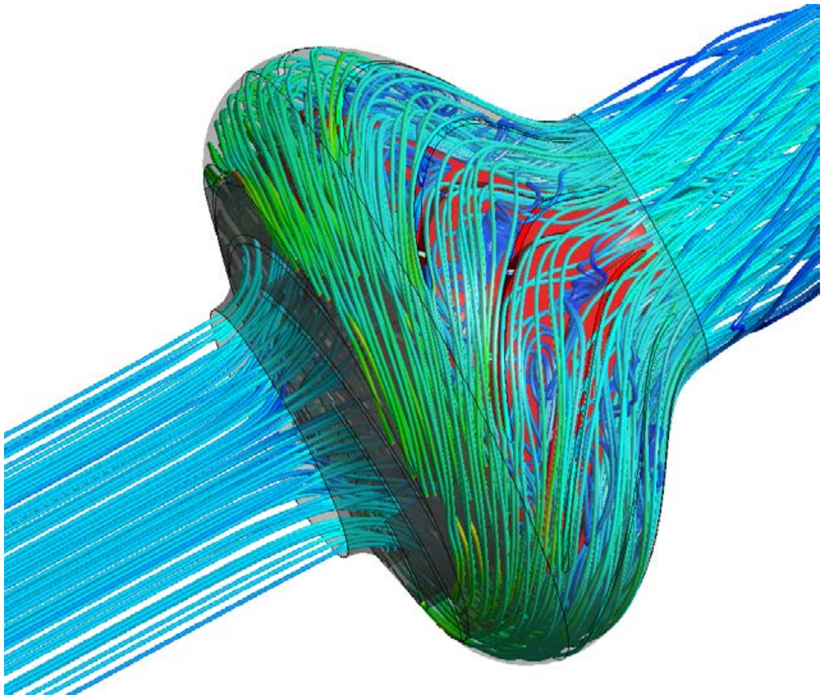
DEVELOPMENT OF AN INNOVATIVE HIGH EFFICIENCY RADON FAN

2017 Building Technologies Office Peer Review



Dr. Edward Bennett
Vice President of Fluids Engineering
Mechanical Solutions, Inc.
e-mail: emb@mechsol.com

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Project Summary

Timeline:

Start date: 6/2016

Planned end date: 3/2017

Key Milestones

1. N/A

Budget:

Total Project $ to Date:

- DOE: $132,200

Key Partners:

Fantech	

Project Outcome:

This project will redesign a radon fan to significantly improve efficiency while approximately maintaining current dimensions. Radon fan market leader Fantech will assist in commercializing redesigned system for maximum impact and energy savings.

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Purpose and Objectives

Problem Statement: Radon fans are an "always-on" ventilation system designed to reduce the risk of radon exposure. However, they are not presently optimized for efficiency.

Target Market and Audience:
- US Radon fan market is presently approximately 600,000 homes
- EPA estimates approximately 6 million homes suffer from elevated radon levels and would directly benefit from a radon mitigation system
- Current installed based represents approximately 0.001 quads, and the potential market 0.01 quads

Impact of Project:
- The final output of the project is a) a high-efficiency radon fan design that b) has a clear path to commercialization and subsequent energy savings.
- Contribution to US energy savings will be directly measurable in product sales.
- Serve as an important benchmark for all indoor air management systems, providing significant derivative follow-on savings.
- The project will advance BTO's goal of reducing building energy use intensity 30% by 2030 compared to 2010 levels.

Approach

Approach: Develop a high efficiency prototype to demonstrate to the private sector the significant energy savings capable at cost parity.

Key Issues:

- Current Indoor Air Quality (IAQ) air movers are not optimized for efficiency, focusing on other attributes like cubic feet per minute (cfm) and sound levels
- Consumer sentiment is shifting toward higher efficiency, but private industry is hesitant to lead
- Need to apply new design in close collaboration with industry to facilitate acceptance

Distinctive Characteristics: Apply advanced Computational Fluid Dynamics (CFD) modeling to optimize design, partner with market leader

Progress and Accomplishments

Accomplishments: Integrated motor fan efficiency significantly exceeds requirement for reduction in energy consumption by a minimum of 25% compared to state-of-the-art units. Multiple fan designs considered and downselect to final configuration has been completed. Downselect design complete and ready for fabrication

