



Turbine Aero-Thermal Technologies for 65% Efficiency DE-FE0031616

November 1, 2018

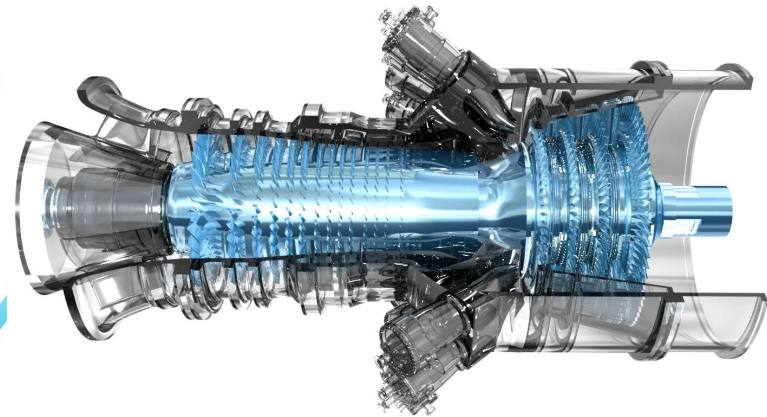
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UTSR Project Review Meeting

Daytona Beach, FL

November 1, 2018



**NATIONAL
ENERGY
TECHNOLOGY
LABORATORY**



**U.S. DEPARTMENT OF
ENERGY**



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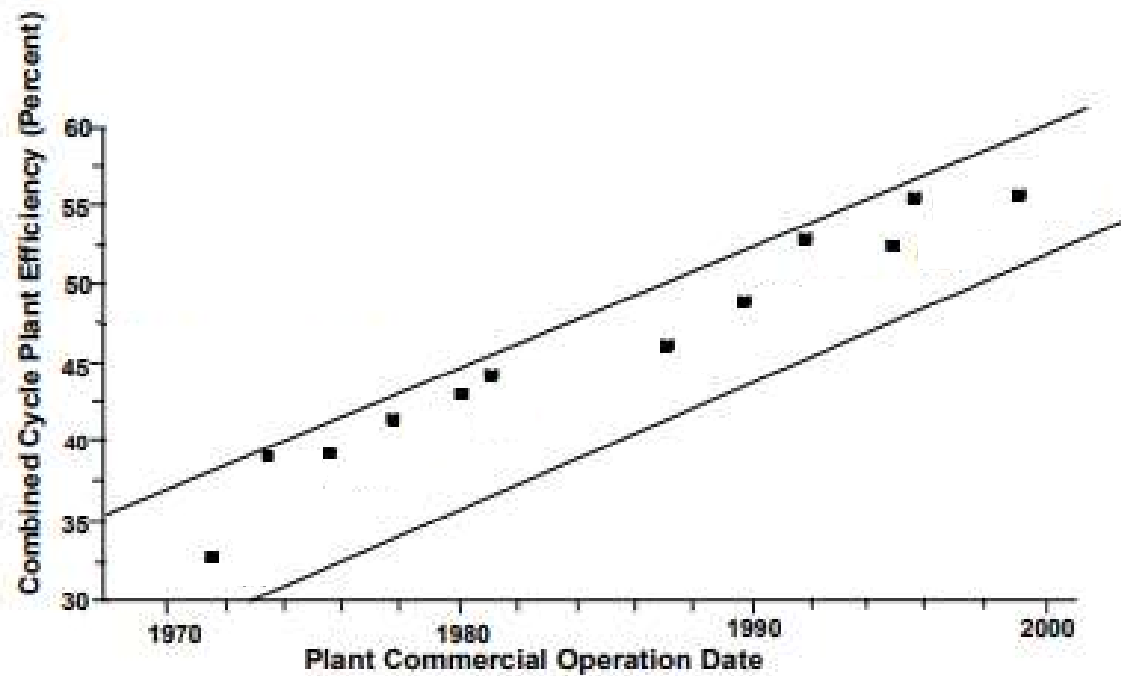
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Agenda

