' with LGO software.

Some Processing Parameters Used in Software

Elevation Angle	:	10^0
Ephemeris	:	Precise IGS Orbits
Troposheric Model	:	Saastamoinen
Ionospheric Model	:	Computed

Processing of the Collected Data

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The coordinates of the;

Garmin OEM receiver are estimated with only float ambiguity solution

whereas

all phase ambiguities are resolved successfully for AC 12 and geodetic-grade receivers.

The main reason of the float solutions can be explained that the initial ambiguity parameters will not, in general, be integer numbers. Instead they will be, in general, multiples of half cycles.

Processing of the Collected Data

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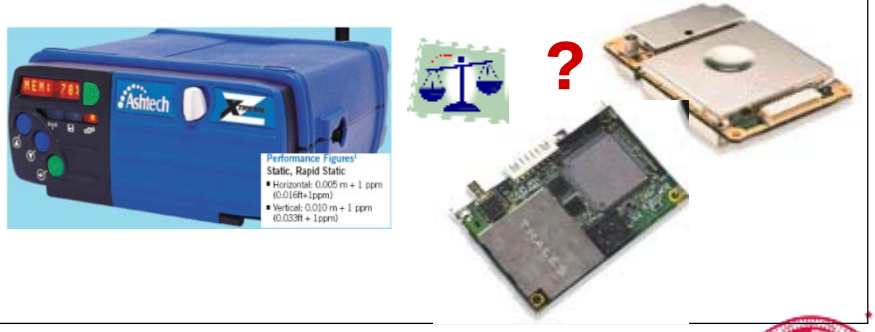
The coordinates obtained with OEM boards were compared to their known values. Differences in the latitude, longitude and ellipsoidal height components with approximate baseline length and occupation time are shown in the following figures.



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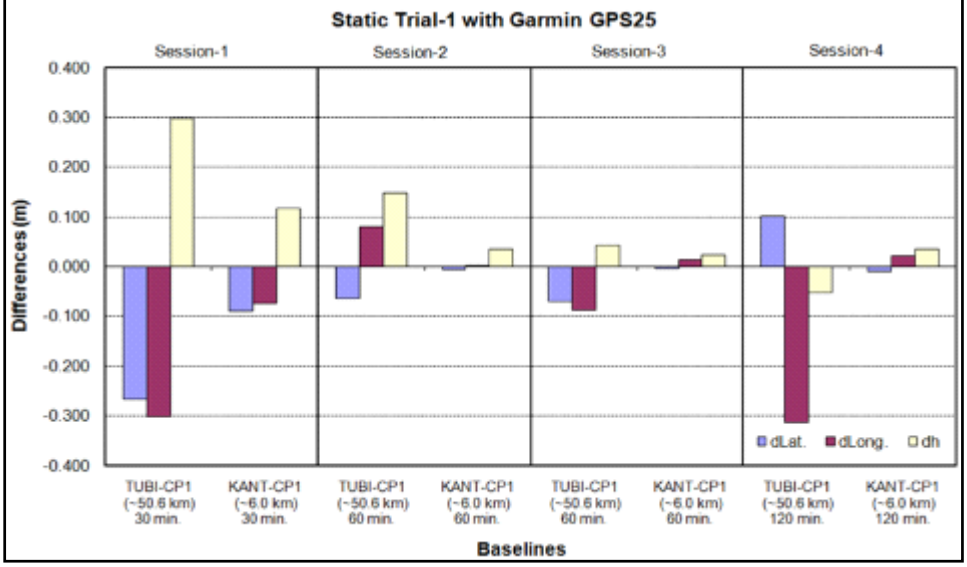
Differences between OEM-derived *Estimated* and Known Coordinates



