



Insitu Thermographic Inspection System for Automated Fiber Placement

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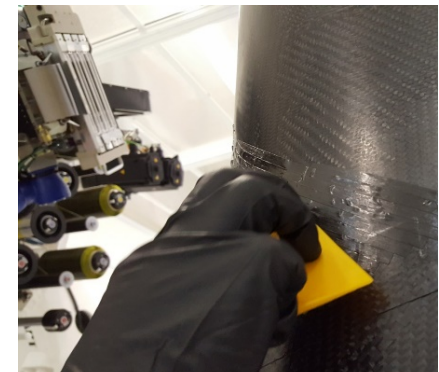
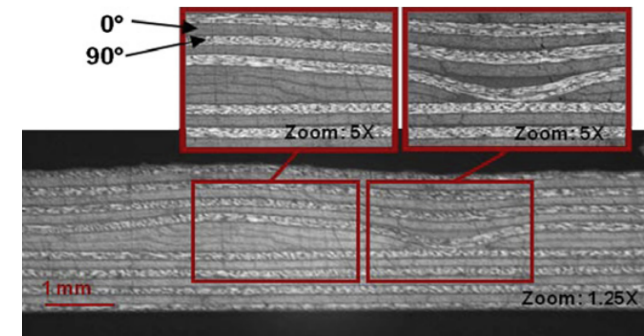
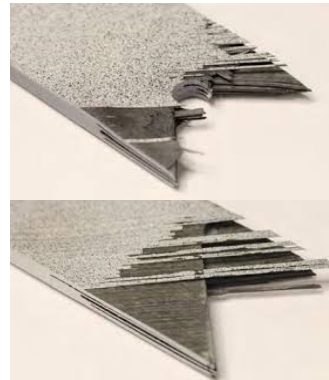
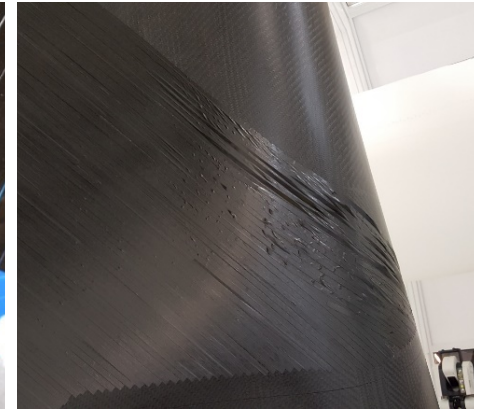
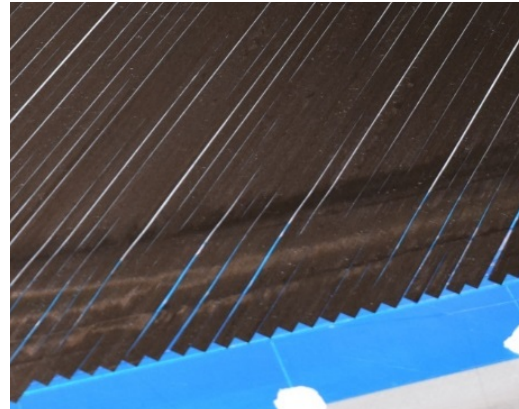
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Challenges of Automated Fiber Placement



- Defects Associated with AFP:
 - overlaps/gaps
 - Wrinkling
 - loss of adhesion
- AFP has long process development cycles to minimize defect occurrence.
- Defect can result in up to 32% reduction in strength.
- Risk mitigation strategies include 100% manual visual inspection of **each ply**.
- Typical AFP cell time:
 - 42% Inspection and data review
 - 19% Layup



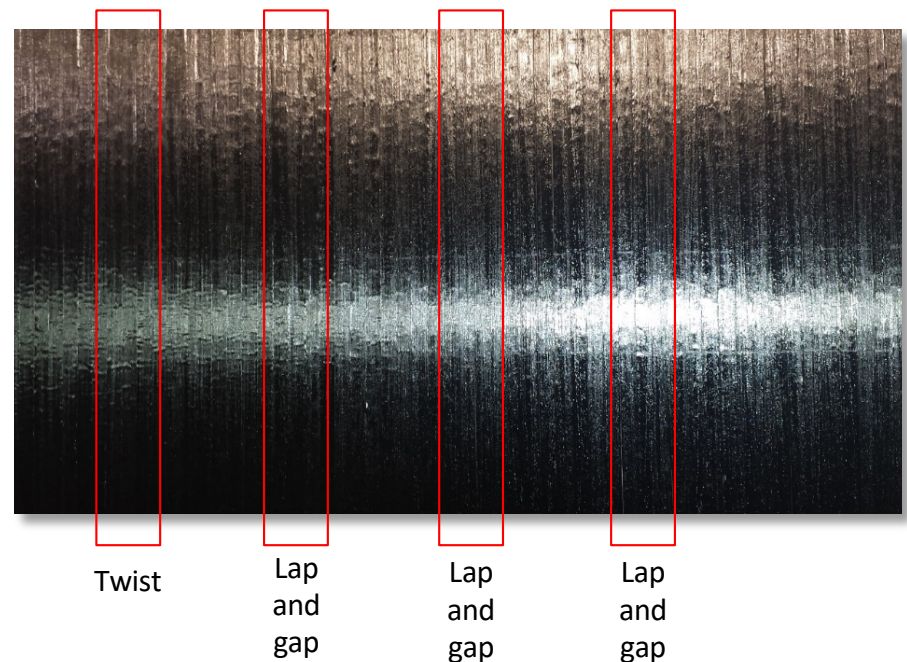
Challenges of manual visual inspection



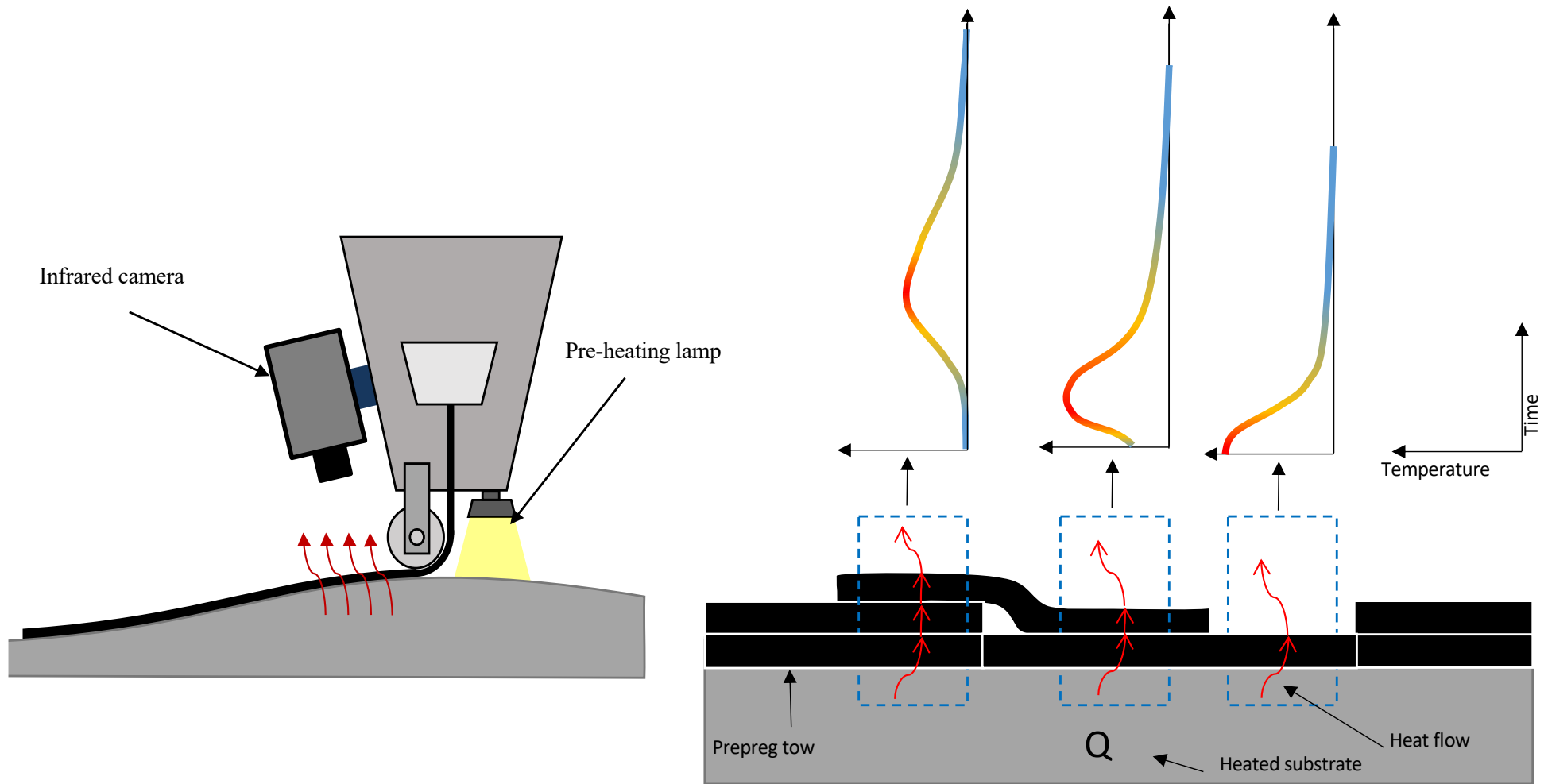
- Massive aerospace structures with large number of ply layers means long inspection time between layups.



