



**Michigan Scientific**  
Corporation®

Precision Instrumentation and  
Measurement Solutions





Est. 1960 by Hugh Larsen, former director of Vehicle Development at General Motors.

Today there are 100+ engineers, technicians, machinists, and supporting staff.

Annual Turnover \$15+ million

Hundreds of customers worldwide

Countries with active Michigan Scientific

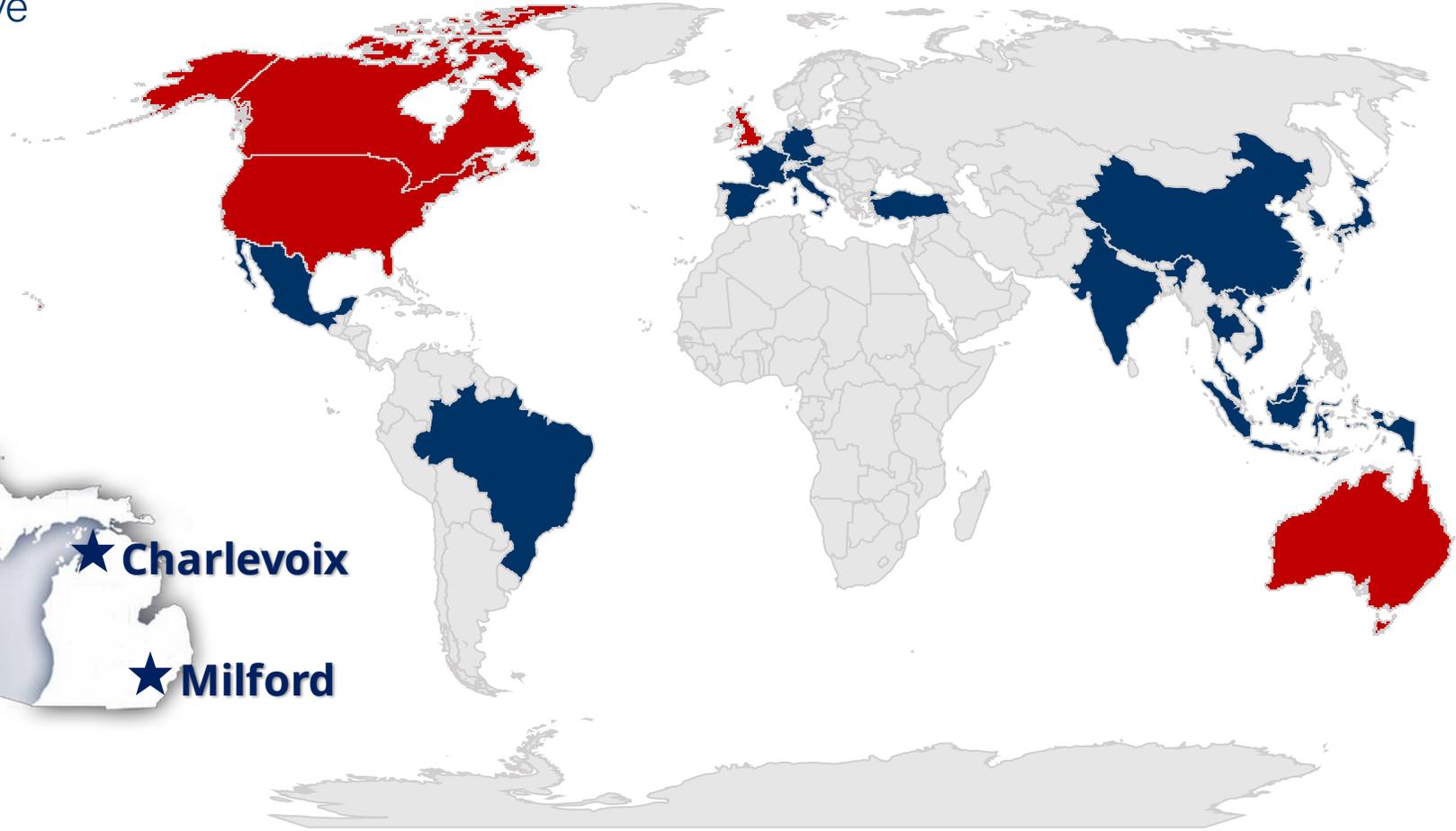
Direct Sales ■  
Support Agent ■

Michigan Scientific facility locations ★



★ Charlevoix

★ Milford



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# Global Presence





Slip Ring Assemblies



Transducers



Instrumentation  
Assemblies

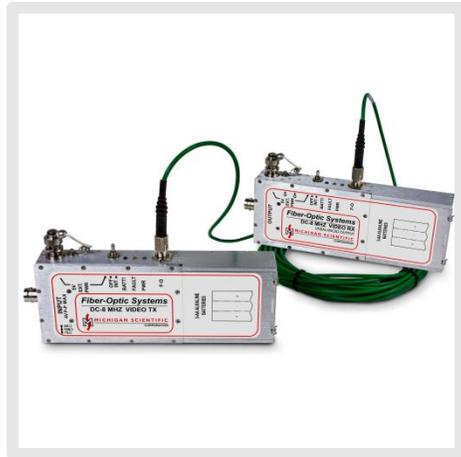
**60+** years of engineering  
excellence

**Made in America**

Instruments measure force,  
torque, strain, temperature,  
angular speed and position,  
and acceleration



Wireless Telemetry



Fiber Optic Systems



Signal-conditioning  
electronics

# Wheel Force Transducer (WFT)

- Easy to install and use
- Highly accurate and reliable
- Waterproof (IP67) and temperature-compensated
- Lightweight
- Continued investment in development

## Used in:

Durability testing • Vehicle dynamics testing  
Brake development and testing • Traction studies  
Suspension durability lab testing • Road-to-lab correlation

**Measures:**  
**THREE forces**  
**THREE moments**  
**TWO accelerations**



Michigan Scientific is a top supplier of WFTs for off-road and on-road applications.



- Heavy equipment
- Military equipment

- Fork trucks
- Tractor
- ATVs



# Off-road WFT Applications





- Motorcycles
- Passenger cars
- Light trucks
- Heavy trucks
- Buses
- Electric Vehicles

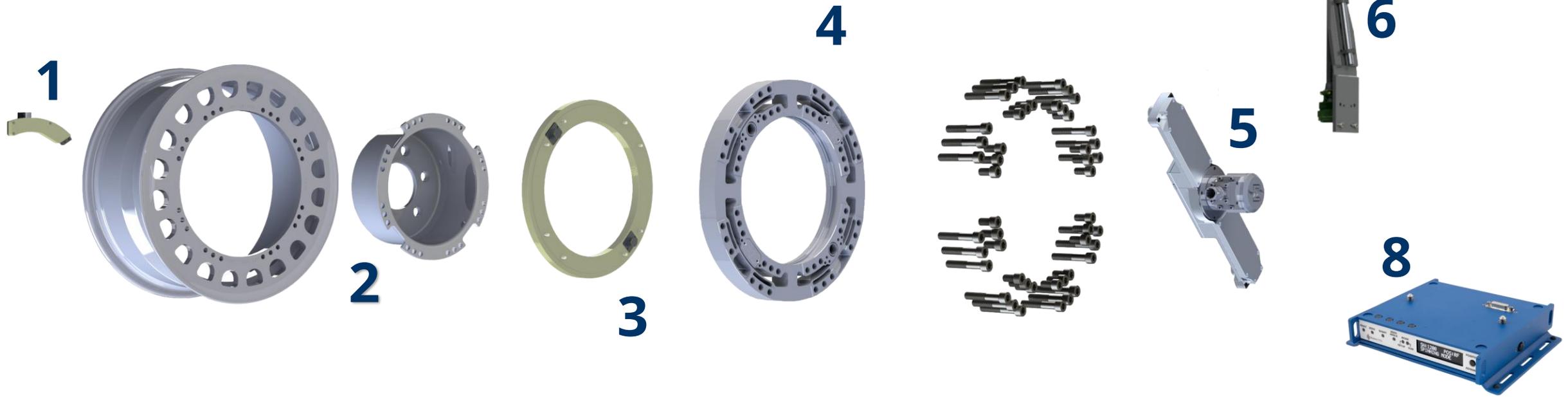
# On-road WFT Applications



- 3<sup>rd</sup> Generation WFT User Interface
- CAN 2.0, CAN FD, Analog, EtherCAT, & Ethernet Signal Outputs
- Enables Tri-axial accelerometers in amplifier packages
- Simple USB-C connection for access to embedded webpage
- Compatible with both outboard slip ring and inboard telemetry systems
- Front display screen shows internal settings, connected WFT SN, and possible error codes
- IEEE 1588 PTPv2 synchronization

