Structural Dynamics and Acoustic Systems Laboratory
University of Massachusetts Lowell

EFFECT OF MANUFACTURING-INDUCED DEFECTS ON RELIABILITY OF COMPOSITE WIND TURBINE BLADES

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OVERALL PROJECT OBJECTIVE

The approach focuses on three aspects:

__Process Optimization Models:__ To understand the cause of such manufacturing-induced defects such as wrinkles and minimize or eliminate such defects through material selection, part design and process improvements based on validated forming models;

__Effect of Defects:__ To understand and quantify what effect these wrinkling and waviness defects have on resulting blade performance, static overload failure, and fatigue failure; and

__Digital Image Correlation:__ To develop a rapid, large-area method for the detection of such defects in manufactured blades using digital image correlation.

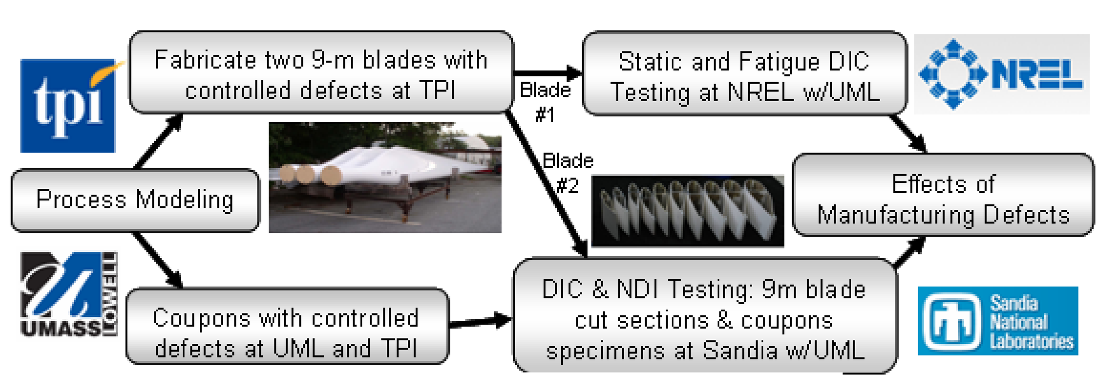
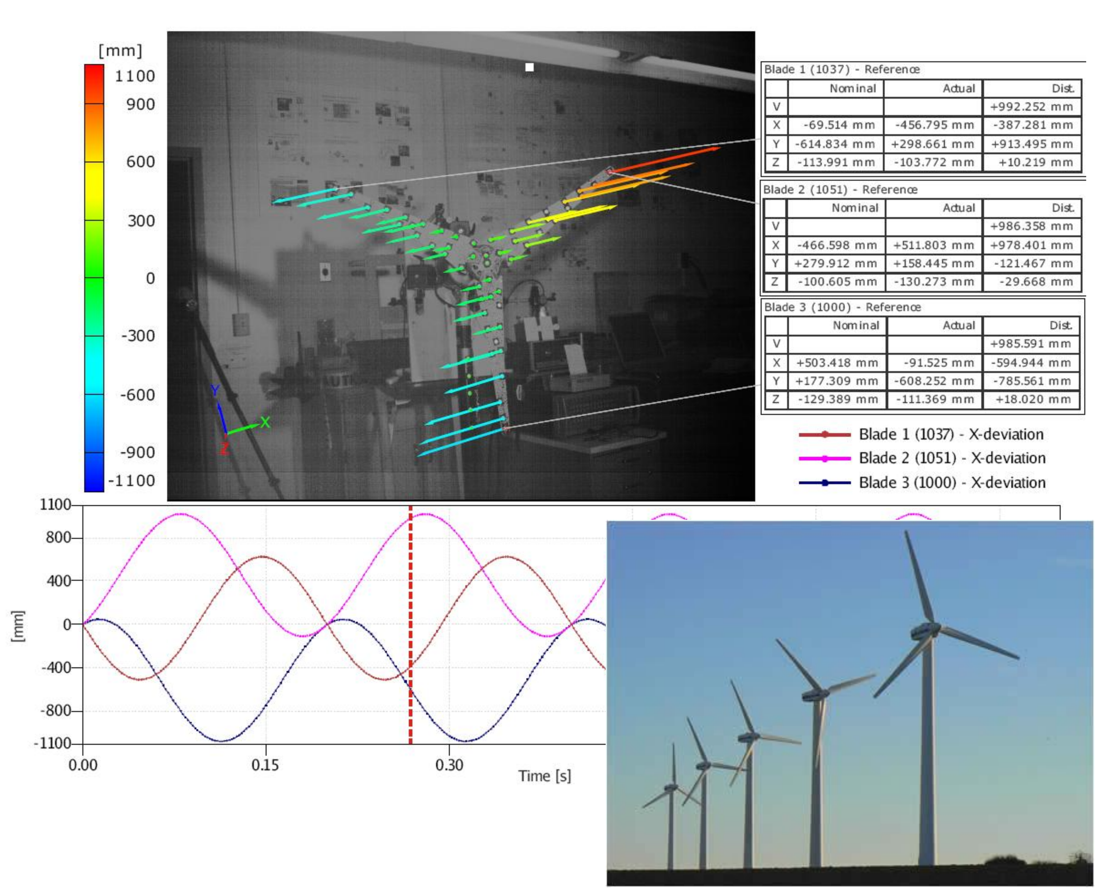


