

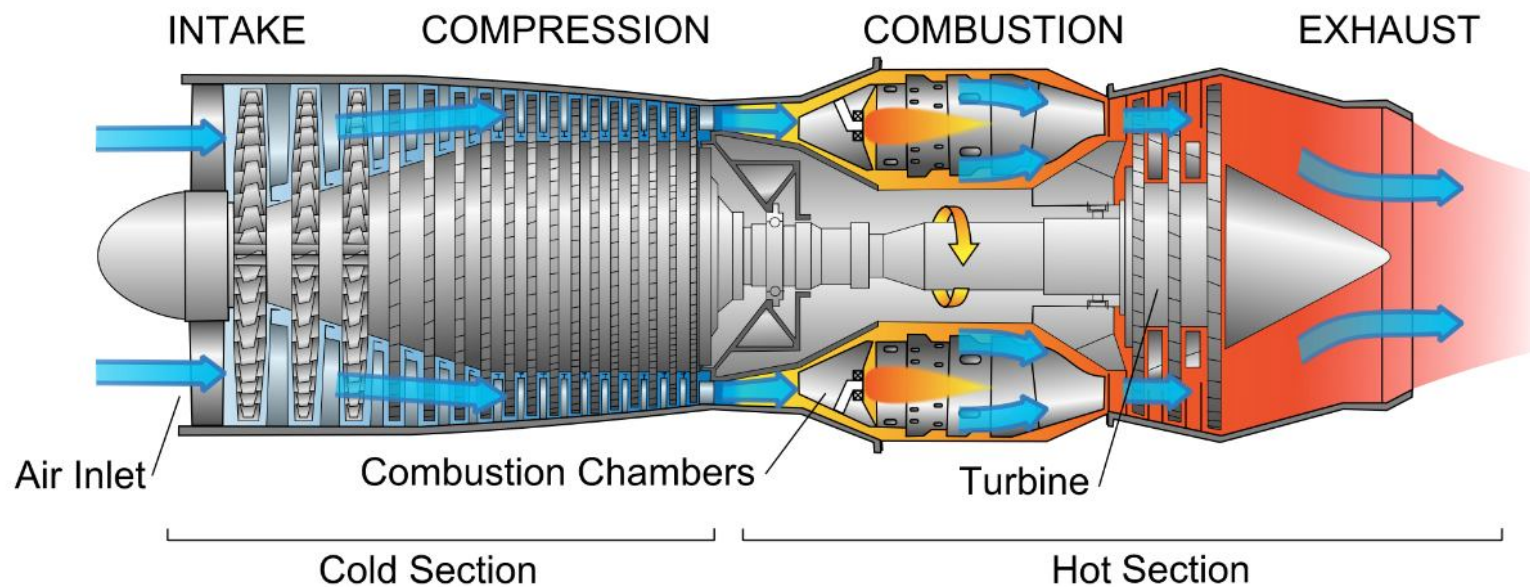
Measurement of Cooling Holes in Gas Turbine Blades using Computed Tomography

Greg Robinson
SURVICE Metrology

- Background to Project
- Selected Approach
- Selection of Measurement Techniques
 - Surface
 - Subsurface
- Geometric Analysis
 - Combining Surface and Subsurface Data
 - Hole Parameter Extraction
- Cooling Film Effectiveness Assessment
 - APOLLO™ Computational Fluid Dynamics
- Summary and Comment

