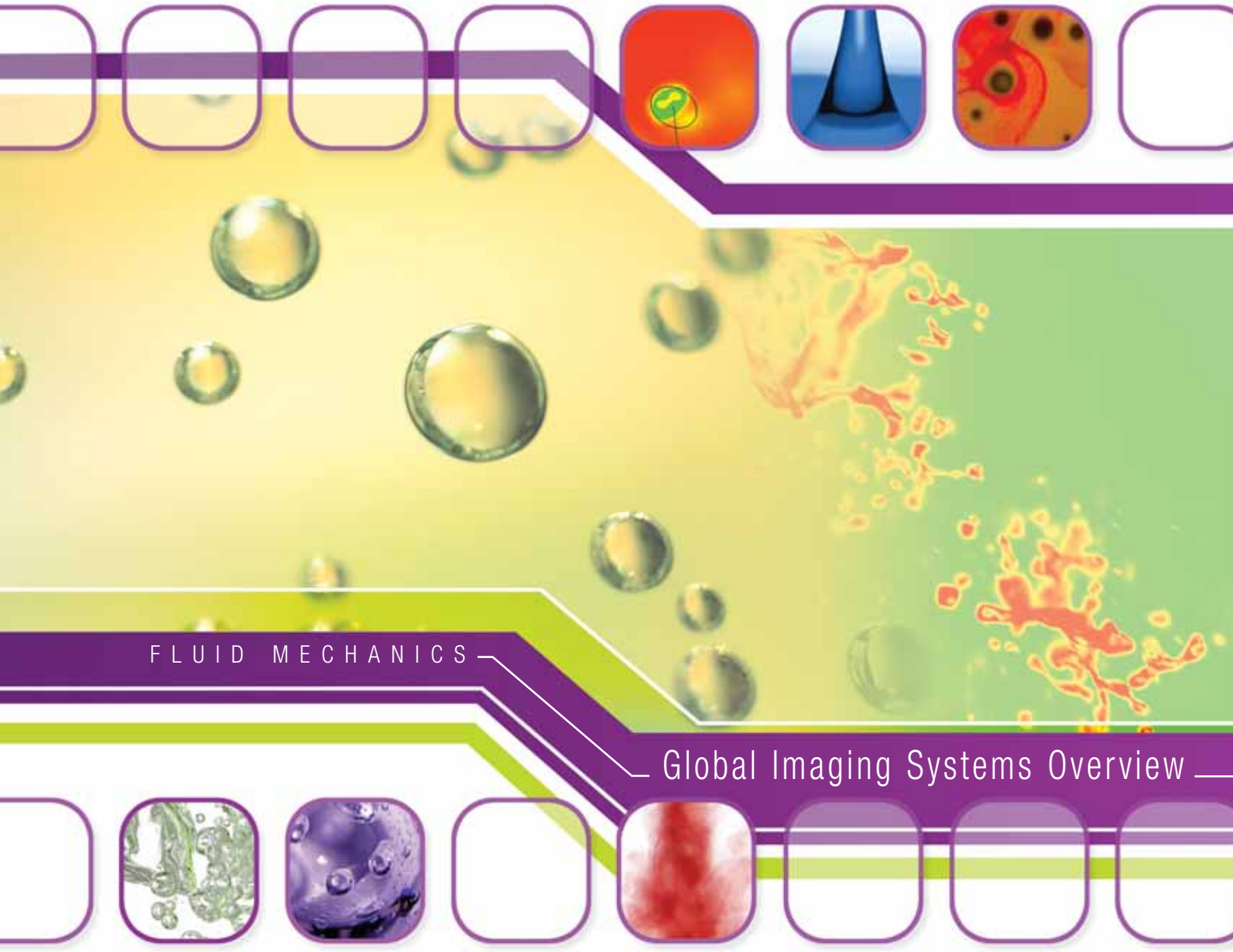
A Family fo Global Imaging Systems to Meet all of your Fluid Mechanics Measurement Needs



FLUID MECHANICS

Global Imaging Systems Overview

TRUST. SCIENCE. INNOVATION.

Global Imaging

Powered by

the most advanced Global Imaging Software Platform available

What is Global Imaging?