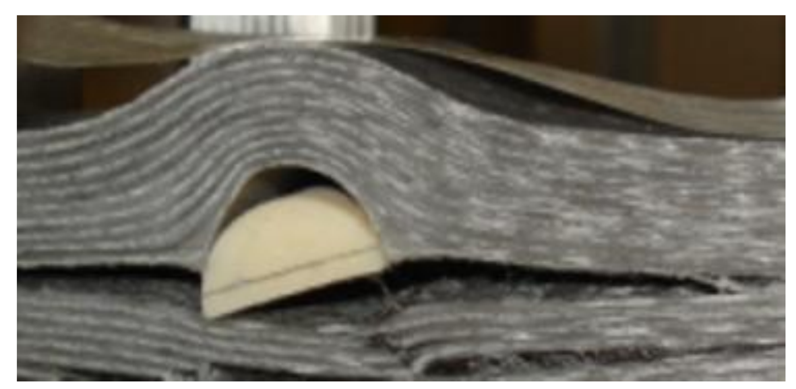
Figure 1. Project Plan of Work and Flow

Other prior efforts have been directed towards the dynamic modeling and testing of rotating turbine blades in operation. The use of Digital Image Correlation and Dynamic Photogrammetry have been used for the test validation of models developed.

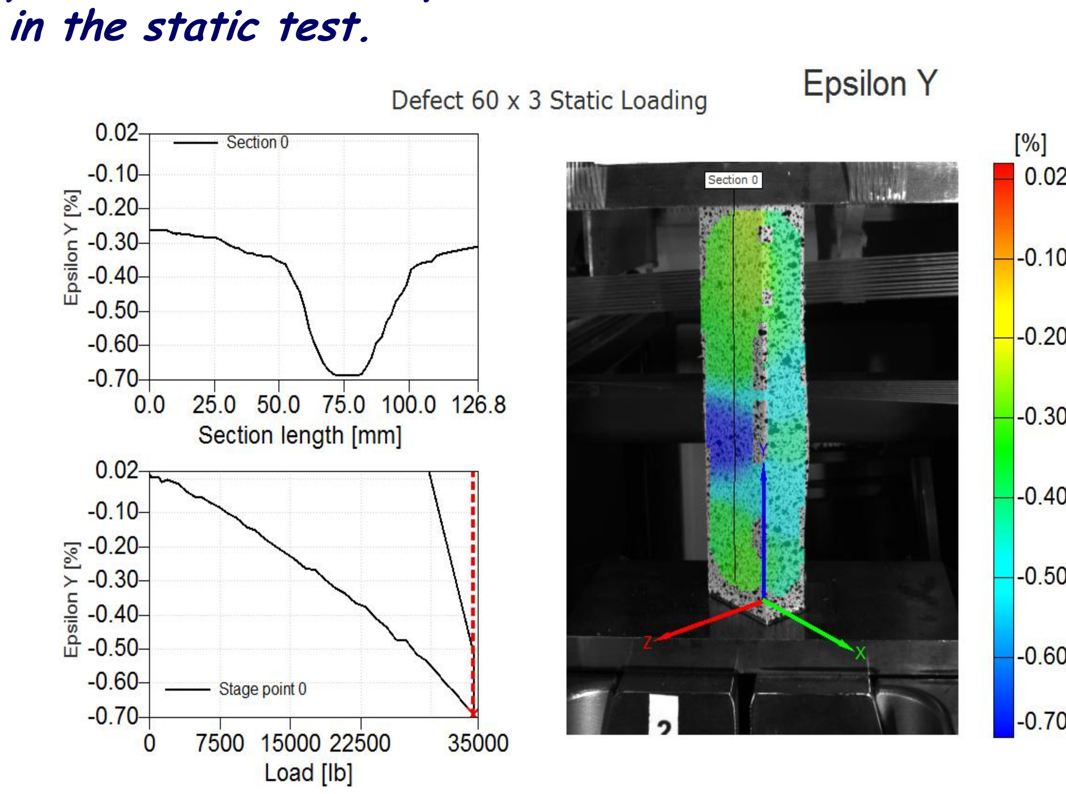


