CONTENTS

Uncertainty Analysis in EFD, Guidelines for Resistance Towing Tank Tests

1 PURPOSE OF PROCEDURE

To provide guidelines for implementation of QM procedure 4.9-03-01-01, "Uncertainty Analysis in EFD, Uncertainty Assessment Methodology."

2 GUIDELINE FOR RESISTANCE TOWING TANK TESTS

Decisions on conducting towing tank experiments should be governed by the ability of the expected test outcome to achieve the test objectives within the allowable uncertainties. Thus, data quality assessment is a key part of the entire towing tank testing process: test description; determination of error sources; estimation of uncertainty; and documentation of results. Figure 2.1 illustrates typical contributions to towing tank reference uncertainty including both model scale and extrapolation to full scale. When extrapolating to full scale multiple error sources have to be considered, here only indicated as Reynolds number, extrapolation. In the example provided in QM procedure 4.9-03-02-02, only discussions with reference to model scale uncertainties for the total resistance coefficient, C_T, for a model scale resistance test are made.

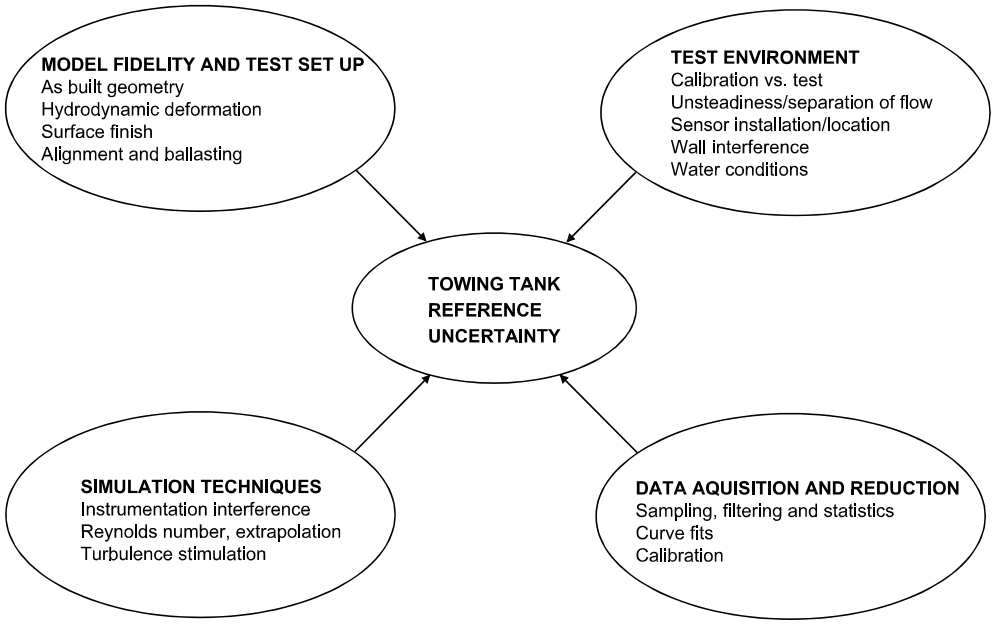
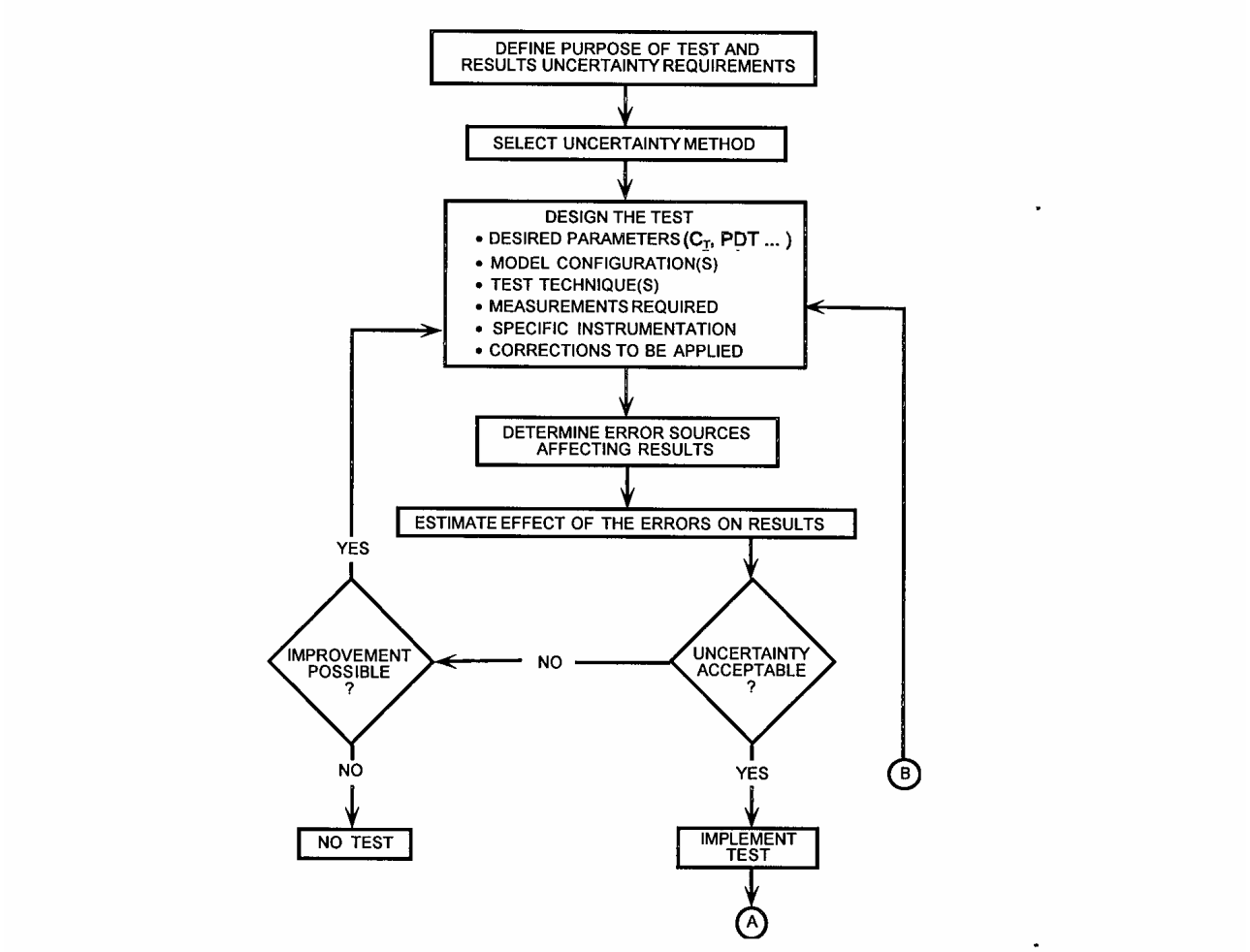


