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**DEVELOPMENT OF A DATA ACQUISITION SYSTEM FOR COMMON  
VELOCITY ANEMOMETERS**

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**ABSTRACT**

The objective of this project was to develop a software package that would allow more efficient, accurate, and easier use of wind tunnel data. The software was to receive an analog signal from an array of hot wire anemometers, convert the signal to a digital format, and then process the raw data, converting it into values of properties which have practical value to the user. Unfortunately, due to scheduling conflicts, this project never left the software development stage. The user interface was successfully designed. The signal conversion portion of the package was not completed and the package was never tested.

## INTRODUCTION

The development of this software package was intended to facilitate greater accuracy and ease of use in experimental wind tunnel testing. Most experiments performed by aerospace engineering students during their curriculum requires a considerable amount of intermediate calculation before useful properties are obtained that are necessary for advanced calculations. This software is designed to eliminate these intermediate calculations. This will allow a savings in time necessary to perform the experiment, and the possibility of additional errors these calculations might incur. The following report will briefly describe the essential workings of hot wire anemometers and their advantages, as well as the usage of the program and its properties.

## THE HOT WIRE ANEMOMETER

A hot wire anemometer consists of a small conductive filament which is exposed to the wind tunnel test section freestream. An electrical current is passed through this filament during the experiment. Heat from the filament is then transferred by convection to the freestream. As the temperature of the filament changes, its conductive resistance changes. This causes the signal strength to vary. Knowing the physical properties of the filament, a direct correlation can be made between variation in signal strength and freestream velocity.

The advantage of using a hot wire anemometer over a Pitot-static tube is that the hot wire system is more accurate, and

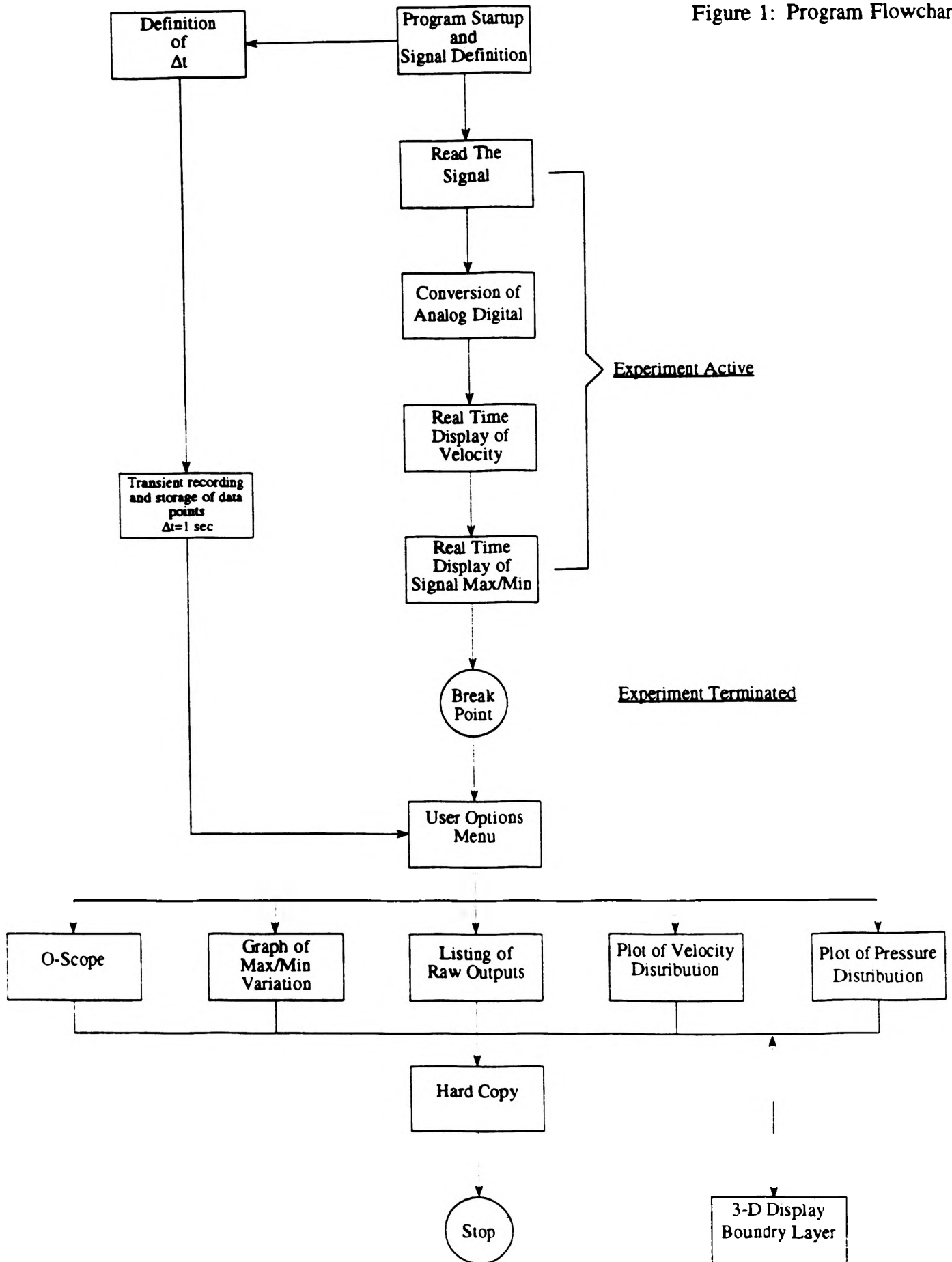
creates less disturbance in the flow down stream of the apparatus. A three dimensional grid of hot wire anemometers could be more accurately used to measure the flow properties over the surface of a body than could be achieved using Pitot tubes.