## CT3 User Interface

# WFT Assembly Installation



1. Telemetry stator restraint and bracket
2. Custom hub and rim adapters
3. Wireless telemetry transmitter subassembly

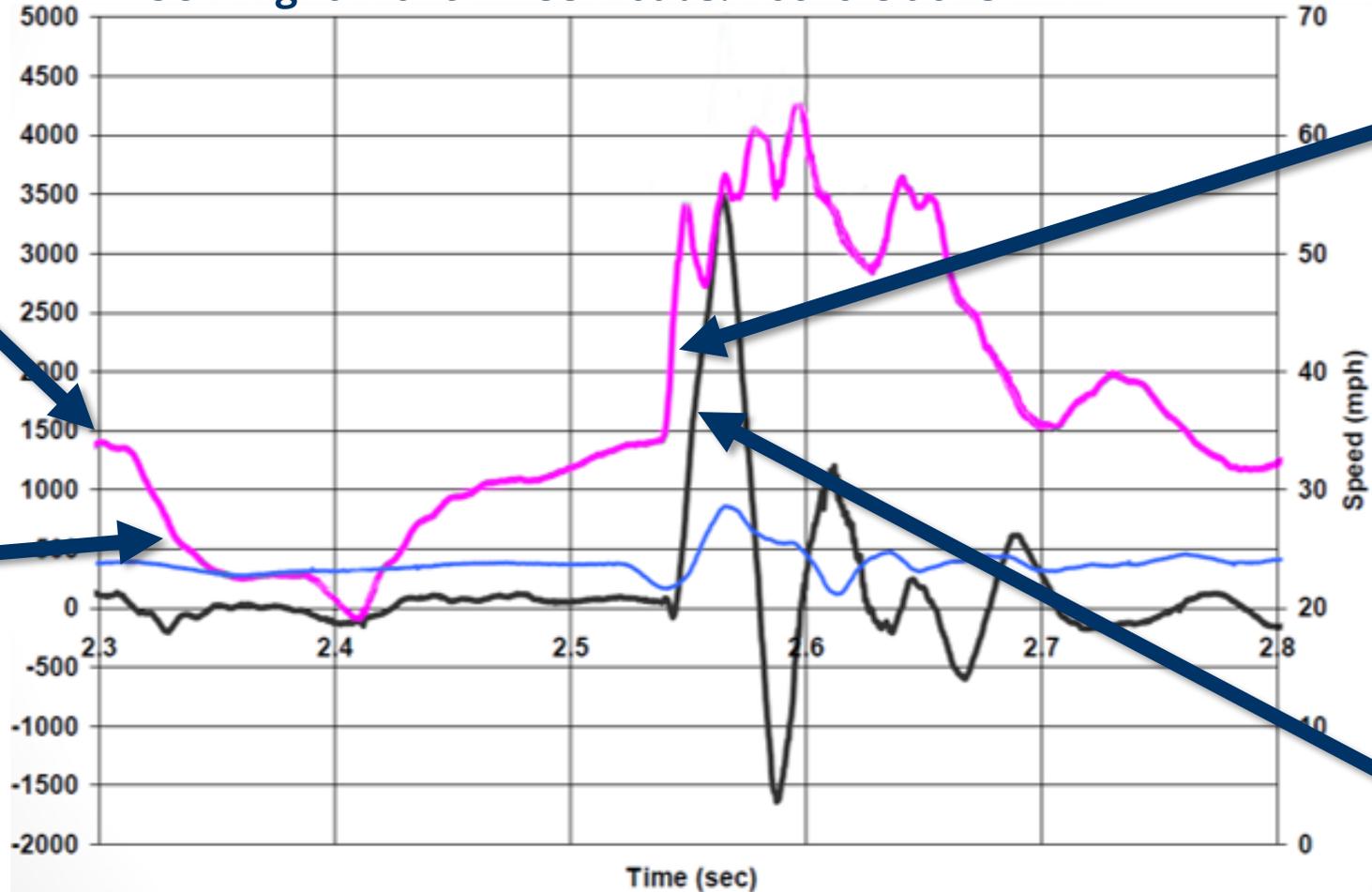
4. Wheel Force Transducer
5. Integrated slip ring and amplifier subassembly
6. Stator restraint rod
7. Stator Angle Correction (SAC) Device
8. CT2 or CT3 User Interface box



## Stator Angle Correction Device SAC & SAC/3

- Eliminates need for custom over-the-wheel bracket
- Prevents error when wheels are steered
- Automatic internal correction with no firmware upgrade
- Compatible with Michigan Scientific WFTs | Sold since 2013

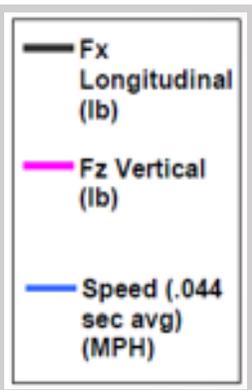
### SUV Right Front Wheel Loads: Pothole at 25 MPH



Weight of vehicle  
(while driving)

Pothole entrance  
(vertical force drops)

Vertical force spikes  
as the suspension  
compresses at the  
bottom of the pothole

