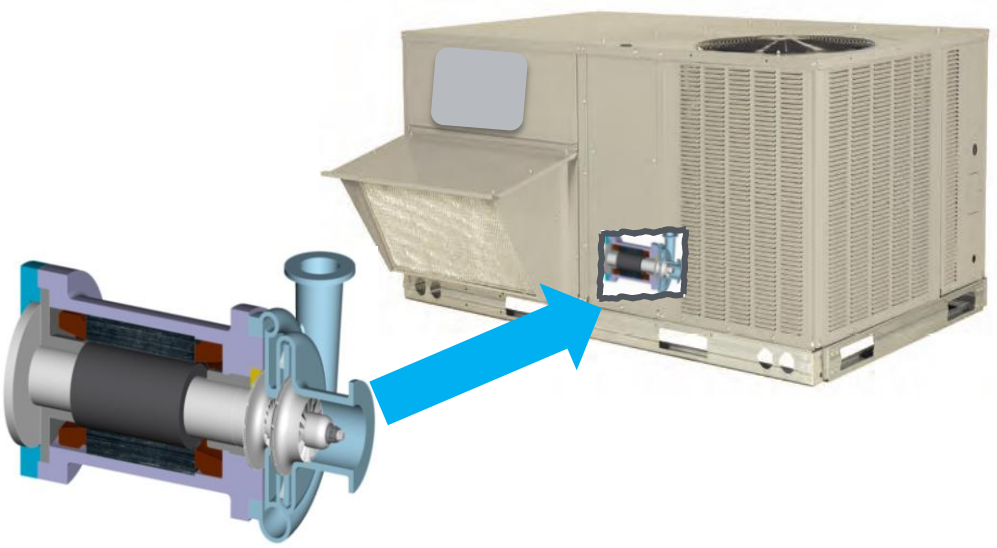

*Concept is similar to superchargers for piston engine aircraft*

Mechanical Solutions, Inc.
Engineering Analysis, Test & Technology

# Supercharger for Heat Pumps in Cold Climates

DOE SBIR Grant No. SC0006162

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# Purpose & Objectives



**Problem Statement:** Electrically driven heat pumps are an effective method of extracting heat from ambient air. As air temperature falls, however, heat pump performance falls off, essentially limiting their year round usefulness to warmer climates. In colder climates heat pump-equipped heating systems typically have a secondary means to provide heat, usually electric or natural gas. This adds complexity, duplication and cost. There are currently no strong candidates for air source heat pump system designs that maintain both capacity and coefficient of performance (COP) in cold climates.

**Impact of Project:** If effective cold climate heat pumps were developed, they could have a significant energy-savings impact in the major population centers of the US, particularly where natural gas is not available for backup heat.

# Purpose & Objectives

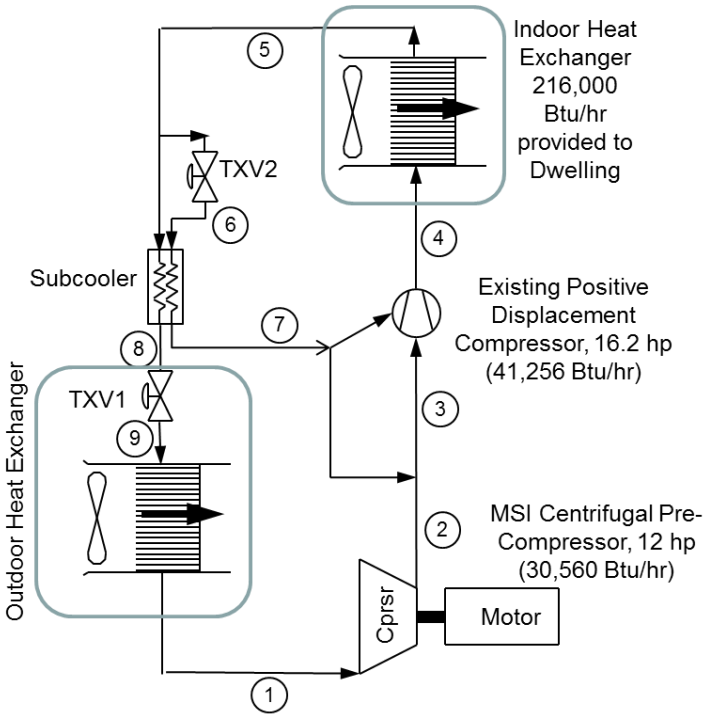


Project Focus: Developing the essential elements of a heat pump *furnace*, which will allow efficient operation in the coldest US climates *with zero backup heat*:

- Adds a second compressor that will, on cold days, operate automatically to boost refrigerant pressure and temperature. The MSI centrifugal-style compressor is compact, highly efficient, and works in concert with a heat pump's traditional compressor.
- Properly configured, the MSI pre-compressor will enable heat pumps to be applied to virtually all of the US market without changing the type of refrigerant employed or the basic design of commercial compressors used in today's marketplace.
- A heat pump that can efficiently function as a furnace, with no requirement for backup heat, will revolutionize a major segment of the HVAC industry.