### **PROGRAM DEFINITION AND USAGE**

This software was designed to operate in two conditions. The first condition would permit user interface in "real time", that is, while the experiment is running. The second condition would allow the operator access to various electronic instruments and advanced displays of data after the experiment had concluded. A flowchart documenting the operation of the program and its features is presented in figure 1.

The first operation condition of this software allows the user to define the operating parameters of the experiment. Parameters such as time step size, hot wire anemometer configuration, and initial lab conditions of temperature and pressure. The variation of time step size permits the user to define at what interval data will be processed. Thus, allowing for a more accurate transient display of flow conditions that would be required for a turbulent flow. This time step size would of course be limited by the speed of the processing unit. Once the experiment was initiated, the software would display a real time level of the signal strength and the flow velocity while at the same time accumulating the values of these data points over the time required to run the experiment. This file of accumulated data would be accessed by condition two of the program. A display of

Figure 1: Program Flowchart



the designed user interface screen is provided in figure 2.

Once the experiment has been terminated, operating condition two of the program would commence. This would consist of a display of a user options menu. This menu would allow access to various electronic instruments and data displays, as shown in figure 1.

#### **The Oscilloscope.**

This is an electronic instrument that produces a display on the computer screen that duplicates the function of an oscilloscope. Thus, the behavior of the hot wire anemometer signal could be observed over the time increment of the experiment. If desired, this instrument could be transferred to condition one of the program to provide a real time graphical display of the signal behavior. This would require only minor changes to the program code, however, it would place additional restrictions on the size of the time step used. A sample program listing is provided in appendix A. This program generates the oscilloscope display for a randomly generated array of values.

#### **Graph Of Max/Min Signal Variation.**

This display would provide a graph of the maximum and minimum level of the hot wire anemometer signal over an inputted time increment. This display would be useful for determining a mean signal level over a prescribed time increment.

#### **Listing Of Raw Data Output.**

This display would provide a listing of signal strength for the condition 1 prescribed time step over the entire time the experiment took to complete. This function would be useful in that it provides the raw data to the user so that checks could be made

FIGURE 2 USER INTERFACE

WIRE ACTIVE?