- Industrial Gas Turbine Terminology
- Major Loss Mechanisms
- Program Objectives – Phase I
- Active Work & Next Steps
- High-Speed Rotating Rig Testing – Phase II
- Product Validation – Follow-on to DOE-Funded Activities



CC Plant Efficiency Timeline



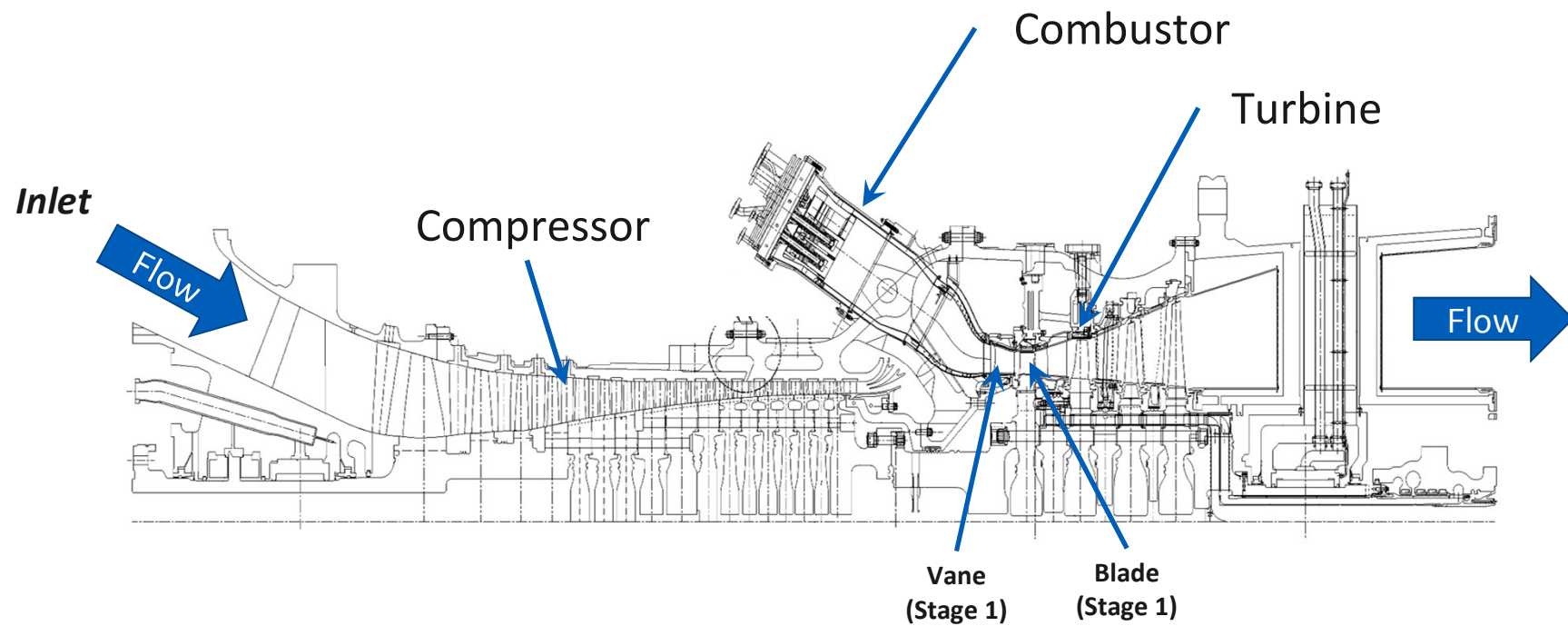
60%
7HS
2007

63.08%
7HA
2018

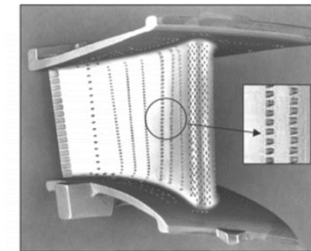
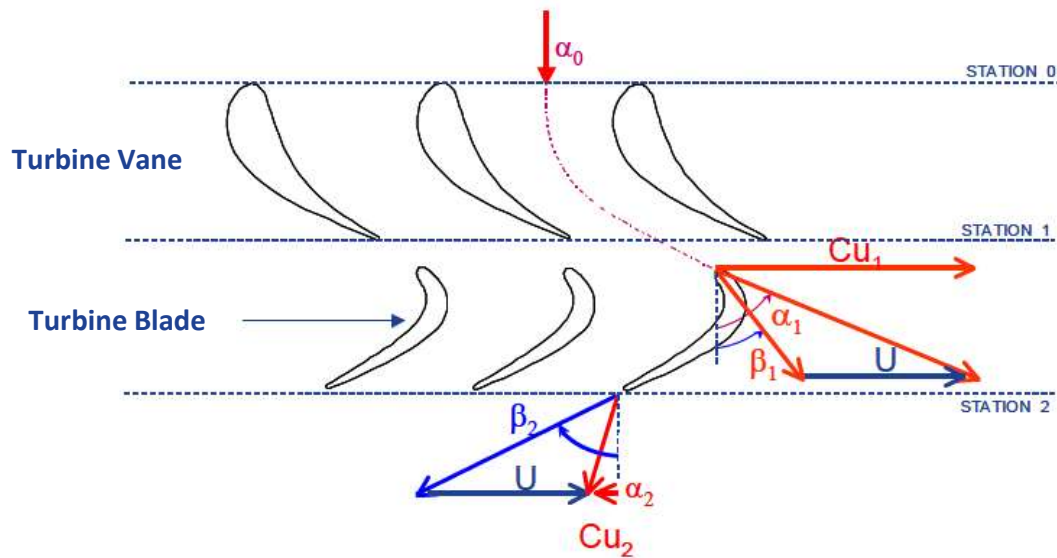
65%



Industrial Gas Turbine Terminology



Euler Work Equation



