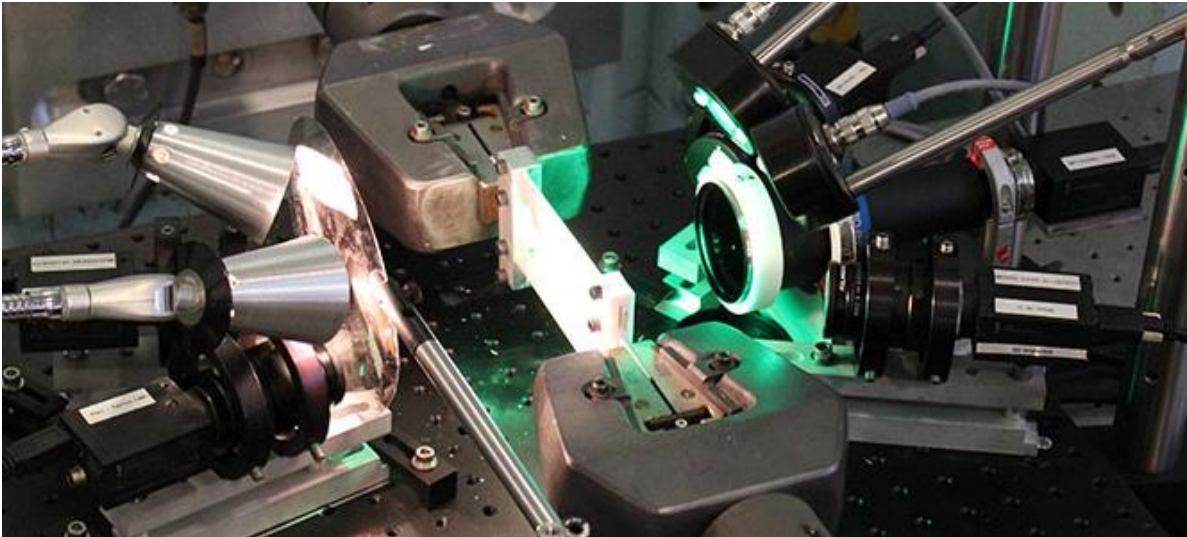# DIC 101

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Welcome to DIC 101!

Course Instructors

▸ Special thanks to Dave Johnson for video editing

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Course Description

▸ Follows the *Good Practices Guide for DIC* (GPG)
▸ Developed by the International Digital Image Correlation Society (iDICs)
▸ Focuses on practical applications of DIC rather than theory or algorithms

Target Audience

▸ New practitioners, to supplement vendor-based or other formal training
▸ Experienced users, to refresh their fundamental knowledge, assist in troubleshooting, and align practices with larger DIC community

Outline

▸ Basic, high-level DIC concepts
▸ Description of the GPG
▸ Design of DIC measurements
▸ Preparation for DIC measurements
▸ Camera calibration
▸ DIC processing techniques
▸ Strain calculations
▸ DIC reporting requirements

Download the GPG!

Before watching these videos, please download the *Good Practices Guide for DIC*, so you can follow along.

https://doi.org/10.32720/IDICS/GPG.ED1

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Disclaimers

This class does not address the health or safety concerns regarding applying DIC in a mechanical testing or laboratory environment. It is the responsibility of the laboratory and user to determine the appropriate safety and health requirements.

Certain commercial equipment, instruments, or materials are identified in this class in order to specify or demonstrate the procedure adequately. Such identification is not intended to imply recommendation or endorsement by the International DIC Society (iDICs), Sandia National Laboratories (SNL), or any other affiliations, nor is it intended to imply that the materials or equipment identified are necessarily the best available for the purpose.

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DIGITAL IMAGE CORRELATION (DIC)

INTRODUCTION

"Keep the dots in the box." -- Prof. Samantha Daly

▸ Digital Image Correlation (DIC) is a diagnostic technique providing full-field shape, displacement and strain measurements on the surface of a solid specimen

▸ Optical (non-contact)

