A System for Automatically Maintaining Pressure in a Commercial Truck Tire

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Overview

Timeline

Project Start – 01-Oct 2011
Project End – 30-Sep 2016
Percent Complete – 90%

Budget

Total Project Funding
> DOE: $1,499,771
> Recipient: $2,572,953

FY15 Funding Received: $ 2,581 (a)
FY16 Funding Expected: $315,290

(a) FY15 was under a no cost extension

Barriers

Verifying system performance under operating (dynamic) conditions

Allowing for the system to function through multiple retreading

Minimizing overall cost of pumping system including assembly

Partners

Goodyear is the lead & sole participant on this project

> Vendors being used for component / testing parts / assembly / mold rings

> JDA / NDA / TSA issued for supply of prototype parts for Validation Phase III

Overall Objective: Develop and demonstrate an in-tire system for automatically maintaining a set pressure in a commercial truck tire.

> The system, referred to as the Air Maintenance Technology™ or AMT, utilizes peristaltic pump technology to automatically maintain tire pressure at the optimum level.

> The project will consist of research, development, and demonstration activities including both laboratory and test tire demonstrations.

> This technology will have immediate positive impact for drivers in terms of safety and performance; and for the environment through improved fuel efficiency, reduced emissions and extended tire life - while decreasing fleet tire maintenance costs.

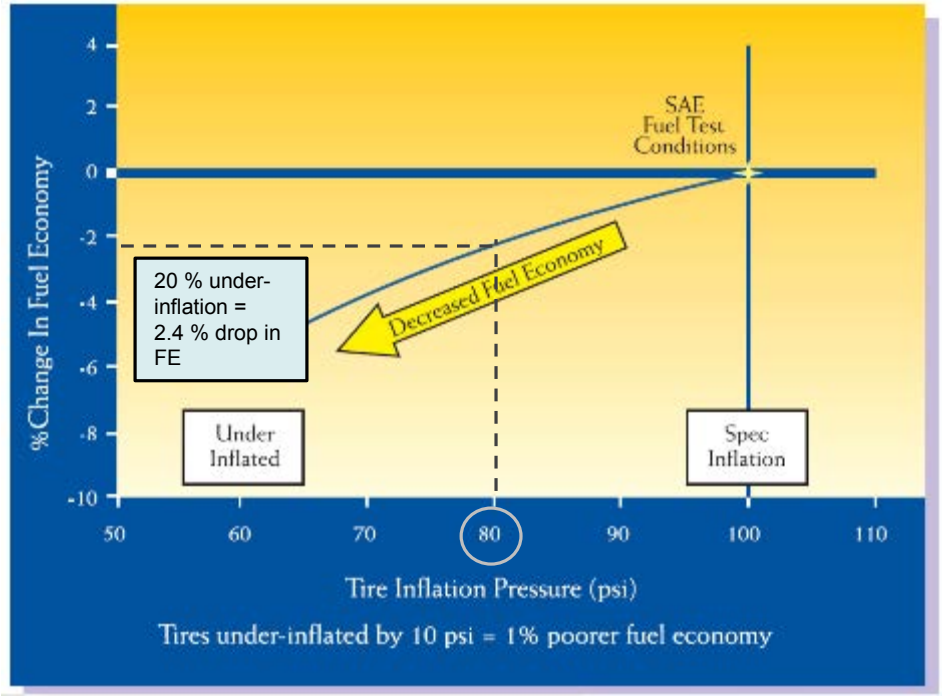
Objectives (March 2015 – March 2016):

> Design and process optimization
- Identify final design for pump regulator and filter
- Identify process to build
- Assemble and test prototype tires

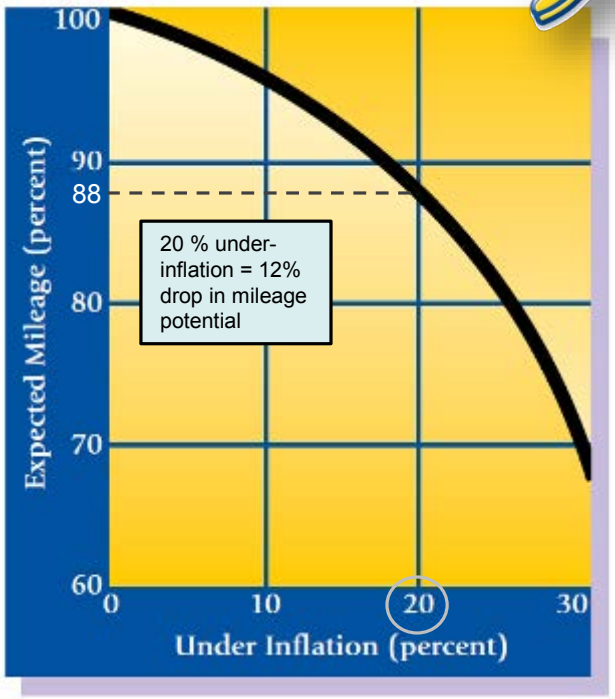
The Air Maintenance Technology™ will certainly have broad appeal across all classes of vehicles – from small passenger cars all the way up to large commercial trucks