# Purpose & Objectives



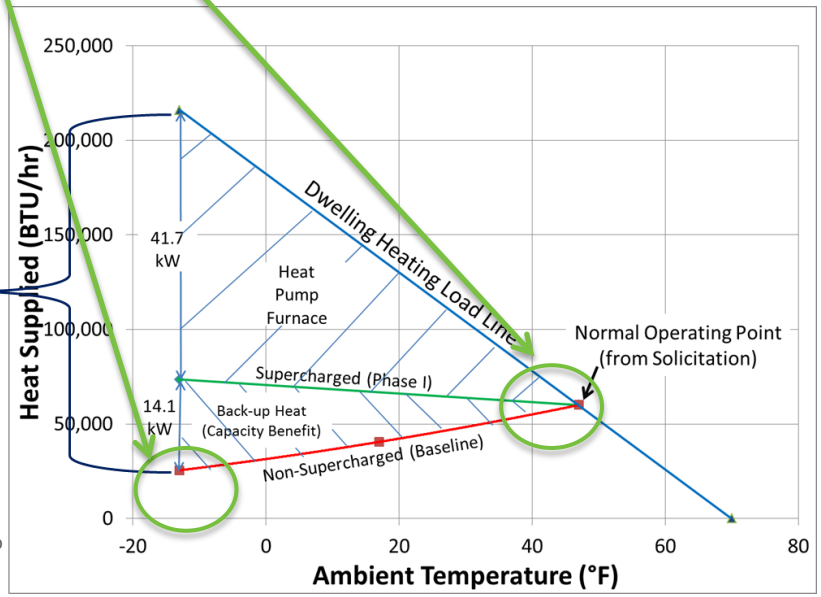



$\frac{\text{——————}}{\text{——————}} = 3.0$

## From DOE Solicitation

| Cold-Climate Heat Pump Performance Targets | | |
|---|---|---|
| Ambient Temperature (°F) | Minimum COP | Maximum % capacity degradation from nominal |
| 47 (nominal rating point) | 4 | 0 |
| 17 | 3.5 | 10 |
| -13 | 3 | 25 |

190 kBtu/hr additional heat* provided by supercharged heat pump vs. baseline, non-supercharged unit




* 190KBtu/hr = 55.8 kW = 75 hp

# Approach



Approach: Design, build and map the performance of a prototype supercharger/pre-compressor. Integrate with a commercially available heat pump compressor and demonstrate performance of the combined package

Key Issues:

A) Obtaining desired compression ratio and mass flow across a range of conditions with good efficiency – requirements met!;

B) Obtaining quality aero parts at reasonable cost & budget – Using additive manufacturing for prototypes; investment casting for production.

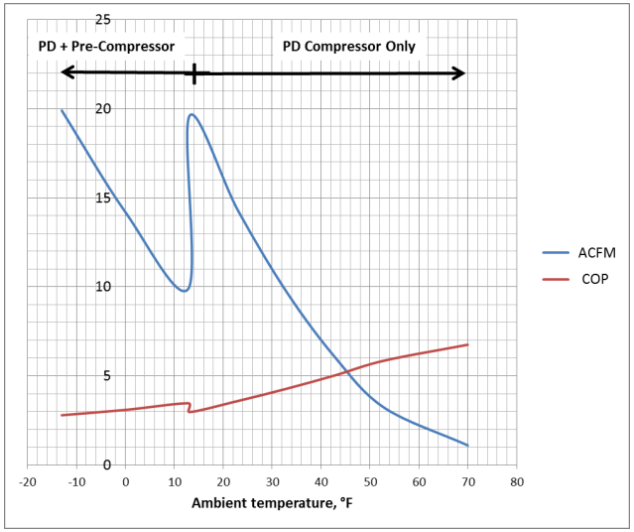
Distinctive Characteristics: Sealed, single stage compressor driven by PM motor running at very high speed on existing MSI process gas hydrodynamic bearings