- Difficult to accurately assess your risk and determine probability of detection with human inspection in a low contrast environment.

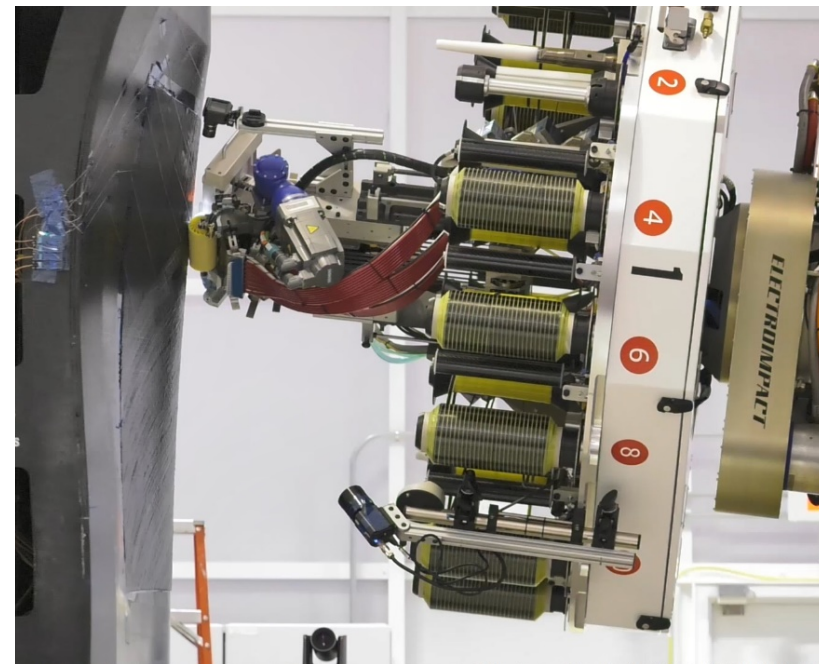
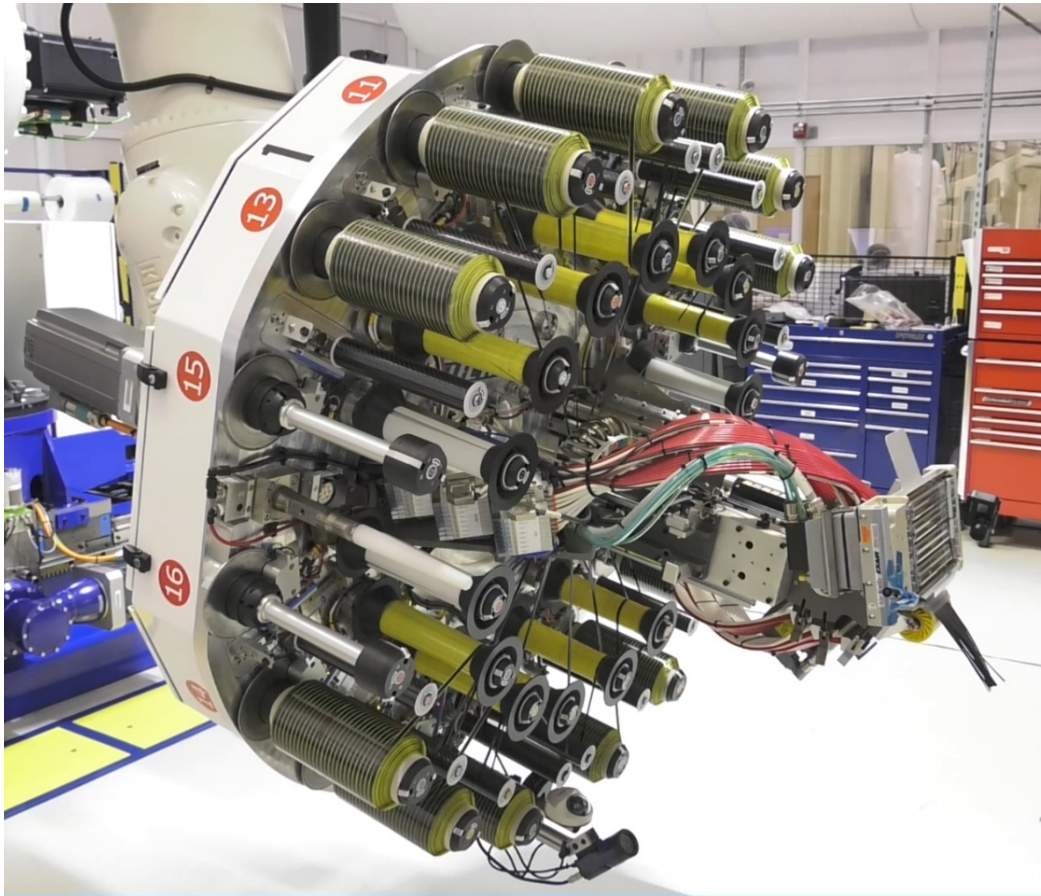


Our proposed solution



Utilize the pre-heated surface as a through-transmission heat source and monitor the heat flow through the new layer using an onboard thermal camera

In Situ Thermal Inspection System (ISTIS)

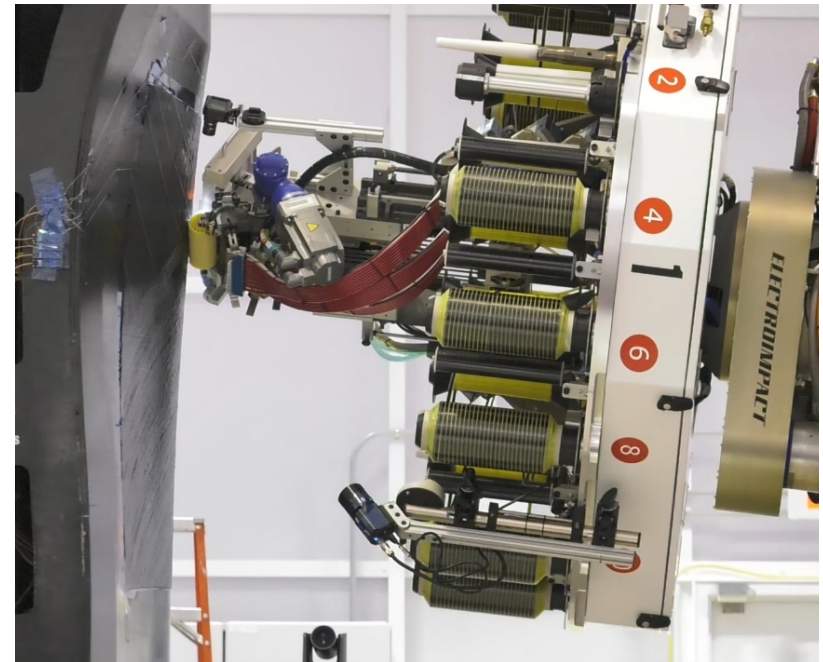


In Situ Thermal Inspection System (ISTIS)

