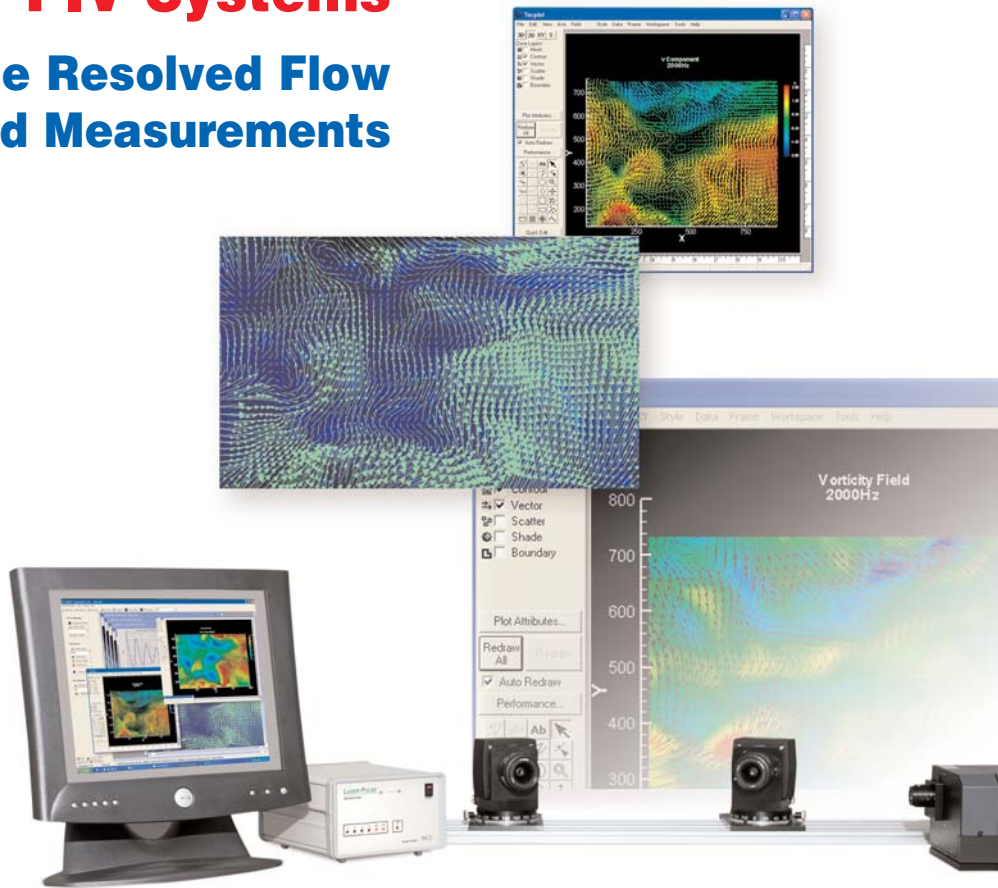


High Frame-Rate PIV Systems

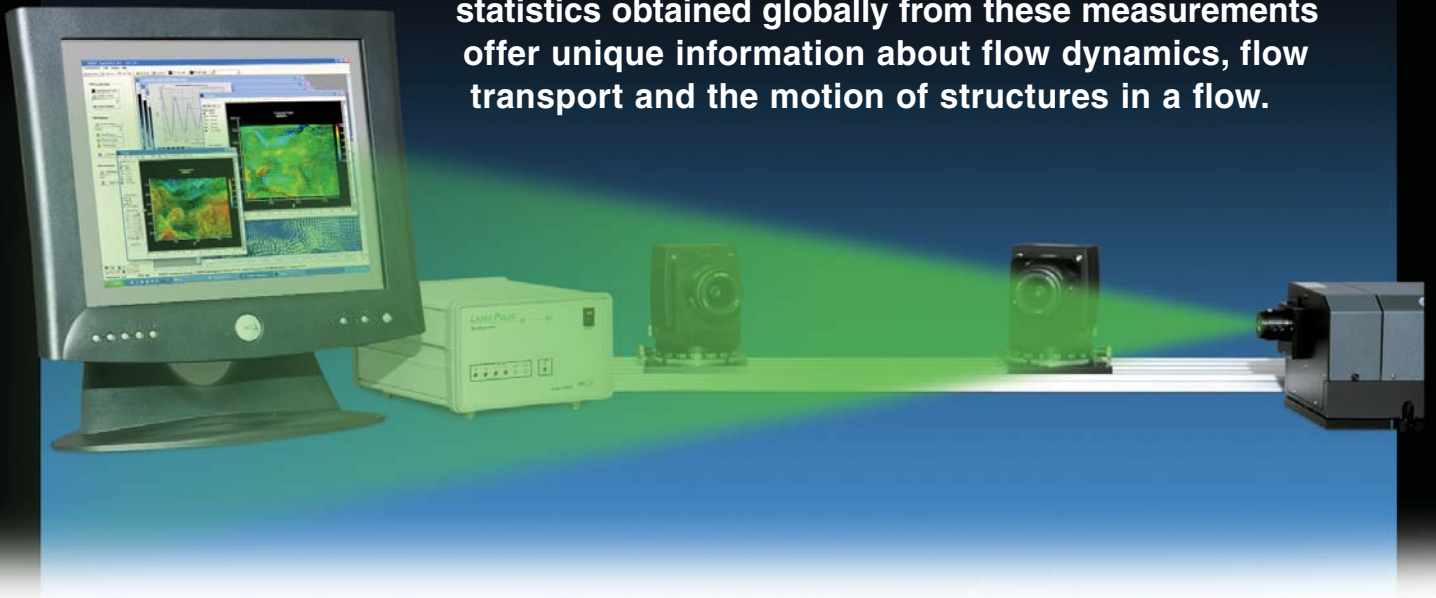
...For Time Resolved Flow
Field Measurements