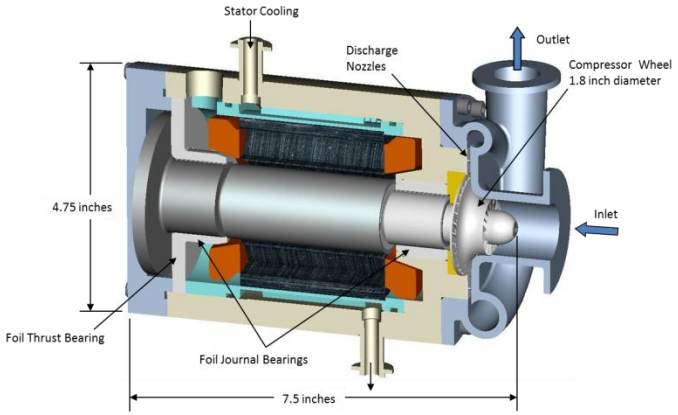
# Accomplishments and Progress



MSI's Pre-Compressor for a Heat Pump that requires zero backup heat

- A compact unit: A motor-driven 100,000 rpm single stage centrifugal compressor device with reduced part count and oil-free MSI gas foil bearings
- A catalog Copeland Scroll™ fits well as the core compressor for a heat pump that delivers 60,000 Btu/hr @ 47°F, increasing to 200,000 Btu/hr @ -13°F
- Good overall COP across the temp range
- Encouraging discussions to date with Emerson Climate Technologies/Copeland (leading compressor OEM) and Goodman Industries (Leading heat pump OEM)



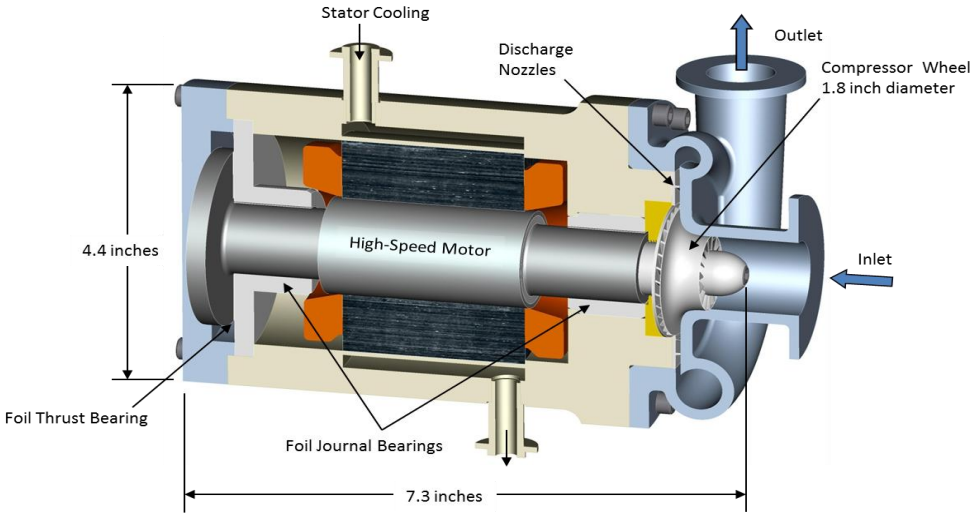
# Accomplishments and Progress



**Accomplishments:** Design of prototype high-speed pre-compressor & motor complete; manufacturing commencing. NOTHING EXISTS due to the complex nature of refrigerants.

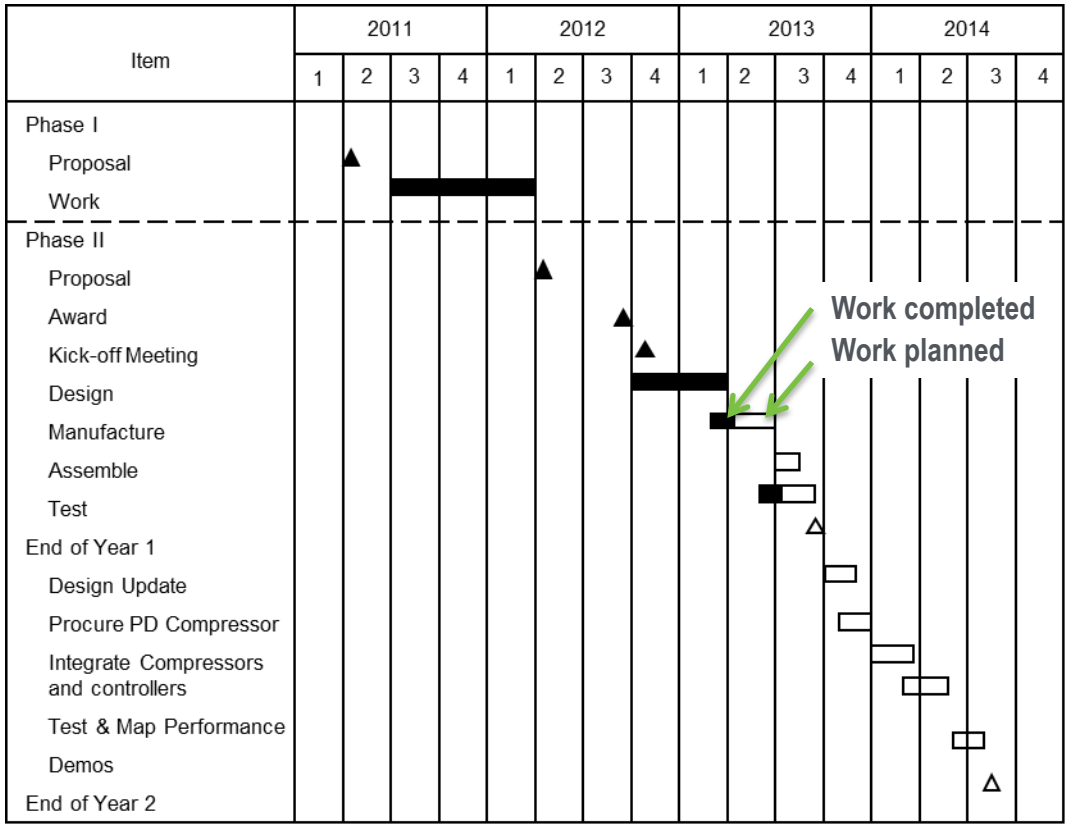
**Progress on Goals:** Expect to have prototype initial operation by mid-summer