Market Impact:

- New Project (Ph I SBIR), so no market impact to note yet
- Partnered with industry leader who is actively involved in design and has plans to replace existing product line with optimized design once ready

Awards/Recognition: N/A

Lessons Learned:

- Pairing technology development with market leadership is worth the early investment of resources during proposal stage of project.
- Impediments to adopting new technology can exist throughout the supply chain, not just with the commercializer

Project Objectives

- Performance
  - Reduction in energy consumption by a minimum of 25% compared to state-of-the-art units. Fan-based devices should include performance curves based on laboratory testing under ideal conditions using AMCA 210 (chart: static pressure (inches) vs volume (cfm))
- Physical Size
  - < 5% larger than state-of-the-art designs
- Required cleaning intervals, or difficulty of cleaning, to maintain as-new performance
  - Little to no increase as compared to state-of-the-art designs
- Susceptibility to damage or corrosion or performance degradation during manufacture, assembly, transportation, installation, or use (indoor and outdoor environments)
  - Little to no increase as compared to state-of-the-art designs for relevant applications; indoor and outdoor applications.
- Lifetime
  - Same as current units
- Cost
  - Little to no increase as compared to state-of-the-art designs. Projects should have a simple payback period no greater than 5 years at full commercial production rates.

Project Integration and Collaboration

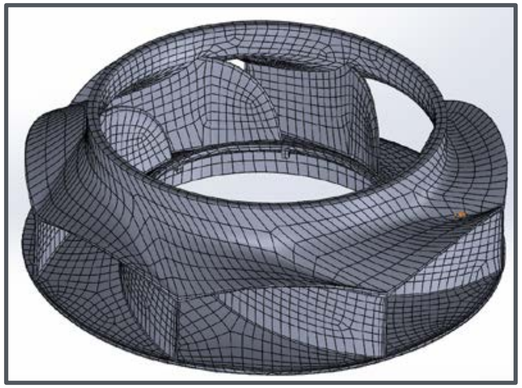
Project Integration: MSI has established an excellent working relationship with a radon fan industry leader, who is able to provide insight into end-user requirements to ensure successful market acceptance.

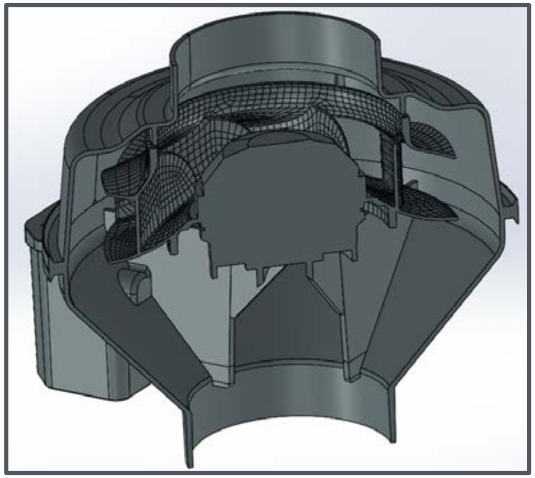
Partners, Subcontractors, and Collaborators: Fantech provides user requirements, supply chain considerations, and market data

