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AUTOSUB Propulsion System Investigation: Laboratory Data Pre-Processing

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CONTENTS

1 Introduction

The laboratory experiments described in (Fallows 2005) were all carried out in the SI Towing Tank using the same apparatus. However, the data was potentially subject to error as a result of distortion within individual records, instrument drift over the period of the experiments and variation of measured speed for a given speed dial setting. This Report describes the pre-processing of the raw data necessary to remove these contaminants.

2 Intra-record drag force measurement distortion

The drag for each run is measured at 60 Hz with the recording only being made during the constant speed portion of the run. The drag for each set of conditions is taken to be the mean of all of the data points for each run.

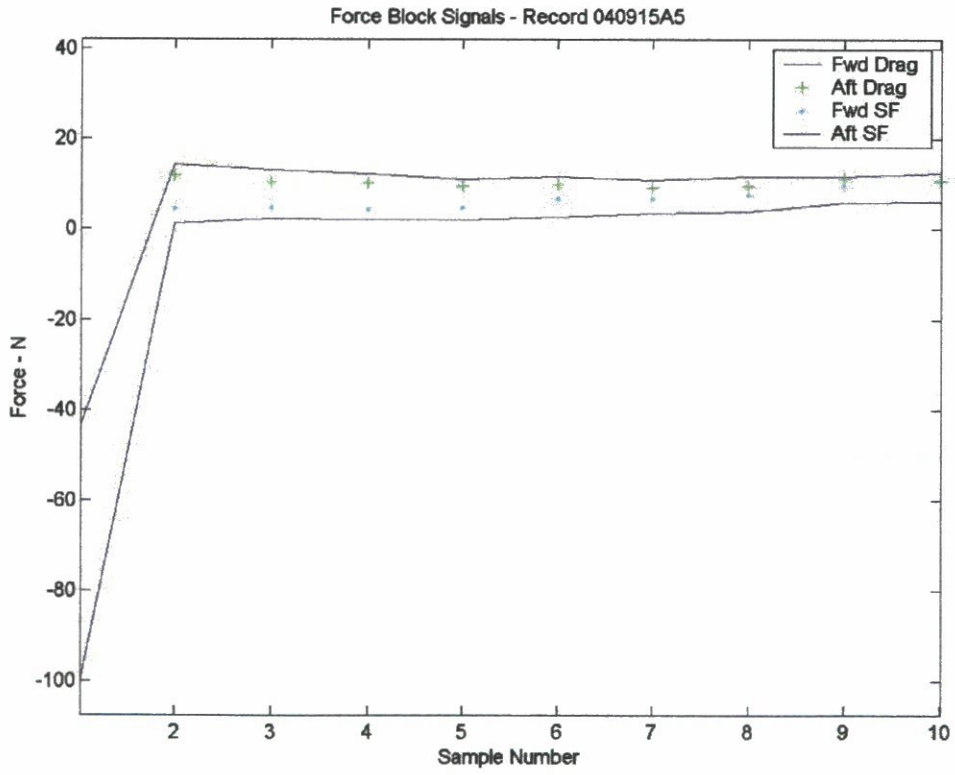

Figure 1 Example of ADC distortion

A Matlab function was written (Fallows, 2005) to enable the data for individual runs to be visualised. Two sources of distortion were observed: the ADC being set high or

low at the beginning of a record (Figure 1); and/or the record beginning whilst the carriage was still accelerating (Figure 2).