▸ Length- and time-scale independent

Reference (undeformed) image

Deformed image

iDICs
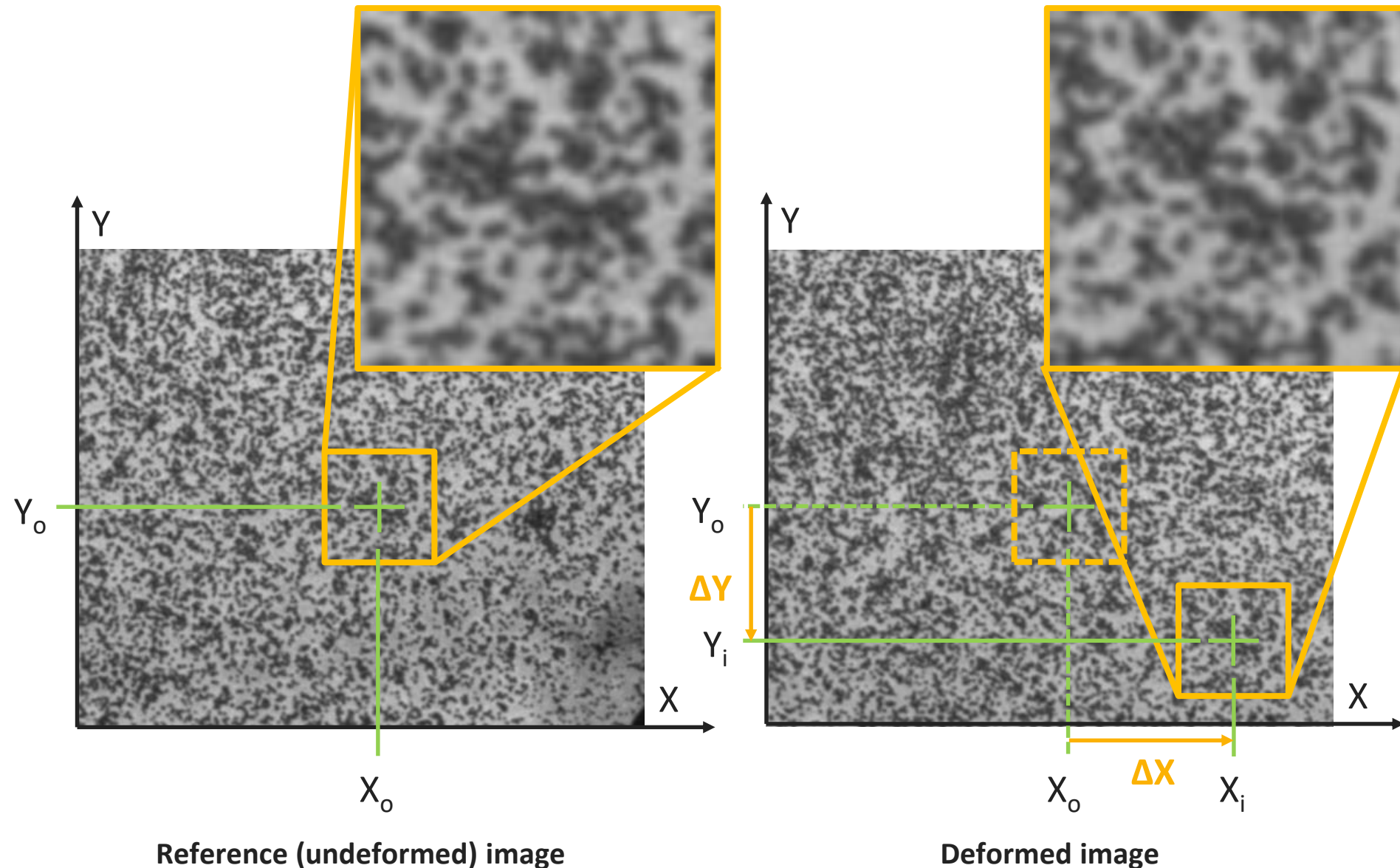
Stereo-DIC utilizes two camera viewing the test piece at an angle to obtain 3D coordinates and displacements.

Left camera

Right camera

iDICs
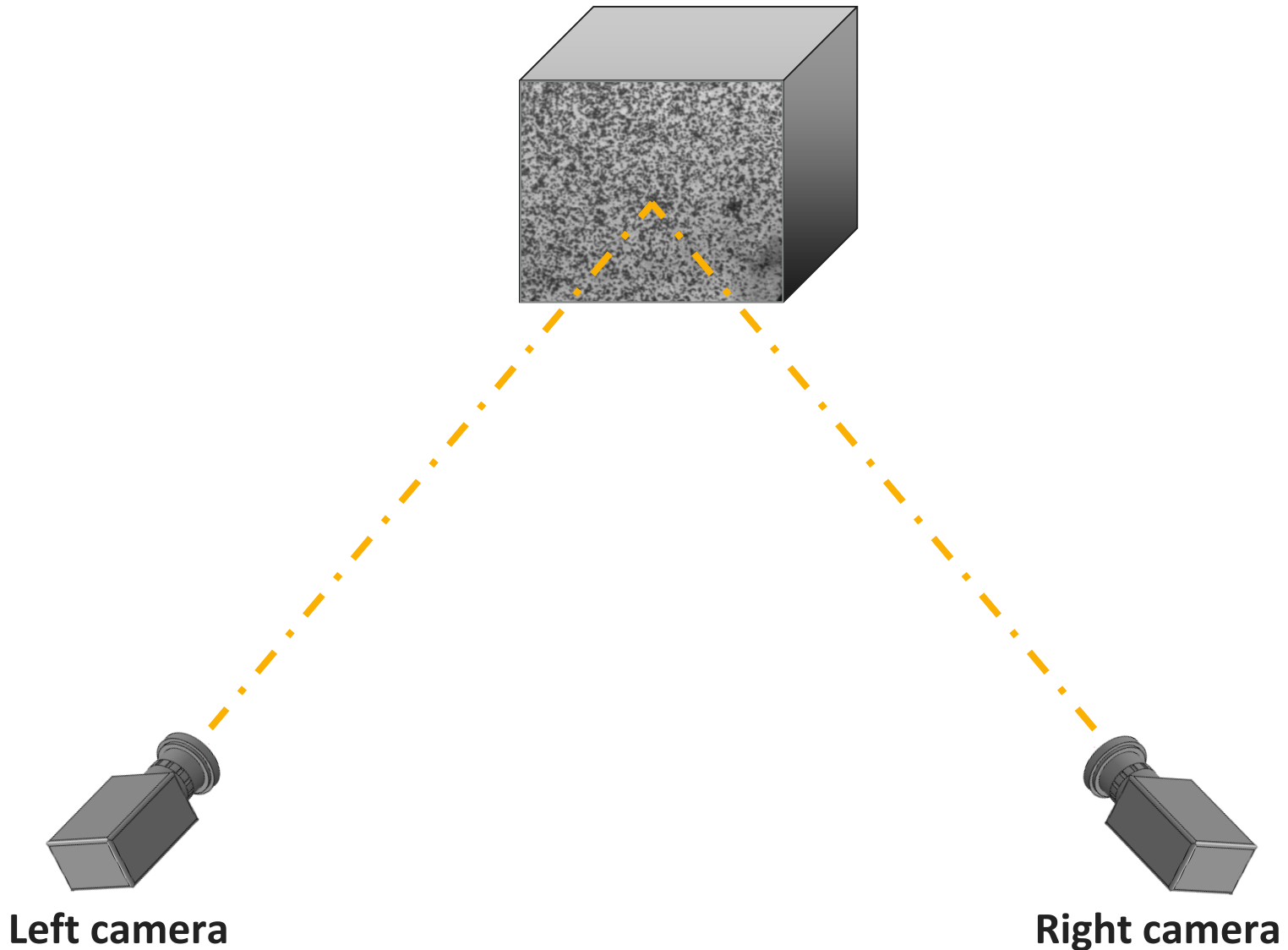
1. Relative location of one camera with respect to second camera and local camera coordinate systems determined through calibration.