Communications: N/A

Baseline Existing Architecture

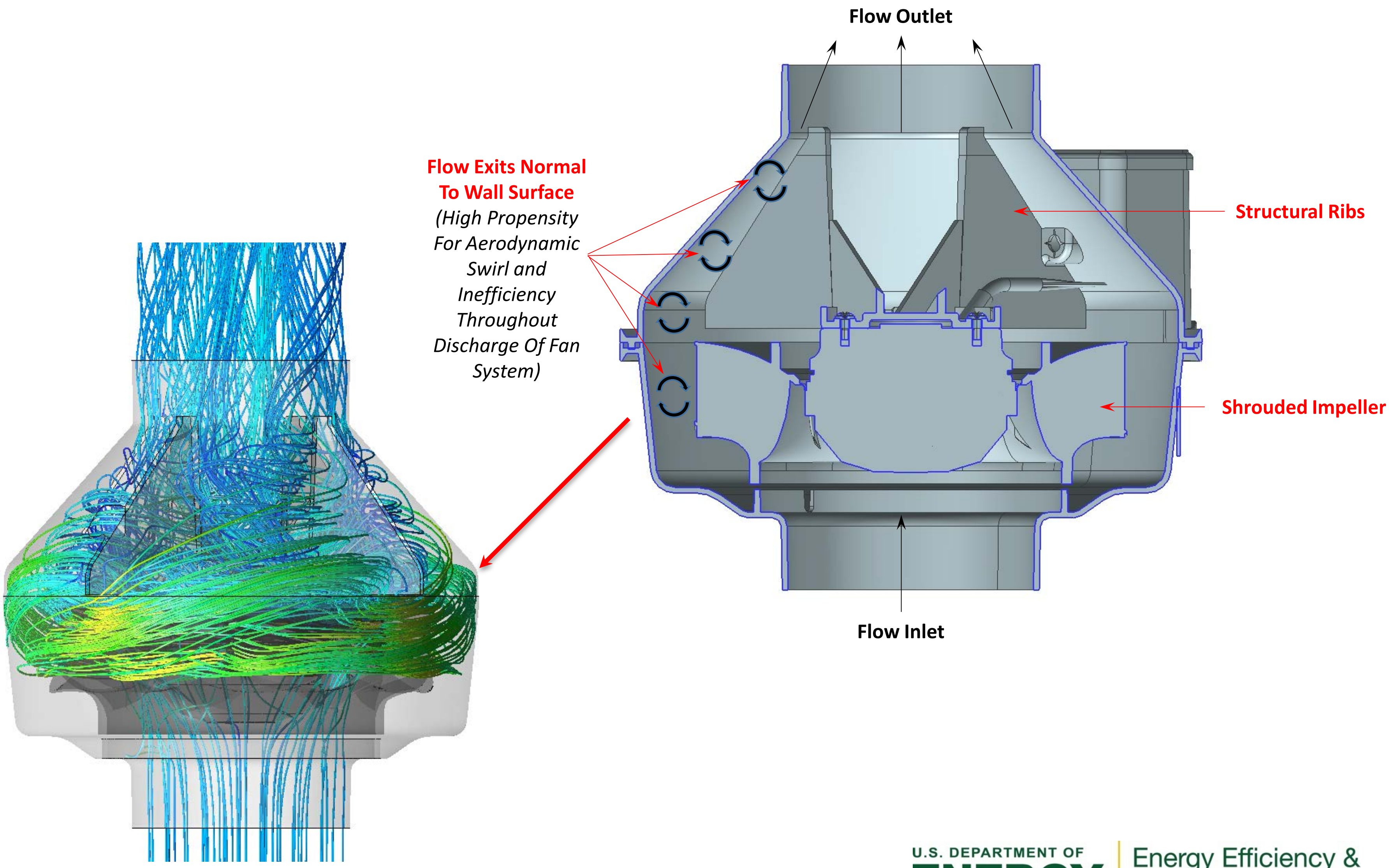
- **Scan data from Shape Fidelity, representing the standard market model impeller, was input into the cad model for a baseline characterization study.**
- **Results were compared with the CFD of the newly designed flowpath, as well as the experimental data.**