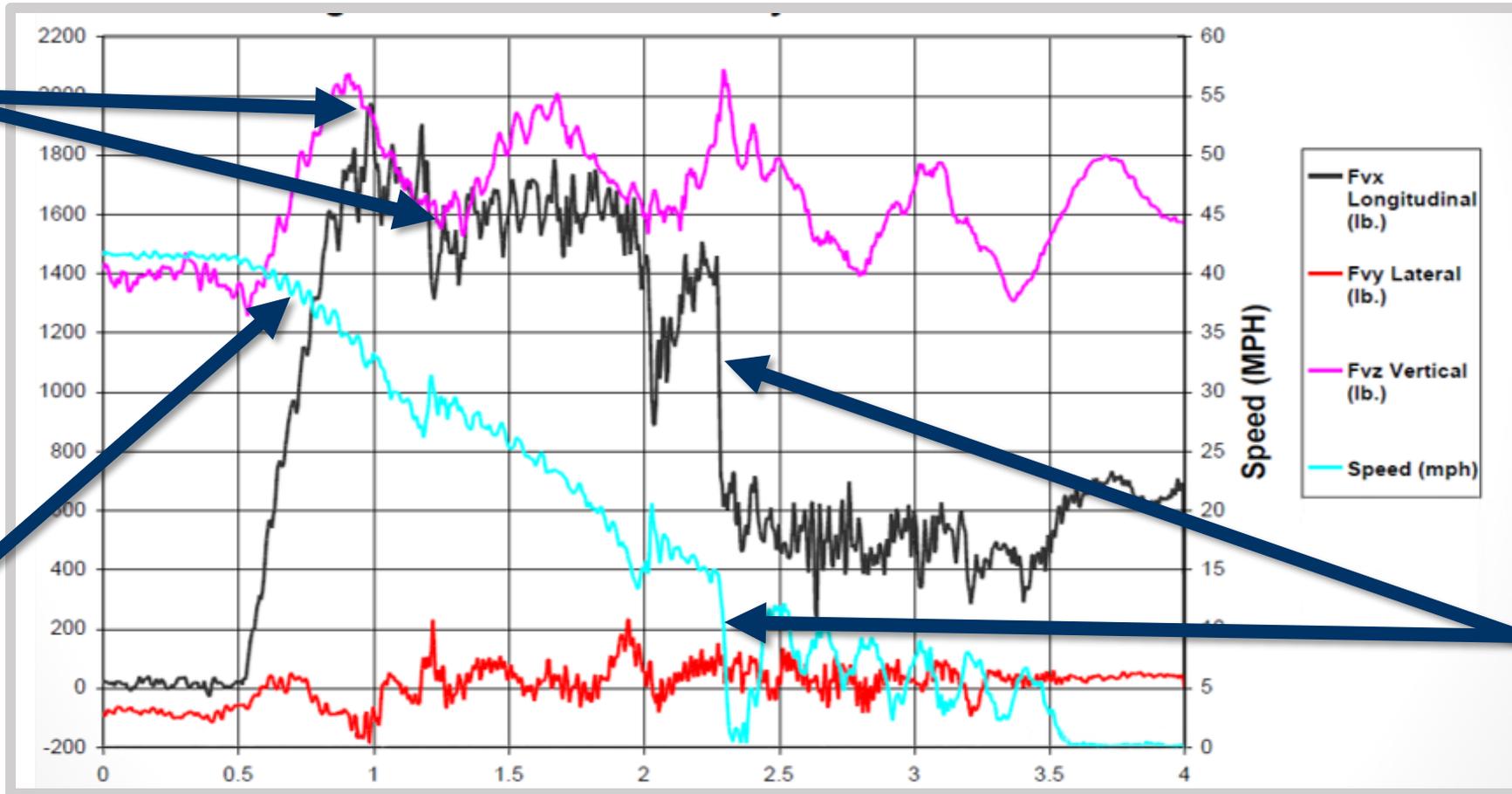


Longitudinal force  
spikes when wheel  
hits the edge of the  
pothole

## Right Front Wheel Loads Recorded on SUV Severe Braking with Transition from Dry Surface to Wet Tile Surface

Load transfer from front to rear of vehicle while braking

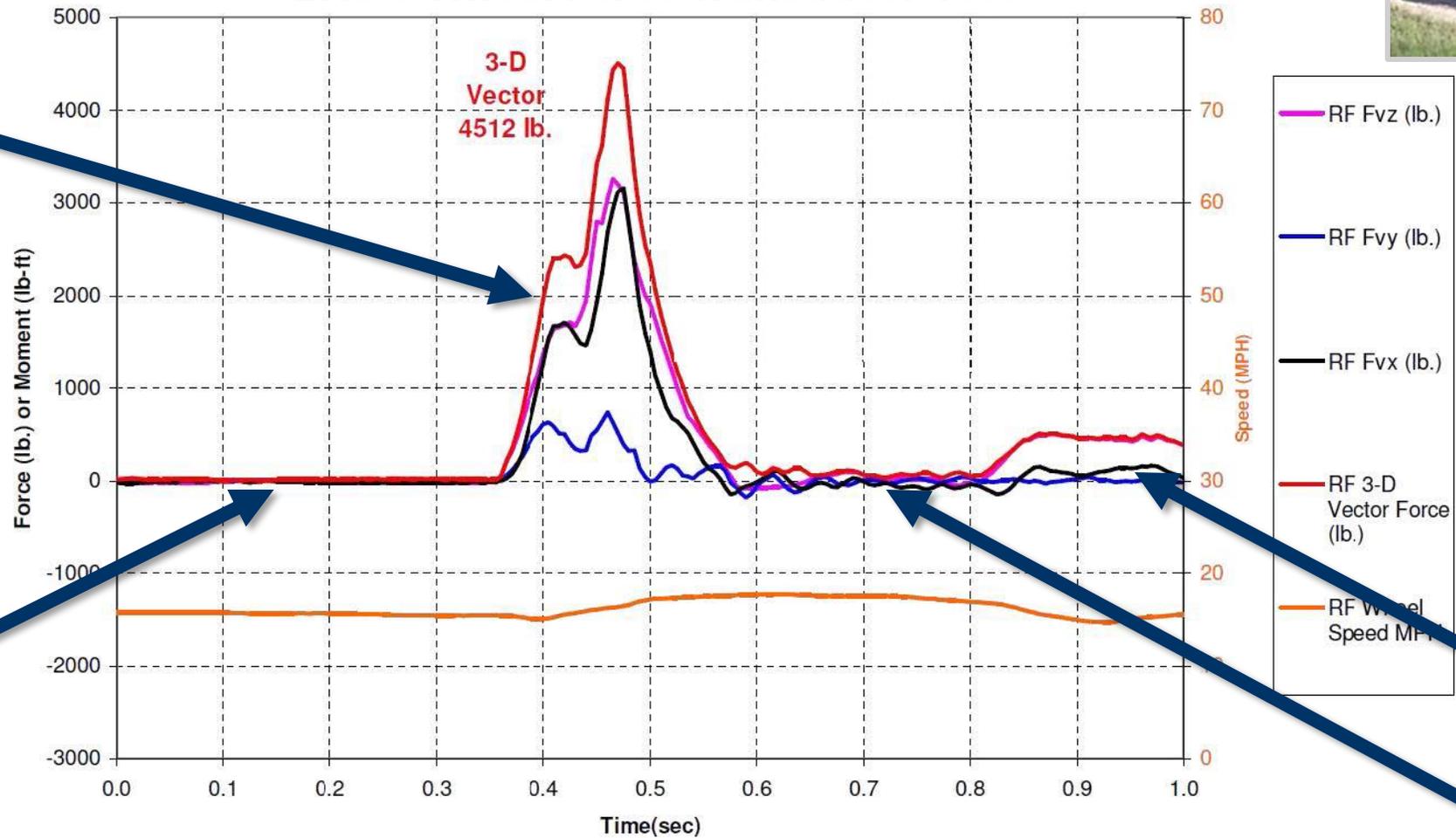
Speed starts to decrease



Wheel speed and longitudinal force drop each time ABS releases brakes



## LW9.5 Wheel Force Transducer Test



Force exerted on the wheel during landing

Zero force of WFT while vehicle is airborne after taking off from a ramp

Normal driving vertical force

Zero force again after wheel bounces

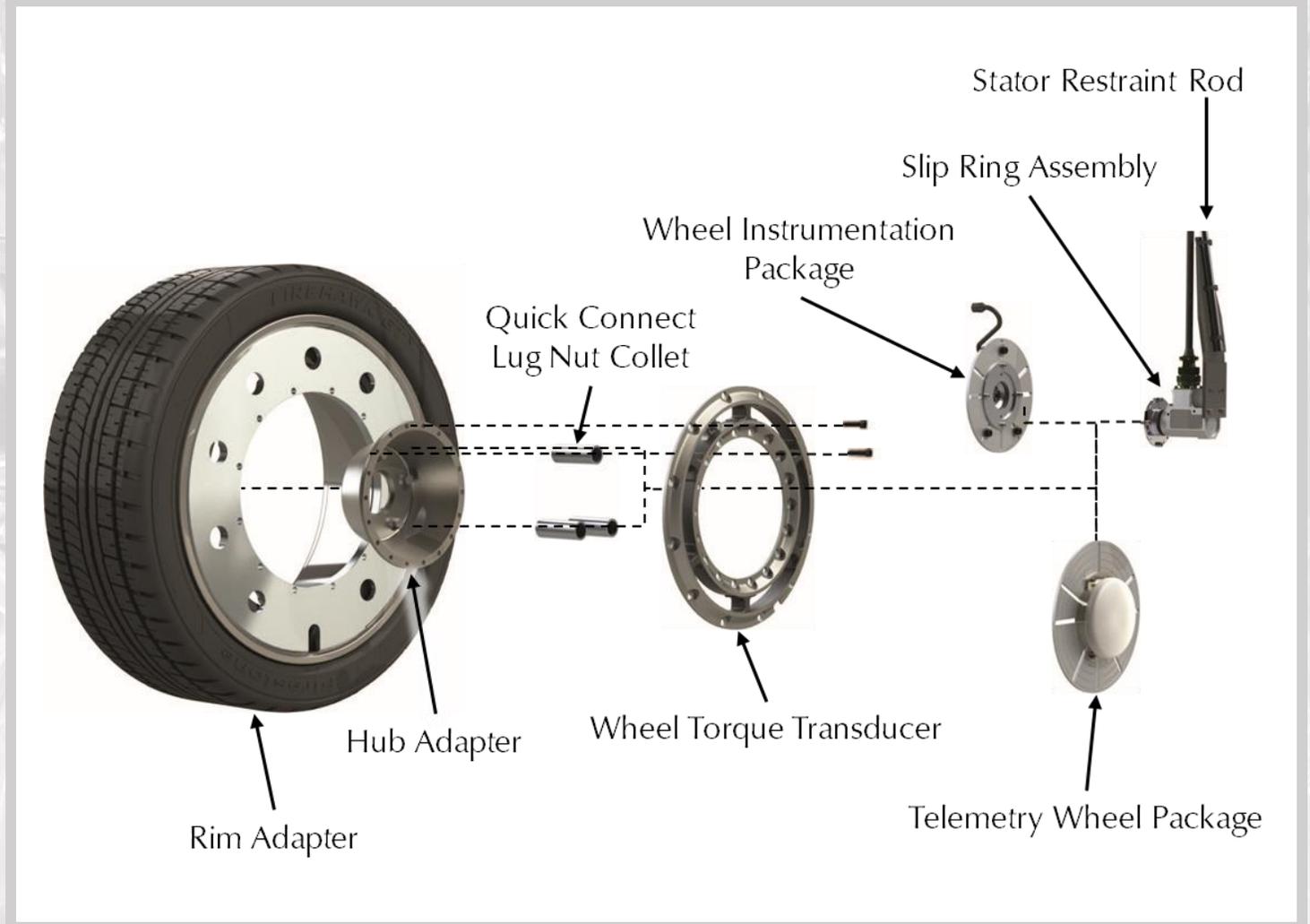


- Over 30 WFTs in rental fleet
- Many WFT models available to rent, including commercial vehicle models
- Rent to own program
- Fast delivery
- Many Adapters also available to rent
- Free Teams session training
- On-site support and RLDA service available
- Pre-assembly and site delivery available

# WFT Rental Program

# Wheel Torque Transducers

- High Accuracy (0.1% full scale)
- Weatherproof and temperature compensated
- 3-year warranty on transducers
- Slip ring with high resolution encoder or wireless telemetry packages available
- Optional thermocouple amplifiers



# High Resolution Wheel Torque Transducers

- Used for efficiency and powertrain testing
- Used in EU 2017/2400 Regulatory CO<sub>2</sub> Emissions and Fuel Consumption Testing
- Can measure aerodynamic drag, brake drag, tire rolling resistance, and bearing seal drag
- Analog and CAN output available