Turbine Vane



Turbine Blade

Euler Work Equation – From conservation of tangential momentum:

Shaft Power: **Power = mass flow * U * ΔCu**

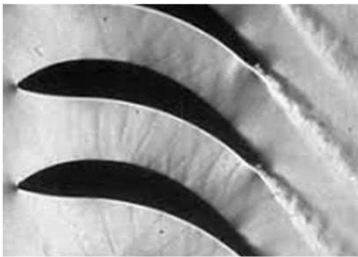
Definition of Enthalpy:

Work per unit Mass: **$\Delta H = U * \Delta Cu$**



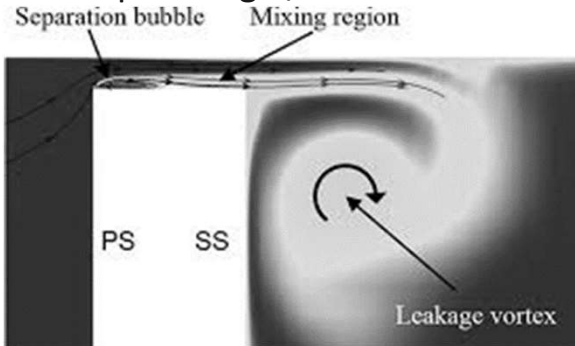
Major Loss Mechanisms

Profile / Trailing Edge Loss (Shock Loss too!)



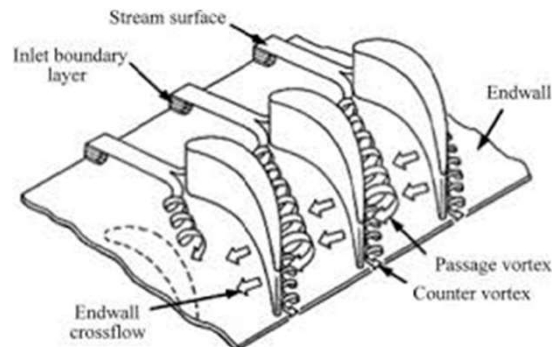
https://www.dlr.de/at/en/desktopdefault.aspx/tabid-1565/2433_read-3790/

