ptc

DIGITAL TRANSFORMS PHYSICAL

Smart Connected Tire Platform

Manufacturers are reimagining tomorrow's mobility future from the ground up – literally – through smart tire technology.

BOSCH

WHITE PAPER

What do automobiles, trucks, tractors, motorcycles, bicycles, and airplanes all have in common?

A major component they share, among other things, is the use of tires. The tire is still important whether the vehicle is powered by a battery, hydrogen or carbon-based fuels. Despite seismic shifts in mobility, developments in powertrains, and the incorporation of software in cars, the tire continues to be the only component of vehicles that contacts the ground. And while tires move things from point A to B, they also play a critical role in safety, particularly braking.

Tires Matter

Most people do not think much about tires and what really happens when the rubber hits the road. At best, we give them occasional glances ("Does that tire look low?" or "How much tread is left?") and take them for periodic check-ups at the service center. Commercial and agricultural vehicles, on the other hand, require more detailed and regular inspections. However, these inspections are neither smart nor automated, and can be easily influenced by subjectivity.

There is a direct relationship between tire condition and accidents, vehicle handling, and fuel consumption. There is also a direct relationship between a tire and the vehicle it is installed on – while the vehicle manufacturer determines what the tire pressure should be, they do not determine what type of tire should be used. It is likely that the same make and model tire, on two different OEM vehicles, will have different pressure settings.

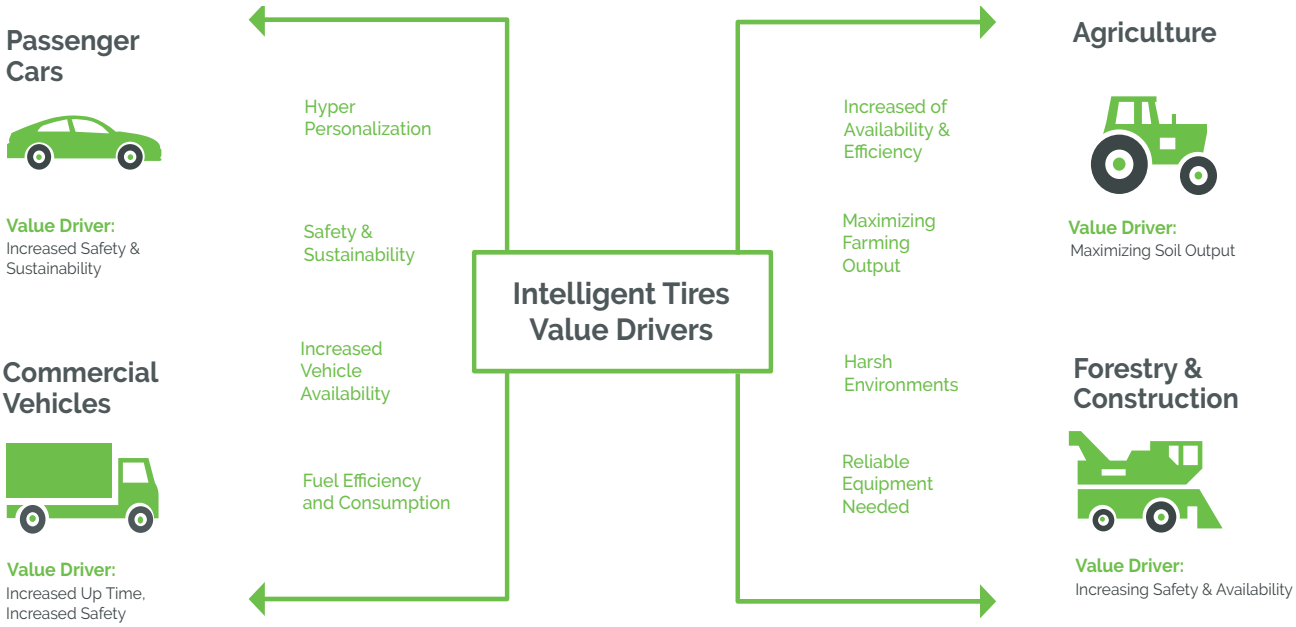
Tires also impact fleet Operating Expenses (OpEx) directly and indirectly through fuel efficiency and maintenance. According to the National Highway Traffic Safety Association (NHTSA), tires can impact OpEx by 10% to 15% in fleets. To put that in perspective, the average American family spends $5,000 annually on fuel for their vehicles. That means tire pressure alone influences between $500 to $750 of that cost. Multiply that by hundreds or thousands of vehicles for large fleets and you have a compelling financial impact. Additionally, discarded tires are a growing environmental concern as they are scrapped unless retreaded or used for alternative applications. Therefore, tires matter. However, not only do we lack a smart way to address these problems, but we also don't fully understand how to optimize these rubber components.