Commercial trucks  
(TWHR2000)  
1.0 N·m resolution

Car, SUV, Light Truck  
(TW12.8HRMS175)  
0.1 N·m resolution



# Instrumentation Slip Ring Assemblies

- Solder terminals and/or connectors
- Optional built-in encoders, frequency-to-voltage electronics, or integrated strain gauge/thermocouple amplifiers
- Available in 4-100 connections



# Slip Ring Assembly Types

End of Shaft Slip Ring Assembly

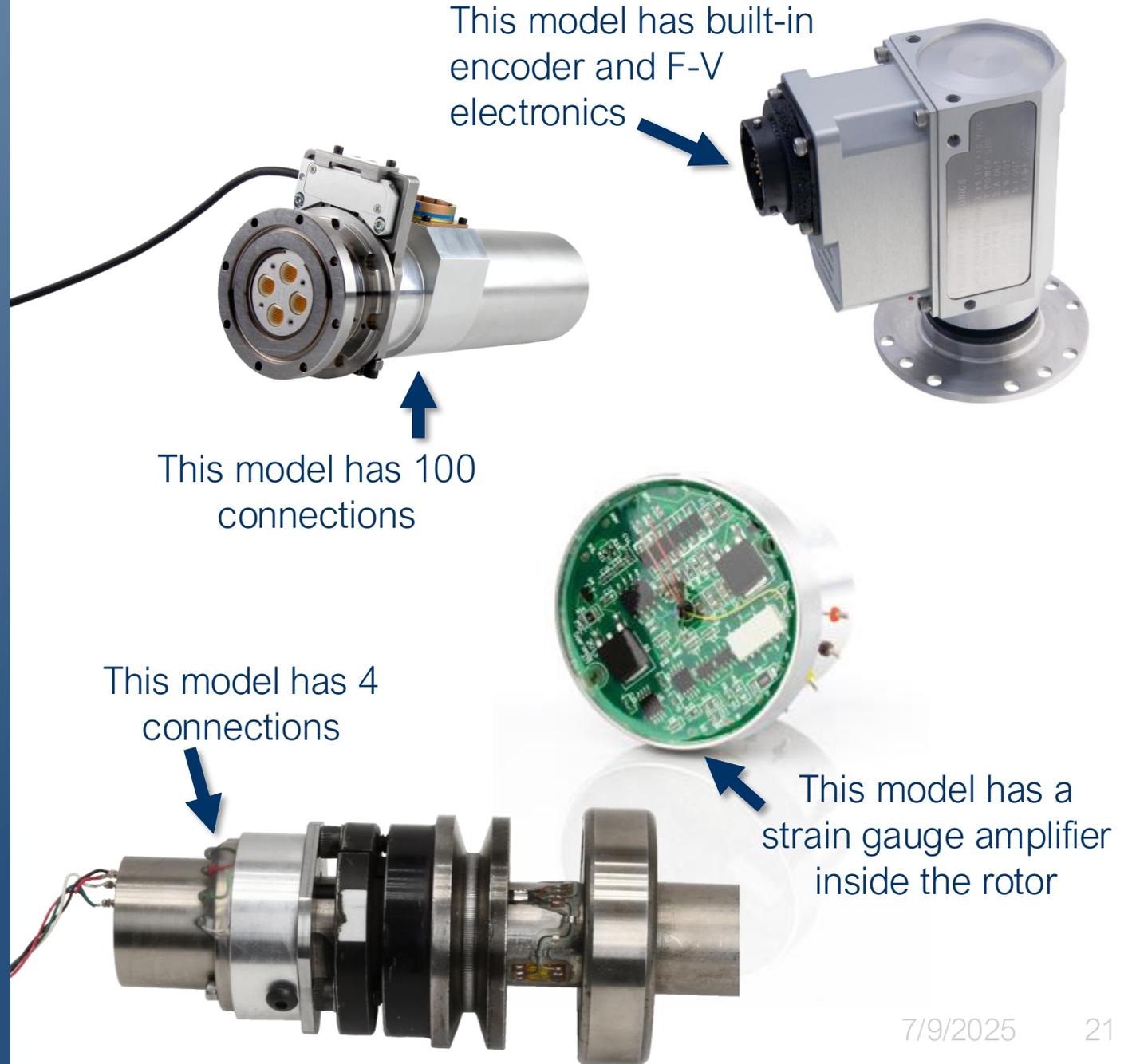


Tubular Slip Ring Assembly



# End of Shaft Slip Ring Assemblies

- Instrumentation quality rings and brushes
- Simple connection to sensors
- Many optional accessories and features
- No bandwidth limits
- Compatible with Ethernet & digital signals



Half shaft



## Tubular Slip Ring Applications: Shafts

- A tubular slip ring assembly can mount directly on a shaft
- Used to make electrical connections when measuring torque or temperature on the drivetrain



Prop shaft

# Signal Conditioning Amplifiers

## Signal Conditioning Amplifiers

- Michigan Scientific manufactures a variety of precision, low-noise differential amplifiers
- Dependable in noisy environments
- Located close to the spinning sensor for improved signal quality



## Amplifier Power and Control Box

- Use with any Michigan Scientific Signal Conditioning Amplifier
- A box can power and control 20+ amplifiers
- Remote shunt-cal and bridge- excitation-kill control



## Strain Gage Amplifier

- Stable bridge excitation voltage
- Adjustable gain and shunt-cal resistor
- Remote shunt-cal and bridge-excitation-kill control