Relevance

Impact on Fuel Efficiency / Tire Life



http://www.goodyeartrucktires.com/pdf/resources/publications/Factors%20Affecting%20Truck%20Fuel%20Economy.pdf (Page 3)



http://www.goodyeartrucktires.com/pdf/resources/service-manual/Retread_All_V.pdf (Page 40, figure 5.4)

Federal Motor Carrier Safety Administration (FMCSA) research:

> Majority of tires were under-inflated

20-25% dual assemblies were mismatched with regards to tire inflation pressure

Lower inflation causes excessive flexing or deflection and generates heat

> Over time, this can deteriorate the tire casing

Improve Inflation Maintenance > Improve Fuel Economy, Mileage and Tire Life

Roadside Breakdowns

- Data from Goodyear Fleet HQ maintenance service:
  - Long haul fleets incur about 1.5 roadside breakdowns per truck per year
  - 75% of those breakdowns involve underinflated tires
  - 0.75 x 1.5 = 1.125 breakdowns due to under-inflation
- 50% of the active tire population is long-haul
  - 0.50 x 71,000,000 (a) = 35,500,000 tires
- 35,500,000 / 18 (one long haul truck) = 1,972,222 trucks running (b)
- Production of one commercial truck tire requires 22 gallons of oil (c)
- 1.125 x 1,972,222 x 22 gals = 48,812,494 gallons of oil potentially saved per year (1.2 million barrels)
- Additional fuel expenditures from service vehicles making road calls

Numbers above are Goodyear estimates, unless otherwise noted

(a) 2011 Active Tire Population by MacKay & Company (2012)
(b) This number could be larger as a small % of long haul trucks are single axle drive configurations
(c) http://www.sttc.com/reasons-retread-commercial-tires