**Awards/Recognition:** Considerable third party interest



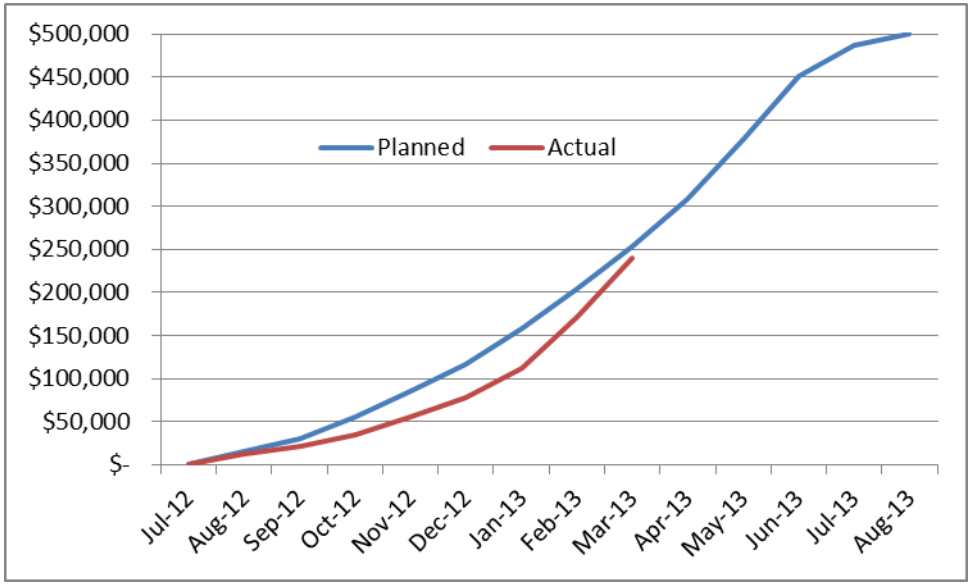

# Project Plan & Schedule





# Project Budget – Year 1






- MSI Internal Funding Aug-Oct: Assessed Additive Manufacturing methods to confirm applicability for aero parts
- Year 2 funding request ($500K) to be submitted by early July 2013

# Project Integration, Collaboration & Market Impact

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Partners, Subcontractors, and Collaborators: Three consultants (thermo cycle, motor design, voice-of-the-customer (NH-based A&E for large residential/small commercial HVAC). Also: NYSERDA interest in energy-saving heating and cooling methods.

Technology Transfer, Deployment, Market Impact: Initial discussions & interest – Emerson/Copeland (compressor OEM); Goodman, Carrier (Heat Pump OEMs). Also: Presentation and initial discussions with Northwest Energy Efficiency Alliance (NEEA) – Heat Pump Water Heaters. Also: Potentially applicable to industrial freezers.

Communications: Planning to submit an abstract to 2014 International Energy Agency Heat Pump Conference (pending ITAR clearance).

# Next Steps and Future Plans



Next Steps and Future Plans: Build initial prototype and map performance on test loop. Incorporate PD compressor and test performance of combined, two-compressor system on test loop; conduct demos. Negotiate partner agreement(s) with OEM(s).

Potential for Scope Expansions: Incorporate both compressors and an overarching controller into a complete heat pump; environmental chamber tests; prototype field tests.

*Summary: A heat pump that can efficiently function as a cold climate furnace, with no requirement for backup heat, will have enormous energy-saving potential; it will revolutionize a major segment of the HVAC industry.*