## Thermocouple Amplifier

- Thermocouple models available with 2 or 3 channels (all TC types available)
- Built-in cold junction compensation
- Eliminates potential error associated with inserting a slip ring within a TC circuit



# Multiplexing Amplifier

- 12 channels amplified, digitized, and multiplexed
- 4 output connections, two for power, two for CAN/CANFD
- Pair with 4 connection slip ring for high channel count rotating applications
- Units are stackable and can be synchronized
- Measure up to 48 strain channels by stacking four MUX units
- Configuration and recording app included



## Quarter Arm Bridge Type

- 350 Ohm Bridge completion for all 12 channels
- 6 connectors, each one for 2 strain gauge connections.
- Straight of 90 degree mating connectors available

## Full Bridge and Thermocouple Type

- Each channel can be connected to either full strain gauge bridge or thermocouple
- 6 tinned lead connections each for 2 channels

# Wireless Telemetry Systems

- Strain gauge or thermocouple-based measurements
- Up to 8 channels
- Non-contacting digital wireless link
- Transmitter powered by induction or battery



# Clamping Telemetry

- Mounts to shafts 22mm and larger with plastic ties or metal banding
- CBT-mini & CBT-micro are IP67 designs that are proven in harsh off-roading
- Up to 25-hour battery life



## CBT-mini

1-channel or 3-channel options

## CBT-micro

Smallest design, 3 channels

## CIT

Induction powered

## CBT-mini on shaft



# High Speed Telemetry Package

- Proven high speed telemetry systems
- Inductively powered
- Bearing free design with no maintenance or wear parts
- Factor configurable for strain gauge or thermocouple
- No drop-outs or data spikes

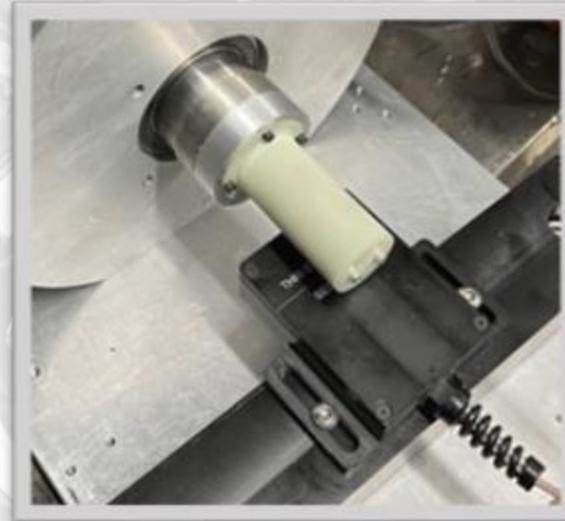


## T3

- Three signal inputs
- Proven to 24,000 rpm

## T8

- Eight signal inputs



# Standard Multi-axis Load Cells

Strain gauge-based transducers

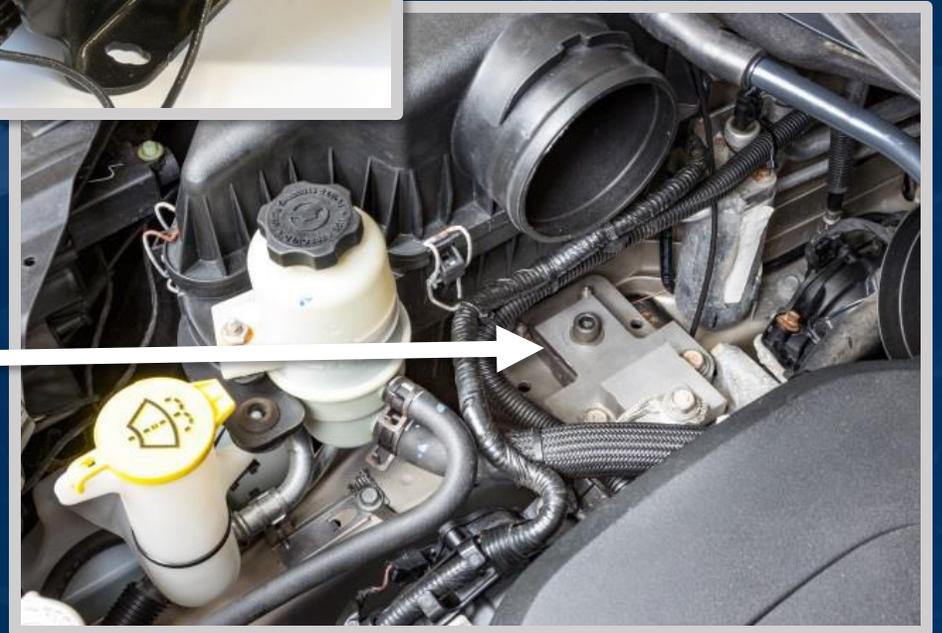
- For up to 6-directional force measurement at component surfaces
- Can be mounted in tandem to calculate roll, pitch, and yaw moments
- Available in capacities 250 lb (1,110 N) to 100,000 lb (444,000 N)

# TR3D Load Cell Applications

Michigan Scientific TR3D Three Axis Load Cells measure forces in three perpendicular directions



Bearing support mount loads



Engine mount loads

# TR3D Load Cell Hitch Force Measurements

TR3D Three Axis Load Cells combined with adapters for hitch mount forces

- Ball hitch adapters with TR3D-C-16K for trailer weights up to 6000 lb.
- Pintle hitch adapters with TR3D-C-40K for trailers up to 20,000 lb.



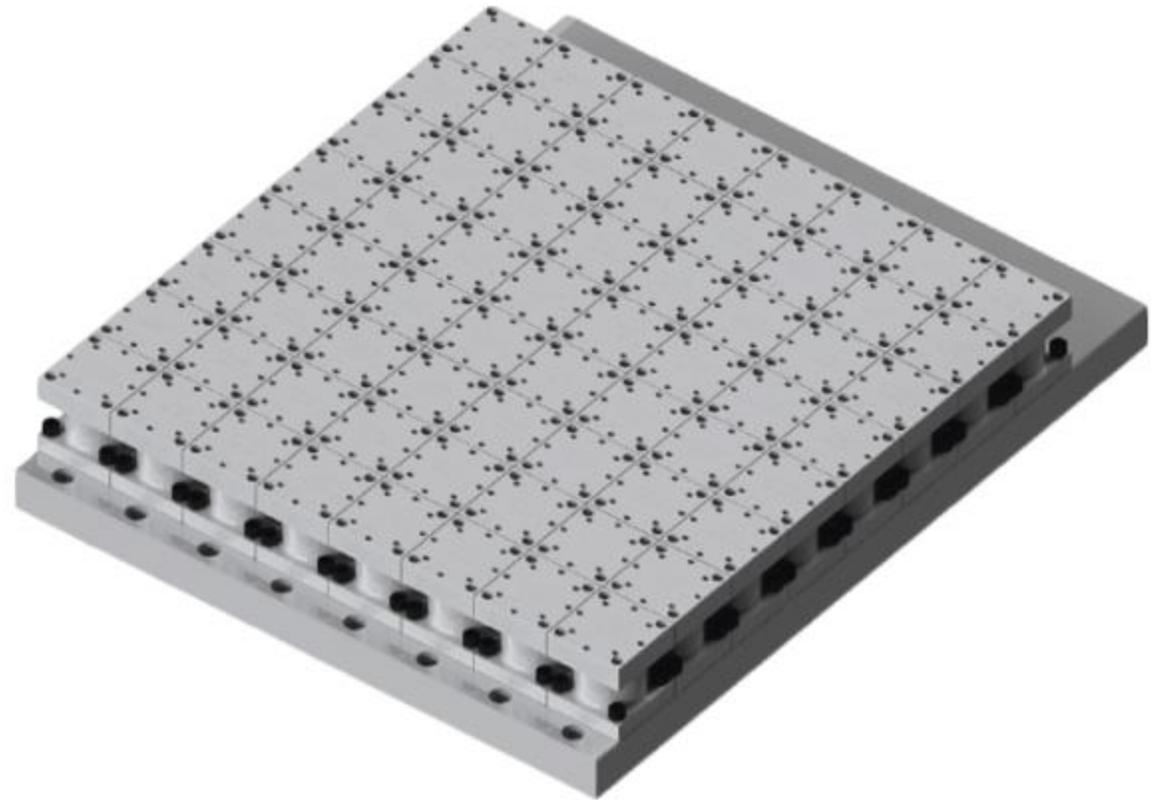
# Crash Barrier Load Cells

Tri-axial strain gauge-based transducers



CT500 & CT440

- Single Axis or Three Axis Load Cell
- Available in capacities of 500kN & 440kN
- Customizable size, load capacity, and number of axis