Baseline Existing Architecture – CFD Results

- **Results identified sources of inefficiency**



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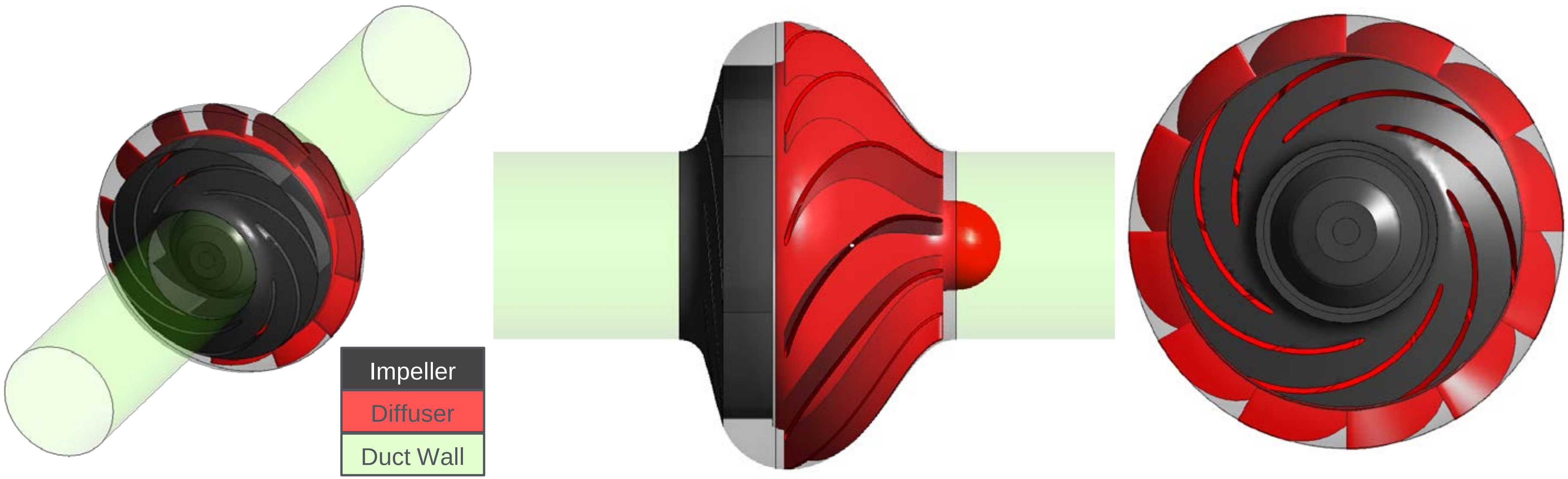
Fluid Domain– CFX Analysis Setup



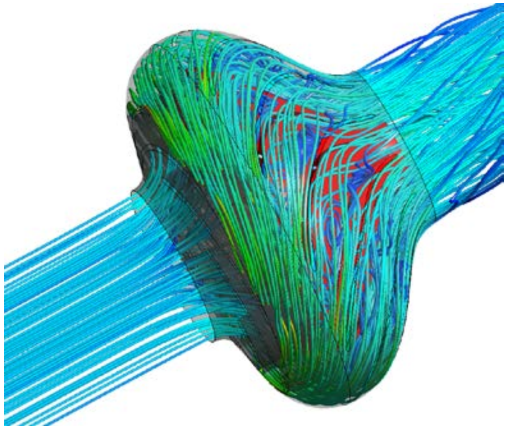
This simulation required four domains: impeller, diffuser and inlet and outlet extensions.

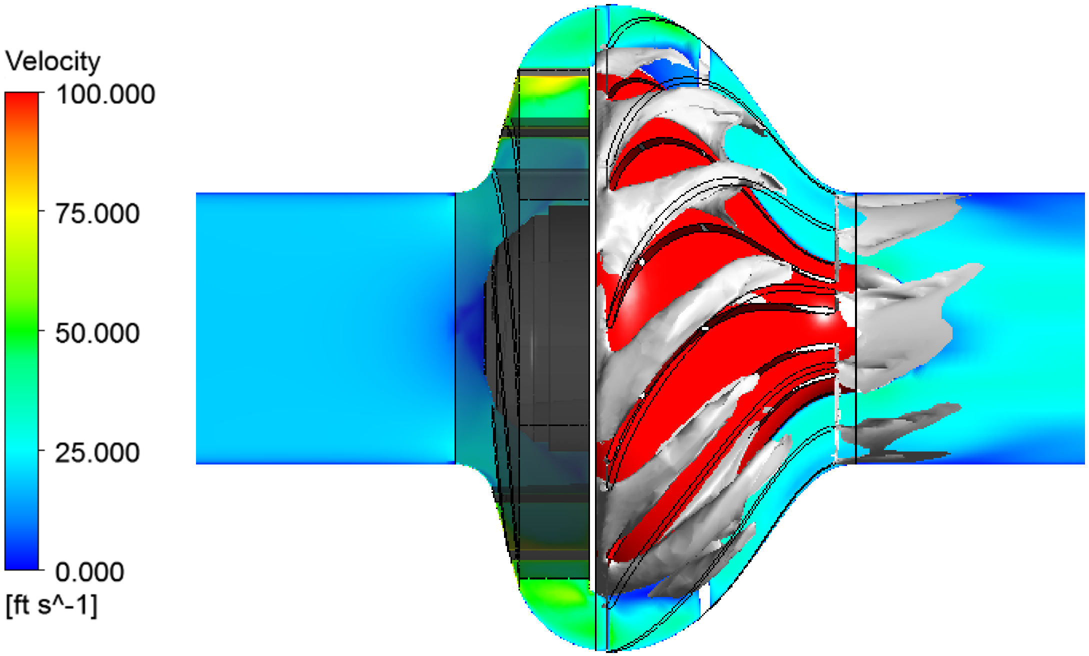
- Solver Conditions
  - Air Ideal Gas
  - Shear Stress Transport Turbulence Model
  - Isothermal @ 25°C
- Domain Conditions:
  - Full 360° Model applied to Rotor and Stator domains
  - Information passed through interface between rotating and stationary frames of reference
    - A specified rotor pitch was applied and the information passed directly from Rotor to Stator (Frozen Rotor approach)
- Boundary Conditions
  - Inlet - $\dot{m}_{in} = 0.11415\ lbm/s$ – (93.5 cfm)
  - Outlet -$P_s = 14.679\ psi$
  - Walls
    - Rotating- Impeller Hub and Shroud, Impeller Blades, Motor Face
    - Stationary- Entire outer casing, All Diffuser surfaces, and Duct Walls.