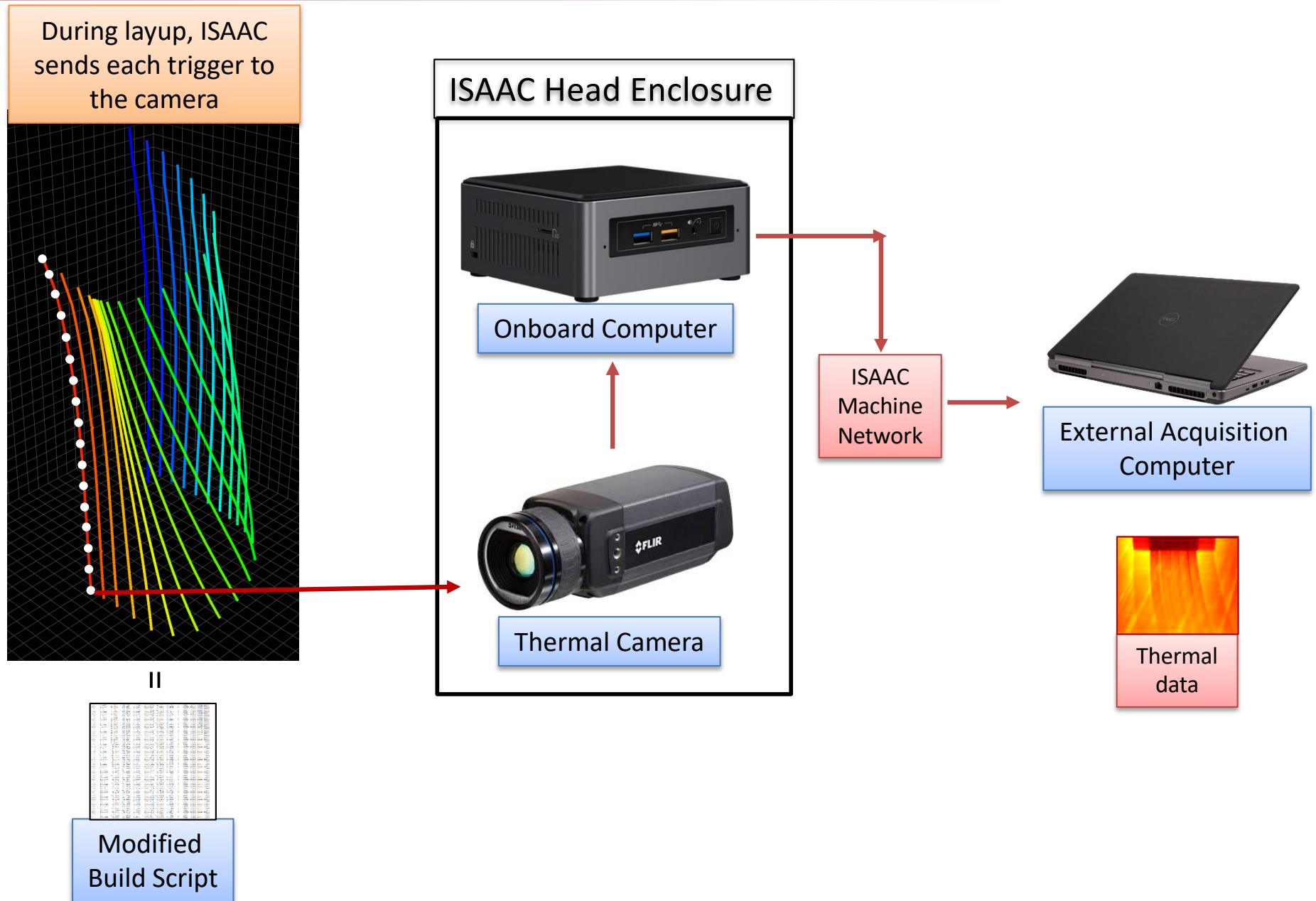


Key benefits

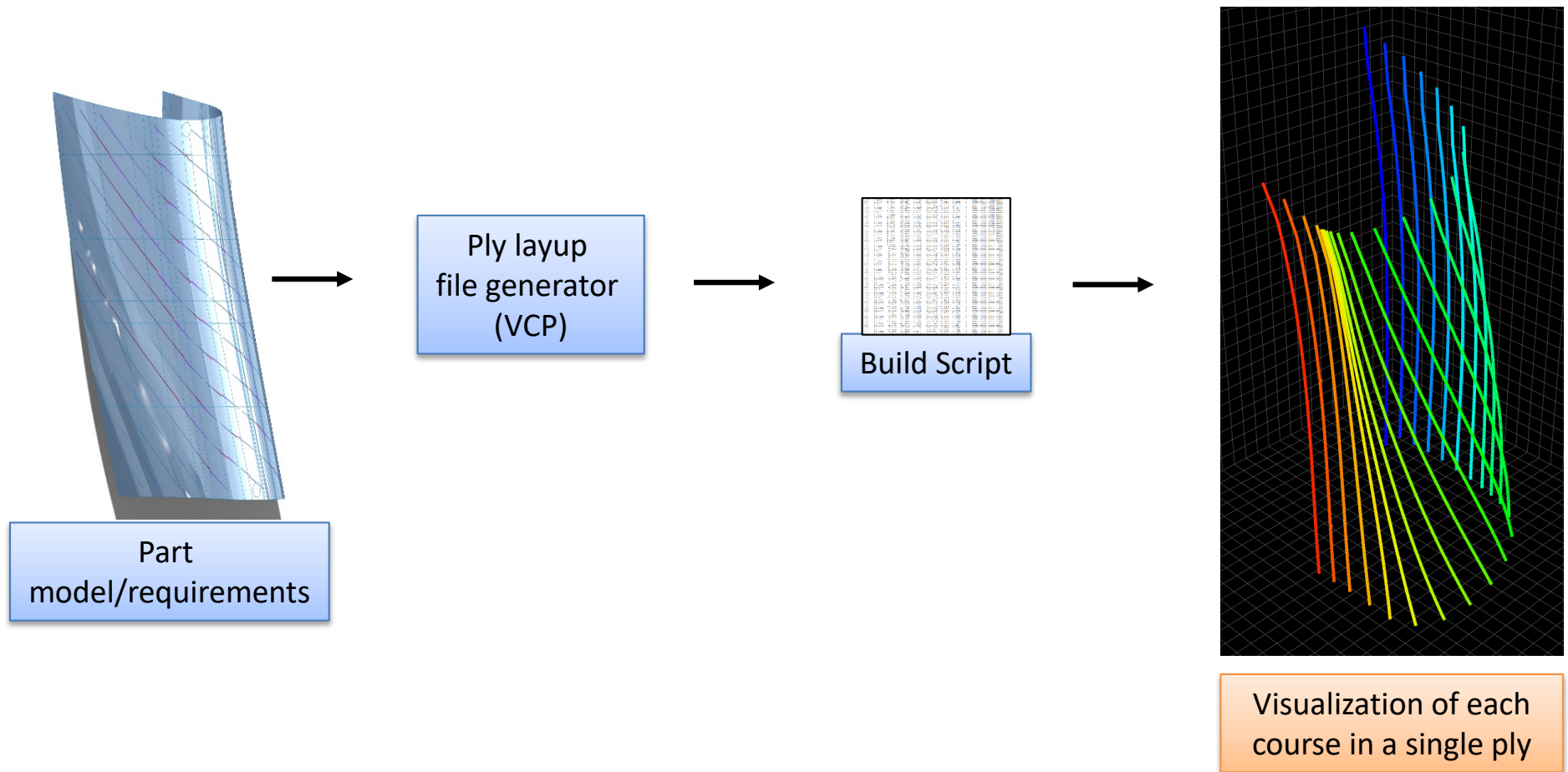
- Operates independent of current layup operations.
- Relatively inexpensive hardware upgrade.
- Each frame of data is already spatially registered to a location on the part.
- Generate 3D models of data.
- Shorten process development time by directly tying part quality to process parameters.
- Inspection data can be quantified and catalogued .