Tip Leakage / Vortex Loss



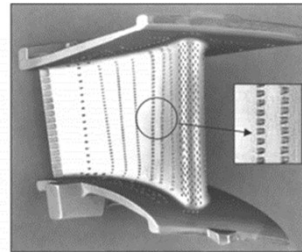
<http://turbomachinery.asmedigitalcollection.asme.org/article.aspx?articleid=1743957>

Endwall / Secondary Flow Vortices / Losses



<https://dept-wp.nmsu.edu/activities/sample-page/lpt/>

Cooling / Purge Injection Losses



<http://www.ccj-online.com/turbine-blade-vane-cooling-a-primer/>

Unsteady Interaction Losses

Impact of periodic unsteadiness on performance and heat load in axial flow turbomachines. OP Sharma, GM Stetson, WA Daniels, EM Greitzer... - 1997 - ntrs.nasa.gov

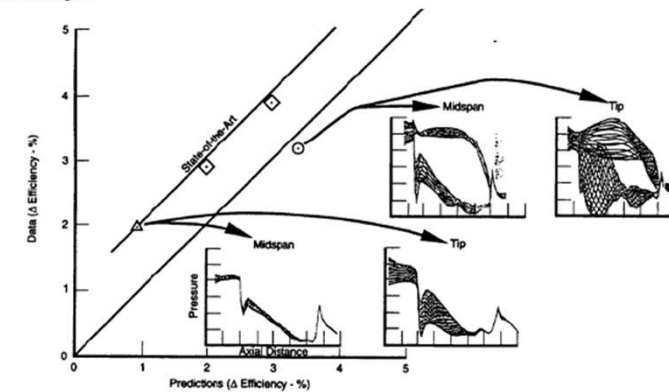
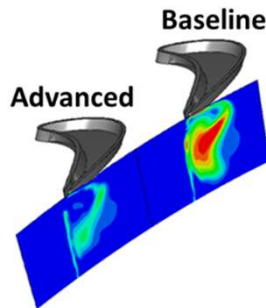


Figure 90. Turbine With Poorer Performance Calculated To Have Higher Levels of Unsteadiness of Airfoil Pressures; Results Obtained by Using Ni's 3-D Multistage Unsteady Euler Code With Surface Shear

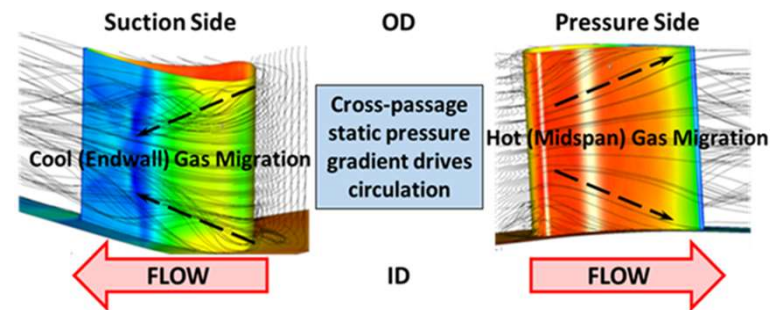


Program Objectives: Phase I – Initial Technology Discovery

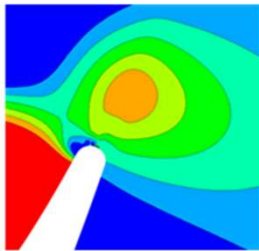
Technologies To Reduce Tip Leakage / Loss