Reducing roadside breakdowns reduces fleet costs and saves energy

Improve Inflation Maintenance > Improve Fuel Economy, Mileage and Tire Life

Milestones

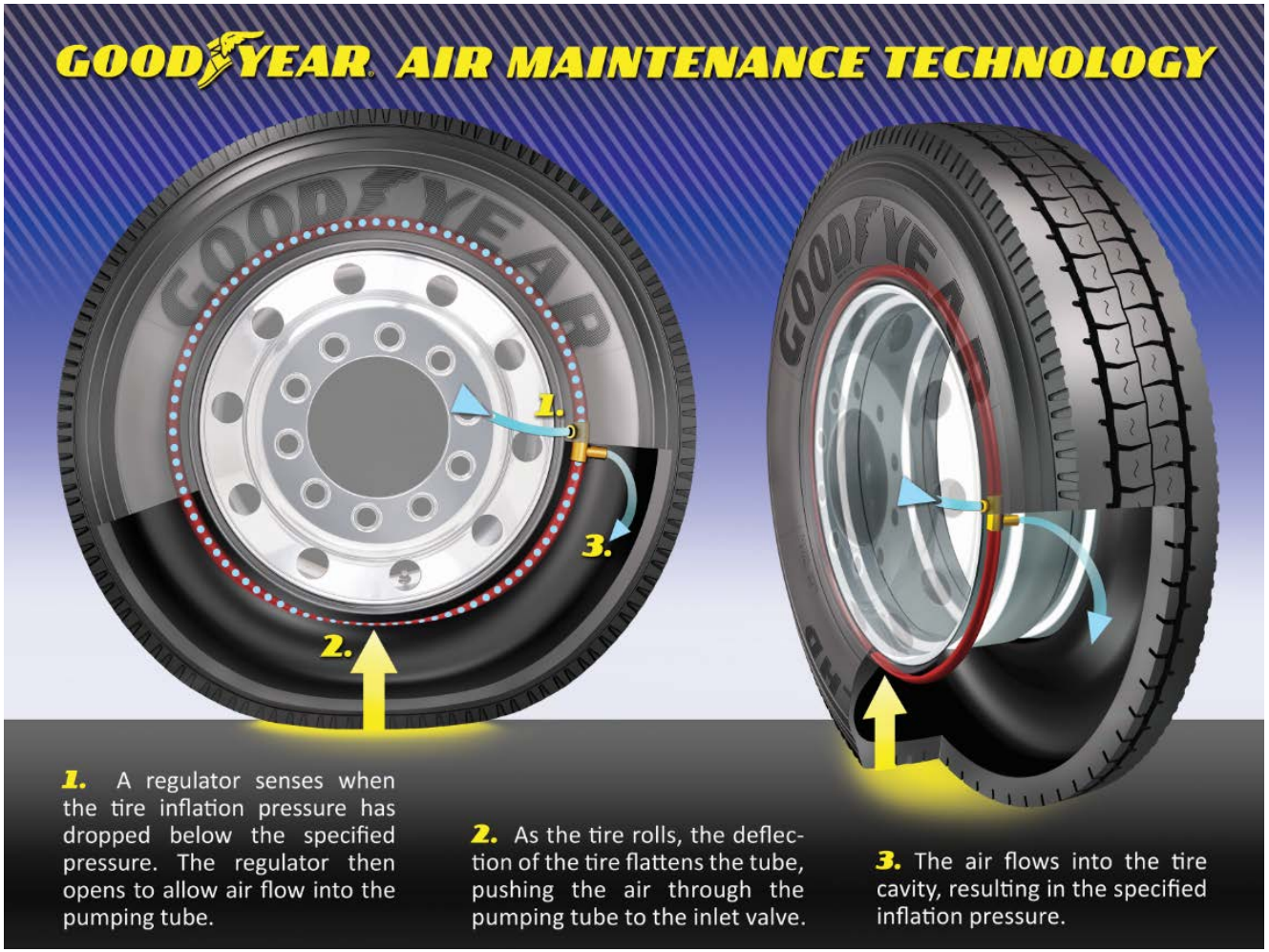
FY2015 / FY2016

Milestones and Go / No Go Decisions	Date	Status
Milestone: Assembly Development Process Center Operational	June 2015	Complete
Go / No Decision: External Regulator Project Accelerated	July 2015	Complete
Go / No Go Decision: Internal Regulator Placed On Hold and External Regulator Chosen as Preferred Solution	January 2016	Complete
Milestone: Focus Fleet Test Running	February 2016	Complete
Milestone: Phase 3 Complete	September 2016	On Track

Approach – Commercial Tire Design

Product Technology Choice

- Integrated into tire as a new feature
- Manufacturing process not to be altered significantly
- No special tire handling or mounting equipment
- Can be immediately used by vehicles in service
- Usable on all axles
- Last life of tire through retread