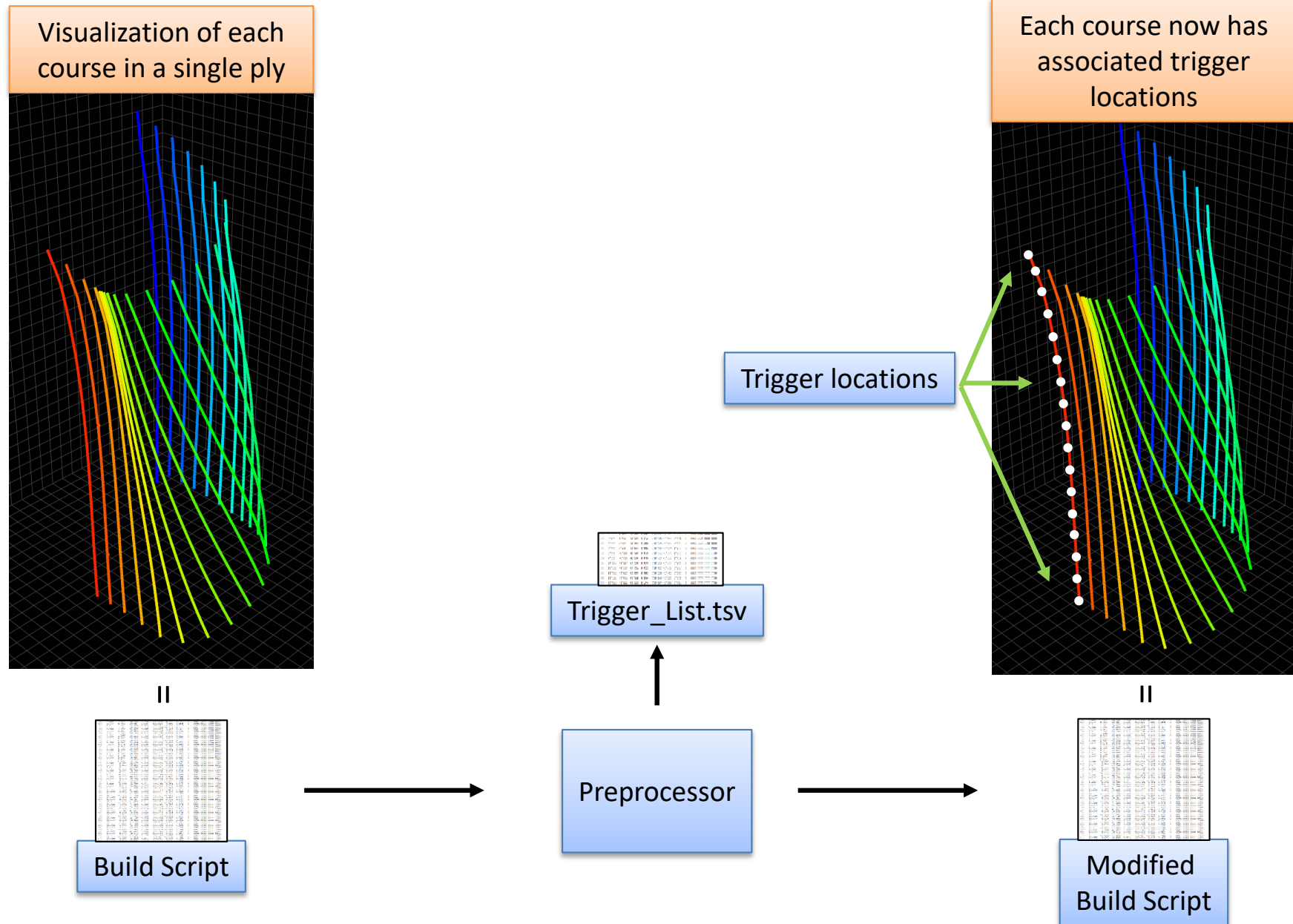
ISTIS Architecture

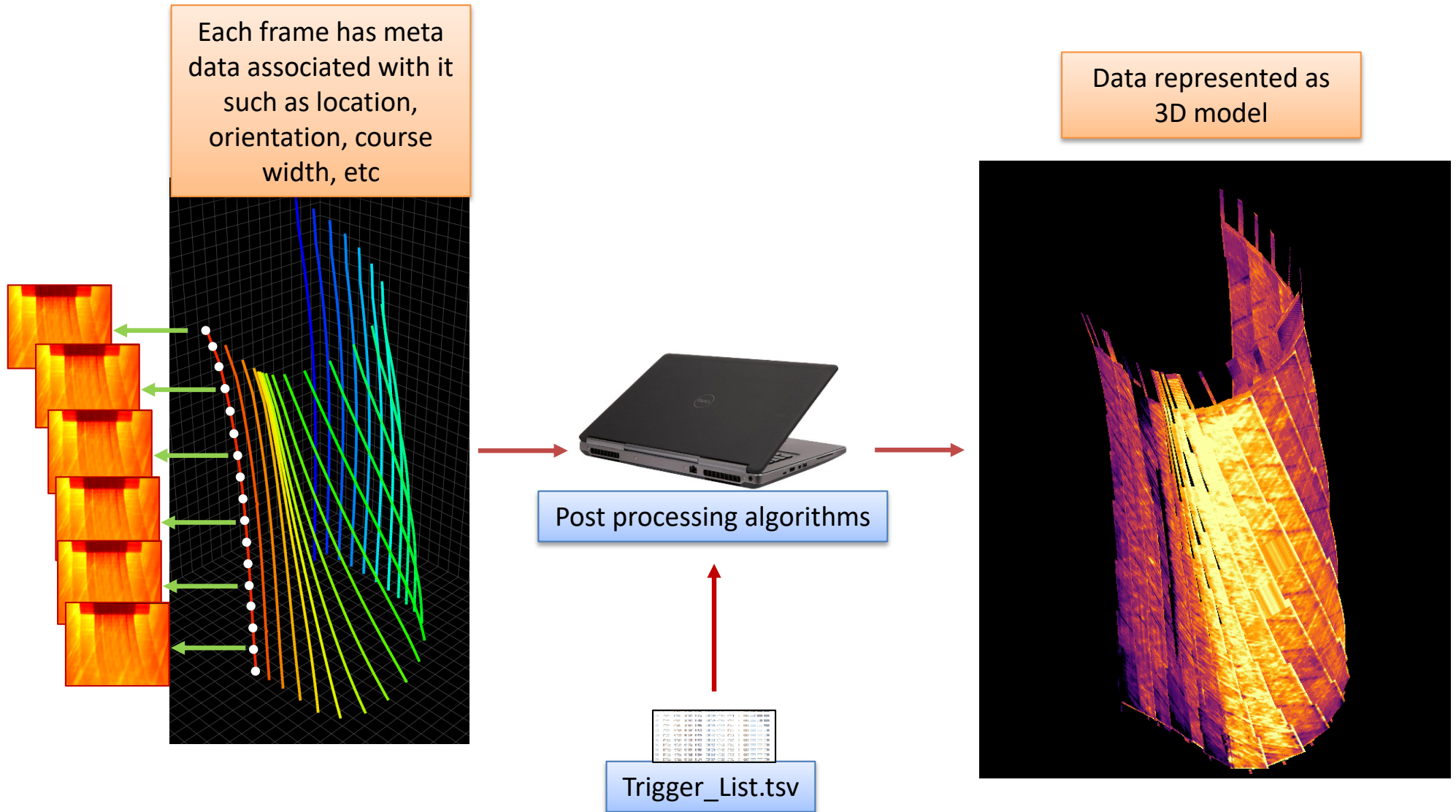


ISTIS Architecture