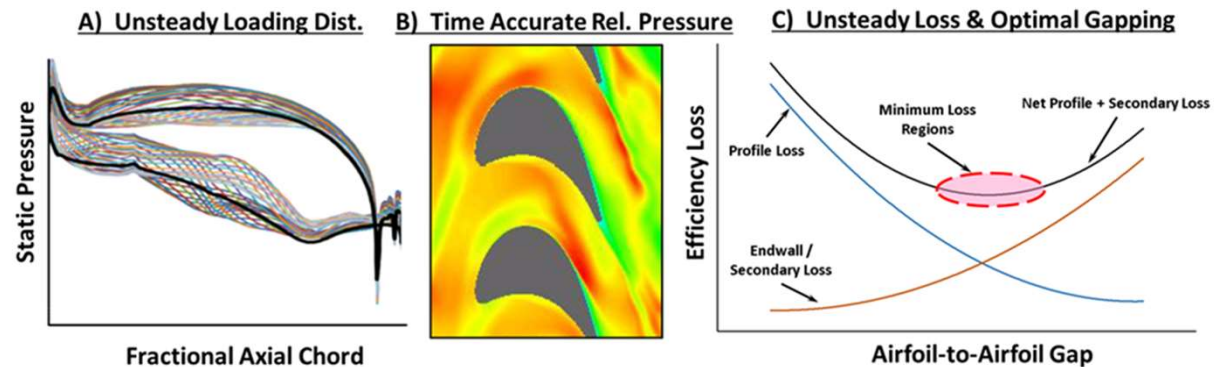
Technologies To Reduce Secondary Flows & Hot Gas Migration



Technologies To Reduce Trailing Edge Loss

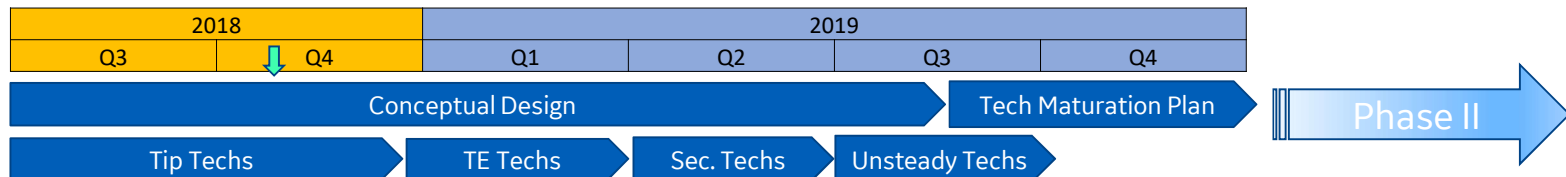
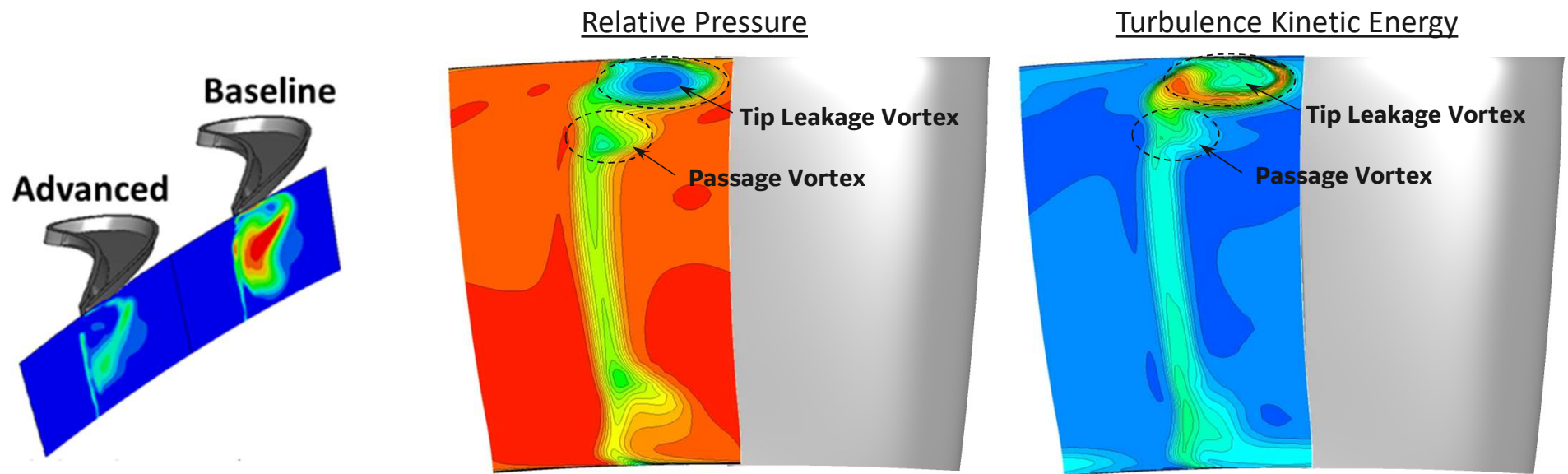


