DETERMINATION OF A CONSENSUS CALIBRATION TRANSFER FUNCTION AND ASSOCIATED UNCERTAINTY FOR THE VECTOR ANEMOMETER TYPES A100R AND A100L2

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SUMMARY

In 1998 Lockhart and Bailey [1] evaluated the calibration of the NRG systems #40 Maximum and developed what has come to be known as the consensus transfer function. Thanks to the number of calibration certificates that Garrad Hassan (GH) has had the opportunity to review, GH is now able to propose a consensus transfer function for VECTOR anemometer types A100R and A100L2. Analysis of the results also enables evaluation of the uncertainty associated with those consensus transfer functions. Discussion of how the consensus uncertainty compares to uncertainties for individually calibrated anemometers leads to conclusion on how calibrations should be applied.

1. INTRODUCTION

It is nowadays common practise in the wind energy industry to individually calibrate cup anemometers for use in wind measurement campaigns. However, this is not always undertaken and in the real world calibration certificates are sometimes lost or calibrations are undertaken in wind tunnels which do not comply with industry norms. In such circumstances it is necessary to make the best use of the available data and assign a realistic uncertainty to the measurement. For this purpose GH, presents the results of a study based on an internal calibration certificate data base for the VECTOR anemometer types A100R and A100L2.

2. VECTOR CONSENSUS TRANSFER FUNCTIONS

The GH VECTOR data base is composed of 631 calibration certificates as presented in Table 2.1. The sample is considered sufficient to perform a statistical analysis for the purposes of this study although it is acknowledged that a larger sample would add further accuracy to the results.

Calibration Institute	**A100L2**	**A100R**
DEWI	388	132
Universidad Politécnica de Madrid	6	-
Svend Ole Hansen	91	5
WindGuard	9	-
TOTAL	**494**	**137**

Table 2.1: GH VECTOR database content

The database contains calibrations starting in 1999 up to 2008, with the majority dating between 2000 and 2006.

The distribution of the slope and offset values for the A100R and A100L2 database can be observed in Figures 2.1 and 2.2, respectively.

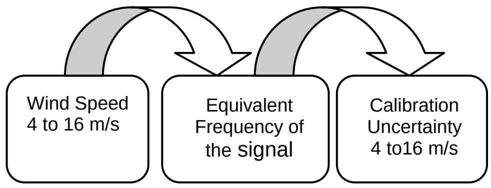
The proposed consensus transfer functions presented in Table 2.2 are determined using all the data present in the database.

	A100L2	A100R
Slope [m/s per Hz]	0.0499	1.2146
Offset [m/s]	0.2400	0.2170

Table 2.2: Proposed consensus transfer functions

UNCERTAINTY ANALYSIS

Following the guidelines of the IEC 61400-12-1 [2], the uncertainty associated with the use of the consensus transfer function can be analysed for each individual wind speed bin. A flow diagram of the methodology employed to calculate the calibration uncertainty is shown in the diagram below.



The scatter in the samples is calculated for both anemometer types. The standard deviation of the slope and offset parameters are presented in Table 3.1.

	A100L2	A100R
Std Dev Slope [m/s per Hz]	0.00052	0.01359
Std Dev Offset [m/s]	0.04166	0.03045

Table 3.1: GH VECTOR database Standard deviation

In order to assess the potential impact in using of the proposed consensus transfer functions in an Energy Production Assessment (EPA), a comparison with calibration uncertainty associated with individual calibration is necessary.

Most of the calibration certificates in the GH VECTOR database have been issued by either DEWI or Svend Ole Hansen, which are all full or associated members of MEASNET. MEASNET members report the results of their uncertainty analysis in each calibration certificate. A comparison of the uncertainties calculated in this work with those currently reported by the wind tunnel facilities named above was therefore undertaken. A plot illustrating this comparison can be seen in Figure 3.1.