α

T_x

Left camera   **Right camera**

iDICs
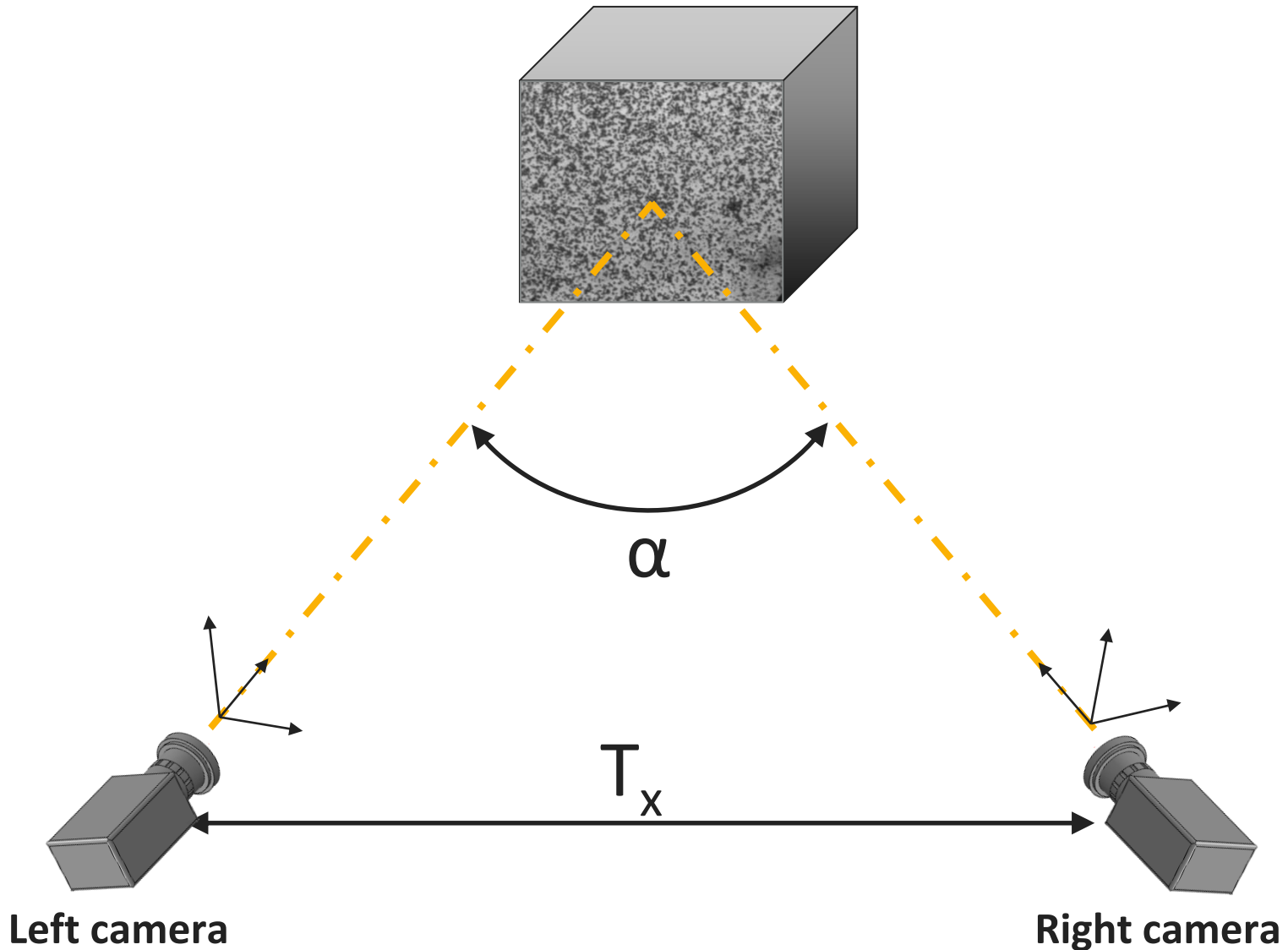
2. Correlation of the left and right cameras identifies the same point in each camera.

