# Applications and Development Work for Digital Image Correlation using High Speed Cameras

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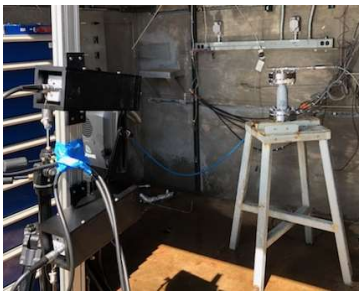
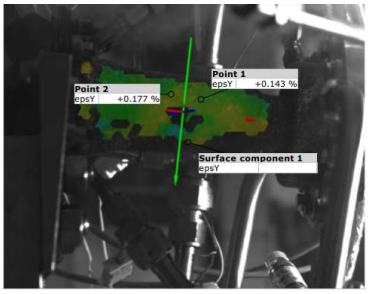
## INTRODUCTION

NASA, Army, and industry partners are working to advance optical measurement techniques used in highly dynamic rocket engine and missile test environments. This allows for direct component data collection during test and flight environments, significantly reduced analysis time, and associated cost savings.

Digital Image Correlation (DIC) uses calibrated stereo cameras to collect three-dimensional (3-D) displacements, strains, and acceleration data by referencing a stochastic speckle pattern applied to the test object. These optical measurement techniques provide significantly improved data resulting in better performance predictions, model validation, and information about components during hot-fire tests and test flights.



Caption: Chamber with Digital Image Correlation Setup




Caption: Hoop Strain plot from Chamber hot fire testing

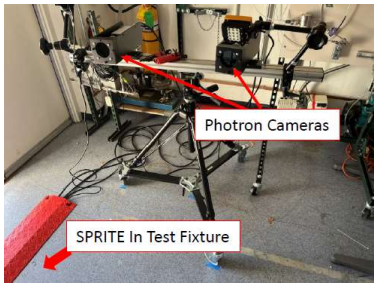
## Background

What is Digital Image Correlation (DIC)?

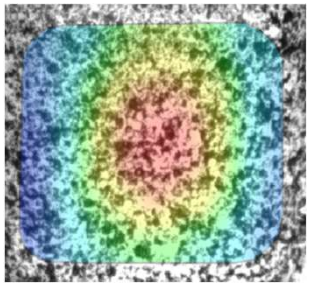
- A method used to measure the deformation of an object based on a set of images of the object in deformation.
- Using a speckled pattern or tracking dots on a surface of hardware and using a camera to capture images while it deforms.

Why use Digital Image Correlation (DIC)?
Structural & Thermal model correlation

- Characterize full-field displacement and strain across length scales from <10 mil to >100 ft depending on field of view.
- Characterize mode shapes.
- Supplements instrumentation (prevent over-instrumentation issues)
- Low Cost.
- Frame Rates up to 4,800 fps at 1.3 MP, or up to 750,000 fps at reduced resolutions.




Caption: Green Propellant Dual Mode module Test Set up



Caption: Von Mises strain plot from Green Propellant Dual Mode module qualification testing utilized to correlate finite element model

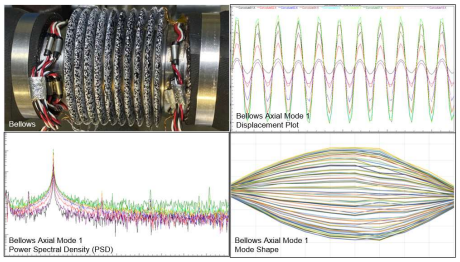
## Testing

NASA Marshall Space Flight Center (MSFC) has adapted and developed dynamic photogrammetry and digital image correlation measurement tools for use during highly dynamic environments, such as rocket engine testing, to obtain full-field surface dynamic strains, displacements, and accelerations.

Previous Testing Performed by MSFC ER41.

- RL10 XR716 Vibration Qualification Test
  - Correlation of nozzle FEM stresses and mode shapes
- The Rapid Analysis and Manufacturing Propulsion Technology (RAMPT)
  - Collected DIC imagery data to aid in the validation of structural models predicting the effects of composite overwrap techniques on the RAMPT chambers previously tested in hot fire at MSFC.
- TVC CAPU
  - Correlation stress models.
- Bellows Flow Testing
  - Demonstrate capabilities for detecting flow induced vibration (FIV).
- Green Propellant Dual Mode module qualification testing.
  - Correlation stress models.
- Bellows Sine Sweep Testing
  - Identified modes, mode shapes, and damping.

Caption: Bellows Flow Test Set up




Caption: Speckled pattern applied to bellows to detect and quantify Flow-Induced Vibration in flexible bellows duct components. Displacements time histories from tracking points used to identify frequencies and mode shapes.

## CONCLUSION

DIC reduces development time and increases cost savings over traditional measurement methods while providing improved capability. Through tailoring of the cameras, lenses, field of view, and speckle pattern, a wide range of time and length scales can be measured. Partnerships across government organizations allow shared development costs and lessons learned to enable expedited technology readiness in the field.

## REFERENCES

*FASTCAM Multi: Multi Head High-Speed Camera System.* Photron. 2016.