Global Imaging refers to the instantaneous, whole field measurement of fluid flow properties using imaging and image analysis techniques. Measured parameters include:

- Fluid velocity field in liquid or gaseous flows
- Scalar field (concentration, temperature) in liquid or gaseous flows
- Simultaneous droplet size/velocity in sprays
- Individual fluid phase velocity field in multiphase flows
- Size/Shape analysis in multiphase flows
- Combustion species measurements (including OH, CH, NO, CO, among many others)
- Fuel distribution and concentration field
- Flame front geometry
- Time-resolved, high-speed imaging and analysis
- Displacement field in solids
- Laser Induced Incandescence, Rayleigh scattering, and Raman scattering signals

INSIGHT 3G: The Global Imaging Software Platform

All of TSI's Global Imaging Systems utilize the *INSIGHT* 3G software platform, the most advanced, innovative software available for image capture, analysis and display.

Hardware Flexibility

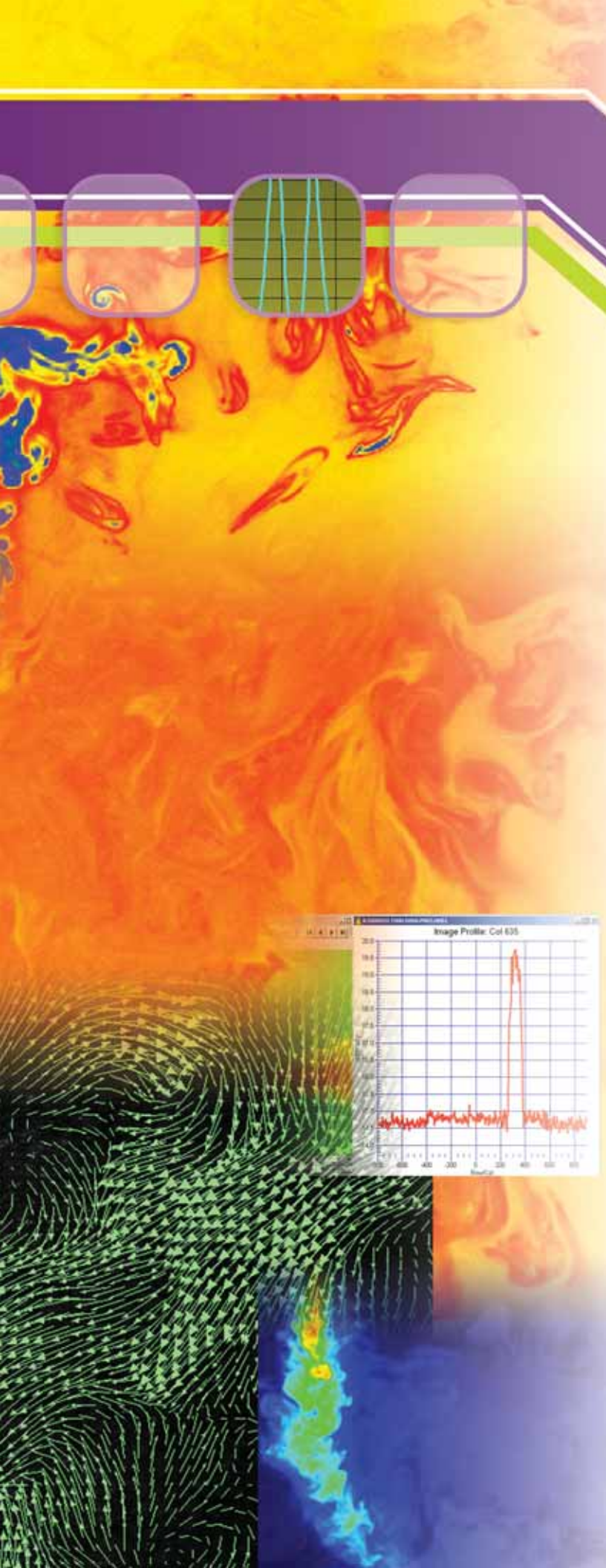
System Hardware

The primary hardware components of Global Imaging Systems are the illumination and imaging components. In most measurements, lasers are the preferred light source, but in some cases strobe lights or other back-illumination sources are used. Scientific CCD and CMOS cameras are used to capture high-resolution, low-noise images of the scattered or emitted light signal.

TSI offers a comprehensive range of laser and camera options. Laser models cover the full spectrum of pulse energies, repetition rates, and wavelength. The camera models are available in a variety of pixel resolutions, framing rates, and spectral sensitivity range. TSI is the only company to protect sensitive camera circuitry from catastrophic damage due to stray laser light with a protective mask.

All hardware components are controlled through the *INSIGHT* 3G system software. Using the unique and powerful processing pipeline along with the icon-driven macro programmer, turn-key system operation can be achieved with a single mouse click, allowing an entire measurement from image capture through image processing, analysis, and display.