Cross-Correlation

Left camera

Right camera
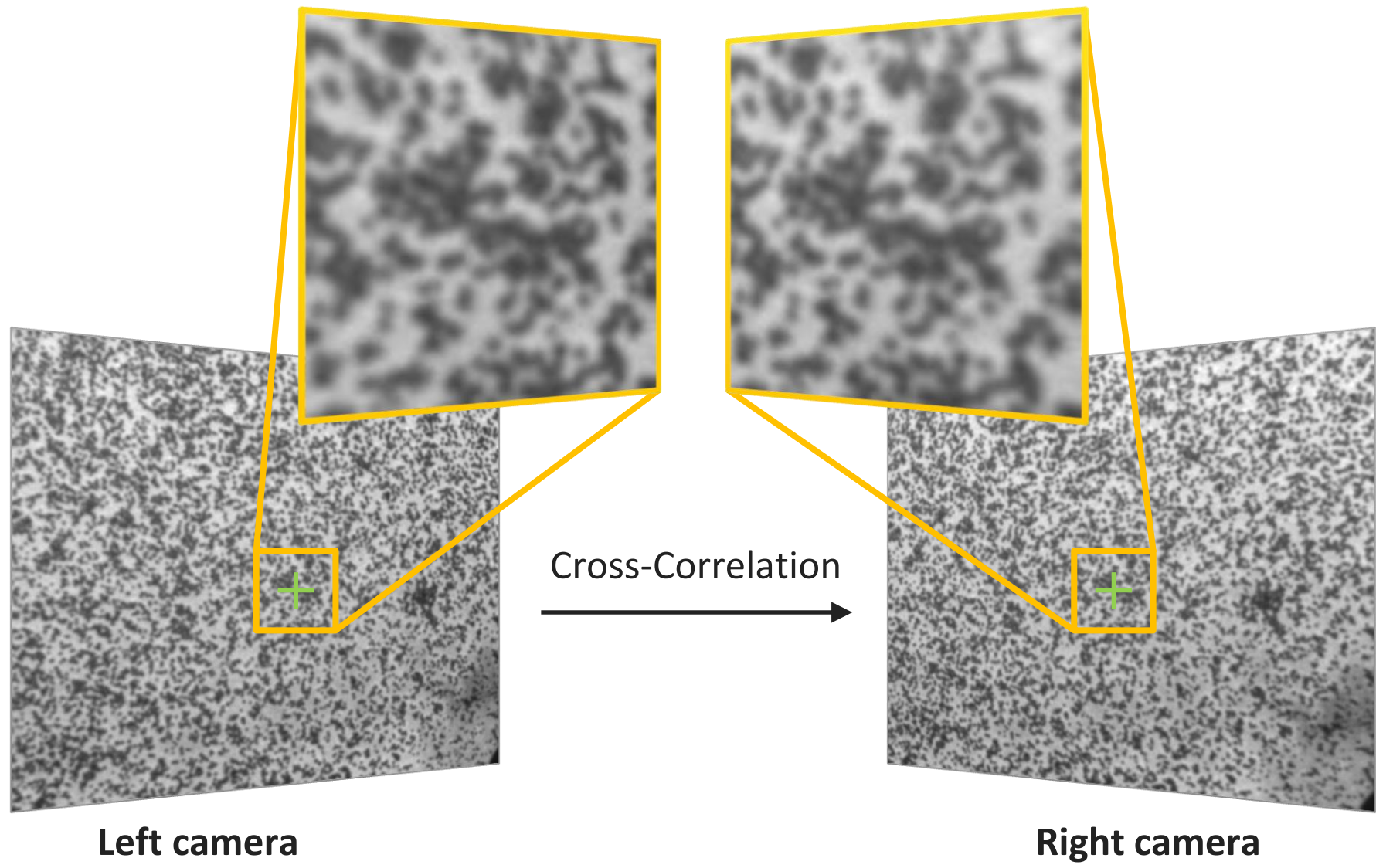
3. Cross-correlation and triangulation gives coordinates in 3D space.

Intersection of two rays gives 3D position in space.

Calibration gives camera coordinate system.