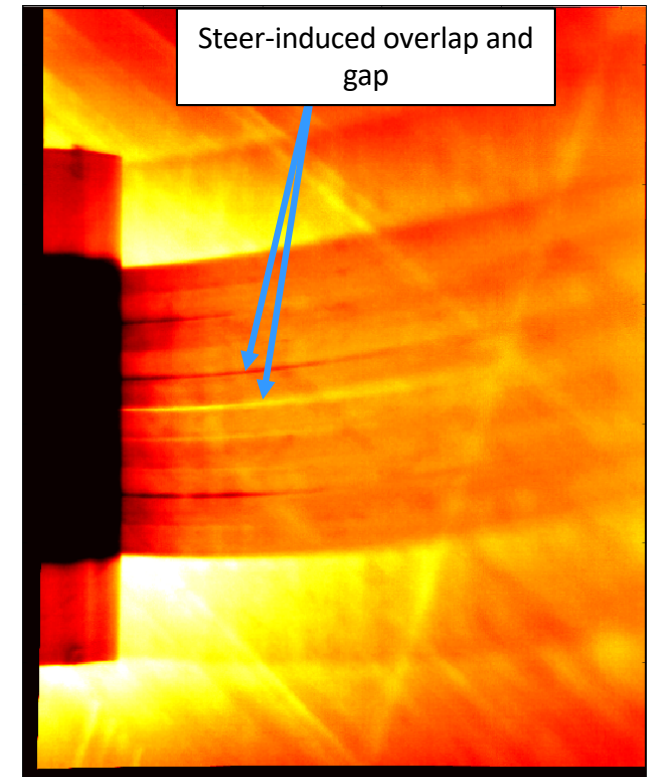
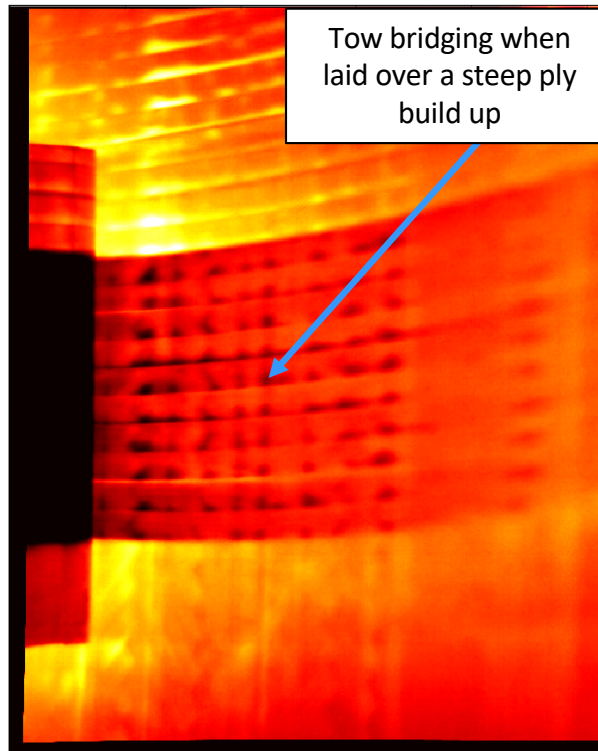
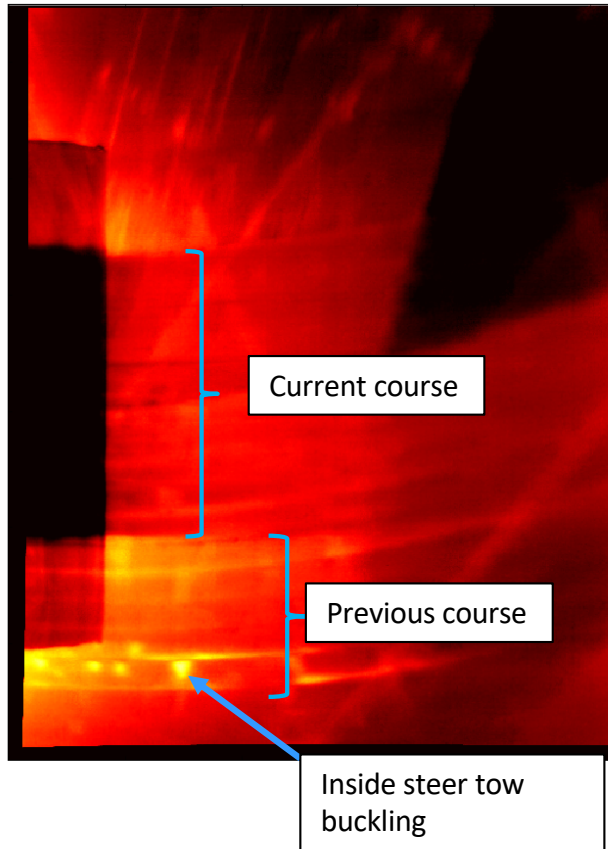