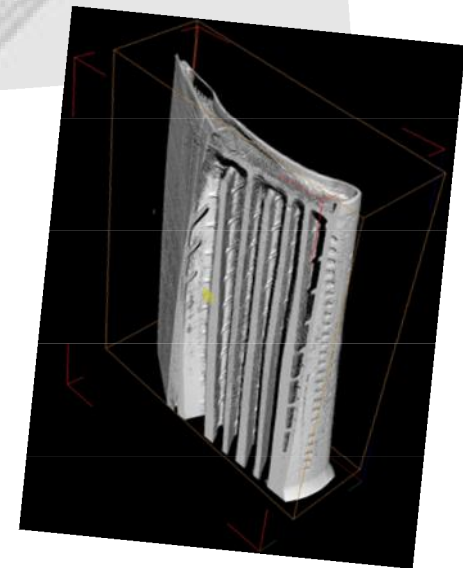
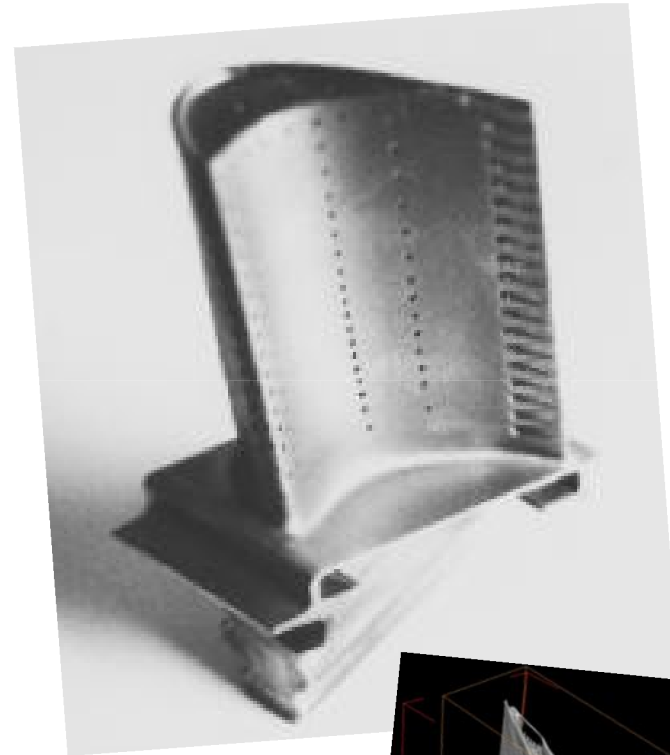
Goal

Accurately measure small cooling holes in gas turbine blades.