Cross correlation

Left camera

Right camera

iDICs
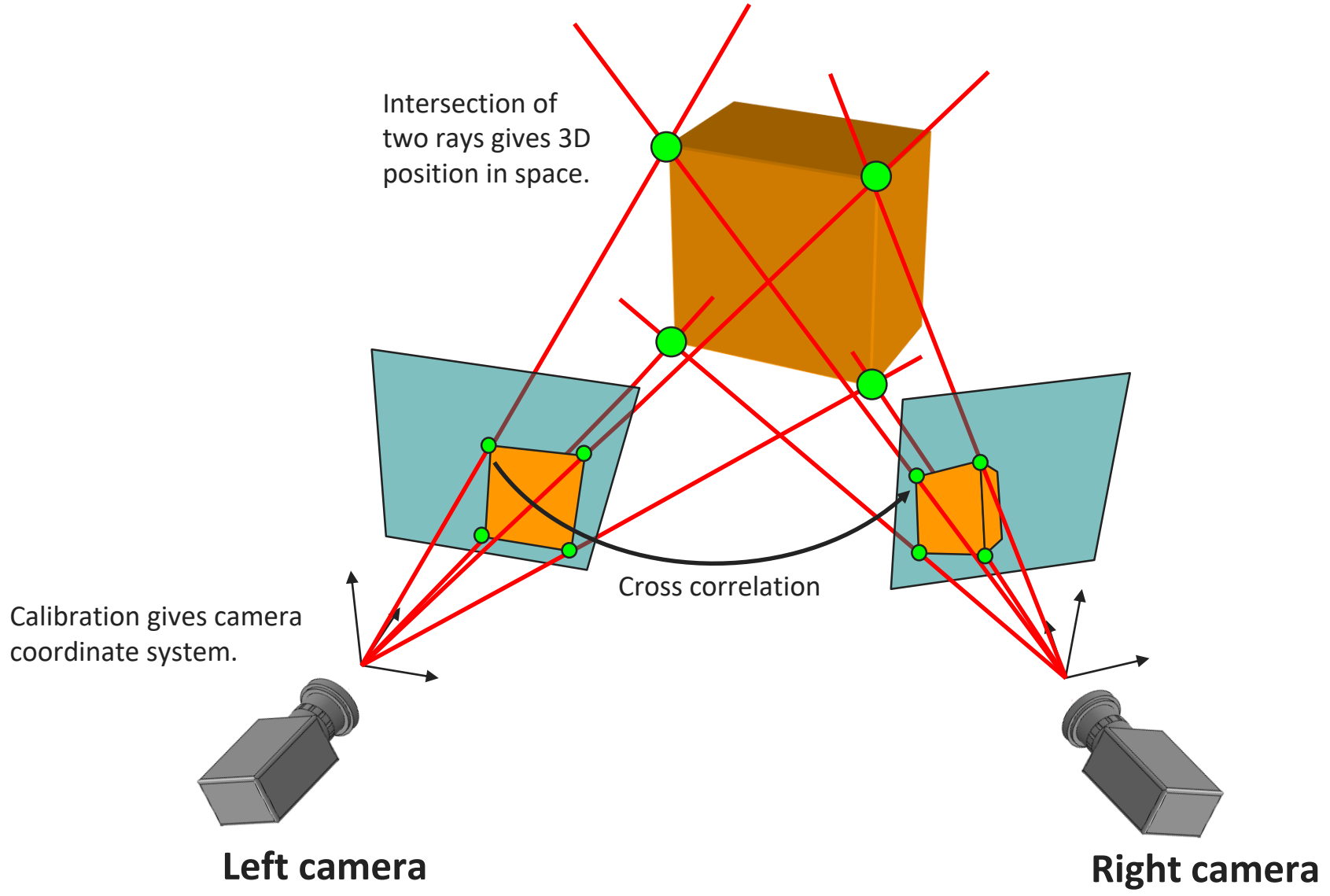
Full-field, time-resolved deformation computed from stereo cameras capturing images throughout the mechanical test.
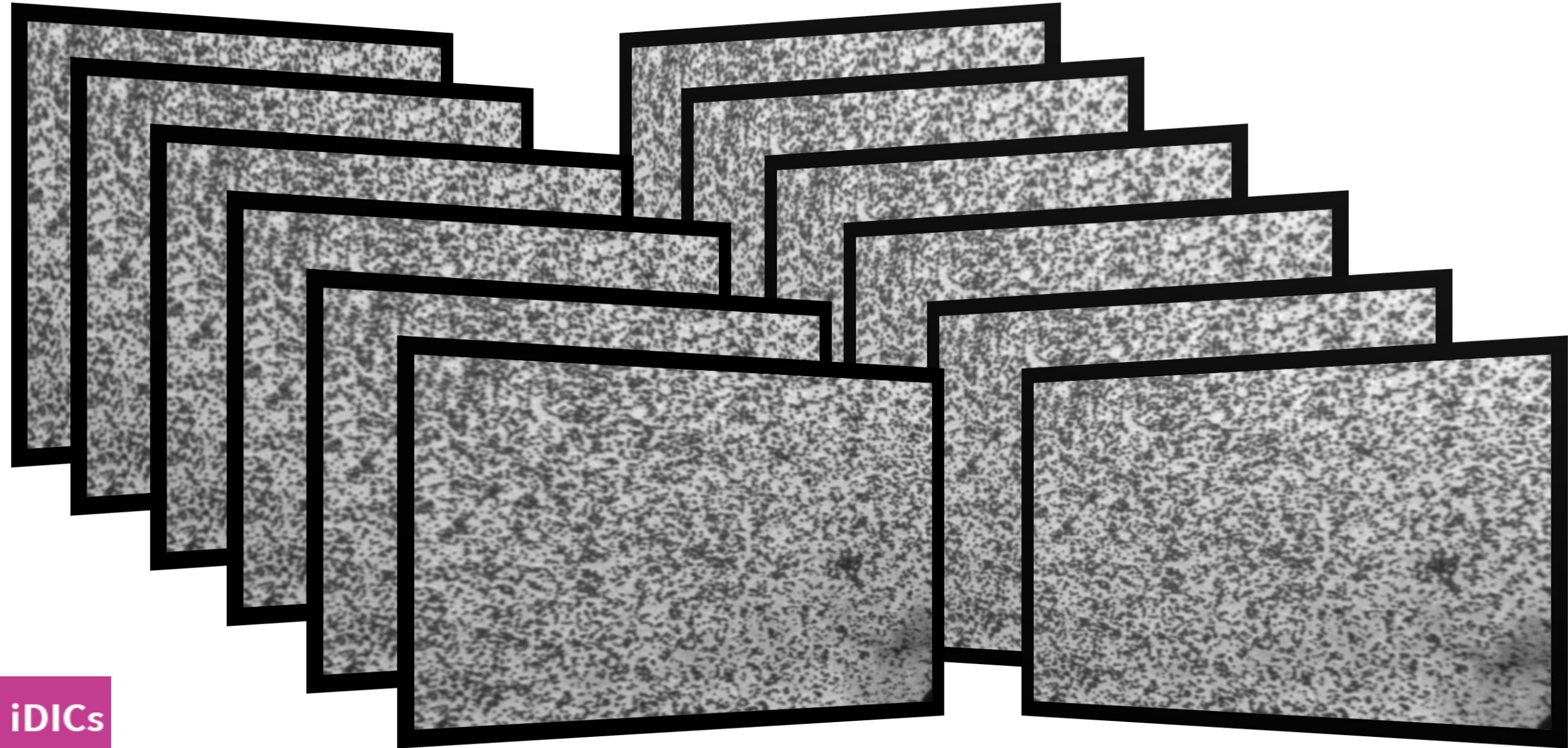
GOOD PRACTICES GUIDE FOR DIGITAL IMAGE CORRELATION