ISTIS Architecture





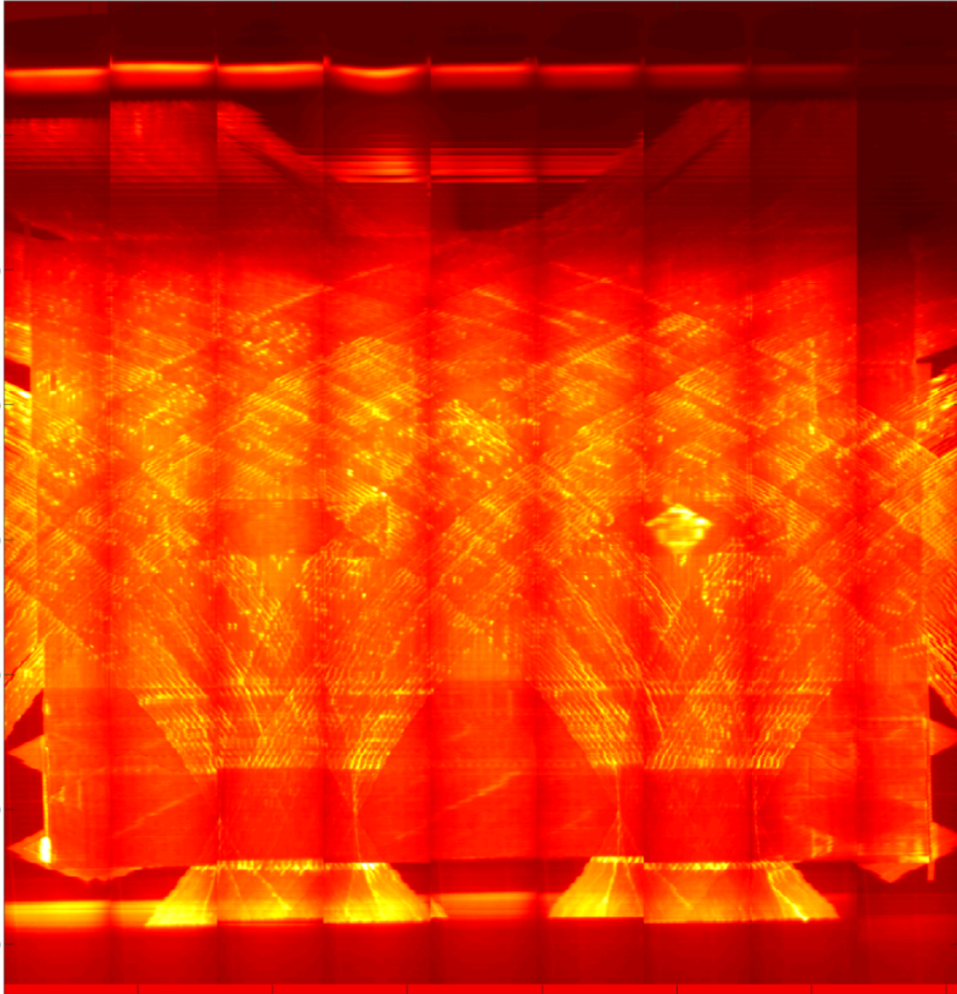
ISTIS Results



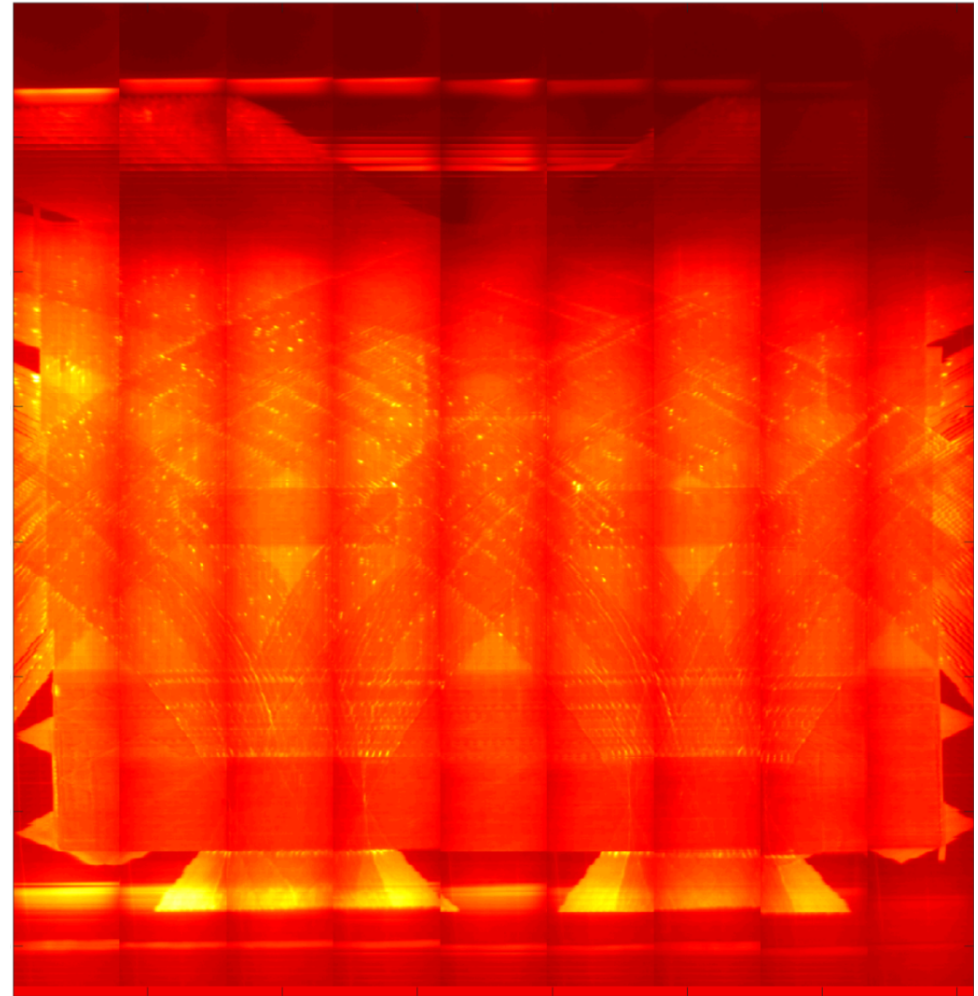
ISTIS Results



Post layup, as is part



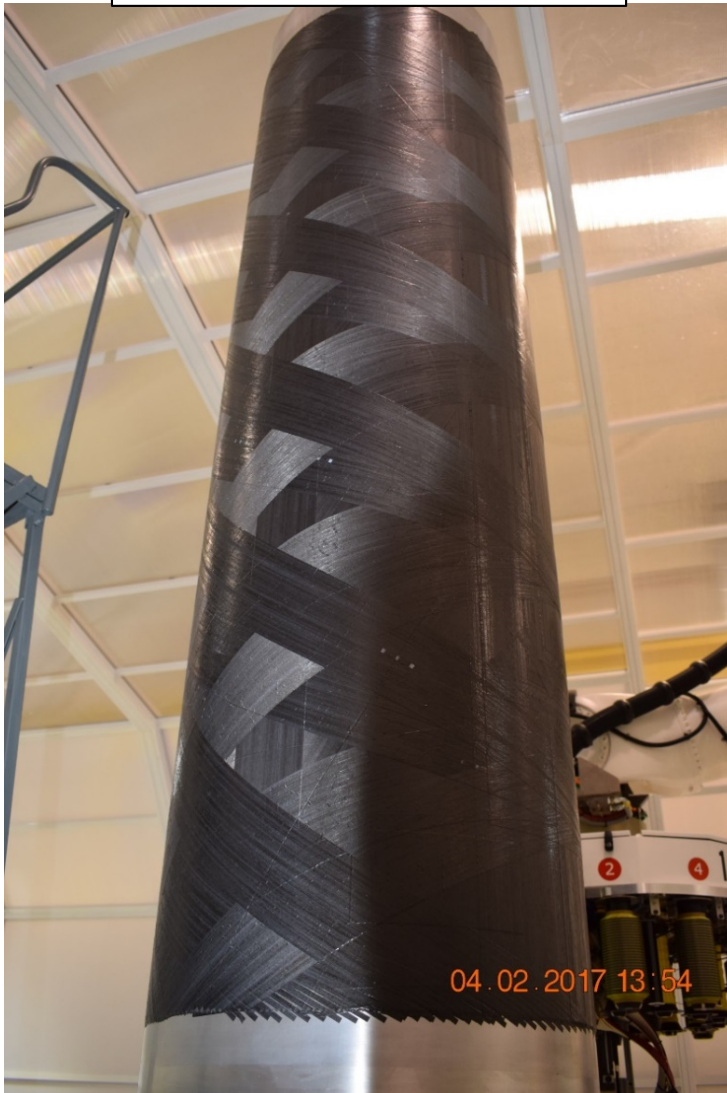
Post layup, after 30 minute debulk cycle