Significance of Smartness

Nearly 4 decades ago, companies started connecting critical capital assets for remote monitoring and support. It started with modems and gradually moved to the Internet where cost and performance enabled more use cases. This ultimately changed product design, as OEMs added software, sensors, error codes and internal diagnostics to aid in remote (and local) troubleshooting. Some refer to this as "smart," others as "intelligence." From the ingenious Bosch bell that alerted drivers of leaking air to RFID1 to the rudimentary Tire-pressure Monitoring Systems (TPMS), the concept of smart tires has come a long way, despite the variations in terminology.

While regulations have driven the adoption of TPMS, this was focused on safety and fuel economy concerns, not tire performance or next generation tire design. Thus, the true potential of smart connected tires is still being explored. It

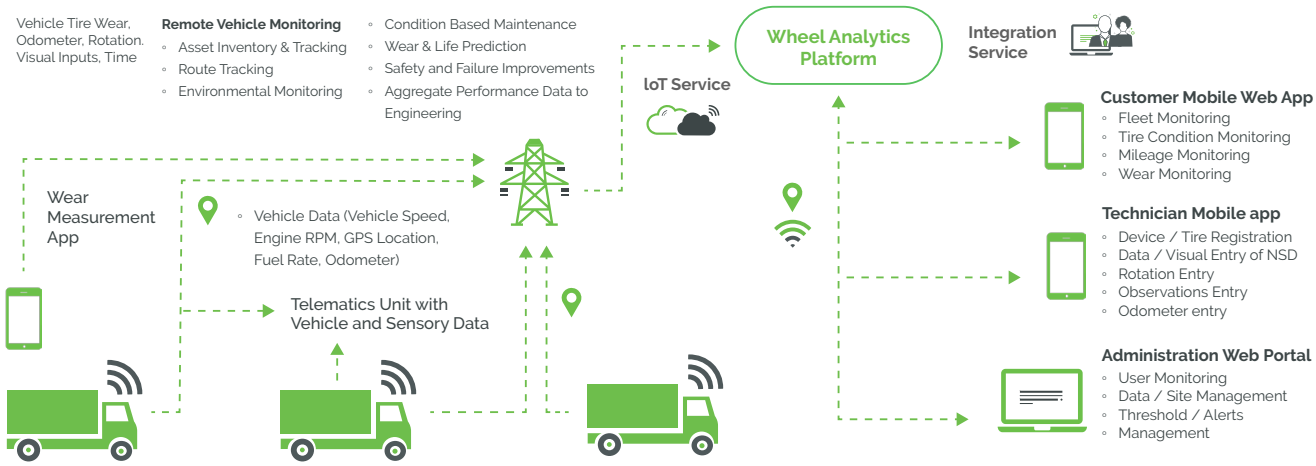
is not enough to only know the temperature or pressure; the rubber holds much more potential for smart technology. Additionally, smart connected tires could also offer cradle-to-grave alternative to ensure eco-friendly use at end-of-life.