About the *Good Practices Guide for Digital Image Correlation (GPG)*

Development of the Guide

▸ Developed by the iDICs Standardization, Good Practices, and Uncertainty Quantification committee

▸ Approved through an open public comment period Nov 2017-Jan 2018
  ▸ 100 people opted-in to the review process
  ▸ All 500 comments addressed
  ▸ Final review by the iDICs Executive Board

▸ GPG is freely available!
  ▸ http://idics.org/guide
  ▸ https://doi.org/10.32720/idics/gpg.ed1

▸ GPG has been translated!
  ▸ 中文 (full version): https://doi.org/10.32720/idics/gpg.ed1.cn
  ▸ Français (glossary): https://doi.org/10.32720/idics/gpg.ed1.fr
  ▸ Deutsch (glossary): https://doi.org/10.32720/idics/gpg.ed1.de

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About the *Good Practices Guide for Digital Image Correlation (GPG)*

A — Checklist and Flow Chart for DIC Measurements and Analysis

This appendix presents a checklist and flow chart of the main points to consider when designing, executing, and analyzing DIC measurements performed during mechanical testing of a planar test piece. Each of the steps listed in the checklist are expounded upon in the main body of this guide, and the flow chart (Fig. A.1) refers in parentheses to specific sections of the guide.

1. **Design of DIC Measurements (2)**

   (a) *Measurement Requirements*
      - ☐ QOIs (2.1.1)
      - ☐ ROI (2.1.2)
      - ☐ FOV (2.1.3)
      - ☐ Position Envelope for Hardware (2.1.4)
      - ☐ 2D-DIC vs Stereo-DIC (2.1.5)
      - ☐ Stereo-Angle (2.1.6)
      - ☐ DOF (2.1.7)
      - ☐ Spatial Gradients (2.1.8)
      - ☐ Noise-Floor (2.1.9)
      - ☐ Frame Rate (2.1.10)
      - ☐ Exposure Time (2.1.11)
      - ☐ Synchronization and Triggering (2.1.12)

   (b) *Equipment Selection*
      - ☐ Camera and Lens (2.2.1)
      - ☐ Mounting Equipment (2.2.2)
      - ☐ Aperture (2.2.3)
      - ☐ Lighting and Exposure (2.2.4)
      - ☐ DIC pattern (2.3)

   (c) *Mock Test (Optional)*
      - ☐ Test DIC pattern technique on extra test piece(s).
      - ☐ Evaluate DIC pattern behavior throughout test.
      - ☐ Evaluate lighting/contrast throughout test.
      - ☐ Evaluate data synchronization and triggering.