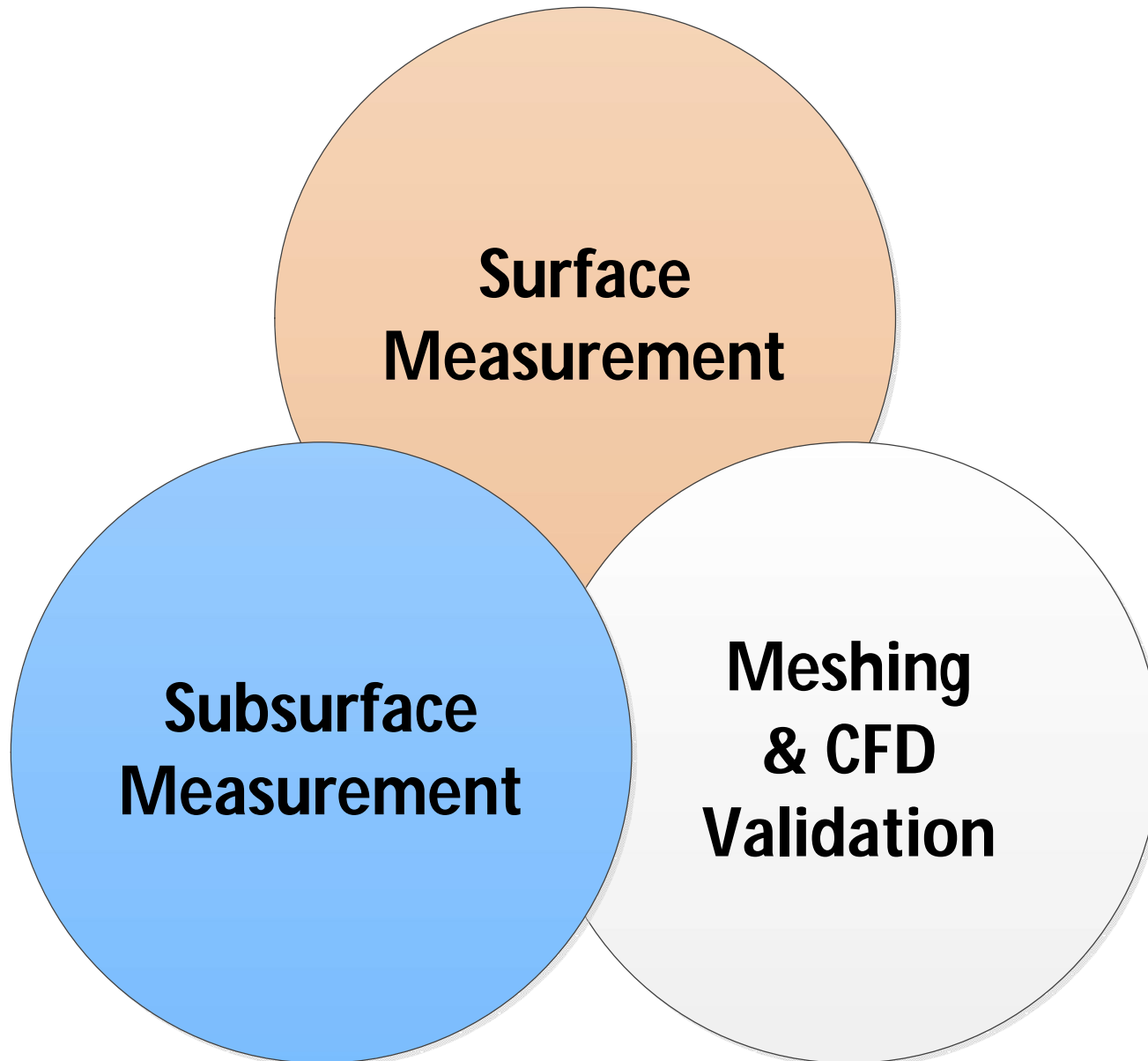


Cooling Holes

- Effect of high temperatures
- Methods of cooling
- Need to maintain effectiveness from blade to blade
- Current measurement techniques



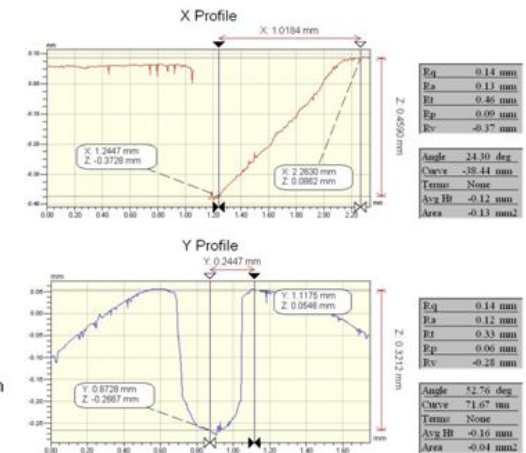
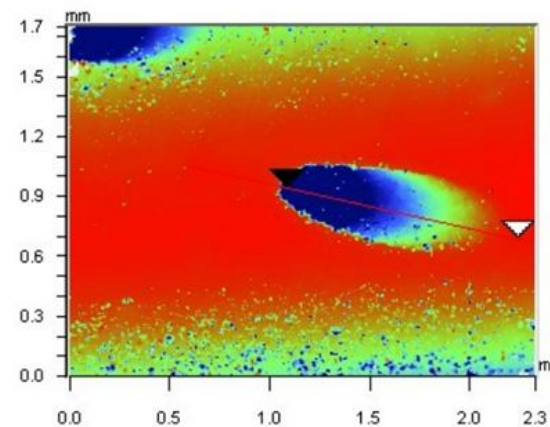
Selected Approach



Survey

Looked at number of very capable systems:

- Laser scanners
- Optical profilers



White Light Scanner

Selected because:

- Accuracy ($< 0.001''$)
- Speed (few seconds)

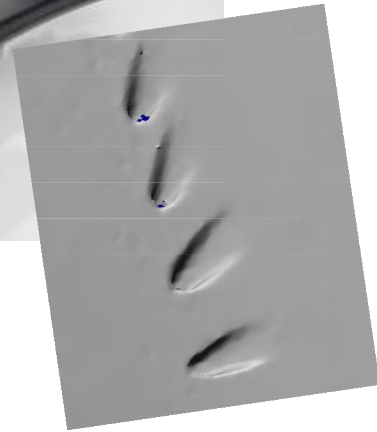
But:

- Problems with shiny objects (like turbine blades)
- Cannot see very far into cooling holes

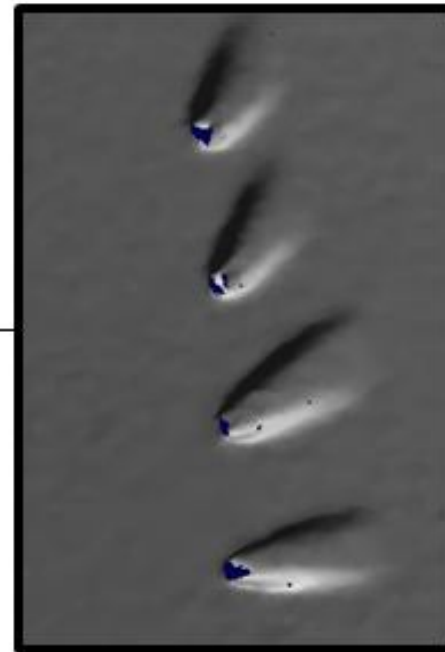
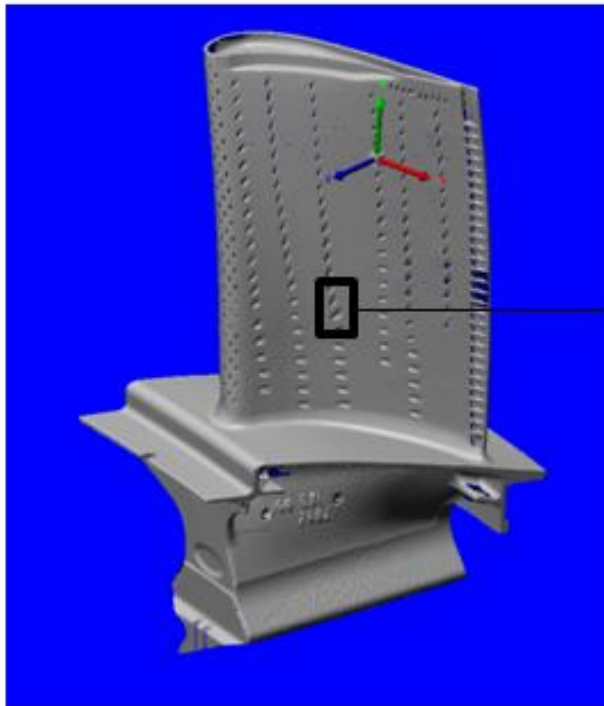