It is observed that the uncertainties associated with the transfer functions presented in this paper are higher than those reported by the facilities noted above. For comparison purposes, a Weibull distribution with a mean value U of 7.5 m/s and a shape parameter k of 2, which is considered to be approximately representative of a typical annual wind speed distribution in Northern Europe, is used to weight the uncertainty for each wind speed bin between 4 and 16 m/s. The results are presented in the Table below:

	GH Consensus A100L2	GH Consensus A100R	Individual calibration
Calibration uncertainty [m/s]	0.13	0.12	0.05 to 0.08

It is noted that the uncertainty calculated is found to be largely related to the consistency of the anemometer manufacturing process and does not reflect in any way the quality of the anemometer.

The process used by VECTOR to manufacture anemometers is understood to involve a large degree of manual operation. A higher degree of scatter is expected in a sample of transfer functions for an anemometer such as this compared to an instrument with a more automated manufacturing process.

3. CONCLUSIONS

Consensus transfer functions have been established for the Vector A100L2 and A100R anemometers based on a database of calibration certificates which Garrad Hassan has had the opportunity to review. The uncertainty associated with these consensus transfer functions has been compared to uncertainties reported by wind tunnel facilities for individually calibrated instruments.

It is advisable to use the consensus function determined in this paper only for comparison purposes or in case of absolute necessity. It is stressed that it remains best practice to undertake individual calibrations for all anemometers.

4. ACKNOWLEDGEMENTS

GH would like to acknowledge their clients who have supplied calibration certificates used in this study.

5. REFERENCES

[1] Lockhart T. J and Bailey B.H - The Maximum Type 40 Anemometer Calibration Project, 1998.

[2] IEC 61400 Part 12-1, “Wind turbine generator systems Part 12: Wind Turbine Power Performance Testing".

