Preparation for Experiments

Any fluid flow experiment requires careful planning and preparation in order to achieve a desirable outcome. The following are the basic steps that should be followed in this preparatory process:

[A] The first step is to determine all the test variables that are pertinent to the experiment including those that are

- to be maintained constant or approximately constant during the experiment, like the ambient temperature or the humidity. Arrangements need to be made to monitor those variables and, if necessary, to control them.
- to be varied during the experiment, the primary variables. A "test matrix" needs to be prepared in which decisions need to be taken in order to adequately (but not excessively) cover the required ranges of those variables. Often this matrix needs to be adjusted so that the experiments can be completed in the available time and with the available manpower. Some flexibility should be built into this test matrix so that additional test conditions can be explored if something unexpected occurs.
- uncontrolled variables that might be important in analyzing and understanding the results of the experiments. Examples might the amplitude of vibration of the facility or the level of acoustic noise during the experiment.

[B] Given the list of test variables identified in [A], all the relevant non-dimensional numbers pertinent to the experiment need to be identified. In almost all fluid flow experiments this will include the Reynolds number, Re, and the Mach number, M. Other non-dimensional numbers such as the Froude number, Fr, or the Weber number, We, may also be relevant. The ranges of these non-dimensional numbers should be examined in order to identify regions of the test matrix where unusual flow behaviors such as flow separation or boundary layer transition might occur.

If the experiment is to be conducted on a small or large-scale model then careful consideration needs to be given to the challenges involved in choosing the scaling and in the interpretation of the results. For example, in testing small-scale ship hull designs in a towing tank facility it is not possible match *both* the Reynolds number and the Froude number of the flow. Similarly in wind tunnel tests it is not possible to match *both* the Reynolds number and the Mach number of the flow. At the other end of the spectrum, in large-scale experiments of very small length-scale flows it is often difficult to match both the Reynolds number and the Weber number of the flow. These and other scaling complications (such as surface finish issues) usually mean that tests on models that are more than ten times larger or smaller than the prototype can be quite misleading.

[C] If the experiments are to be conducted in a newly constructed facility, preliminary designs of that facility should be considered as early as possible. This design should provide a framework for the choice of instrumentation (see [E]). If an existing facility is to be used then detailed drawings of that facility should be available for the same purpose.

[D] Early consideration should be given to the possibilities for flow visualization. It is a truism that some form of flow visualization will add much to an understanding of the flow and the way it changes as the control parameters change. Consequently, if at all possible, provision should be made for flow visualization.

[E] Once the above steps have been completed, it is time to decide upon the instrumentation that is needed and is appropriate for the experiments. Often this involves consideration of a number of instrumentation characteristics including

- the calibration of the instrumentation. How reliable is the manufacturers calibration? Is *in situ* calibration necessary? How frequently should calibration be performed?
- the desired range and sensitivity of the instrument.
- whether time-averaged or time-dependent measurement is desired. For example, a different type and installation of pressure transducer would be be appropriate for these two processes; if a time dependent signal is to be measured then the desired frequency response needs to be determined.
- the vibration and temperature sensitivity of the instrument.
- the durabilibity of the instrument (for example, is waterproofing needed?).

[F] The design of the signal processing and storage system should be considered in combination with the choice of instrumentation. This includes the following issues:

- What filtering and/or averaging (if any) is to be used in processing each of the instrument signals? Filtering can sometimes be appropriate in dealing with induced electronic noise (for example the noise induced in instrument wiring by fluorescent laboratory lighting) but, in general, is better handled during digital processing following the recording of the signals.
- What sampling rate should be utilized for each of the signals? High sampling rates are often desirable but can overwhelm the storage capacity.
- What data storage is desirable? Today the availability of huge gigabyte external hard drives means that this is less of an issue than it used to be though it is a truism that the stored data inevitably grows to fill the available storage space.
- One very valuable feature for any experimenter is the ability to view processed results during the conduct of the experiments. With modern signal processing packages this is now possible and recommended. Time spent during the planning stage to design and build such an online presentation system can lead to much more efficient use of the available experimental time.