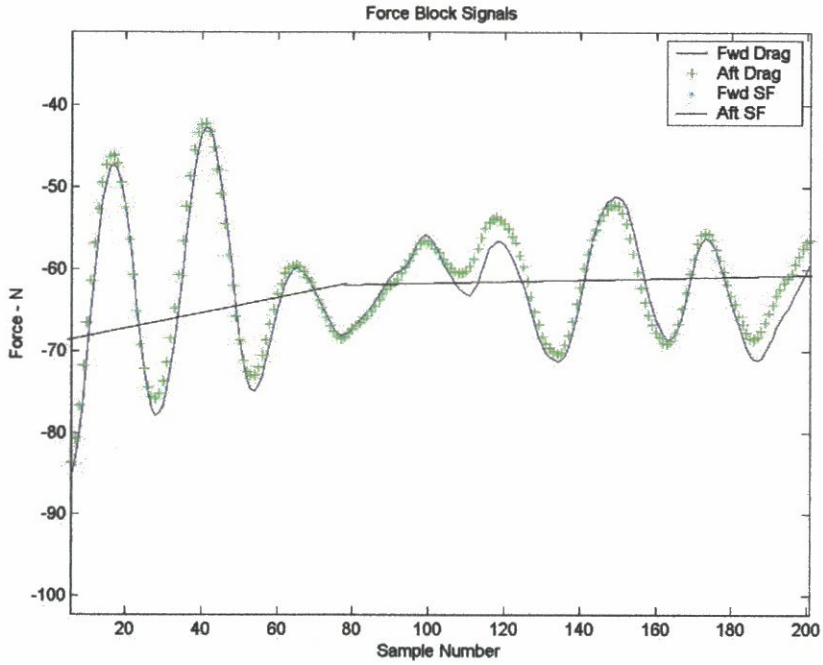

Figure 2 Example of acceleration distortion

Each record was examined and, where necessary, truncated, using another Matlab function written for this purpose (Fallows, 2005). The effect of removing these distortions is shown in Figure 3. The ADC effect was comparatively small with the main correction being due to acceleration contamination during the high-speed runs. Even these corrections were very small as a percentage of the total force (~ 1%).

Before assembling the dynamometer, a 4-point calibration (0, 30, 70, 100 N) was undertaken on each force block using the same amplifiers and data logger as used in the experiments. This demonstrated that the transducers are linear to within the measurement accuracy of the data system and, therefore, linear interpolation between the calibration points would be satisfactory.

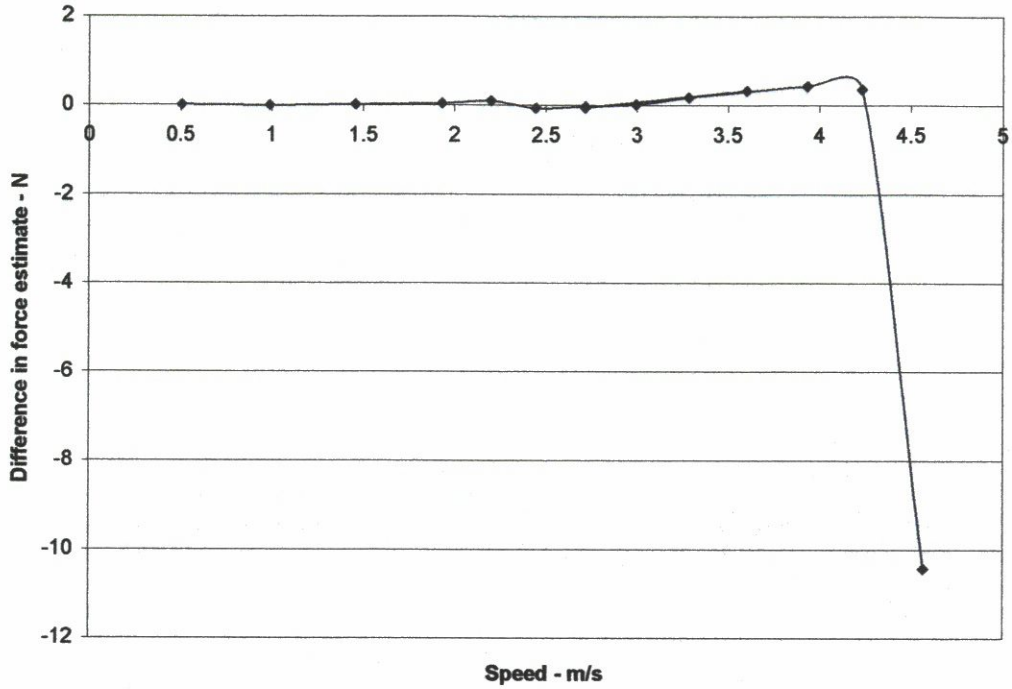

Figure 3 Effect of ADC and acceleration correction

After assembly of the dynamometer the measurement system was zeroed and a load in the drag direction of 60 N was applied as shown in Figure 4.

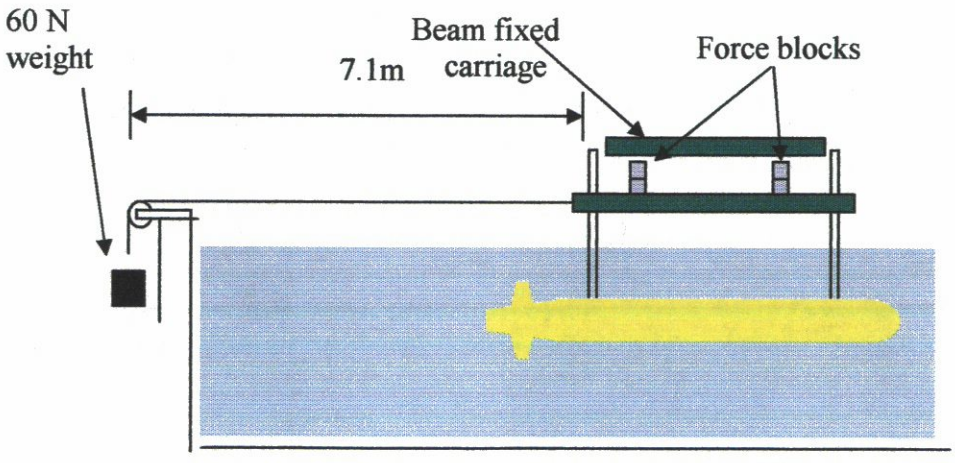

Figure 4 In-service calibration

A measurement of drag force was taken. This process was repeated twice more, with the sense of the applied force being changed on each occasion. A mean reading of