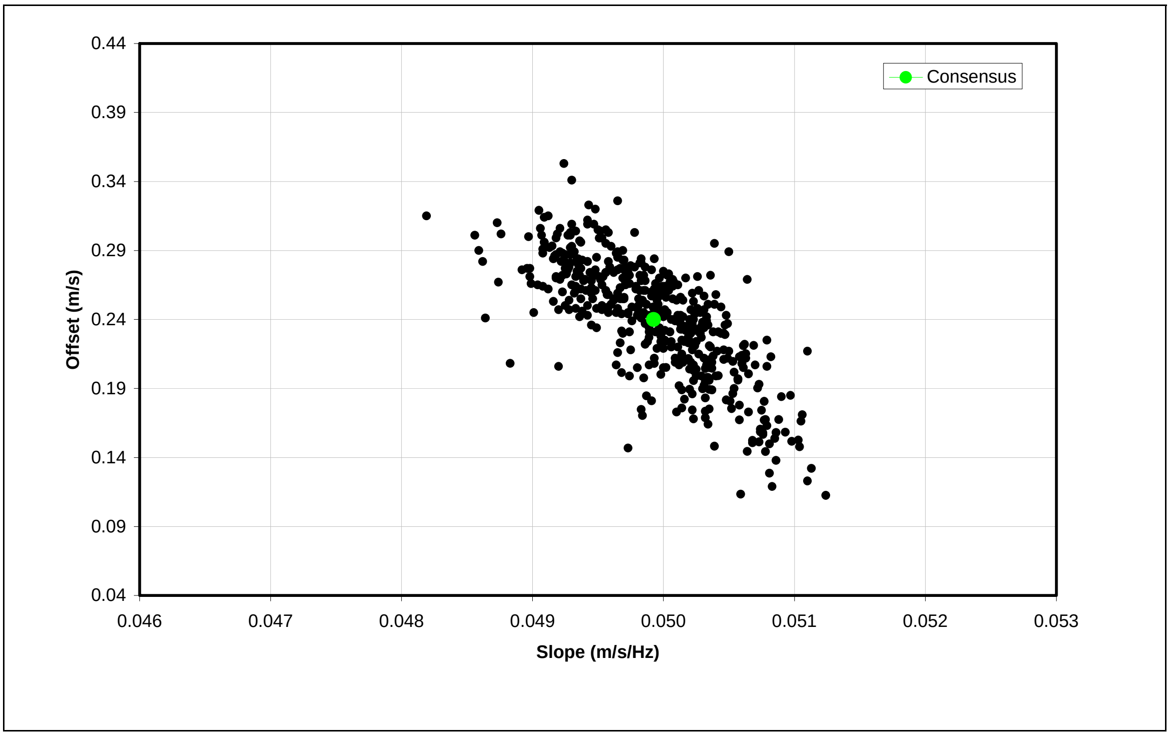


Figure 2.1 – Slope and Offset parameters reported for the VECTOR A100L2 anemometer

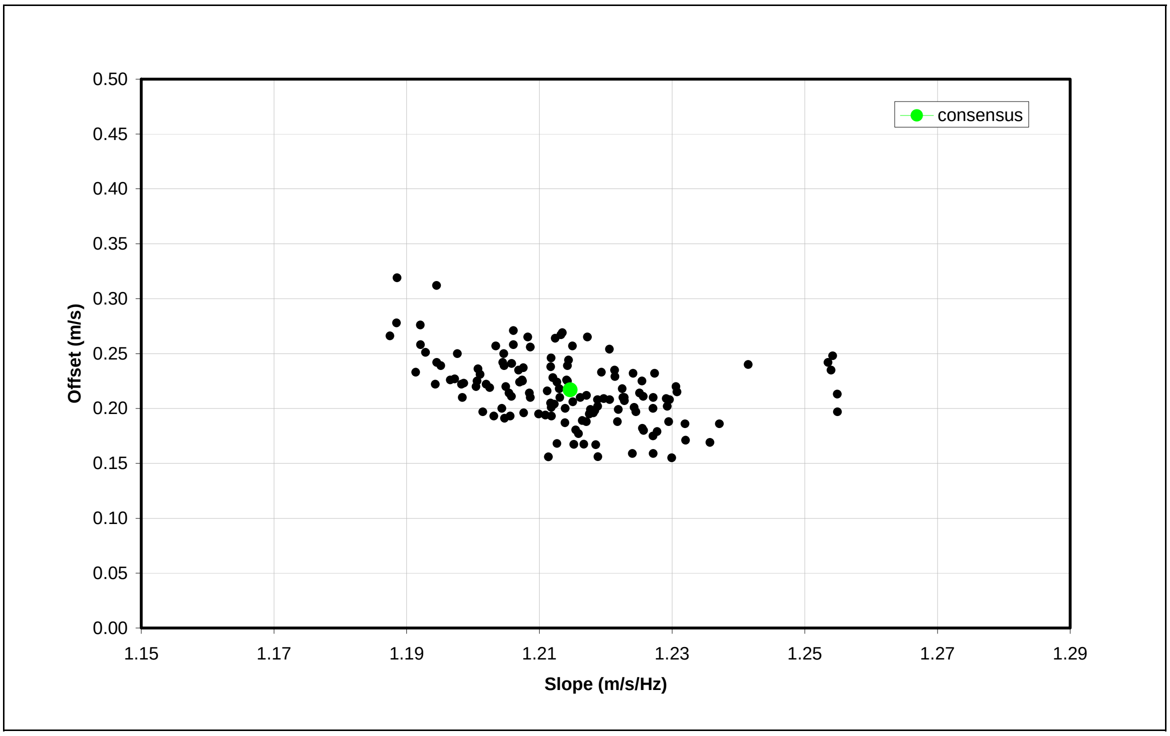


Figure 2.2 – Slope and Offset parameters reported for the VECTOR A100R anemometer