Tests

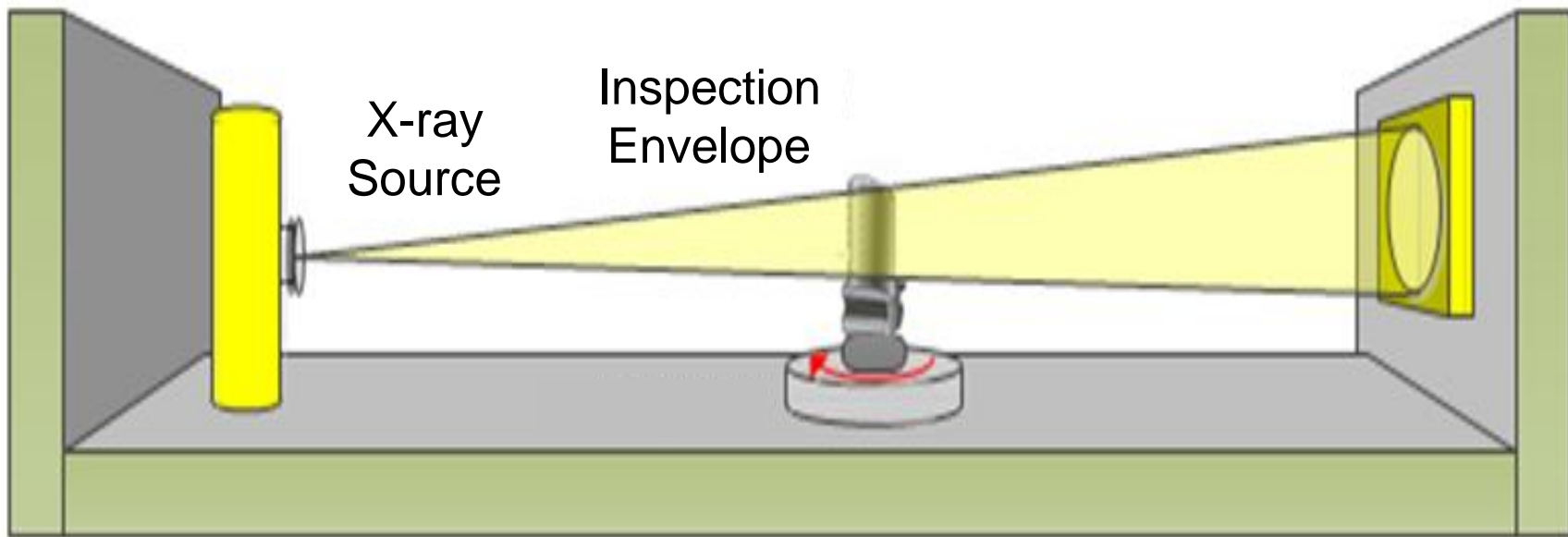
1. SURVICE Metrology
(OptoTOP HE 125 mm FOV)
2. ACCUREX Measurement, Inc.
(Breuckmann StereoSCAN
60mm FOV)
3. Breuckmann 30mm FOV



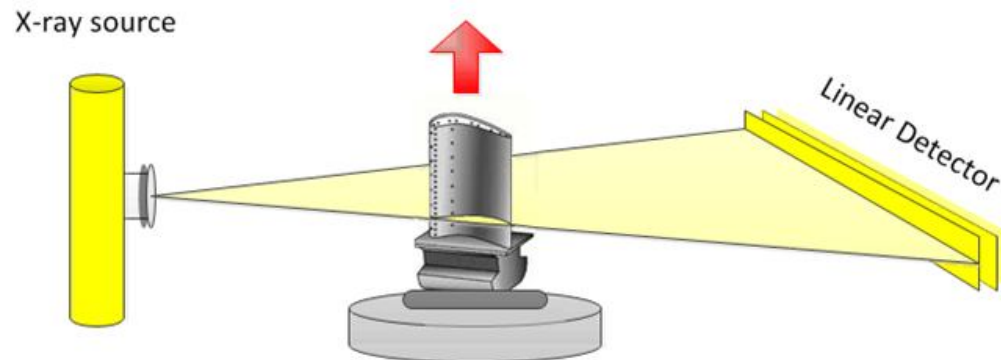
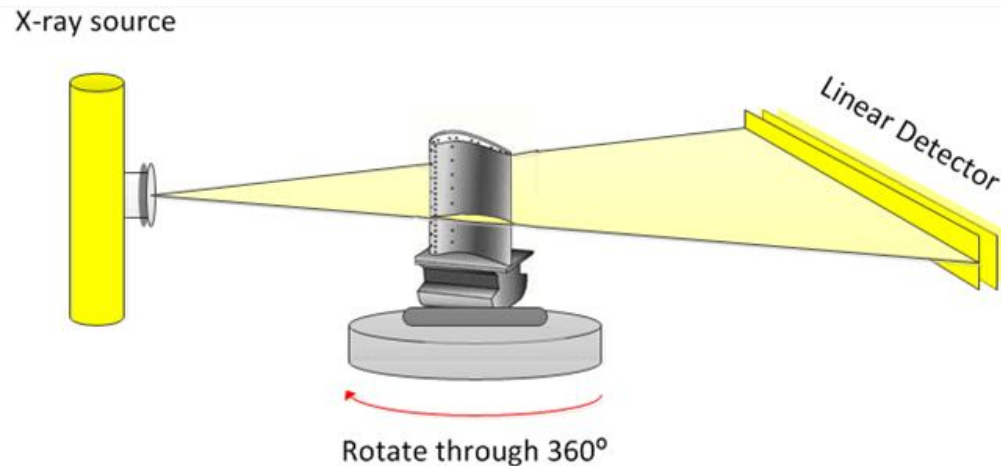
WLS results 60 mm FOV