Coupon Testing using DIC

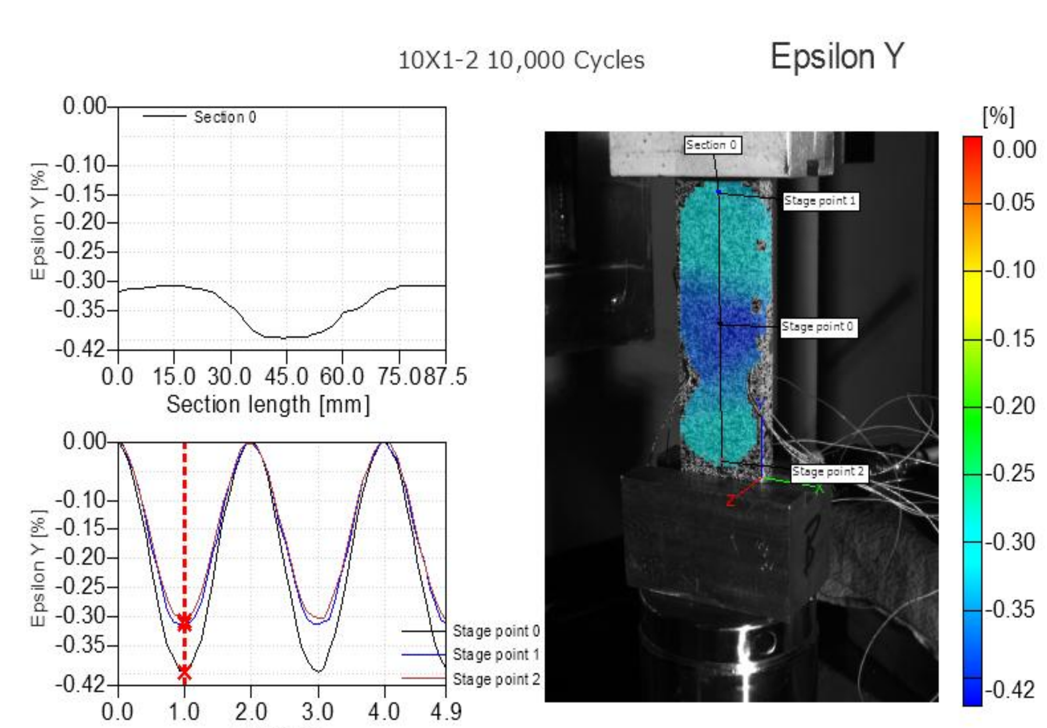
Many defects are observed in the fabrication of wind turbine blades.
To identify how the defects affect static strength and fatigue cycles to failure, several small scale coupon tests were performed. Coupon specimens are fabricated to study defects with varying aspect ratios and amplitudes.