58.74 N was obtained, indicating that the post-assembly calibration system was showing a bias of 1 N, probably due to friction in the pulley wheel and slight misalignment in the direction of application of the force.

Inevitably, the sensitivity of the measurement system would vary during the campaign resulting in calibration drift. To counter this, in-service calibration, using the same method as the post-installation calibration check, was carried out at regular intervals throughout the campaigns. An example of the results is shown in Figure 5.

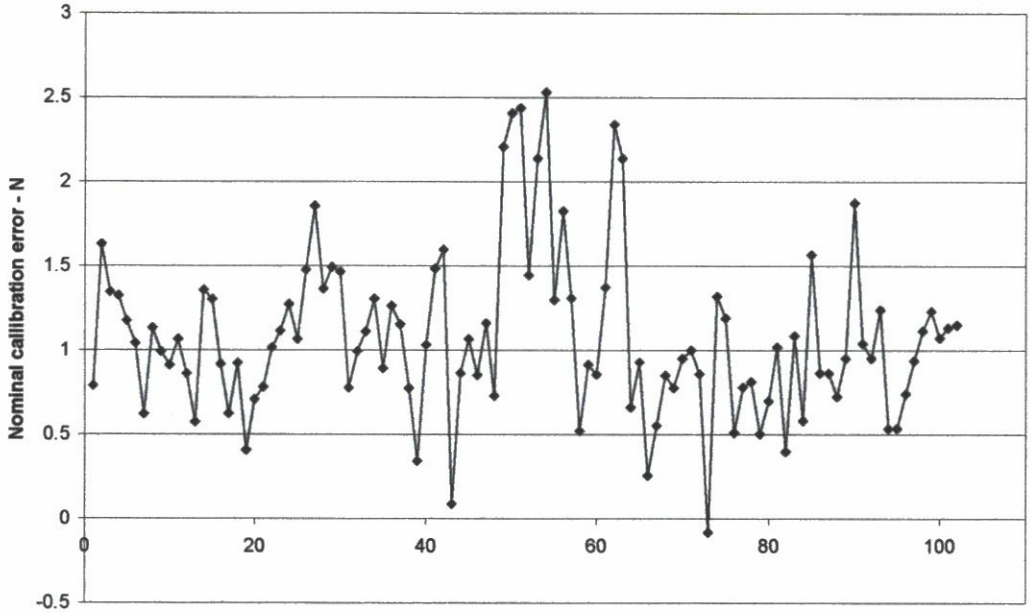

Figure 5 Time series of calibrations – Campaign 0704

A constant mean offset of 1 N was found to occur with small variations (standard deviation of 0.4N) about this mean. This is virtually identical to the results obtained from the post-assembly calibration check. The calibration check results shown on a daily basis are given in Figure 6. There is no discernable pattern to the diurnal variation. These results taken together indicate that there is virtually no calibration drift, and such as there is has no discernable pattern. No calibration correction is, therefore, considered necessary.