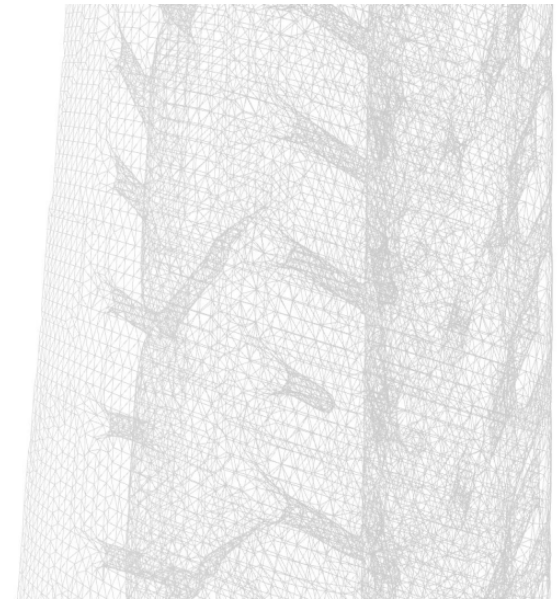
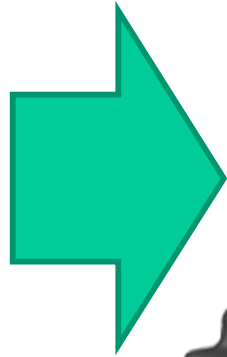
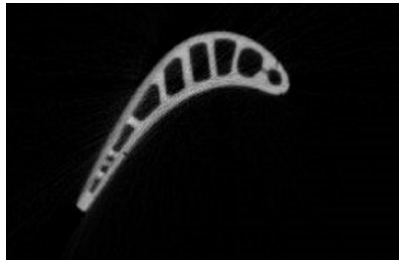
Computed Topography - Panel Detector