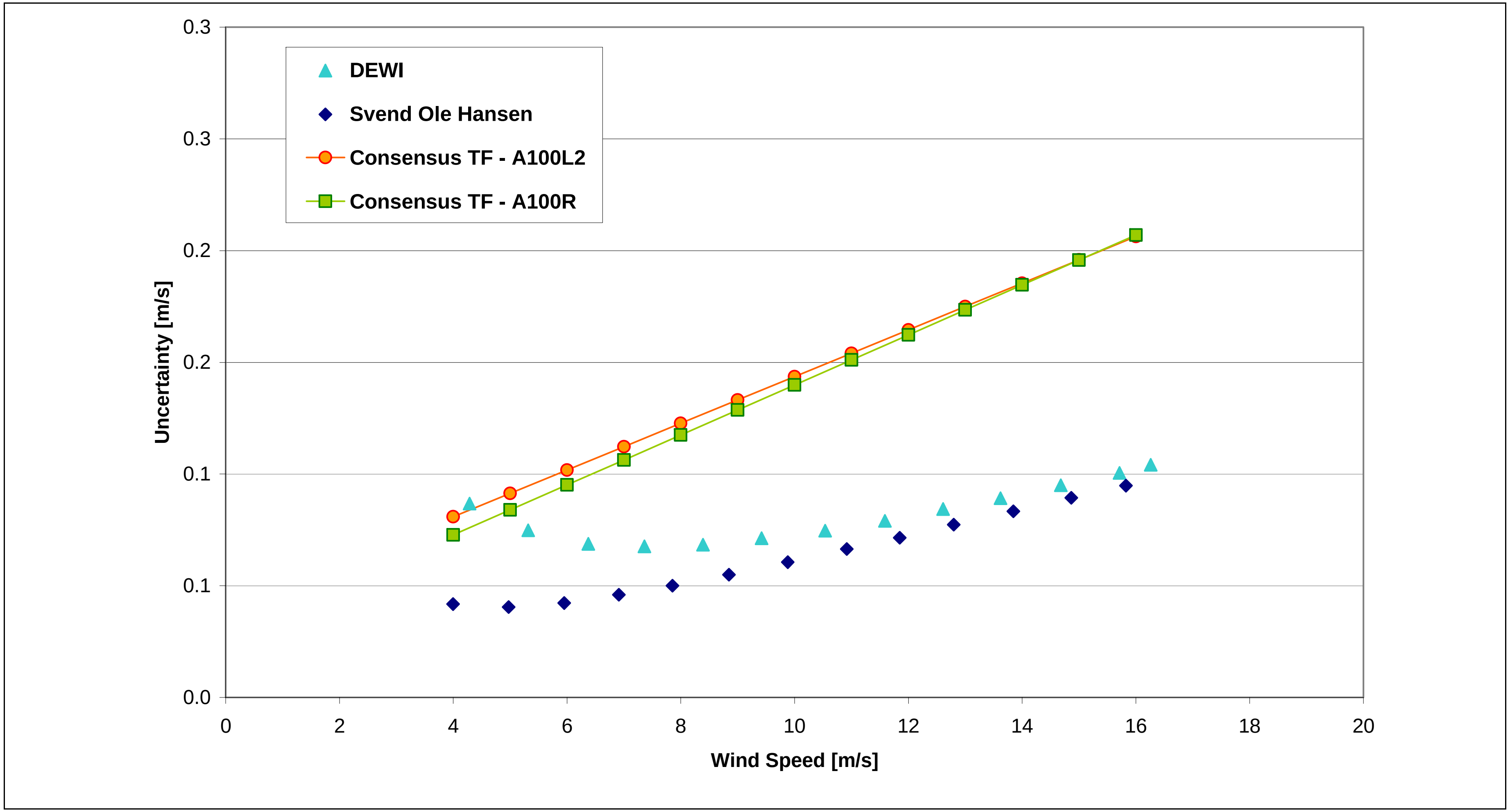


Figure 3.1 – Comparison of uncertainty associated with the proposed consensus transfer functions and industry standard wind tunnel