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Introduction to Aerodynamic Measurement Technology Special Section

In physical science a first essential step in the direction of learning any subject is to find principles of numerical reckoning and methods for practicably measuring some quantity connected with it. I often say that when you can measure what you are speaking about, and express it in numbers, you know something about it; when you cannot express it in numbers, your knowledge is of a meager and unsatisfactory kind; it may be the beginning of knowledge, but you have scarcely, in your thoughts, advanced to the stage of science, whatever the matter may be.

—Speech to the British Institution of Civil Engineers by William Thomson (Lord Kelvin), May 3, 1883.

I AM pleased to introduce this special section of the *AIAA Journal* promoting aerodynamic measurement technology (AMT). The goals of AMT follow Lord Kelvin's philosophy of over 100 years ago. To understand aerodynamic flows, one must measure many quantities: pressure, temperature, velocity, electron densities, and chemical species concentrations. In recent years, the development of new laser-based flowfield methods, low-cost diode laser sensors, smart structure sensors, and improved charge-coupled device cameras have resulted in the expansion and diversification of AMT.

This is the second special section sponsored by the AIAA AMT Technical Committee that was formed in 1990. The first special section was published in March 1993. The focus of the AMT committee is to promote advanced and novel techniques for flowfield and surface measurement in ground-based or flight application. For the last five years, the AMT Technical Committee has sponsored papers at the AIAA Aerospace Sciences Meeting. All the papers presented here are revised versions of papers selected from the 33rd Aerospace Sciences Meeting, Reno, Nevada, Jan. 9–12, 1995. Although most of the papers were presented in AMT sessions, there are contributions from sessions organized by the Air Breathing Propulsion, Ground Testing, and Thermophysics technical committees.

Recent trends in AMT are illustrated in the 16 papers in this special section. The first eight papers elucidate the importance of quantitative flow visualization to understanding aerodynamics. With planar Doppler velocimetry, velocity fields are imaged in sonic and supersonic flows by sensing the Doppler shift of laser light scattered from the flow. In liquids, photoactive dyes allow laser tagging of the fluid to image the internal circulation of a liquid drop. Planar laser-induced fluorescence (PLIF) is used for fuel/air mixing studies. In a supersonic ramp fuel injector, mixing is studied by imaging iodine in cold flow and imaging OH radicals in reacting flow. In high-pressure combustion, OH radicals are imaged to study fuel/air mixing uniformity. In other work, temperature distributions are measured by PLIF of nitric oxide in a supersonic shock wave. Laser-induced fluorescence of oxygen is used to determine temperature in a premixed flame.

The low cost of laser diodes has led to their wide use in information and communication technology. In aerodynamics, laser diodes are leading to the development of miniature, low-cost sensors of gas composition, temperature, pressure, and velocity. In this issue, gas species concentrations and temperature are measured using laser-diode techniques in laboratory flames and a hypersonic wind tunnel.

There are also techniques that do not depend on lasers. In this issue, a pulsed electron beam fluorescence method is presented for measurement of temperature and number density in rarefied gas flows. Also, infrared emission from hot water vapor is used to determine water vapor concentration and temperature in a shock tube. The recent development of smart materials and their incorporation into solid surfaces is an important new AMT field. As presented here, pressure sensitive paints are studied to determine their dynamic response.

New AMT methods are increasingly being applied to the often hostile environment of ground test facilities. Often, these applications involve collaborations between the method developers and ground test facility operators. Examined here, a laser Doppler velocimeter is developed to measure velocity in a large (12×40 m) wind tunnel. Hydroxyl radicals are imaged in a high pressure, lean premixed combustor for high-speed propulsion. Nitric oxide concentrations are determined in an arc-driven hypersonic wind tunnel to study hypersonic propulsion in a collaboration of French and American researchers. Temperature images in a supersonic shock are determined in a shock tube driven supersonic wind tunnel in an Australian–American collaboration. Atomic oxygen spectroscopic line shapes are investigated in an electric-arc heated shock tube driven wind tunnel.

These novel methods for flowfield and surface measurements of aerodynamic flows show that the future of aerodynamic measurement is bright. The transition of AMT sensors to test facilities promises to give meaningful new insights into practical aerodynamic flows.

I wish to thank the contributing authors and the technical reviewers for making the timely completion of this special section possible. It is their efforts that are the essence of this publication. I am also grateful for the assistance of the editorial staff of the *AIAA Journal* and Gabriel Laufer, Associate Editor. Finally, I would like to thank the Editor-in-Chief of the *AIAA Journal*, George W. Sutton, for once again supporting a special section on AMT.

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