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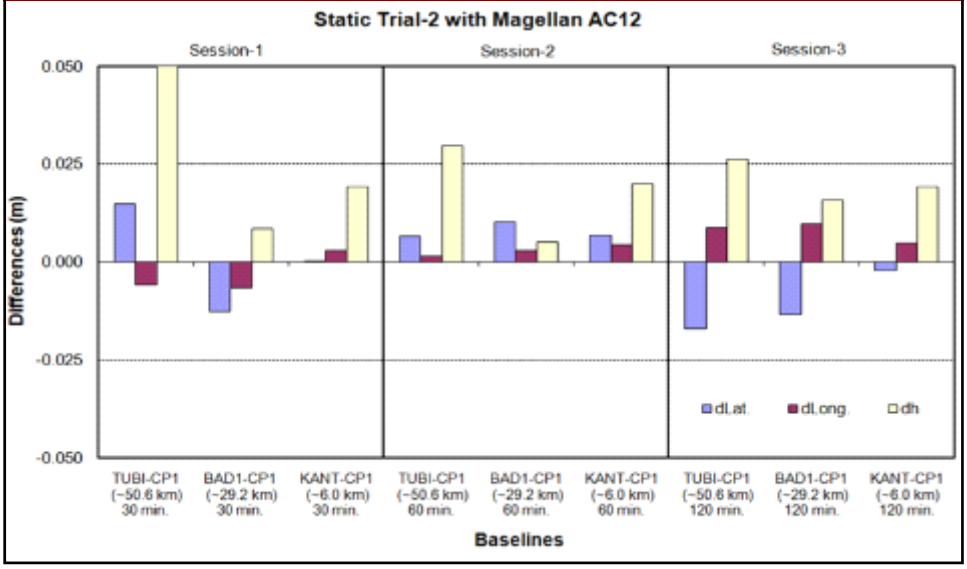
Differences between OEM-derived *Estimated* and Known Coordinates



Processing of the Collected Data

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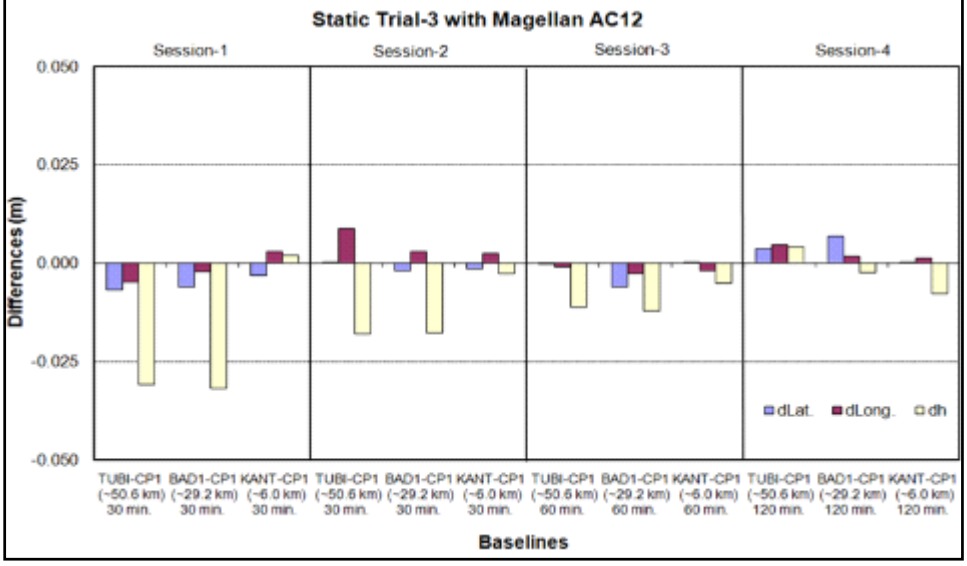
Differences between OEM-derived *Estimated* and Known Coordinates



Conclusion

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The results obtained from the **Garmin GPS25** receiver showed that **position accuracy at a few centimetre-level is possible for the short baselines (i.e. 6.0 km) when the occupation time of 60 minutes or more is used.**

In contrast, the results for the 51 km baseline are relatively poor, i.e. a few decimetre-level, even for 2 hours occupation time is used. The results for the height component is similar to position component.

Conclusion

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On the other hand, the coordinates estimated by the AC12 receiver agree with the known coordinates with a difference of a few centimetres for both short and long baselines (i.e. 6.0 km, 29.2 km and 50.6 km) even with a shorter occupation time (30 minutes) both in position and height components.

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CONCLUSION

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It is clear that such a level of accuracies obtained from both AC12 and GPS25 receivers provide the requirements of **a number of surveying and GIS applications**.

Results also showed that **using such a low-cost system would decrease the cost of surveying tasks**; therefore, it can be regarded as a strong economical alternative to the geodetic type GPS receivers.

Acknowledgements

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Thank you very much for your
interest and attention…
Questions???
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