The strain field overlay on the coupon sample strain field possesses a clear amplification in the area of the defect in the static test.

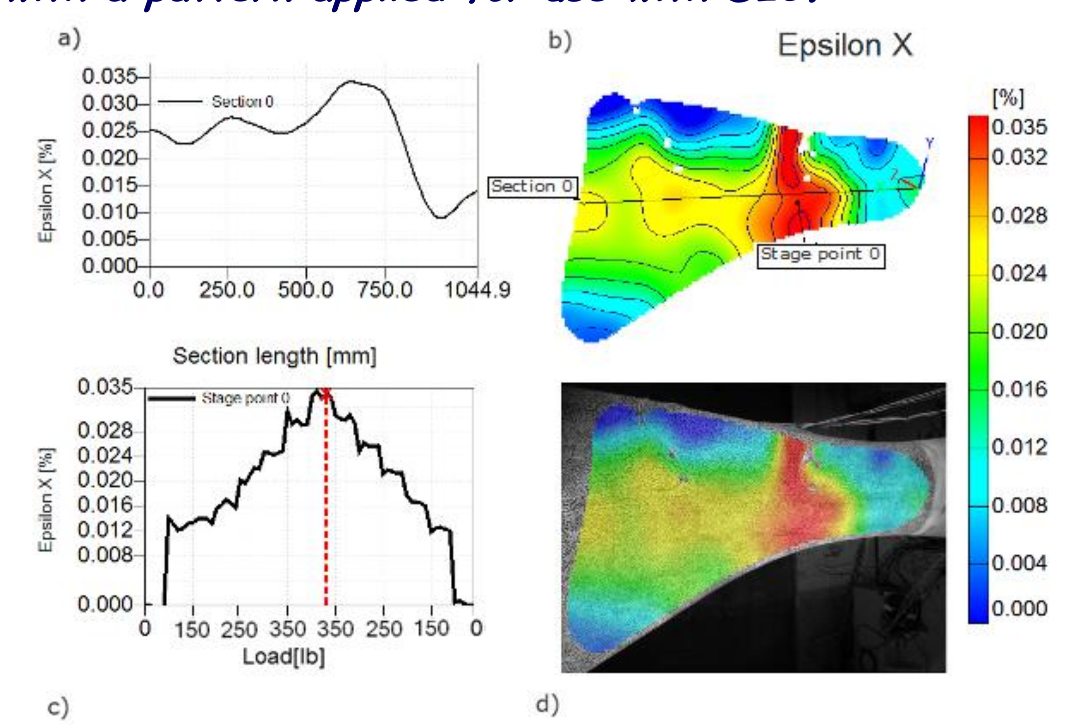


In the fatigue test, the strain amplification due to the presence of the defect at Stage Point 1 (close to the defect) is clearly observed with the DIC measurement.