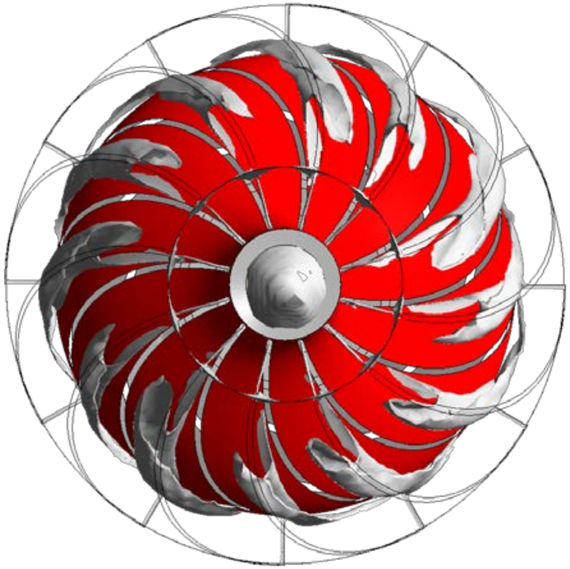
} Matched Experimental Point 6

Initial Fan Design

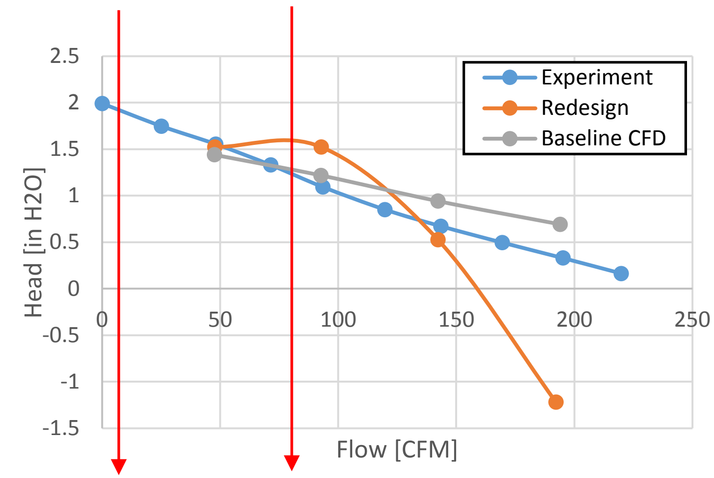
- Some minor recirculation zones are present
  - Inlet to diffuser
    - Sharp hub angle just following impeller exit
    - Suction side of vane separation
  - Exit to PVC
    - Realignment to axial direction around shroud
    - Exit hub nose (shape not finalized)