START

STOP

TIME INCREMENT

0.1 SECONDS

0.2 SECONDS

0.5 SECONDS

1.0 SECONDS

2.0 SECONDS

10 SECONDS



STRIP CHART TO  
DISPLAY VELOCITY

STRIP CHART TO  
DISPLAY SIGNAL

with theoretical calculations to determine if the apparatus is functioning properly.

#### **Plot Of Velocity Distribution.**

This display would provide a graphical representation of the value of freestream velocity versus time. This display would be valuable in determining a root mean square velocity for the experiment time frame, or in determining the velocity distribution and size of the flow boundary layer for multiple hot wire anemometers.

#### **Plot Of Pressure Distribution.**

This display would provide the same distribution properties as the velocity distribution plot described above, only it would do so for pressure. An option for this display would be to calculate and display the pressure coefficient over the surface of a body for multiple hot wire anemometers. This function could also perform a check on the validity of the pressure data by comparing the velocity obtained with that necessary for the fluid compressibility threshold, and if necessary to correct the pressure coefficient for compressible fluid.

#### **Three Dimensional Display Of The Fluid Boundary Layer.**

If multiple hot wire anemometers were placed over the surface of the body to be tested, both parallel and perpendicular to the flow direction as well as in varying height above the body, the boundary layer development over the body could be monitored by making comparisons of the fluid velocity at varying height over the body with the velocity of the freestream. This display would provide a graphical representation of the height of the boundary



layer with respect to the body.

### CONCLUSION

The advantage of this software package is that it would provide the operator with real time and accumulated displays of both the raw experiment data, and values of properties of practical interest, such as velocity, pressure, and boundary layer distribution. This would provide significant savings in time necessary to perform the experiment as well as providing greater accuracy of the results. This accuracy would be achieved in two ways. First by allowing more data points to be obtained at time intervals to small for a human to record manually. Second, by performing the necessary intermediate calculations necessary to achieve the velocity, pressure, and boundary layer distributions, the possibility of operator error would be eliminated.

It is unfortunate that this project was unable to be completed, due to scheduling conflicts, and an underestimation of the time required to perform this research as well as satisfactory completion of course work. A significant portion of this time underestimation was due to the fact that undergraduate course credit was not provided for this project, forcing an additional course to be added.

The extent of the software package that was developed consisted of the user interface screen which was previously provided in figure 2. and the development of the condition 2 electronic instruments and displays. The signal conversion portion of the package was not completed, thus the package could not be

tested using the wind tunnel. All that remains to complete this project is to develop the software to perform the signal conversion and to complete the package by linking all of the subprograms already developed into a cohesive program. The signal conversion would be performed mainly by hardware management of an interface board that connects the hot wire anemometer apparatus to the Lab Windows hardware and software.

#### **ACKNOWLEDGMENTS**

The faculty advisor for this project was Dr. F. Finaish, Associate Professor Of Aerospace Engineering. Thanks are extended to him for his guidance and patience.

#### **REFERENCES**

All code for this software package was generated using the Lab Windows software package developed by National Instruments. Specifications of this software package or any additional information will be provided upon request.

## APPENDIX A.

```
#include "C:\LW\include\analysis.h"
#include "C:\LW\include\formatio.h"
#include "C:\LW\include\lwsystem.h"
#include "C:\LW\include\userint.h"
#include "C:\LW\INSTR\SCOPE.h"
static int err1;
static int err;
static double waveform_array[128];
static double x_zero;
static double delta_t;
static double Waveform_array[100];
double my_array[100];
double mean_value;

void main ()
{
    int i;

    cls ();
    for (i = 0; i < 100; i++) {
        my_array[i] = (double)rand () / 32767.0;
        FmtOut (" %d \t %f \n", i, my_array[i]);
    }
    scope_init (1);
    scope_config (1, 1.0, 1, 1.0e-3);
    scope_read_waveform (1, waveform_array, &delta_t, &x_zero);
    err = YGraphPopup (my_array, 100, 4);
    err1 = YGraphPopup (waveform_array, 128, 4);
    scope_close ();
    Mean (my_array, 100, &mean_value);
    FmtOut ("mean = \t %f \n", mean_value);
}
```