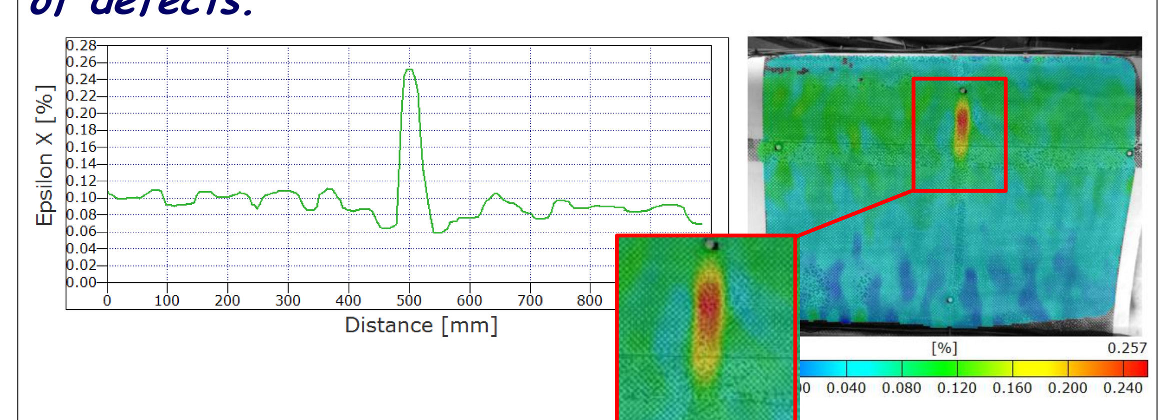


Blade Testing using DIC

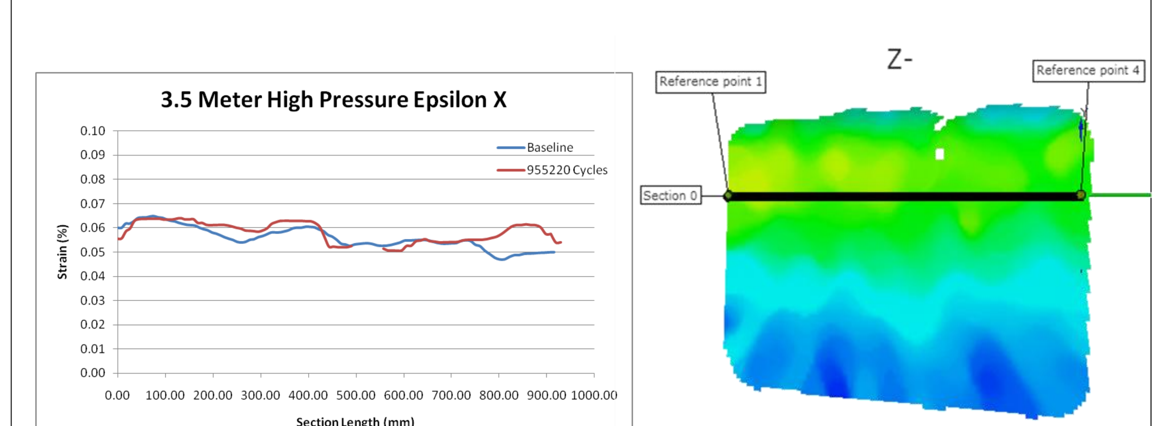
Large area inspection techniques are needed to identify manufacturing defects (waves, voids, delamination, etc.).
Digital Image Correlation (DIC) is being investigated as a means to inspect wind turbine blades.
CX-100 TPI Composites Inc., 9 meter blade is shown with a pattern applied for use with DIC.



The contour shown indicates that there is a crack or "damage" causing a locally high strain in the area. The optical imaging approach is able to detect strain amplification and deformation caused by the presence of defects.

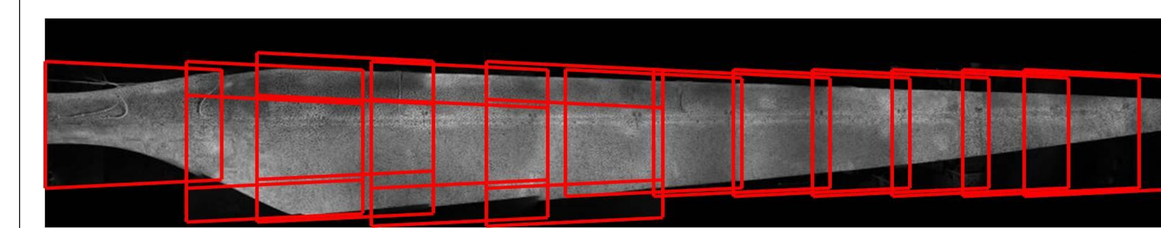


The DIC measurement of the blade in the fatigue test shows the small differences of strain. The strain is slightly higher along the section length after the ~955,000 cycles are applied although there are no significant changes in the blade surface characteristics.