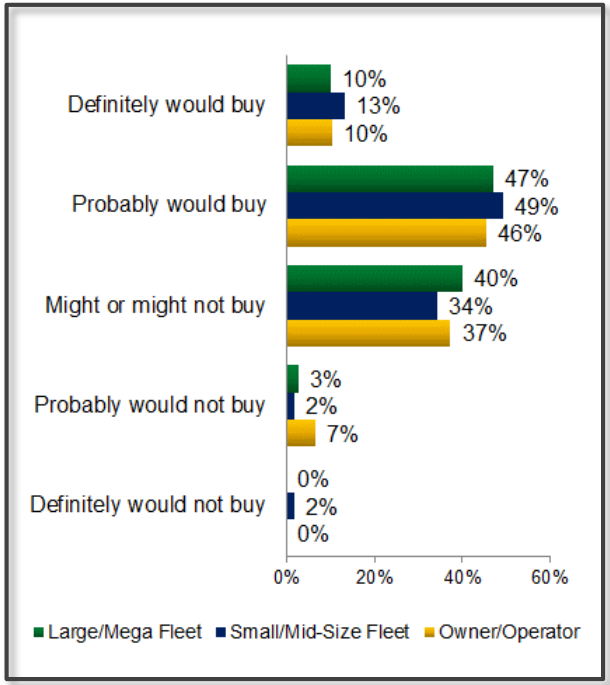


Test on Multiple Trucking Fleets in FY2016

Approach

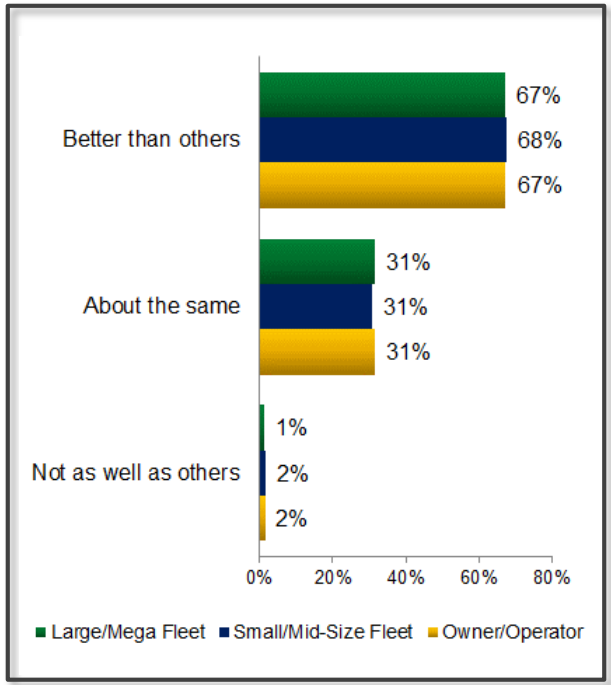
Concept Testing - How do customers respond?

What is the interest?



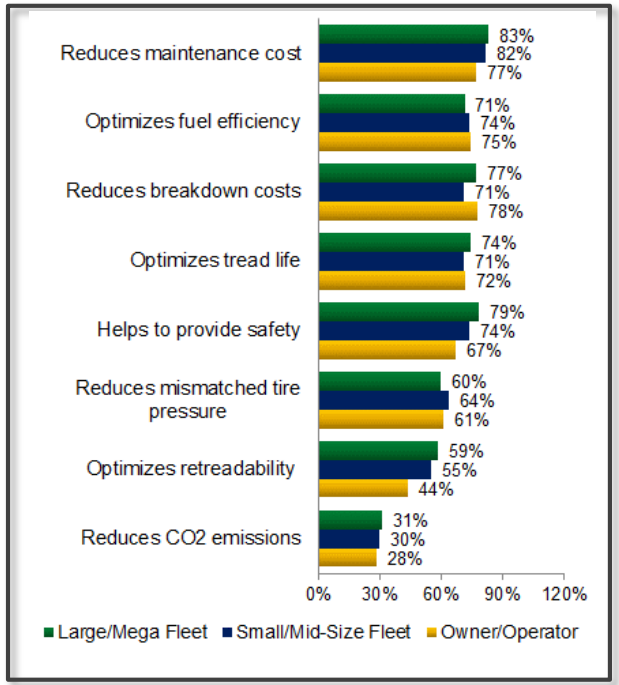
58% probably or definitely would buy

Does it fulfill your needs?



2/3 say that it would meet their needs

Appeal of benefits?



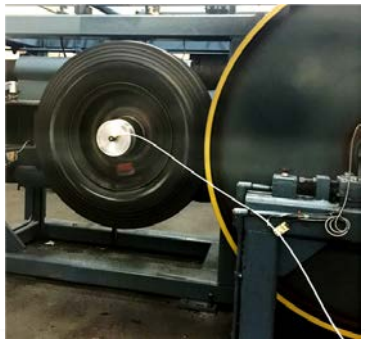
Cost, efficiency and safety drive appeal of AMT

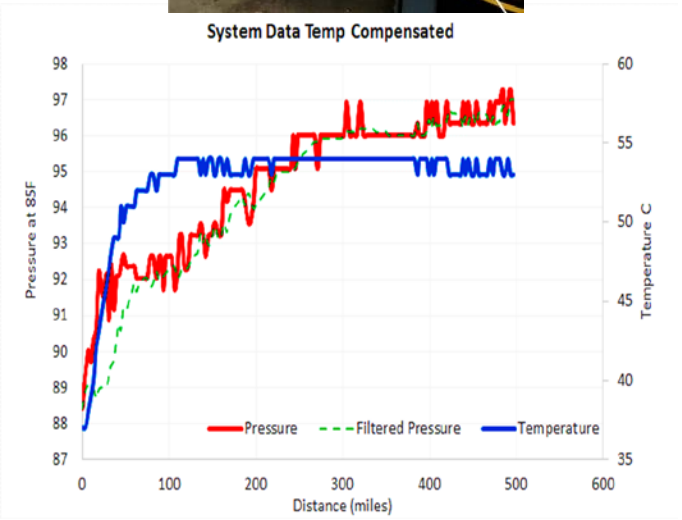
Owner/Op: 1-25 trucks Small/Mid-Size: 26-200 trucks Large: 201-499 trucks Mega: >500 trucks