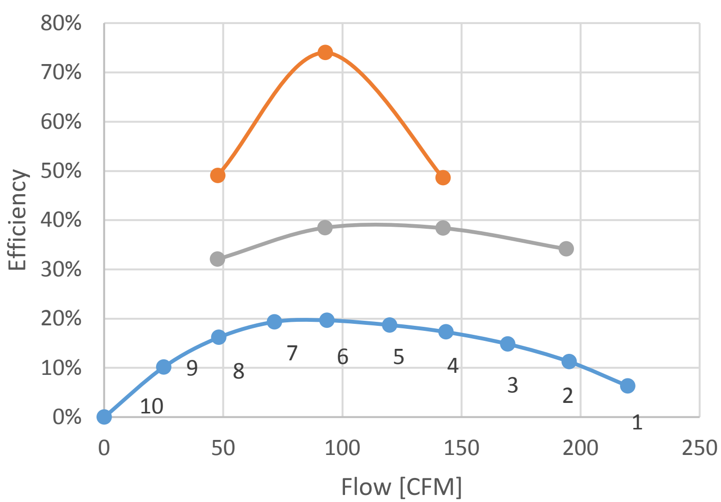






Performance Results and Comparison

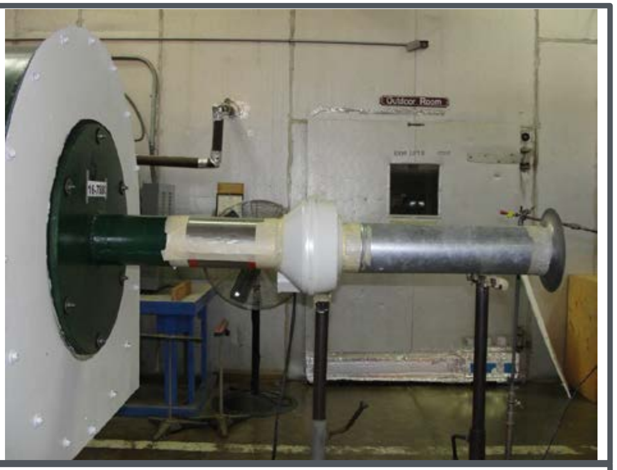




Exp-Baseline

	Inlet	Outlet	
Pt	14.641	14.6803	[psi]
m_dot	0.114	0.114	[lbm/s]

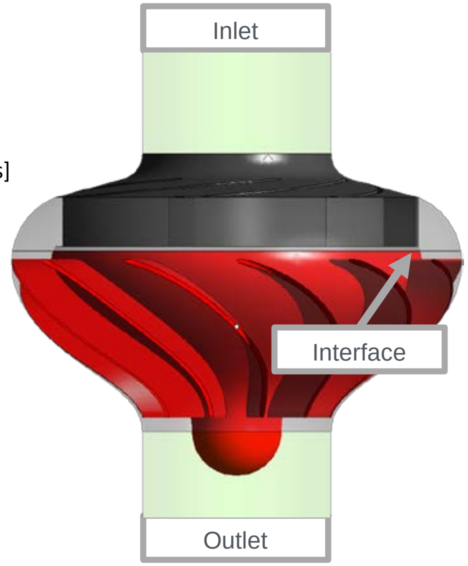
Inlet Flow	94	[cfm]
Delta P	.039	[psi]
Shaft Power	61.1	[watt]
Efficiency	19.66%	



CFX-New Design

	Inlet	Imp_Diff	Outlet	
Ps	14.624	14.676	14.679	[psi]
Pt	14.627	14.69	14.682	[psi]
m_dot	0.114	0.115	0.115	[lbm/s]
V	214.125	502.368	240.724	[in/s]
Vc	0	-474.219	-10.184	[in/s]