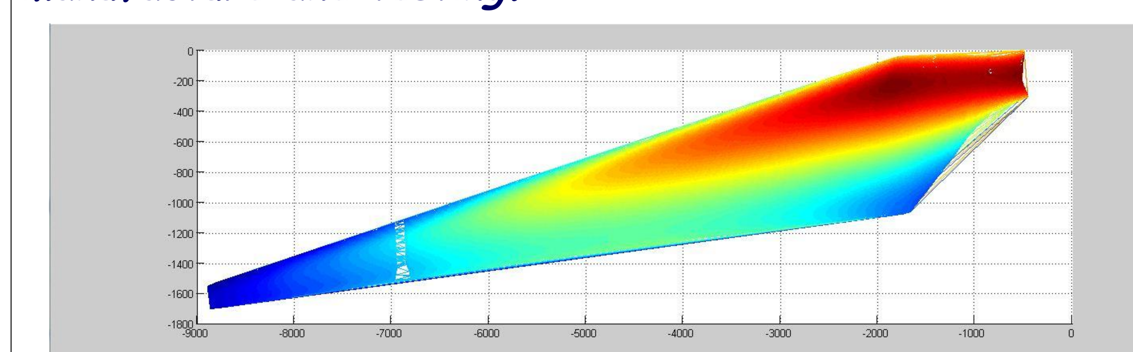


DIC Stitching Results

Multiple scanned sections can be combined from different fields of view to capture the shape of the entire blade surface.

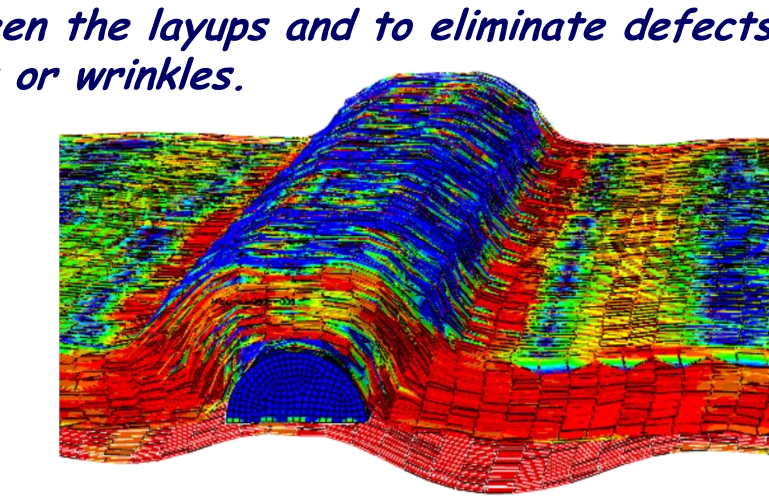


Sixteen fields of view were combined to observe the entire blade and demonstrate that multiple cameras can be used to perform in-situ monitoring during blade manufacture and testing.