- Design
  - Identify Final Pump Regulator and Filter
- Assembly
  - Identify Build Process
- Testing
  - Assemble and Test Prototypes
    - Tire Test Lab
    - Over the Road Trucks

- **Regulator and Filter**
  - Internal Regulator Design
    - Regulator Performance Acceptable, but Leaking between Regulator and Dock in Dynamic Testing
    - Dock Redesigned with Replaceable Seals
    - Leaking Performance Still Unacceptable
  - Switched to Contingency Design
    - External Regulator
    - Filter Design Incorporated into Regulator
    - Acceptable Performance in Dynamic Testing
- **Pump Tubes**
  - On Going Long Term Durability Testing on Internal Trucks Since December 2013
    - Over 2,800,000 Tire Miles Tested to Date
    - Acceptable Performance

External Regulator in Lab

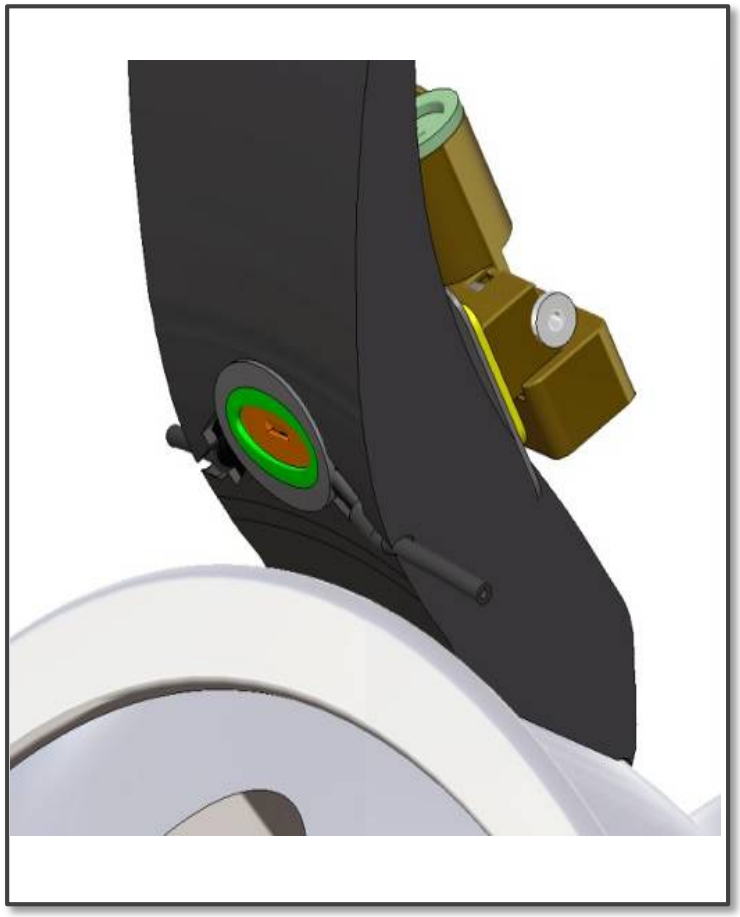




Pumping at 1.75 psi / 100 miles
(Goal: >1 PSI / 100 miles)

External Regulator Chosen as Preferred Solution

Internal Regulator



External Regulator

External Regulator and Filter Design Finalized

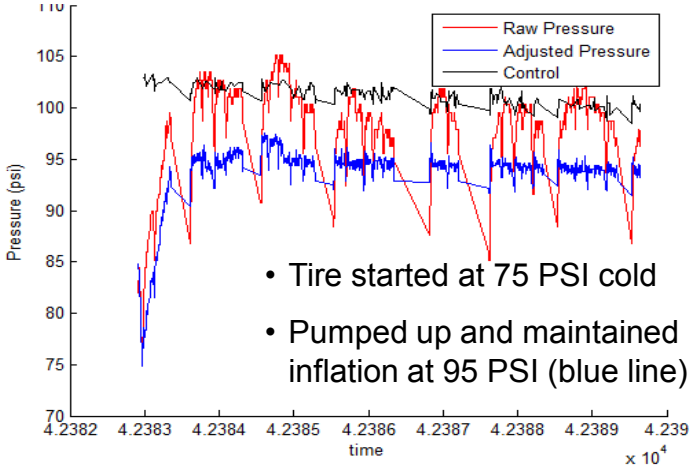
- Assembly Cell
  - Prototype Assembly Cell Online
  - Process Optimization
    - Pump tube installation
    - Cover strip installation
    - Curing
- AMT Production – 2015 / 2016
  - Test Lab and Internal Truck Tire Tests
  - All Focus Fleet Evaluation Tires