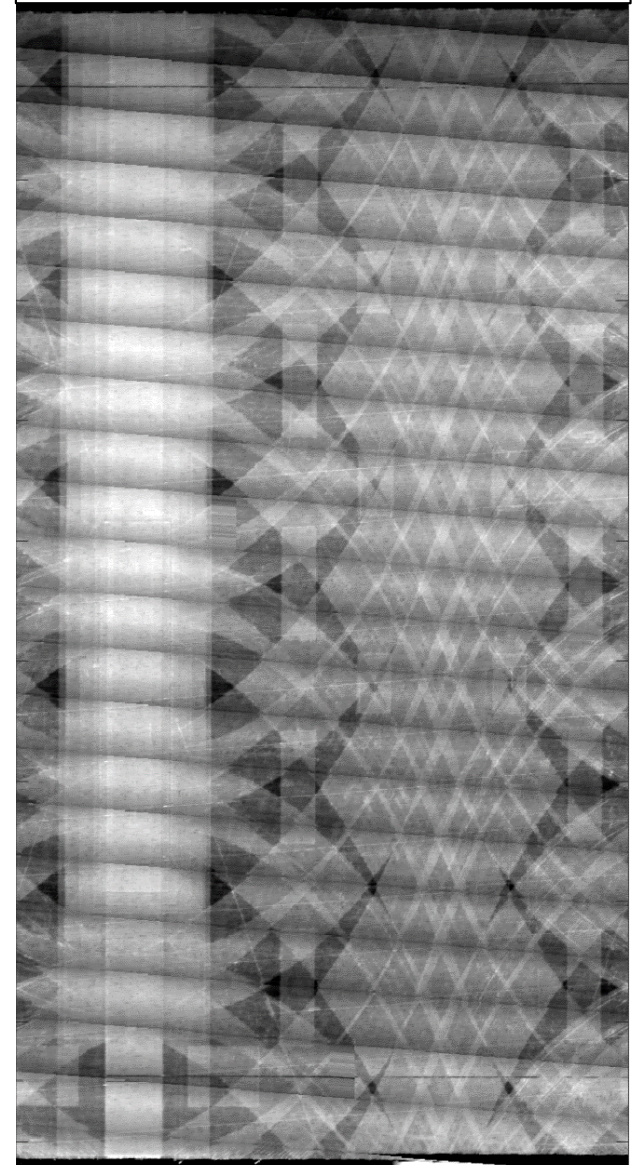
ISTIS Results



Cylinder



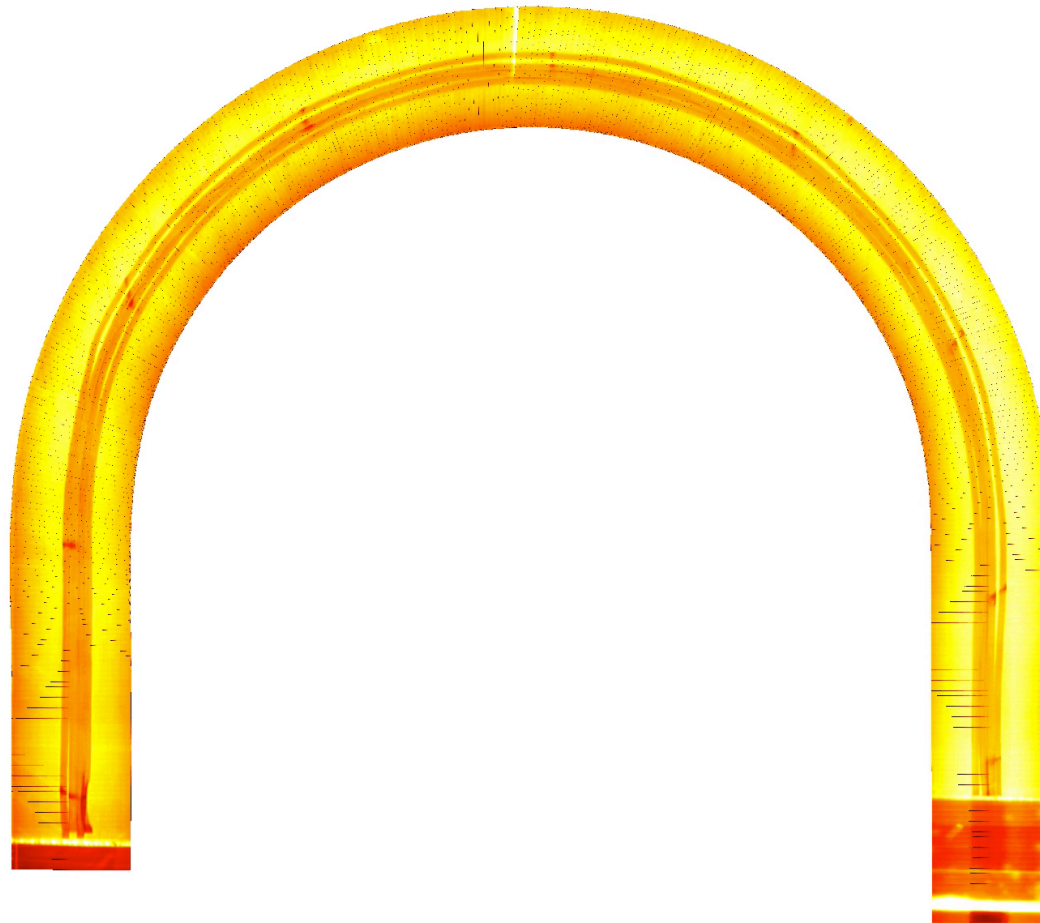
Thermal Reconstruction



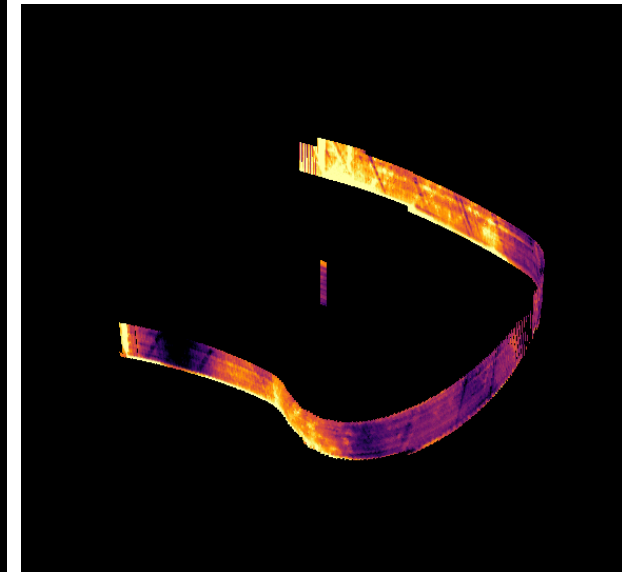
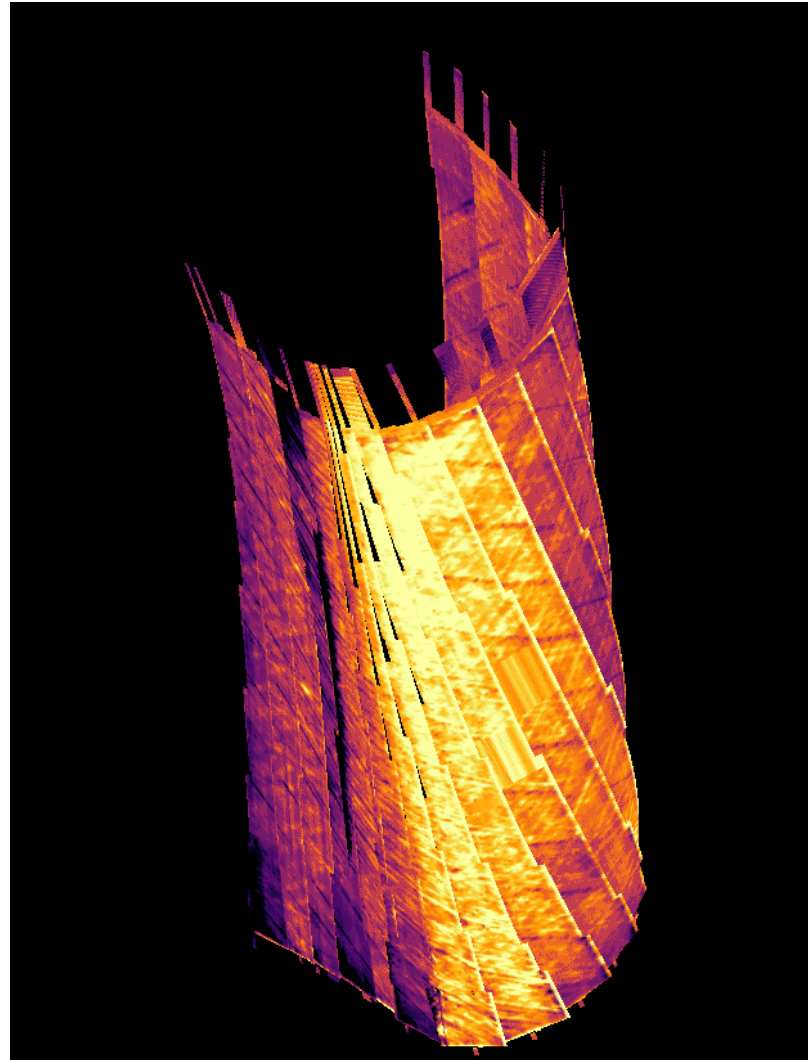
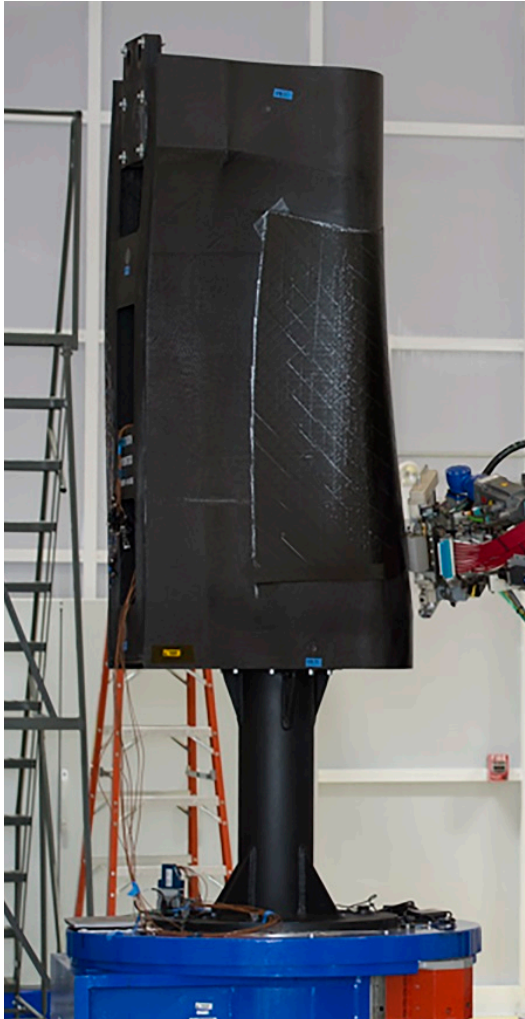
ISTIS Results