2. **Preparation for the Measurements (3)**

   (a) *Pre-Calibration Routine (3.1)*
      - ☐ Review test procedure (3.1.1).
      - ☐ Check cleanliness of camera detector, lens, and calibration target (3.1.2).
      - ☐ Warm up cameras (3.1.3).
      - ☐ Synchronize cameras to each other and to other data acquisition (3.1.4).
      - ☐ Apply DIC pattern (3.1.5).

   (b) *Pre-Calibration Review of System (3.1.6)*
      - ☐ Position test piece in load frame (3.1.6.1).
      - ☐ Position cameras for desired FOV and image ROI (3.1.6.1).
      - ☐ Verify FOV, focus, DOF (3.1.6.2).
      - ☐ Lock all moving parts of cameras, lenses, and mounting system (3.1.6.3).
      - ☐ Adjust orientation of polarization filters if using cross-polarized light (3.1.6.3).
      - ☐ Review static images (3.1.6.4), looking for:
        - Glare
        - DIC pattern that is too coarse or too fine
        - Defects in applied DIC pattern
        - Out-of-focus regions of the image
        - Poor contrast
        - Non-uniform lighting
        - Overexposed or underexposed regions
        - Dirt, smears, foreign object on lens or camera detector
        - Vibrations or other camera motion
      - ☐ Adjust DIC system until high-quality images are obtained.

   (c) *Calibration (3.2)*
      - ☐ Select calibration target of appropriate size. (3.2.2.1).
      - ☐ Create a clear working space in which to perform calibration (3.2.2.2).
      - ☐ Lock all moving parts of cameras, lenses, and mounting system (3.2.2.2).
      - ☐ Adjust lighting/exposure (3.2.2.3).
      - ☐ Ensure there is uniform contrast and no glare as the calibration target is rotated, tilted, and translated (3.2.2.3).
      - ☐ Acquire calibration images that have well-extracted features in the entire working volume of the optical system (3.2.2.4).
      - ☐ Calibrate the system (3.2.2.5).
      - ☐ Review calibration results (3.2.2.6).
      - ☐ Review calibration parameters (3.2.2.7).

   (d) *Post-Calibration Routine (3.3)*
      - ☐ Reset system: Position test piece in test frame (if removed for calibration) or reposition stereo-camera system (if moved for calibration) and lock any moving parts (3.3.1.1).
      - ☐ Adjust lighting/exposure (3.3.1.2).
      - ☐ Acquire static images (3.3.1.3).
      - ☐ Review static images (3.3.1.4 and 3.1.6.4), looking for:
        - Glare
        - DIC pattern that is too coarse or too fine
        - Defects in applied DIC pattern
        - Out-of-focus regions of the image
        - Poor contrast
        - Non-uniform lighting
        - Overexposed or underexposed regions
        - Dirt, smears, foreign object on lens or camera detector
        - Vibrations or other camera motion
      - ☐ Acquire rigid-body-motion images of test piece for noise-floor analysis (3.3.1.5).
      - ☐ Verify calibration (3.3.2).
        - Intrinsic parameters (3.3.2.1)
        - Extrinsic parameters (3.3.2.2)
        - Absolute distances (3.3.2.3)
      - ☐ Perform abbreviated noise-floor analysis and ensure the noise-floor is acceptable (3.3.3.1).
      - ☐ Look for heat waves (3.3.3.2), system stability (3.3.3.3), and any other lab-specific system verifications (3.3.3.4).

3. **Execution of the Test with DIC Measurements (4)**
   - ☐ Verify correct file name, location, and storage capacity for DIC images.
   - ☐ Verify that the correct test procedure or macro has been selected.
   - ☐ Verify force and other measurements of interest are set to record and are synchronized with DIC images.
   - ☐ Verify triggering of test frame and DIC images.
   - ☐ Verify that lights are on, exposure is correct, frame rate is correct.

4. **Processing of DIC Images (5)**
   - ☐ Select initial correlation and user-defined parameters.
   - ☐ Perform initial correlation of images.