Prototype Assembly Cell

Assembly Cell Online – Process Optimization Continuing

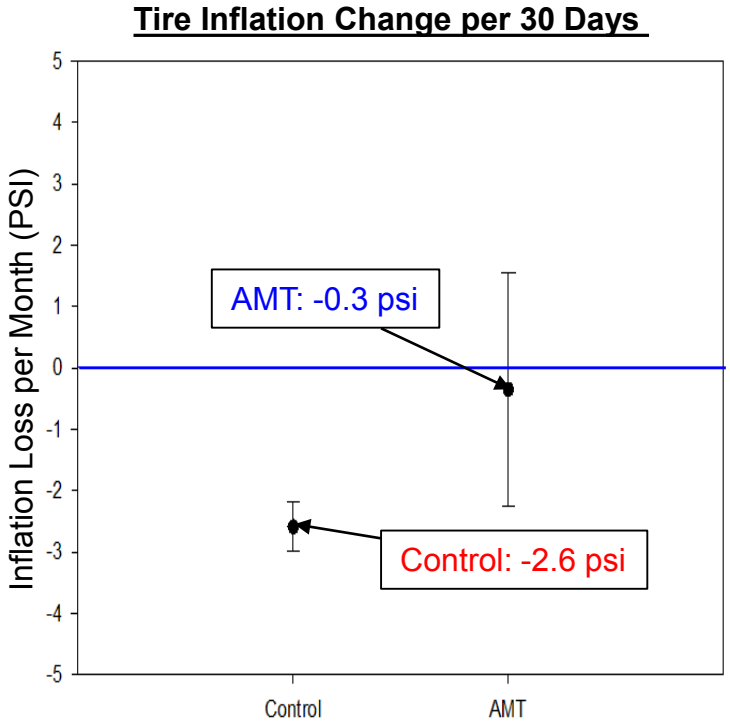
- Test Lab – High Cycle & Deformation Testing
  - ODR (Outdoor Resiliometer)
  - High Speed Durability
  - Bead Durability
  - Endurance

- Internal Truck Testing
  - Testing over public roads – 1150 miles per day
  - Multiple trucks currently running
  - Pumping rate goal of 1 psi / 100 miles exceeded



Durability and Pump Rate Testing Shows Excellent Performance

- Focus Fleet Testing
  - External customer fleets
  - Multiple fleet trials running
    - Different climates in the US and Canada
    - Continuous TPMS (temperature and pressure) monitoring of each tire's performance
    - Control (standard, non AMT) tires used for reference



Results Show AMT Tires Maintaining Inflation Pressure

Project was not reviewed in 2015

- **Collaborator A**
  - **Internal Regulator, Dock, and Filter - Design and Prototype Supply**
    - **Performance Unacceptable**
- **Collaborator B**
  - **External Regulator and Filter - Design and Prototype Supply**
    - **Performance Acceptable**

- Retreading Evaluation
  - New AMT tires
    - Treads have been buffed off and placed through the retread process 2-3 times
    - AMT pumping performance measured after each retread
  - Worn AMT tires
    - Both internal truck and focus fleet worn out tires are being placed through the retread process
    - AMT pumping performance measured after each retread
    - Tires returned to trucks for additional mileage
    - Steps will be repeated after 2nd wear out

No Retread Issues to Date

Proposed Future Work
FY2016

- Continue to refine AMT system and assembly process
  - Focus fleet testing
    - Real time acquisition of pressures & ambient temperature weekly on all tires
    - Visually Inspect tires and AMT system components regularly
    - Fuel economy evaluation
    - Track any maintenance and air adjustments
  - Assembly process optimization and scale up for industrialization
- Continued performance and durability testing
  - Long term trials in lab and San Angelo test facility
  - System tire retread trials and evaluations

Summary

- ☑ Final design selected for regulator and filter
- ☑ Regulator size and weight reduced
- ☑ Improved component attachment methods developed
- ☑ Pump tube materials refined and tested for durability
- ☑ Pumping rate goal of 1 psi / 100 miles exceeded
- ☑ Internal on vehicle testing of systems underway since Dec 2013
- ☑ Focus fleet testing underway since Feb 2016
- ☑ Over 46 US Patents granted, additional filings in process
- ☑ DOE project on track for completion the end of the 3rd quarter 2016