Global Velocity and



Global Velocity Measurements

Measurements of the global velocity field utilize various forms of particle velocimetry, including particle image velocimetry (PIV), particle tracking velocimetry (PTV), and super resolution particle velocimetry (SRPV). All of the techniques measure the displacement of small tracer particles suspended in the flow to determine the local fluid velocity. The measurement region is illuminated by a planar sheet of laser light. A single camera can be used to measure the two components of velocity that lie in the plane of the light sheet, and a dual camera, or stereoscopic system can measure all three components of velocity.

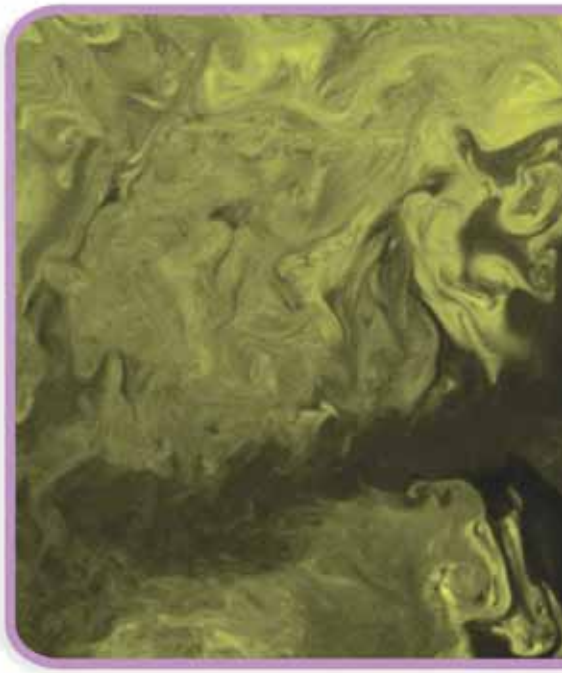
PIV measures the group velocity over small regions in the flow, with spatial resolution varying between tens of microns up to several millimeters or more, depending upon the measurement objectives. PTV measures the velocity of individual particles in the flow, and is useful when system requirements mandate low densities of tracer particles. SRPV combines information from PIV and PTV along with advanced interpolation algorithms to provide velocity measurements at the highest possible spatial resolution.

Scalar Measurements

Innovative Algorithms

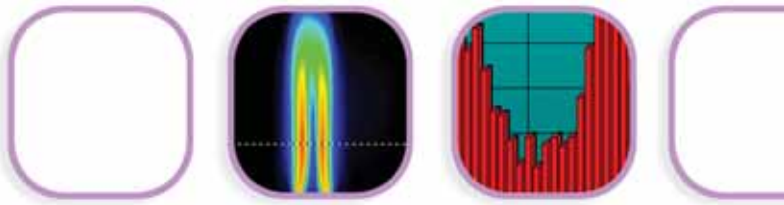
Global Scalar Measurements

Global scalar measurements, such as concentration, temperature, combustion species distribution, and fuel concentration fields, utilize the planar laser-induced fluorescence (PLIF) technique. These measurements are often performed to investigate mixing phenomena in a variety of applications. Similar to velocimetry methods, the PLIF measurement region is defined by a planar sheet of laser light. Fluorescent species within the flow absorb laser light and emit a shifted fluorescence signal that is captured with the camera. The intensity of measured fluorescence signal is then used to determine the desired scalar property.



Typical Applications:

- Fluid velocities in wind and water tunnels
- Analysis and optimization of flow through devices
- Turbulence research
- Performance testing and optimization of turbulent and laminar mixing devices
- Combustion measurements, such as flow velocity and evolution, combustion species distributions, and fuel mixing and local concentration



Multiphase Flow

Multiphase flow measurements

Global Imaging Systems from TSI feature a host of techniques and tools for detailed analysis of multiphase flows, including sprays, particle-laden flows, and bubbly flows.

Global Sizing and Velocimetry (GSV)

GSV simultaneously measures the droplet size and velocity in sprays. Patented algorithms are used to analyze defocused droplet images to determine the droplet size, and a unique camera slit arrangement allows measurements in higher-density sprays than competitive systems. Also, the TSI solution utilizes a single camera to measure both properties; while many competitive systems require two cameras.