Figure 2.1 Typical contributions to towing tank reference uncertainty, model and full scale.

Figure 2.2 illustrates integration of uncertainty considerations into all phases of the towing tank testing process, including the decision whether to test or not, the design of the experiment, the conduct of the test, and the important step of proper analysis and documentation of the uncertainty of final results. Along with this philosophy of testing, rigorous application/integration of uncertainty assessment methodology into the test process and documentation of results should be the foundation of all towing tank experiments.



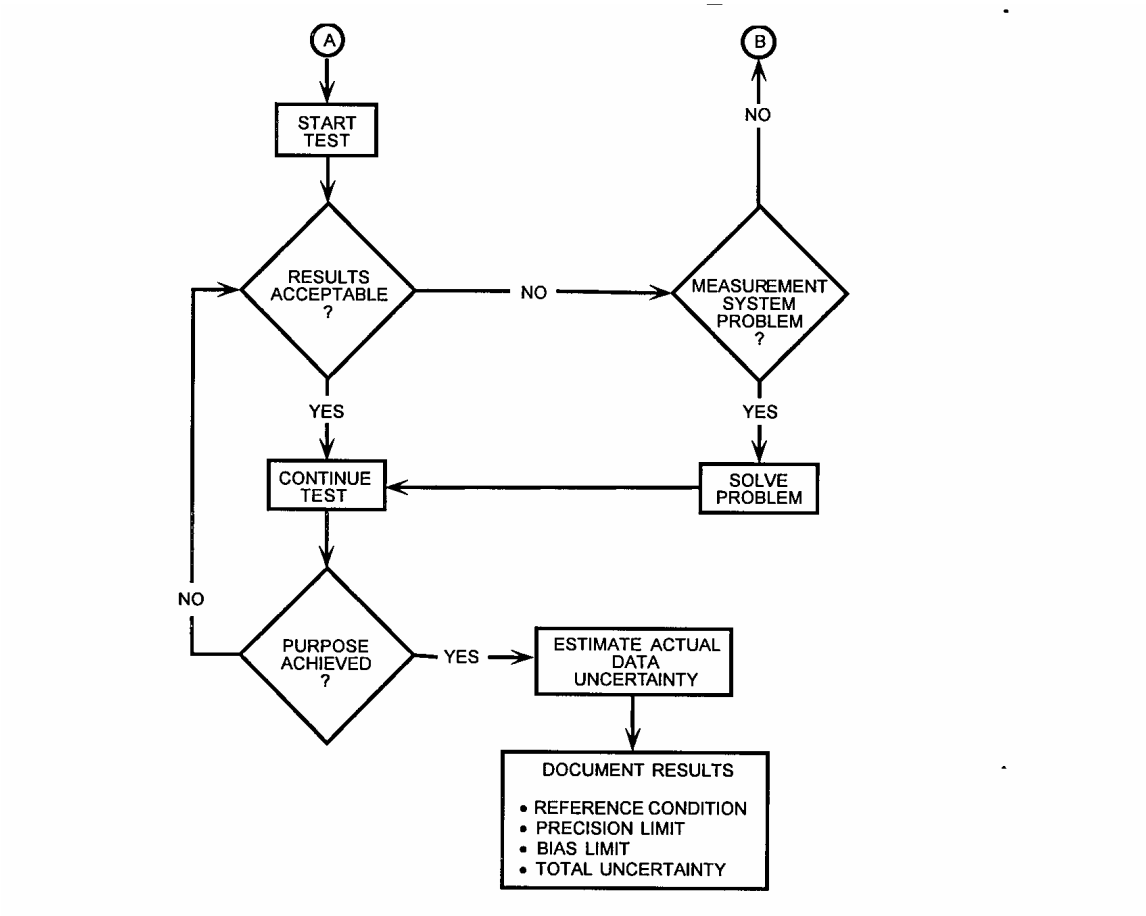


Figure 2.2 Integration of uncertainty considerations in an experimental process.

Recommendations for application / integration of uncertainty assessment methodology are as follows:

1 Recognition that uncertainty depends on entire towing tank testing process and that any changes in the process can significantly affect the uncertainty of the test results.

2. Full integration of uncertainty assessment methodology into all phases of the towing tank testing process including design, planning, calibration, execution and post-test analyses.

3. Simplified analyses by using prior knowledge (e.g., data base), tempered with engineering judgement and with effort concentrated on dominant error sources and use of end-to-end calibrations and/or bias and precision limit estimation.

4. Documentation, including:
   a. towing tank test process, measurement systems, and data streams in block diagrams.
   b. equipment and procedures used.
   c. error sources considered.

d. all estimates for bias and precision limits and the methods used in their estimation (e.g., manufacturers specifications, comparisons against standards, experience, etc.).
e. detailed uncertainty assessment methodology and actual data uncertainty estimates.

Recommendations for management are as follows:

1. Commitment to full implementation, including provision of adequate resources.

2. Provision of proper initial and continued training for responsible test engineers.

3. Facilitate application/integration through development of appropriate handbooks and databases.

4. Informing customers of the uncertainty assessment methodology used and which uncertainties that can be expected for each type of tests.

3 REFERENCES

AIAA, 1995, "Assessment of Wind Tunnel Data Uncertainty," AIAA S-071-1995.

ANSI/ASME, 1985, "Measurement Uncertainty: Part 1, Instrument and Apparatus," ANSI/ASME PTC 19.I-1985.

Coleman, H.W. and Steele, W.G., 1999, "Experimentation and Uncertainty Analysis for Engineers," 2nd Edition, John Wiley & Sons, Inc., New York, NY.

ISO, 1992, "Measurement Uncertainty," ISO/TC 69/SC 6.

ISO, 1993a, "Guide to the Expression of Uncertainty in Measurement," ISO, First edition, ISBN 92-67-10188-9.

ISO, 1993b, "International Vocabulary of Basic and General Terms in Metrology," ISO, Second edition, ISBN 92-67-01075-1.

ITTC, 1990, "Report of the Panel of Validation Procedures", 19th International Towing Tank Conference, Madrid, Spain, Proc. Vol. 1, pp. 577-603.

Moffat, R.J., 1988, "Describing the Uncertainties in Experimental Results," Experimental Thermal and Fluid Science, Vol. 1.

Steele, W.G., Taylor, R.P., Burrell, R.E., and Coleman, H.W., 1993, "The Use of Data from Previous Experience to Estimate the Precision Uncertainty of Small Sample Experiments," AIAA Journal, Vol. 31, No. 10.

Taylor, B.N. and Kuyatt, C.E., 1993, "Guidelines for Evaluating and Expressing the Uncertainty of NIST Measurement Results," NIST Technical Note 1297.