Data Collected on tow steered arches of various radii.



ISTIS Results

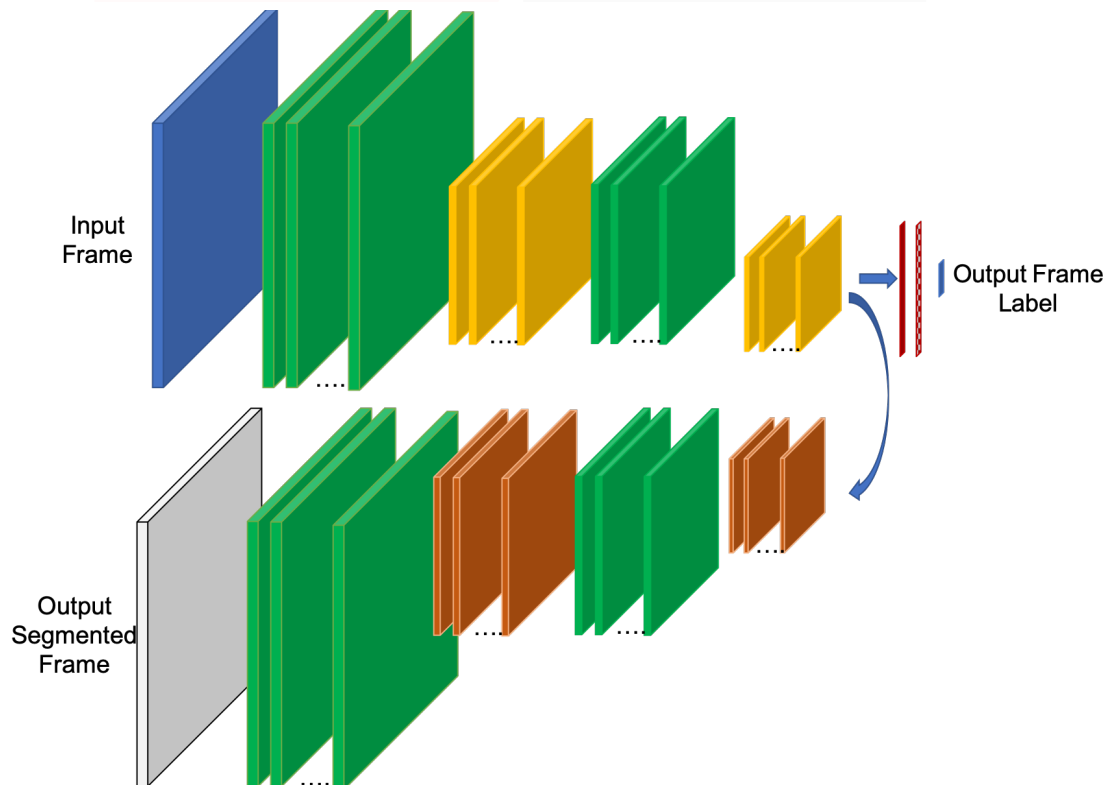
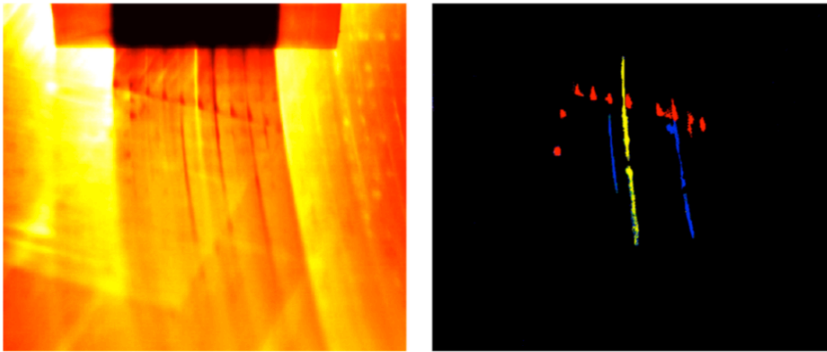


Complex Contour Tool layup trials

On going work



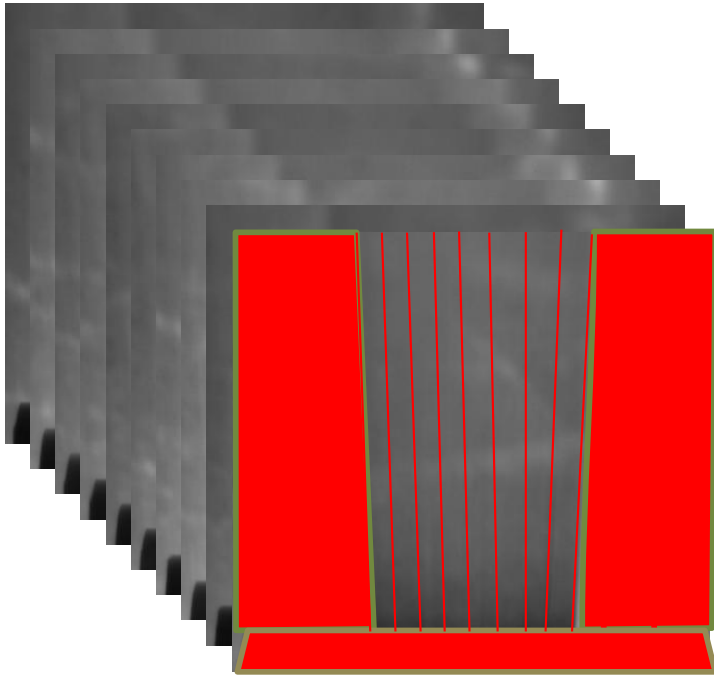
Convolutional Neural Network Machine Learning



New Thermal Camera and Mount



Preprocessing for Machine Learning



- Frames are treated as independent data sets.
- Simple event monitoring
 - Alert for temperature thresholds
- Denoising
- Edge detection for data down-select
 - Remove the roller.
 - Remove extra data from the frame that is not part of the coarse.
 - Identify individual tows.

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