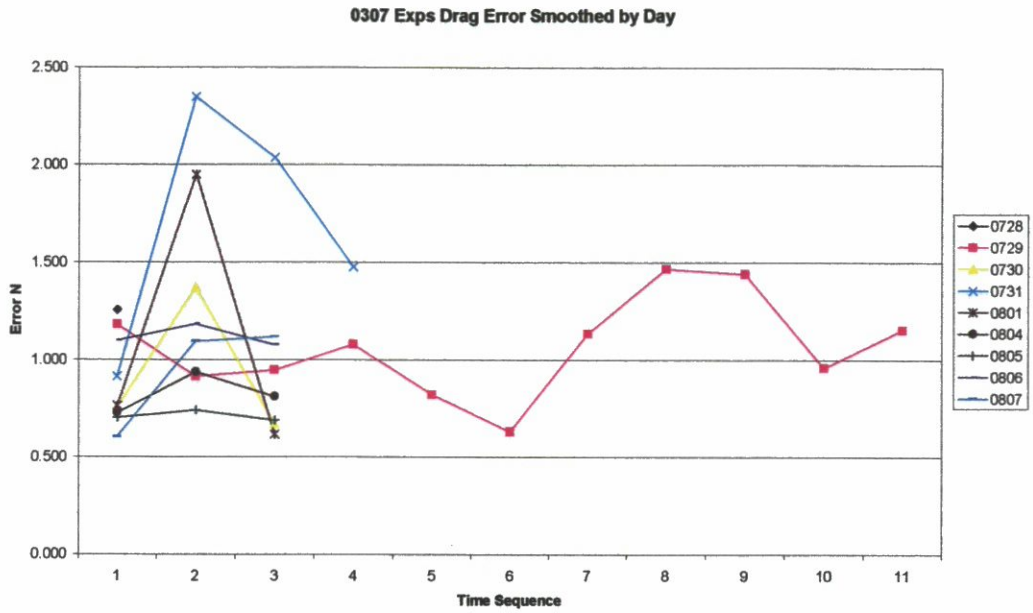

Figure 6 Results of calibration checks by day

3 Speed measurement calibration

The speed at which each experiment is to be run is set by means of a dial in the range 0 to 999. The corresponding measured speed shows slight variation between runs for a nominal dial setting. The statistics are given in (Fallows, 2005). The overall relationship between measured speed and dial setting is marginally non-linear and is shown in Figure 7.

A look up table for speed related data is given in Annex 2. This provides data for parameters such as Reynolds Number, Froude Number and Depth Froude Number for both model and full scale conditions, as well as the speed blockage corrections discussed in the next Chapter.

An automatic speed look-up function was written for use with Matlab applications as at (Fallows, 2005).

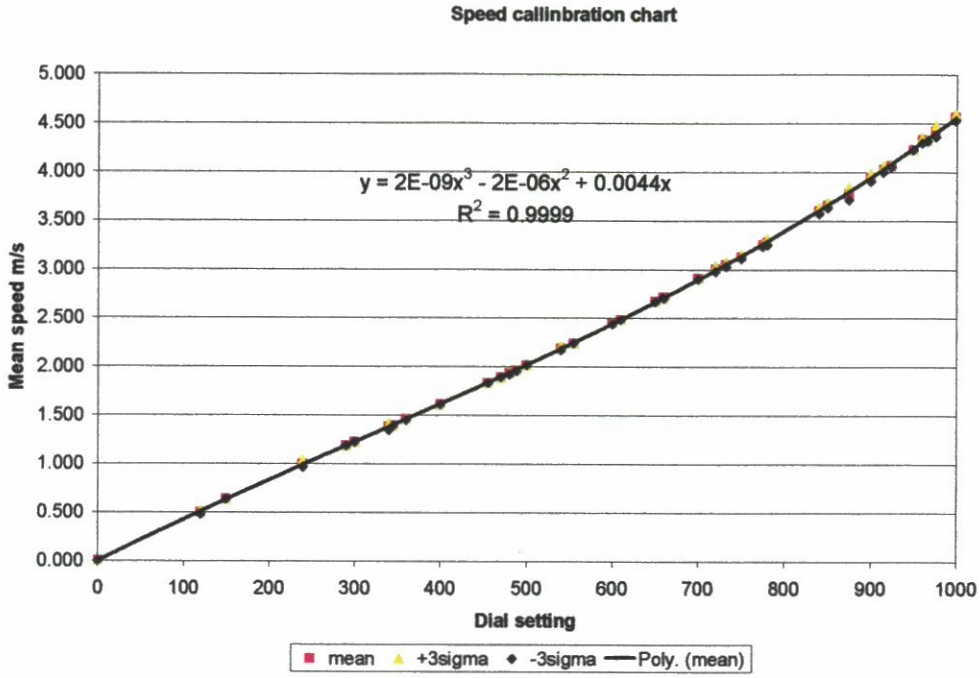

Figure 7 Speed calibration chart

Conclusions

The method of pre-processing the raw data obtained from the experiments has been described. The intra-drag records need correcting for both: ADC initial bit errors; and for recording of drag force beginning before the speed becomes constant. Neither of these effects is significant, involving correction of the order of 1% at worst, and usually much less. Inter-record drag measurement drift during the campaigns is shown to be negligible and have no identifiable pattern. Correction for this effect is, therefore, shown not to be necessary.

The relationship between speed dial setting and measured speed, has been well characterised and look-up facilities have been described.

References

Fallows, C.D. (2005), '*AUTOSUB Propulsion system investigation - Supplementary information*', University of Southampton, University of Southampton, School of Engineering Sciences, Ship Science, Report 135, pp. 8.

Fallows, C.D. (2005), '*Characterisation of the propulsion systems of autonomous underwater vehicles*', University of Southampton, University of Southampton, School of Engineering Sciences, Ship Science, Thesis.