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About the *Good Practices Guide for Digital Image Correlation (GPG)*
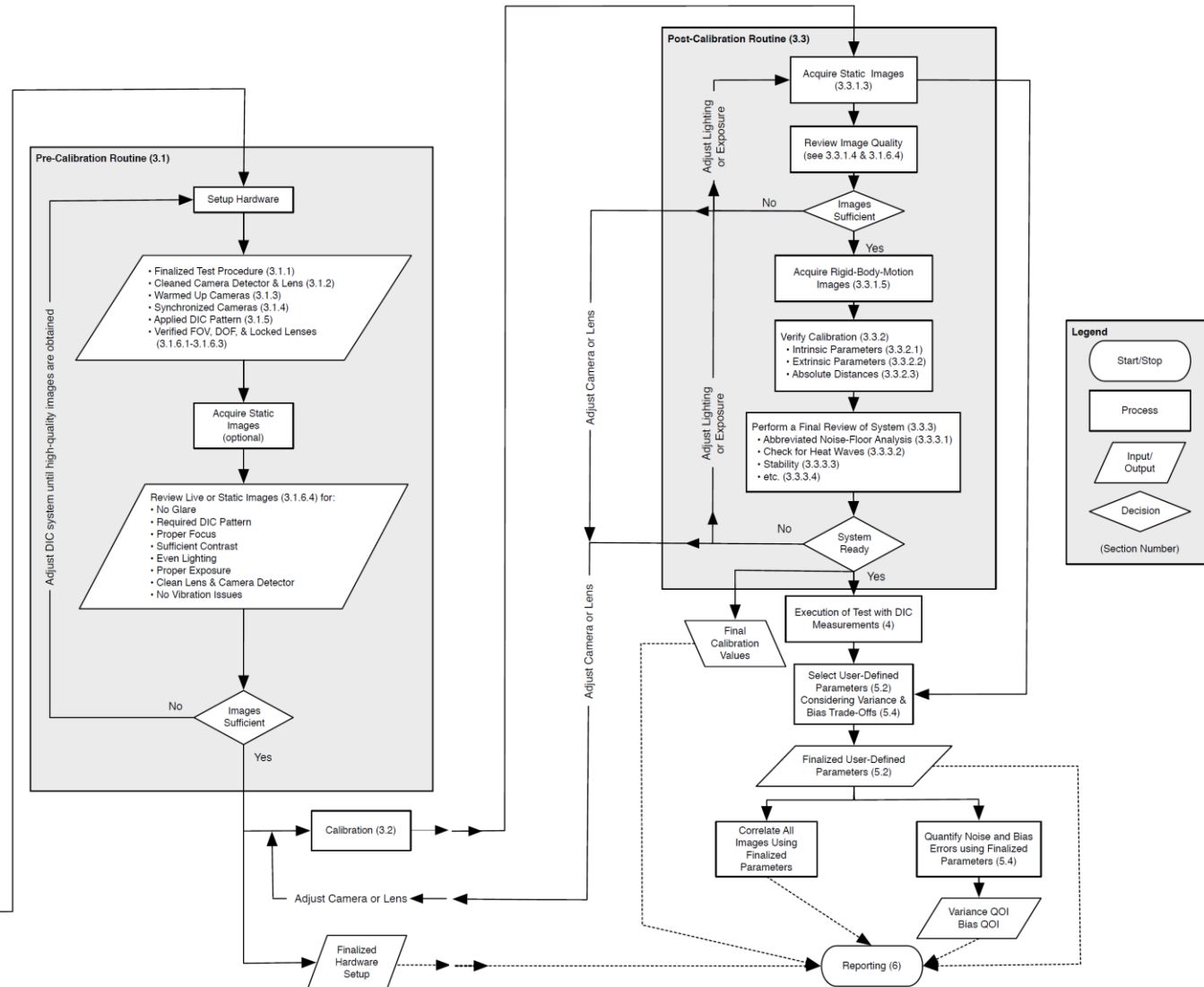

Figure A.1: Flow chart illustrating the main steps involved when conducting DIC measurements in conjunction with mechanical testing of a planar test piece (part 1).
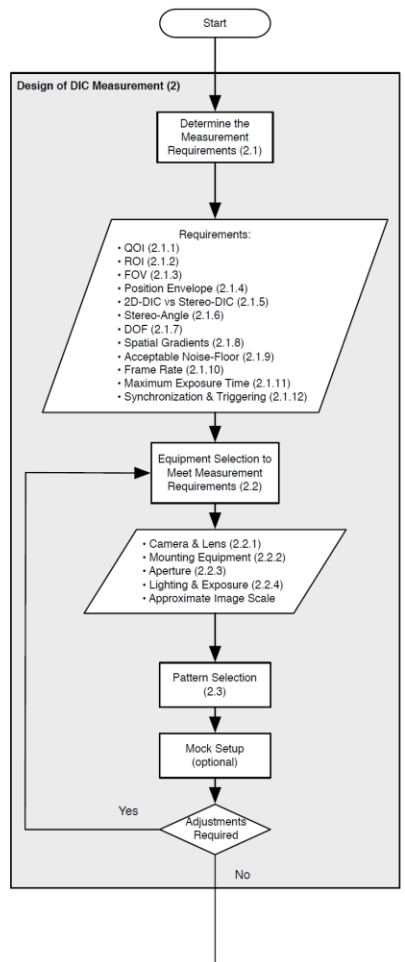
Figure A.2: Flow chart illustrating the main steps involved when conducting DIC measurements in conjunction with mechanical testing of a planar test piece (part 2).

About the *Good Practices Guide for Digital Image Correlation (GPG)*

Current Scope of GPG

▸ Common mechanical tests with DIC measurements

▸ Standard lab/ open air environmental conditions

▸ Planar test piece, moderate sizes, strains, and rates

▸ 2D-DIC and stereo-DIC using local, subset-based DIC algorithms

Improvement and Expansion of the Guide

▸ 6 working groups:
1. Figures, references, and examples
2. Non-planar test pieces
3. Global DIC
4. Library of patterning techniques
5. Dynamic tests and high-speed DIC
6. Noise and bias quantification

▸ Translations to other languages
  ▸ Chinese: Released August 2019
  ▸ German: Released March 2020
  ▸ French: Released March 2020
  ▸ Japanese: In progress
  ▸ Portuguese: In progress

Get Involved!

▸ All are welcome to participate, regardless of experience level

▸ Contact guide@idics.org

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