High Frame-Rate PIV Systems

The Particle Image Velocimetry (PIV) technique for the first time offered experimentalists the ability to capture the instantaneous spatial nature of a flow field. TSI PIV systems, incorporating patented processing algorithms such as Hart Correlation*, have provided flow field information with very high spatial resolution for several years. The temporal resolution of PIV measurements has been limited, however, because the update rate of velocity measurements, governed by the camera frame rate and the laser pulse rate, was too low for most practical applications. The ability to measure flow field evolution as a function of time has always been of great interest to experimentalists.

To obtain detailed temporal and spatial information of the flow properties, TSI has developed an integrated, high-frame rate PIV system that makes flow measurements with very high update rates. The detailed temporal statistics obtained globally from these measurements offer unique information about flow dynamics, flow transport and the motion of structures in a flow.



Synchronizer System

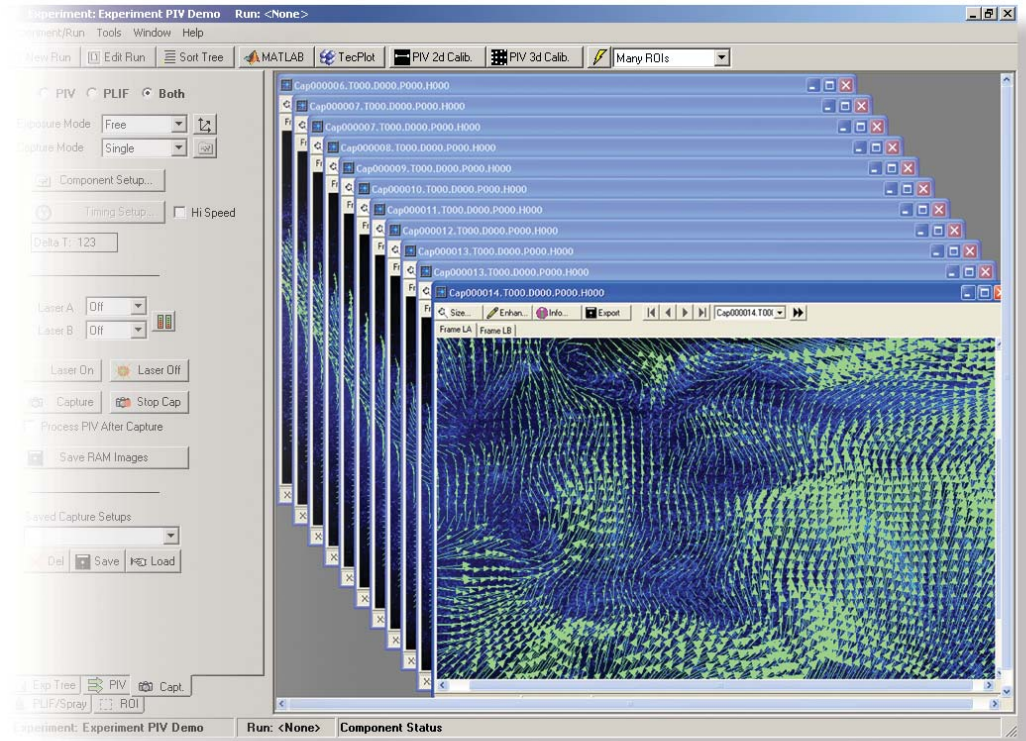
TSI developed a new master control unit for use with the high-update-rate cameras and lasers. This synchronizer system automates the timing control, start of data acquisition and trigger signals needed to activate other devices or systems. For measurements in periodic flows or flows initiated by an external event, a TTL trigger signaling the event tells the Synchronizer to initiate data taking. This enables phase-averaged measurements in periodic flows or ensemble-averaged measurements in externally triggered flows.

*Patent number 6,108,458

Imaging System— POWERVIEW™ HS Cameras

TSI initiated the use of cameras designed specifically for PIV applications with the introduction of its POWERVIEW PIV cameras. POWERVIEW HS cameras, recently developed for high-frame-rate PIV, are the newest members of the POWERVIEW family. The POWERVIEW HS cameras have a built-in mask that protects and prevents fatal damage to the camera circuitry from potential laser light reflections. This unique feature makes these cameras ideally suited for imaging laser illuminated flows. They accommodate small time intervals between laser pulses (image captures) and, hence, are well suited for measuring flows with high velocity.