# Custom Multi-Axis Load Cells

Strain gauge-based transducers



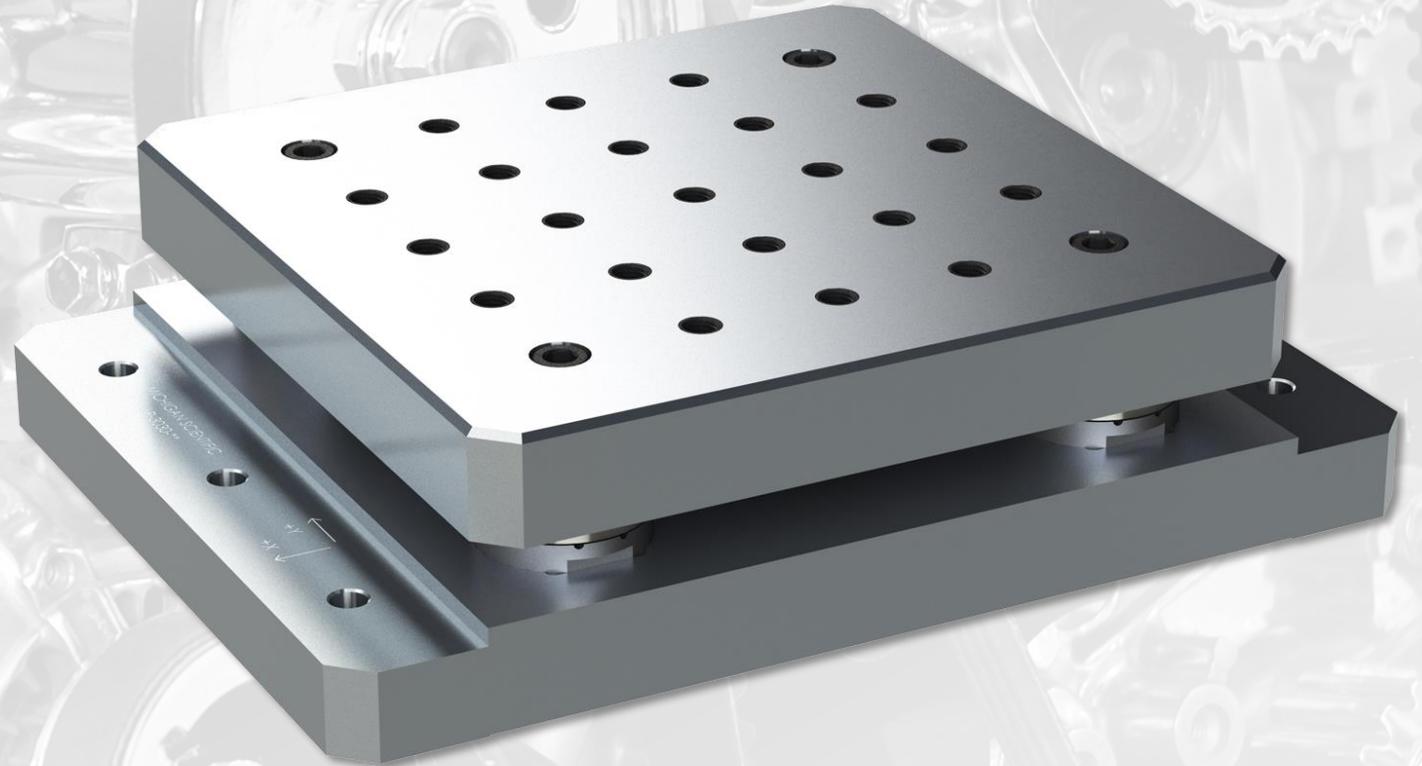
- 1-6 axis load cells
- Force capacity from 250 N to 667 kN
- Moment capacity from 100 N m to 203 kN m
- Design and manufacture custom load cells for any order quantity
- Available for different standards of weatherproofing



# Model LP-3030 Load Platform

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- Three load ranges: 3,400 lb (15 kN), 10,000 lb (45 kN), and 17,000 lb (75 kN)
- Universal mounting pattern
- Temperature compensated



# Brake Pedal Force Transducers

- 500 lb (2,200 N) capacity
- High accuracy for on- and off-center loading
- Fits standard brake pedals
- 3 standard sizes available



# Wheel Pulse Transducer (WPT)

Uses a rotation sensor to measure velocity, angular position, and direction of rotation

- Encoder wheel speed sensor
- Up to 5,000 ppr
- Up to IP67 weatherproof protection
- NIST traceable calibration



A close-up photograph of a silver alloy wheel with a black tire. A white, circular sensor assembly is mounted to the center of the wheel. The assembly features a central hub with a logo, several screws, and a yellow tag. A vertical metal rod is attached to the top of the assembly. The background is a plain white surface.

## WPT Applications

- Precision speed measurement
- Vehicle brake testing
- Distance measurement
- Map validation

# EC-LV

## In-line signal conditioner

- Used in conjunction with a WPT
- Frequency to voltage converter
- Angular position 0-360°
- Angular velocity
- Externally adjustable full-scale RPM and direction

# TrueSlip Side Slip Sensor

- Optically measures Slip Angle
- CAN Bus output
- Mounting kits for wheel or vehicle body available
- Works in variety of road conditions and all lighting conditions
- Designed to work with Michigan Scientific WFTs



# Steering Wheel Torque Transducer

## SW-SR2

- Measures steer effort torque, steering angle, and steering rate
- $\pm 1440$  degree high resolution encoder
- Analog & CAN signal outputs
- Easy Zeroing User Interface box
- Optional Heads Up display



## SW-TEL

- Measures steer effort torque
- Wireless system
- Easy installation



# Torque Flange Transducer

- Measures torque, speed, and position
- High accuracy and low noise
- Analog and CAN signal outputs
- IP67



# Power Take Off (PTO) Transducer

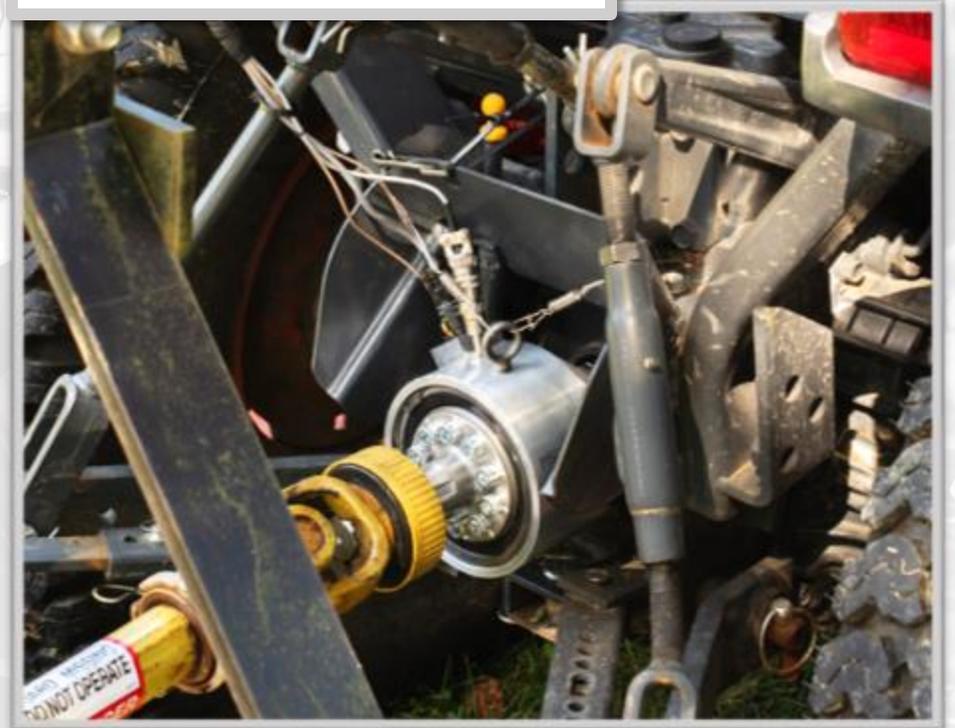
- Measures torque and speed between PTO spline & implement
- Robust, pre-calibrated designs
- Multiple standard spline sizes available