Computed Tomography – Linear Detector

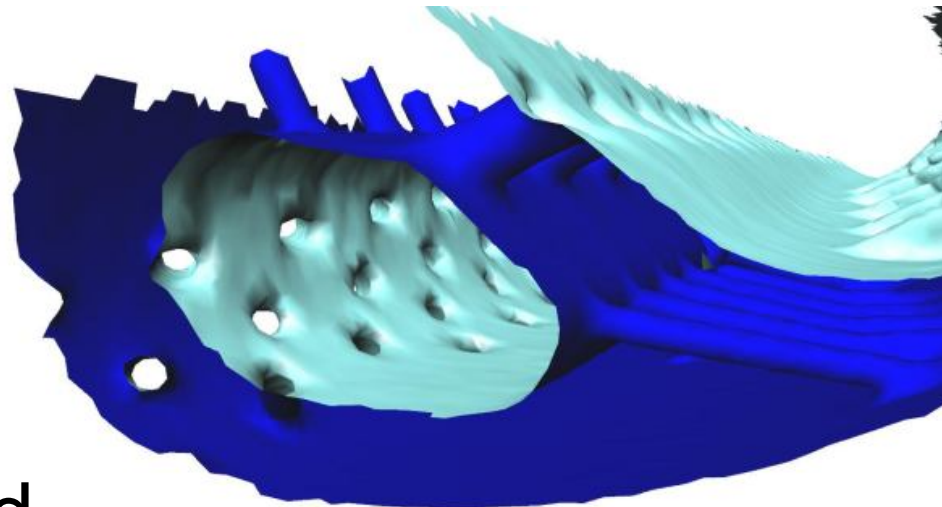


Computed Topography – Linear Detector



Alignment of WLS and CT scans

- PolyWorks Modeler
- Alignment to 0.002"
- CT scan data replaced by WLS data



Hole parameters extracted manually

- Diameter
- Orientation
- Location, etc.

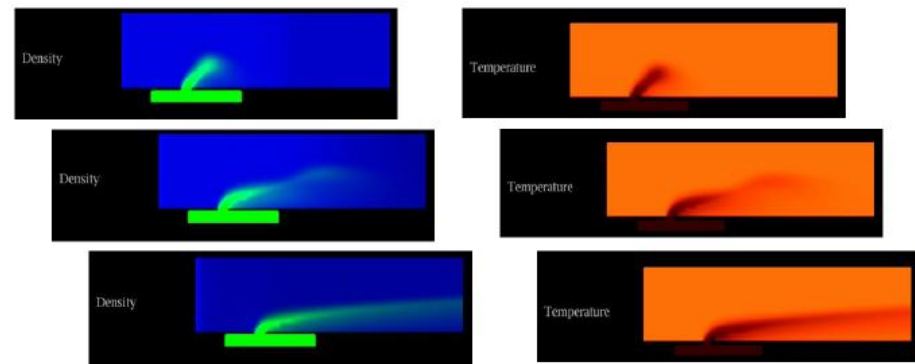
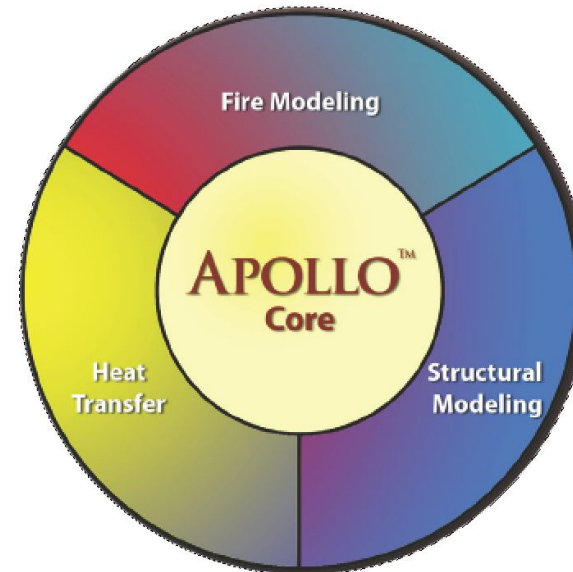
Planning to automate this process in future.