Technologies To Reduce Unsteady Interaction Loss



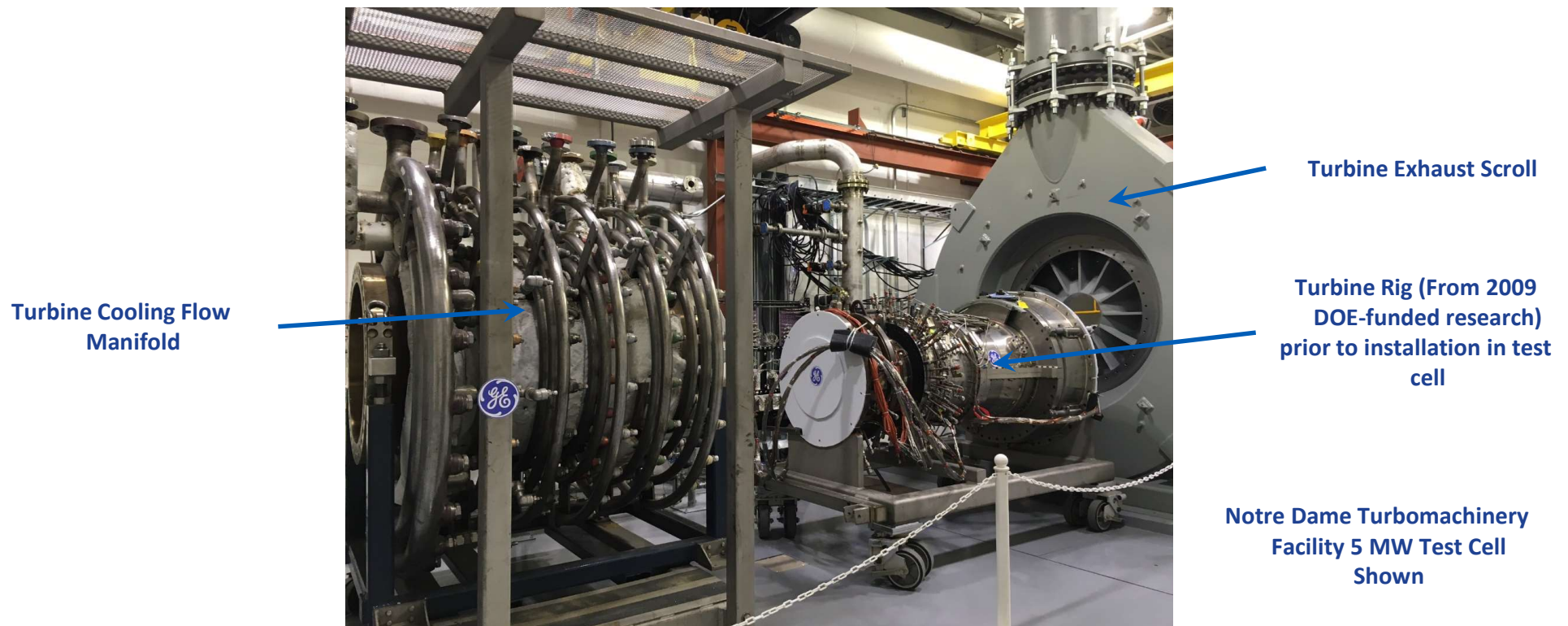
Active Work (Tip Leakage Loss) & Next Steps

Applying technologies to reduce tip leakage performance loss ...



High Speed Rotating Rig Tests – Phase II (Continued Learning)

Highly-Instrumented Turbine Rig Testing Provides Performance & Insight Into Flow Physics



Product Validation – Follows DOE-Funded Program

GE's Test Stand 7 Enables Validation Over A Broad Range of Operating Conditions