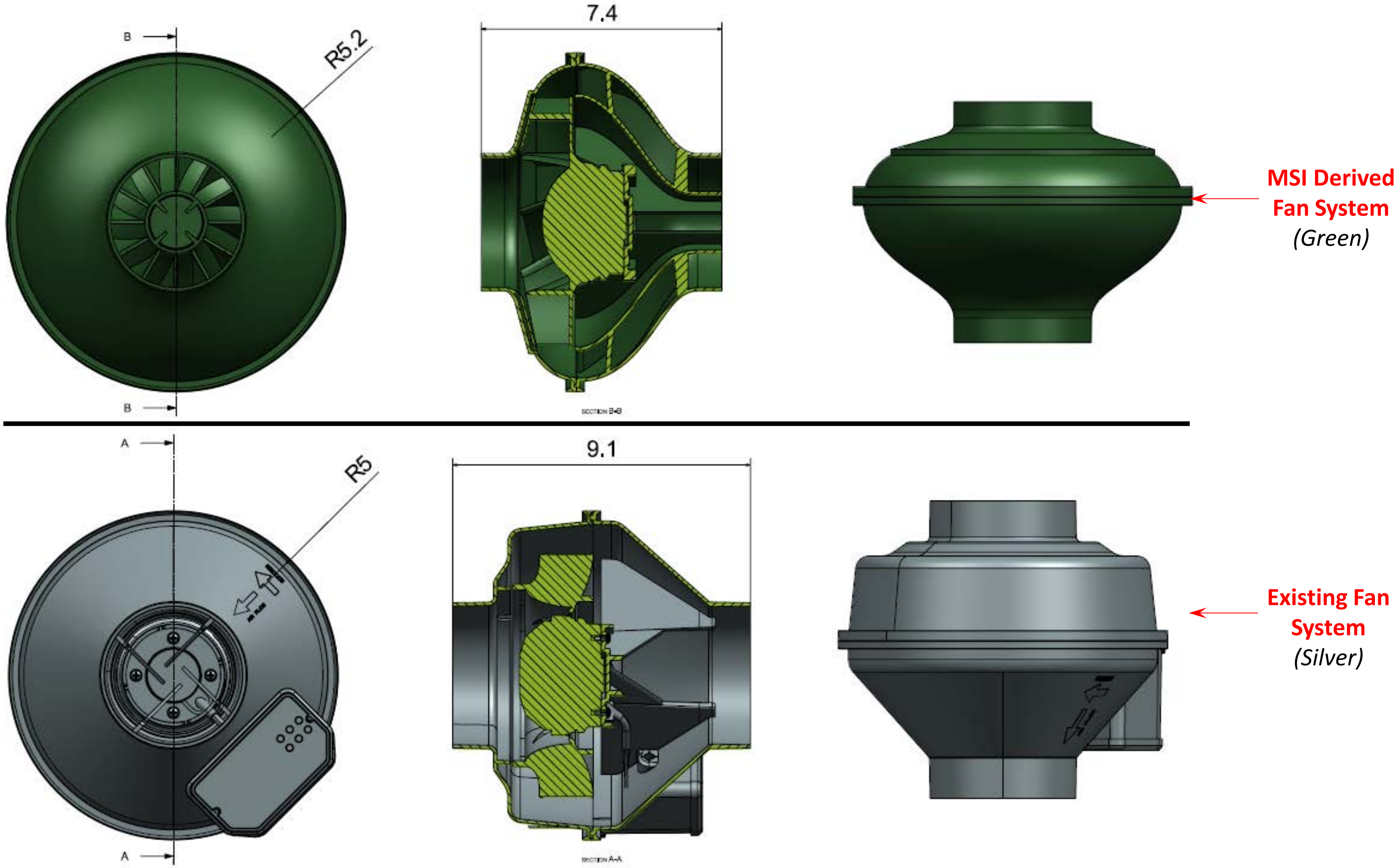
Inlet Flow	92.83056	[cfm]
Delta P	0.055	[psi]
Torque	0.053572	[ft lbf]
RPM	2950	[rpm]
Shaft Power	22.43823	[watt]
Efficiency	74.02%	



Fan Meets Requirements With Increased Efficiency

- MSI design meets geometric requirements versus existing architecture

All Dimensions In Inches



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Recent Accomplishments

- Integrated motor fan efficiency significantly exceeds requirement
  – Reduction in energy consumption by a minimum of 25% compared to state-of-the-art units
- Study of various fan designs performed and Downselect to final configuration conducted
  – MSI investigated six different fan designs (seven total configurations – includes exit diffuser)
- 3-dimensional CAD model generated
- Aero/mechanical design of integrated fan/motor nearly completed
- Material investigation for manufacturing and cost purposes nearly finalized
- Downselect design complete and ready for fabrication
  – Phase II

Project Budget

Project Budget:
- DOE: $150,000

Variances:
- Currently no variances specific to project

Cost to Date:
- DOE: $132,200

Additional Funding:
- N/A

Budget History					
06/2016– FY 2016 (past)		FY 2017 (current)		FY 2017 – 3/2017 (planned)	
DOE	Cost-share	DOE	Cost-share	DOE	Cost-share
$21,000	N/A	$132,200	N/A	17,800	N/A

Next Steps and Future Plans

- Complete final report supporting Phase I tasks and objectives
- Secure funding for prototype development and test
- Transition to market with commercial partner