# Paper 6.2

# Distortion Compensation for PIV Systems

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## ABSTRACT

PIV images can be distorted for many reasons, including oblique viewing and window aberrations. Calibration methods are now available for a rigorous description of distortions and extraction of all the information available in PIV images even under difficult measurement conditions.

The concept of the *measurement plane* is introduced. This plane is tangential to the distorted surface being imaged. Orientation of the measurement plane, specified by the *Measurement Plane Pointer* (MPP), may vary from point to point within the region being viewed (the object space).

Generalized relationships are provided for computing MPPs over the entire object space using 3D calibration data. Also, a 2×3 matrix is derived for converting displacements from the image plane into the measurement plane. This matrix is a generalization of the 2×2 matrix conventionally used for distortion correction in standard (single-camera) PIV.

When the above scheme is applied to a dual-camera stereoscopic system, the two maps of MPPs can be combined to compute the sensitivity of the out-of-plane component and its distribution over the entire object space.

In order to specify MPPs, one needs to obtain 3-dimensional calibration data from the object space (in the same manner as the calibration of a stereoscopic PIV system). If a planar target with markers is used for calibration, it must be imaged at two or more locations along the principal axis of the camera. Traversing of the target may be cumbersome and a potential source of errors. A solution to this impediment was first sought by imposing a physical constraint, called *isotropic magnification*, on the imaging process.

Isotropic magnification assumes that magnification is independent of the direction within the measurement plane. Using experimental data, it is shown that isotropic magnification works well for a typical stereoscopic PIV system, provided that the Scheimpflug condition is met and that the measurements are taken in air. In a water flow, where there is a change of medium between the camera and the light sheet, the experimental results show significant deviations from isotropic magnification, indicating that it is not always a reliable means for a complete calibration.

Finally, a bi-planar target (included in Stereoscopic PIV Accessories of TSI, Model 610050) is introduced that provides complete 3D calibration data while obviating the need to traverse the target. This new calibration target includes a reflector on one side that helps align the device precisely with the laser light sheet.