The entire camera operation is controlled through **INSIGHT 3G™** software. With the computer, the user can set various camera operating parameters to suit the measurement requirements. Similar to other TSI systems, remote focusing, aperture control and/or Scheimpflug adjustment, features that let the user set up and align the system remotely, are available as options. Depending on the update rate (frame rate) required for capturing flow details, different POWERVIEW HS cameras can be used.

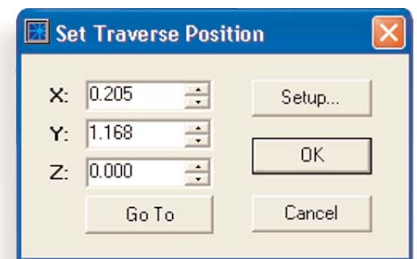


Laser System

Pulsed lasers operating in the kHz range are attractive for high-frame-rate PIV measurements. The lasers used in TSI systems offer the ability to vary the time between pulses to cover a wide range of flow measurement applications. Laser power, laser pulse rate and other laser operating parameters are controlled through TSI's **INSIGHT 3G** Image Capture, Analysis, and Display Software.

Light sheet generation optics can be attached directly to the laser or the laser system output can be directed to the desired location using TSI's Laser

Light Arm. In the latter case, the laser beam is delivered through light sheet generation optics attached to the arm exit. The Light Arm can be used alone for measurements in a fixed plane or combined with a TSI traverse system for moving the measurement plane in up to three directions.



Data Analysis and Display

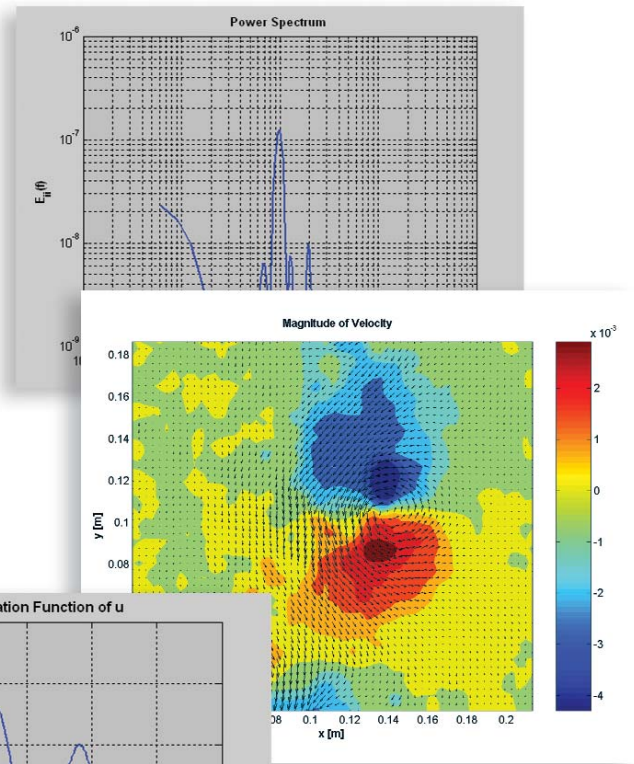
INSIGHT 3G Image Capture, Analysis, and Display Software provides complete control of the high frame-rate PIV system. In addition to set-up and control of system operation, new developments in image capture and analysis are also included.

The concept of plug-ins, pioneered by TSI, has been further advanced in **INSIGHT 3G** software. Plug-ins enable significant customization while the fundamental robustness of the basic software package is retained. Further, techniques for extracting additional flow properties from the time-series analysis of the velocity fields are also incorporated. In order to perform a detailed set of data analyses and extract correlations in the space-time domain, a MATLAB®-based package is integrated with the software.

The vector processing capability of the **INSIGHT 3G** software takes full advantage of the computer multiprocessor configuration to increase processing speeds significantly. The ability to store and retain raw image fields is also enhanced. This makes it possible to re-analyze and examine velocity field information at a later time.

Detailed displays graphically illustrate the variation of the different flow properties. This is achieved through the seamless integration of the TecPlot® graphical package (in addition to MATLAB) with the **INSIGHT 3G** software. The **INSIGHT 3G** software package is designed to easily implement new developments in camera and laser systems as well as new approaches to data analysis and display.

MATLAB is a trademark of the Mathworks, Inc.
 TecPlot is a trademark of Amtec Engineering, Inc.



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DANGER

Invisible and/or visible Laser
 Radiation—Avoid eye or skin exposure
 to direct or scattered radiation.

Energy/pulse 2 Joule Maximum
 Pulse Duration 15 Picoseconds to
 30 Nanoseconds
 Nd Wavelength 1064 532 355 266
 Nanometers
 Class IV Laser Product