## PTO2

- Slip Ring based cost efficient design
- Use with DIGI-PTO for CAN output of torque, speed, & power

## PTO Telemetry

- Inductively Powered Telemetry
- Changeable spline ends
- Use with DIGI-PTO for CAN output of torque, speed, & power



# Fiber-Optic Signal Links

Monitor, stimulate, or control a device under test. Used for:

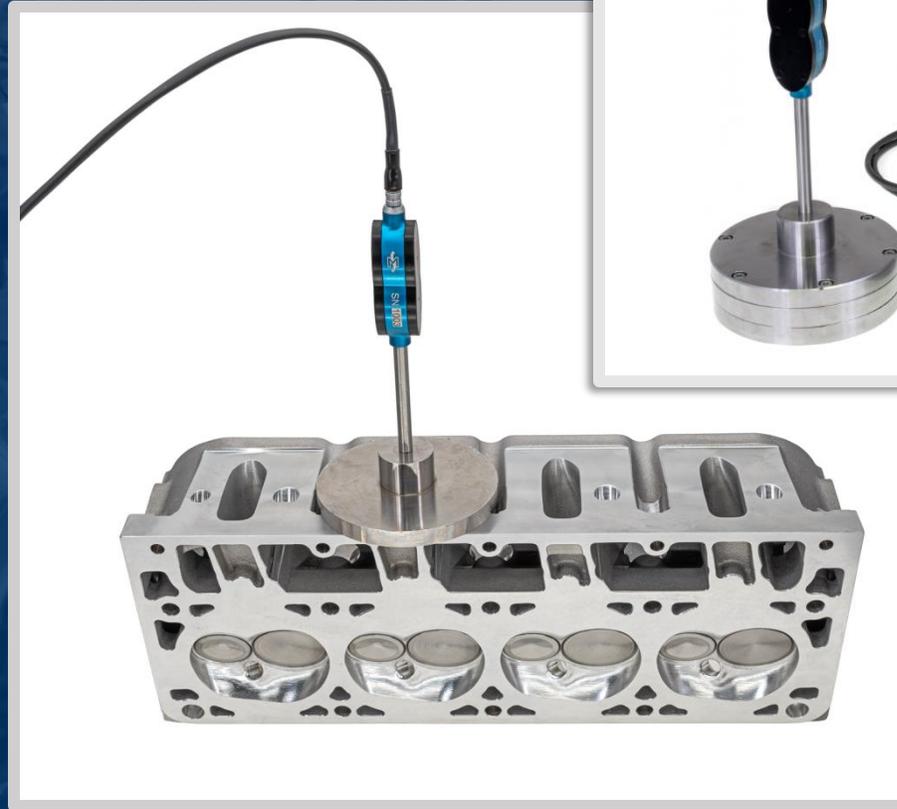
- EMI/RFI engineering and electromagnetic compatibility (EMC) certification
- EMC laboratory certification for the American Association for Laboratory Accreditation (A2LA) or the Automotive EMC Laboratory Recognition Program (AEMCLRP)



# Volumetrics

Used to:

- Measure cavity volume
- Measure compression volume
- Measure total volume
- Determine engine piston cylinder volume and compression ratios
- Locate top dead center



# Common Strain Gauge and Thermocouple Services

Michigan Scientific specializes in the design and manufacture of custom strain gauge or thermocouple transducers from prototype and production components. Common custom transducers include:

- Half Shaft | Torque
- Shear Pin | Two perpendicular forces
- Tie Rod End | Axial force
- Drive Shaft | Torque and Thrust
- Suspension Link | Axial Force
- Ball Joints | 2D & 3D Force
- Suspension Dampers | Damper Rod and Damper Clevis Force



# Specialty Strain Gauge and Thermocouple Services

Experts in gauging, Michigan Scientific can help obtain accurate measurements in difficult applications

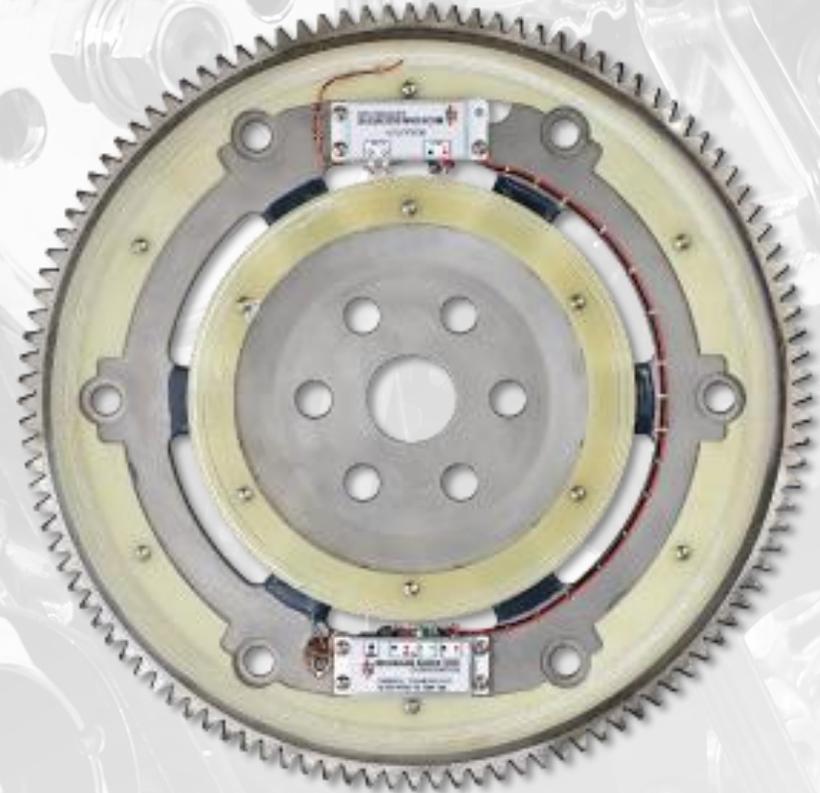
- Small components
- Noisy areas
- Limited spaces

