Results and Advantages of Using an Advanced Technology
Airborne Gravity Meter to Map the Geoid in the U.S.

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Introduction

The National Geodetic Survey (NGS) has been acquiring airborne gravity data over the entire United States and its territories for the past 10 years as part of the GRAV-D project (http://doi.org/10.1029/JB073i014p04675) to directly measure the geoid and redefine the vertical datum for elevation in the USA.

The geoid can be measured by airborne gravimeters with a desired resolution of better than 2 milliGals. However, results can vary depending on aircraft stability and degrade quickly with increasingly turbulent flying conditions. The result can be days wasted waiting for smoother air or re-flights when the data quality is too poor to be of use. It has therefore been of some interest from the NGS and other airborne survey groups to see the development of an improved airborne gravity system which can increase data quality while reducing the time and cost for large airborne gravity surveys.

The purpose of these flight tests was to determine the suitability and performance of the Advanced Technology gravity meter to use in airborne gravity surveying and in particular whether it could be used in the GRAV-D geoid mapping program. The new system was flown concurrently with an NGS TAGS-7 gravity meter and compared to calculated EGM 2008 for reference.

The advanced technology gravity system developed by Dynamic Gravity Systems has been designed to address the shortcomings of both the gimbal platform and sensor noise of older systems, such as the ones used currently by NGS. The gravity signal measured by gravity sensors is reduced whenever the platform is ‘off level’ due to turns or course deviations from straight and level flight. These horizontal motions result in accelerations that cannot normally be separated from the acceleration due to gravity which is the desired signal. In other words, the sensor is no longer measuring the true vertical vector component of the gravity signal. This can be corrected for, but usually inadequately, especially when the system is experiencing turbulent conditions.

The AT system reduces this effect by keeping the platform significantly closer to level during flight by using GPS aiding from an Inertial Navigation System (INS). The INS also provides a higher resolution position which is important during processing of the gravity data.

The AT sensor is modeled on the zero length, metal spring concept, developed by Lacoste and Romberg, that has proven to be a robust and reliable survey instrument over many decades. The AT sensor uses new electronic upgrades, including magnetic damping and a force feedback system, that eliminate most of the mechanical sources of error and noise in the sensor.

NGS has access to a Pilatus PC-12 which is an ideal small aircraft for the geoid project as well as having the capacity to run two survey systems at the same time. The plan was to test the new system during normal survey flying using the NGS system as a baseline along with gravity calculated from EGM 2008.

Sixteen survey lines were flown including two repeat lines as shown in the Figure below. Thirteen lines were flown in an east-west direction with the lines having an average length of 550 km. The line spacing for the grouped lines was approximately 10km. The lines were flown at an average speed of 120 m/sec and altitude of 6km.

Gravity and GPS data are recorded at 10Hz and then synchronized during processing to ~0.0005 sec by maximizing the correlation between the GPS vertical acceleration and the sensor gravity output.

The results of the flight test survey clearly show the value of the new Advanced Technology system over the TAGS-7 gravity system currently used by the National Geodetic Survey. Before line leveling of the survey using the crossing points, the AT meter achieves an accuracy of about 1.3 milliGals which improves to about 0.5 milliGals after leveling. The NGS meter obtains reasonable results after the large spike is removed but still does not approach the accuracy of the AT meter mainly because of the ‘off level’ problem. The figures show that the AT meter has much less susceptibility to vertical accelerations due to turbulence.

The flight test results indicate that the new AT airborne meter would be a significant upgrade to the TAGS meters currently used by the National Geodetic Survey for surveying the geoid.

The final Free Air Gravity results were filtered using a 3 pass 120 second Gaussian filter. As discussed, the Advanced Technology platform maintains level when flown in GPS aided mode so that no ‘off level’ corrections were required. Standard off level corrections were applied to the NGS TAGS-7 meter processed by NGS.

The following figures show examples of line profiles resulting from the processed data for the systems and computed EGM 2008 as well as the amount of turbulence during the flight, plotted as vertical acceleration.

References and Acknowledgements


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Summary

| The Pilatus PC-12 Aircraft Used for the Test Flights | Advanced Technology Gravity Meter Installed on the Pilatus | Location of Flight Lines Surveyed During Test Flights from Tulsa | The Pilatus PC-12 Aircraft Used for the Test Flights | Advanced Technology Gravity Meter Installed on the Pilatus | Location of Flight Lines Surveyed During Test Flights from Tulsa | The Pilatus PC-12 Aircraft Used for the Test Flights | Advanced Technology Gravity Meter Installed on the Pilatus | Location of Flight Lines Surveyed During Test Flights from Tulsa | The Pilatus PC-12 Aircraft Used for the Test Flights | Advanced Technology Gravity Meter Installed on the Pilatus | Location of Flight Lines Surveyed During Test Flights from Tulsa |

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