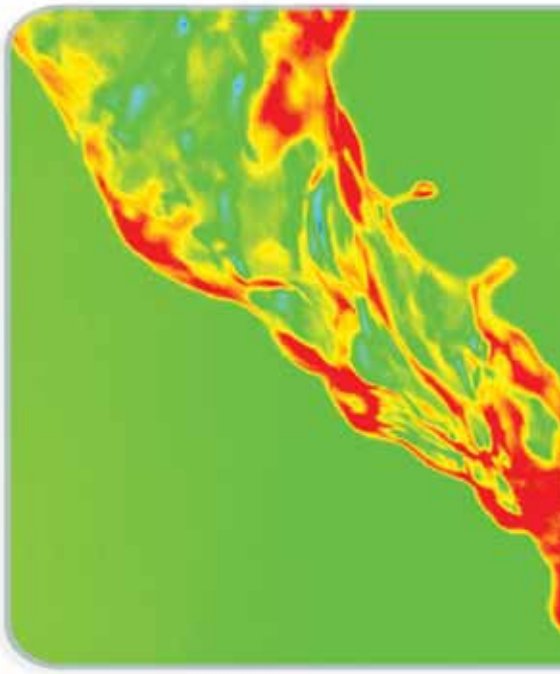
Patternation and Spray Analysis

Global Imaging measurements allow detailed analysis of the spatial and temporal nature of sprays. Measured parameters include the spray penetration and cone angle, as well as the Pattern Factor. The Pattern Factor quantifies the symmetry and repeatability in the spray, and can be measured in both a sector (angular) geometry and a ring (radial) geometry.

Measurements

Direct Image Size – Shape – Velocity Analysis

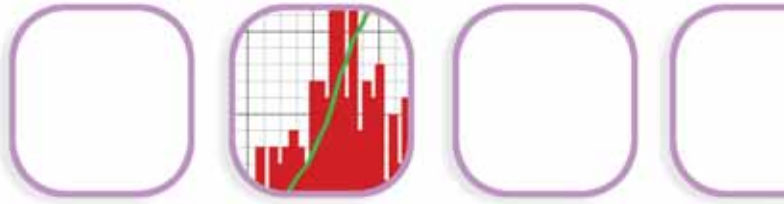
In other types of multiphase flows, direct image analysis can be used to measure the size, shape, and velocity. The size, shape, and velocity statistics of the dispersed phase (droplets, bubbles, suspended particles) and the velocity field within the continuous phase can both be measured using a single camera. Numerous methods, both through experimental and computational approaches, have been developed to separate the phases.

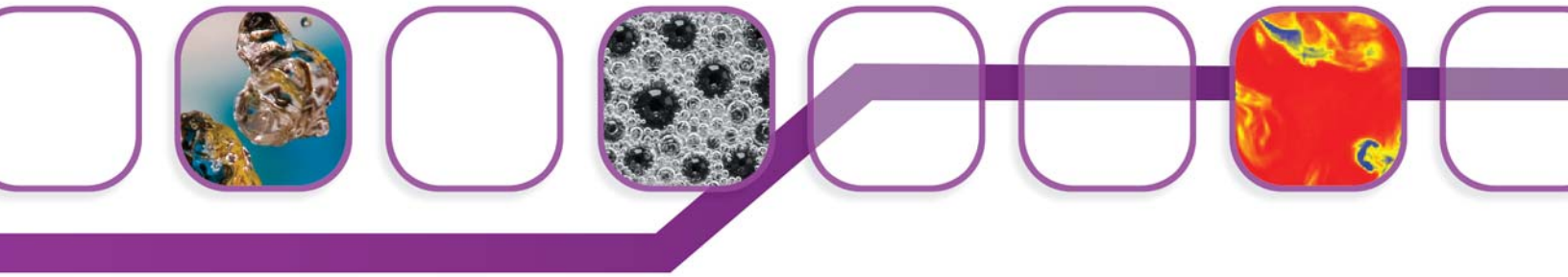


Measured parameters for the dispersed phase include the mean diameter, minor and major diameters (ellipticity), Feret diameter, center of mass, area, and velocity. For some objects, the deformation and solid body rotation can also be measured. The total area occupied by the dispersed phase, and thus the void fraction, can also be measured.

Typical Applications:

- Spray performance testing and optimization
- Breakup phenomena
- Collisional coalescence
- Bubbly flows
- Particle-laden flows





TSI Incorporated serves a global market by investigating, identifying and solving measurement problems. As an industry leader in the design and production of precision instruments, TSI partners with research institutions and customers around the world to set the standard for measurements relating to aerosol science, air flow, indoor air quality, fluid dynamics and biohazard detection. With headquarters based in the U.S. and field offices throughout Europe and Asia, TSI has established a worldwide presence in the markets we serve. Every day, our dedicated employees turn research into reality.

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