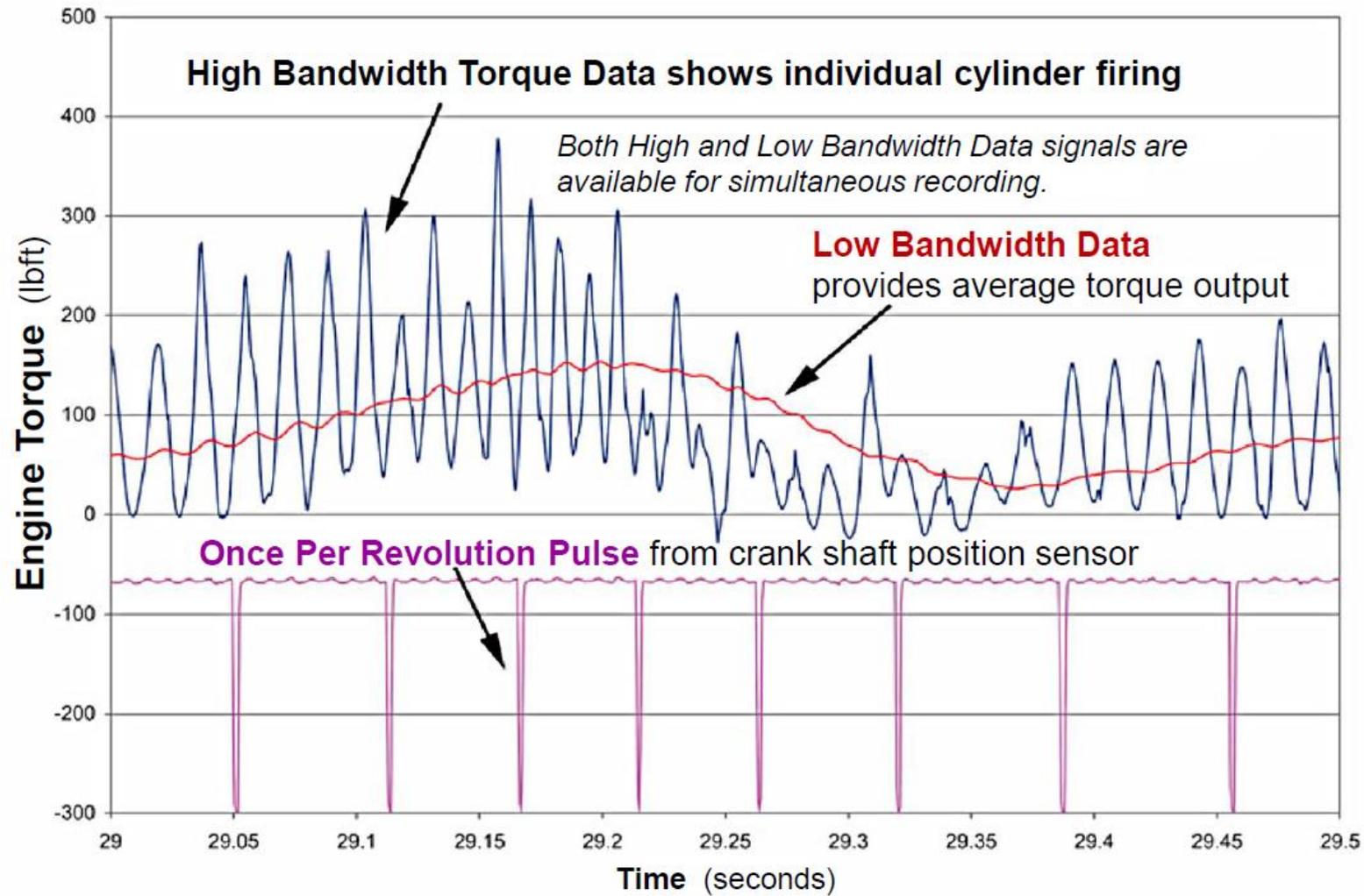


# Induction-powered Flexplate Telemetry System

Measures high-frequency dynamic engine torque input to transmission

- Induction-powered with autotune feature
- Custom engineered, built, and balanced for accurate measurements





# Telemetry Data from Flexplate Transducer

# On-site Data Acquisition and Analysis

Instrumentation and data collection experience

- Full vehicle instrumentation
- Data validation
- WFT and adapter rental
- Data acquisition rental
- Accelerometer and load cell rental with custom mounting

## Partial WFT Customer List



KATECH (South Korea) - 1999  
Daimler Chrysler (USA) - 1999  
NHTSA (USA) - 2001  
General Motors Truck Group (USA) - 2002  
Goodyear Tire and Rubber Company (USA) - 2003  
General Motors Vehicle Center (USA) - 2003  
Ford Motor Company (USA) - 2003  
Polaris Industries (USA) - 2004  
Arvin Meritor (USA) - 2004  
Honda (USA) - 2006  
Robert Bosch Corporation (USA) - 2006  
International Truck and Engine Company (USA) - 2006  
General Motors RLDA (USA) - 2007  
General Motors R&D (USA) - 2008  
General Motors PATAC (China) - 2008  
Lockheed Martin (USA) - 2008  
U. S. Army (USA) - 2008  
Harley Davidson (USA) - 2008  
CATARC (China) - 2010  
Link Engineering (USA) - 2010  
General Motors Holden (Australia) - 2011  
Proton (Malaysia) - 2011  
Club Car (USA) - 2011  
General Motors Technical Center (USA) - 2012  
CIMC (China) - 2012  
Nissan Technical Center (USA) - 2012  
FAW (China) - 2012  
SAIC (China) - 2012  
Meritor (USA) - 2012  
CNH (USA) - 2012  
SGMW (China) - 2013  
KingLong Bus (China) - 2013  
Volvo Truck (USA) - 2013  
BATC (China) - 2013  
SAF Holland (USA) - 2013  
Bombardier Transportation (USA) - 2013  
JAC (China) - 2013  
Shanghai University of Engineering & Science (China) - 2013  
KHAT (China) - 2013  
CNH (Italy) - 2013

Crown Forklifts (USA) - 2014  
Dongfeng Nissan (China) - 2014  
Doosan Bobcat (USA) - 2014  
Shanghai Huizhong Automotive Manufacturing Co., Ltd (China) - 2014  
MIRA (UK) - 2014  
Dicastal (China) - 2014  
HFUT University (China) - 2014  
Southeast Motors (China) - 2014  
PACCAR Trucks (USA) - 2014  
CAERI, Ltd Truck (China) - 2014  
WANAN (China) - 2014  
Dongfeng Renault Automotive Company (China) - 2015  
Bombardier Recreation Products (Canada) - 2015  
E-Z-GO (USA) - 2015  
Jianan Axle (China) - 2015  
SGMW (China) - 2015  
FAW R&D (China) - 2015  
ZF (USA) - 2015  
SAIC (China) - 2015  
GITI (China) - 2015  
CATARC Truck (China) - 2015  
General Motors PATAC (China) - 2015  
Renault (France) - 2015  
General Dynamics Truck (Canada) - 2016  
BYD (China) - 2016  
Nanjing Truck (China) - 2016  
Dongfeng (China) - 2016  
Cooper Tire (USA) - 2016  
Artic Cat (USA) - 2016  
GAC (China) - 2016  
Yutong (China) - 2016  
Geely (China) - 2016  
Changan Passenger Vehicles (China) - 2016  
Hyster Yale (USA) - 2016  
Ford (Australia) - 2016  
Hyundai Commercial Vehicles (Korea) - 2017  
General Dynamics Europe Truck (Switzerland) - 2017  
BJEV (China) - 2017  
Tesla (USA) - 2017  
Link Manufacturing (USA) - 2017

YIHE Axle (China) - 2017  
ZOTYE (China) - 2017  
BATC (China) - 2017  
BYD (China) - 2017  
BRP (Canada) - 2017  
SGMW (China) - 2017  
NTN Bearings (USA) - 2017  
Accuride (USA) - 2017  
ADD (Korea) - 2017  
Shougang (China) - 2017  
JIAT (Korea) - 2017  
Changan Commercial Vehicles (China) - 2018  
HUFT (China) - 2018  
JKS (Korea) - 2018  
Lvchi (China) - 2018  
Bucknell University (USA) - 2018  
HIT (China) - 2018  
FAW Passenger Vehicles (China) - 2018  
SWINS (China) - 2018  
BYD Trucks (China) - 2018  
Polaris Motorcycles (USA) - 2018  
TUOPU (China) - 2018  
Hyundai Passenger Vehicles (Korea) - 2018  
KITECH Heavy Equipment (Korea) - 2018  
Ford RLDA (USA) - 2018  
VOLVO Trucks (Brazil) - 2018  
BYTON (China) - 2018  
ZhaoQing (China) - 2019  
RIOH (China) - 2019  
Horiba MIRA (UK) - 2019  
iCAT (India) - 2019  
Mahindra Tractors (India) - 2019

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Charlevoix, Michigan  
231.547.5511

Milford, Michigan  
248.685.3939

[mscinfo@michsci.com](mailto:mscinfo@michsci.com)



# Thank You

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Charlevoix, Michigan  
231.547.5511

Milford, Michigan  
248.685.3939

[mscinfo@michsci.com](mailto:mscinfo@michsci.com)