Metrological Problems with Modern Gravimeters

Manfred Bonatz
Institute for Geodesy and Geoinformation, Bonn University, Germany

Extended Abstract

At present, spring gravimeters for relative field measurements are produced by two companies only:
the Burries-Gravimeter by ZLS (http://www.zlscorp.com/) and
the CG-5 Gravimeter by Scintrex (http://www.scintrexltd.com/).
The Burries Gravimeter is equipped with an astatised metallic spring sensor basing on the classical LaCoste principle, the CG-5 Gravimeter holds a linear quartz sensor.

There is a trend to be recognized towards a fully automation of the measuring process. That measure can doubtlessly facilitate the gravimetric observations – *if* the associated software is sufficiently understood or can at least be handled correctly! From a practical point of view it is often difficult to filter relevant references out of the abundant information: The voluminous operation manual to the CG-5 Autograph System contains for instance more than 200 pages of software description and application advises. As counter-example: when the author got his Model G LaCoste-Romberg Gravimeter in 1984, the Instruction Manual consisted of just a dozen sheets, and once having read the relevant two pages, one could immediately start the measurements. At that time the user was solely concerned with the direct sensor annunciation, without considerations about the contribution of any automation and any software, generating the final gravimeter output signal.

The aspect to investigate the properties of individual sensors (for discrimination from the properties of the following-up components) gets the more relevance the less the manufacturer informs about relevant metrological features when obvious troubles occur.
Recent parallel measurements with 10 Scintrex Gravimeters in the German Fundamental Station Bad Homburg revealed that only six of them fulfilled the performance advertised by the manufacturer. Four gravimeters exhibited anomalous drift features and outliers of unknown origin. For error sourcing it suggested itself to connect the gravimeters to a common high-efficient data acquisition system with permanent real-time data access and data visualization, preferably parallel with a well known reference gravimeter. Unfortunately, that analog output which is mentioned in the manual can't be used since it is for manufacturer's testing purposes only and recommended not to use for CG-5 data monitoring because of the non-linear drift over time. That message from the Scintrex Service refers obviously to the enormous drift of the quartz sensor, which amounts up to about 1 mGal per day. Different from metallic spring gravimeters that drift rate can not be reduced by an optimisation of mainly the ambient temperature since it is due to matter properties of quartz. For comparison: a metallic spring gravimeter presently installed in the GeoDynLab of the Walferdange Underground Observatory reveals a mean drift rate of 1 mGal per **year**. That small drift rate advertised by Scintrex refers to a *trend corrected* drift and not to the true sensor drift! This discrimination is metrologically essential.

What concerns the Burries Gravimeter, at least with one instrument serious problems occurred just recently when in the course of spatially extended field measurements the feedback range (+/-25 mGal) had to be shifted.

For the reasons mentioned before, fully automated spring gravimeters should be equipped with an additional *analog* signal output, independent from the subsequent internal data processing system. That output could enable a permanent monitoring of the "true" gravimetric sensor positions by an *external* data acquisition device. In the case of the Scintrex CG5-Gravimeter with its strong sensor drift, an independent access to the *trend corrected* drift is needed. A simple solution would be to establish an additional trend corrected raw data output and to retransform the digitized values into analog signals by means of an appropriate digital-analog-converter; that solution should not raise major difficulties.

Problems with spring gravimeters occurred in the past too, prior to the era of automation.
But it was easier to identify the sources and causes, as a precondition for either a principal elimination of the malfunction source or for modeling the perturbing effect and for reducing the data correspondingly. But one has to take into account that the larger the magnitude of a perturbing systematical effect is the higher gets the necessary relative resolution of the correction.

Perhaps one should recall again that reasonable metrological principle: *Keep it simple*. At least as an additional option for the user.