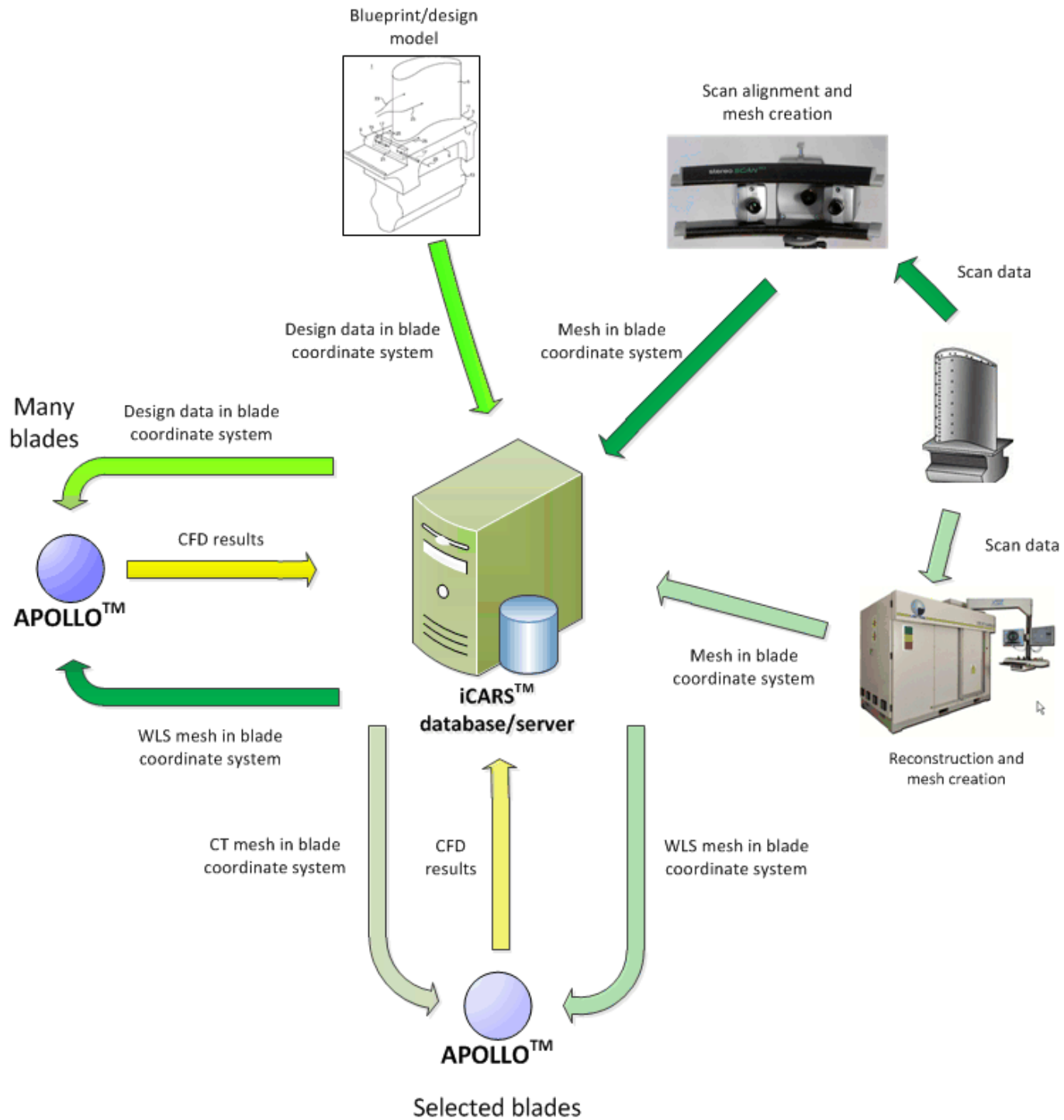
Cooling Film Effectiveness Analysis

APOLLO™ **Computational Fluid** **Dynamics**

Developed for Office of
Naval Research

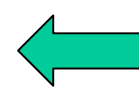
May be adapted to
predict airflow over the
“as-built” blade





- WLS scanning provided high accuracy, low noise surface data.
- CT scanning provides inner dimensions of holes but data can be noisier.
- Data was aligned and the relatively noisy CT scan data discarded.
- Using resulting hole parameters, cooling effectiveness sample holes computed using APOLLO™.

Via Partnership with Chesapeake Testing, SURVICE Metrology will have access to a state-of-the-art Nikon Metrology 225-450kV microfocus Computed Tomography system. Will be operational in the Fall of 2011.



Leveling the pad for the new scanner.