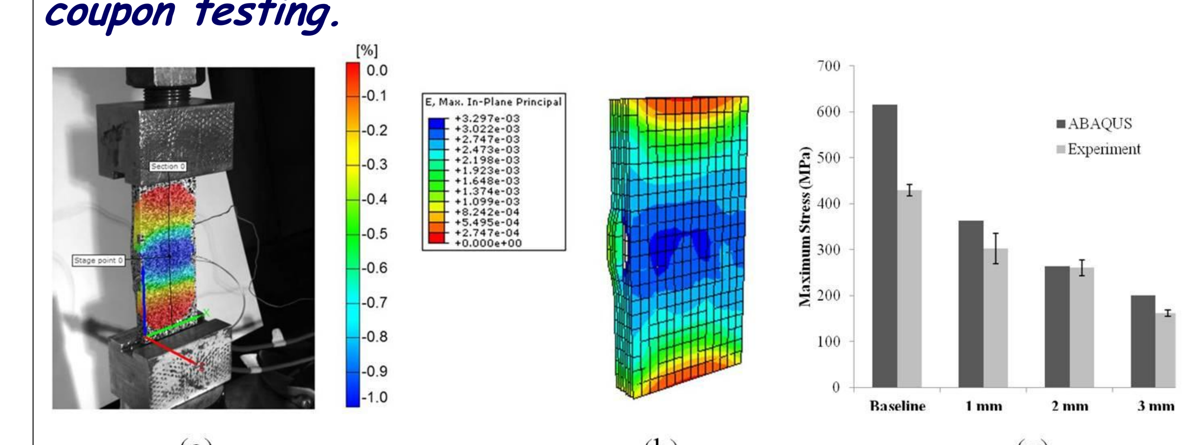


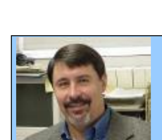
Finite element models of blade fabrication help to predict how multiple composite layers combine and interact during layup, vacuum bagging, and manufacture.

The models will be used to understand the interaction between the layups and to eliminate defects such as waves or wrinkles.



A comparison of DIC and finite element results for coupon testing.





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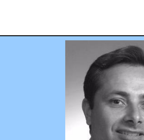

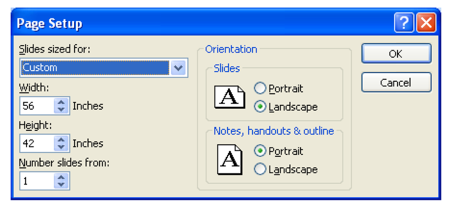

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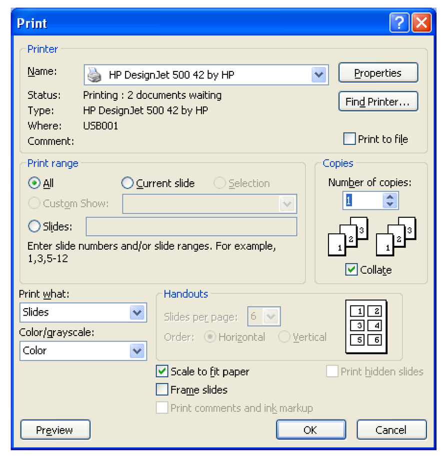

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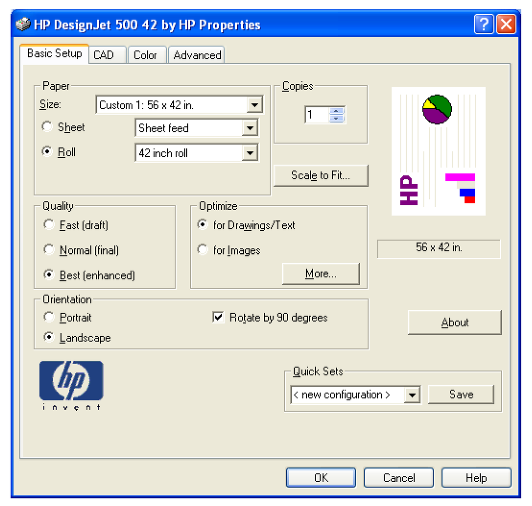

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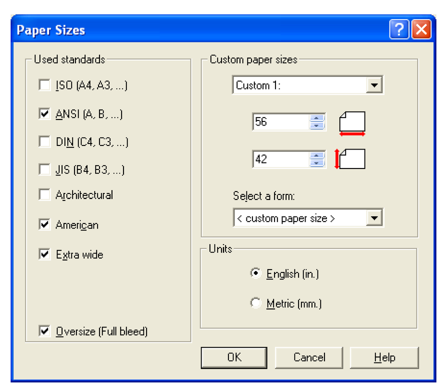

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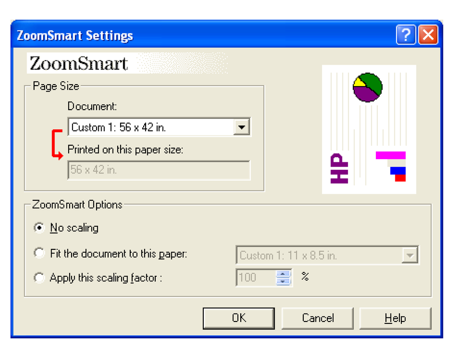

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