From Sensing to Making Sense

A wide range of possibilities exists, such as preempting tire failure, prolonging tire life through optimization, measuring tire wear and tread depth, and determining vehicle alignment and load. Depending on who you ask, the depth, breadth, and value of these possibilities may vary. Major tire manufacturers, startups, and other innovators have realized that this potential is indeed feasible. Through sensor output and the deduction of contact patch patterns using machine learning algorithms, disruptive innovation is taking place. As a result, the tire's innovative potential is coming to life. Many industry leaders have made strategic acquisitions of telematics and fleet management service providers, recognizing that tire management is a key differentiator for future-proof fleet solutions.

Connected Tire Platform



A System of Systems

What about going beyond managing the safety and performance of a single vehicle?

From optimizing tire condition to streamlining the operations of systems of vehicles through vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) communication, tire technology can revolutionize road safety and traffic management. Software-defined vehicles (SdV) are already upending the mobility landscape and reimagining personalized customer experience at scale. Smart tires could be a key component application in the vehicle app stores with emerging use cases beamed Over-The-Air (OTA). While lidar, radar, and computer vision have played a significant role in enhancing vehicle autonomy, they cannot replace the sensory input of an experienced driver. Smart tires, however, can augment the visual cues with the sense of touch and feel that other components cannot see or hear. As smart tires continue to evolve, they will undoubtedly contribute to smarter, safer, cleaner, and more efficient mobility, transforming the way we drive, and eventually, the way we are driven.

Why now?

The early days of connected products focused on monitoring expensive, stationary assets that had a reasonable return on investment. There were many contributing factors behind that choice – connectivity was expensive and underpowered as the internet, wi-fi and cellular were in their infancy; computers were large and expensive; organizations were siloed, and data was quite literally hoarded and never even analyzed. Today, those technical, social, and even political barriers have been broken down in many industries and corporations. The age of the Digital Thread and Digital Twins, combined with ubiquitous and affordable connectivity and inexpensive computing power, has fueled a new wave of innovative thinking, and seemingly endless possibilities.

In the classic design model, we gather user information, hypothesize a design, turn that into a product we can build, and then test it. Depending on the product, we may perform unit- or system-level performance tests, maybe even leveraging tools like Highly Accelerated Life Testing (HALT). These tests, however, are limited by time to market constraints, budgets, resources and even our imaginations. Connected assets and tires expand this world of "testing" to the real world of everyday use – thus exposing us to driver, vehicle, weather, loading and road condition configurations we may not have envisaged or had the ability to recreate. Once we are aware of the scenarios, we can leverage simulation tools to test new ideas without ever building them. Even if the data does not expose new scenarios or variables, it provides statistically relevant data, with confidence levels we could never achieve on our own. While marketing groups focus on the "voice of the customer (VOC)," this is a "voice of the product" and "voice of the process" program which may validate the VOC but is independent of any possible bias the customer may have.

Benefits of connected product solutions:

Acquisition of product intelligence is the primary motivation of any connected asset solution. Such solutions bring in many benefits such as connectivity, visibility, alarms and alerts, as well as augmented remote assistance and a variety of other functionalities. Product intelligence comprises of two components: Service Optimization and Product Innovation.

The Service Optimization solution extends product capabilities by:

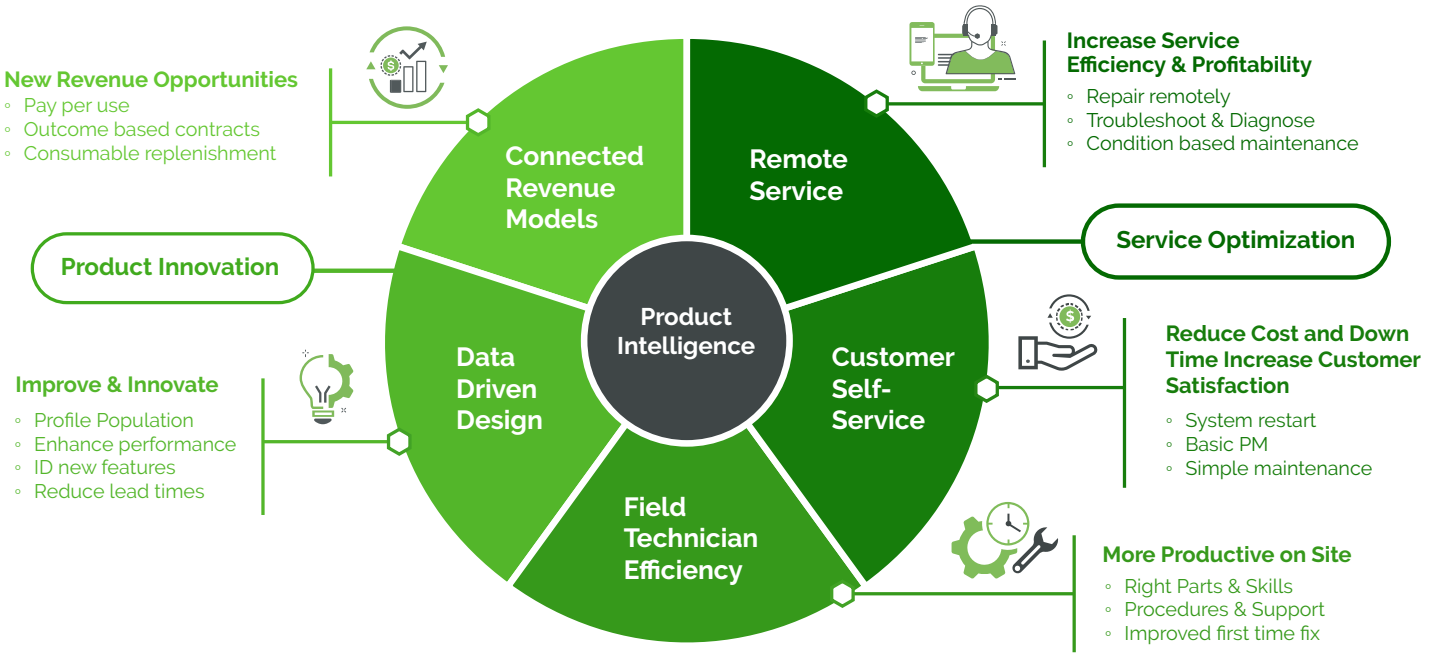
- Resolving issues without truck rolls by using remote service offerings
- Using customer self-service, which enables users to handle their own issues, speeding resolution and increasing satisfaction

With Product Innovation, the manufacturers can drive home the following benefits:

- More effective sales of consumables by knowing how customers are using the equipment
- Automated notices of when there is an opportunity for cross-sell and up-sell
- Product-as-a-service business models
- Greater project rollout visibility for engineering and R&D teams

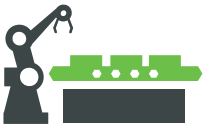
Connected product solutions allow all types of organizations to reduce their service costs and boost customer satisfaction. Smart connected tires offer a variety of value drivers for passenger cars, commercial vehicles, and agricultural, forestry, and construction equipment. The tire's intelligence opens the door for data-driven designs, connected revenue models, remote service, customer self-service, and field technician efficiency – all of which have the potential to provide significant financial impact at your organization.

Dimensions of a connected product solution:



Intelligent Tires Business Case

Exists across the value chain...



Tire Manufacturer

- Product Improvements
- Tire as Service Model
- Customer Retention
- Warranty Management
- Value-Added Services

Vehicle OEM

- Vehicle Dynamics
- Fuel Consumption
- Safety and Reliability
- Warranty Management
- Customer App

Dealers/ Retailers

- Customer Connect
- Value added Services
- Inventory Management
- Predictive Diagnostics
- Product Traceability

Consumer / Fleet Owner

- Diagnostic Information
- Fuel Consumption
- Tire Maintenance
- Safety and Alerts
- Insurance Premiums
- Road Conditions / State

Analytics at the Tractor Wheel

What to get out of Intelligent Agri Tires

Monitoring Use-Cases

- Pressure Monitoring
- Temperature Monitoring
- Speed Monitoring
- Active an Idle Monitoring
- Shock Monitoring
- Accelerated Events Monitoring
- Breaking Events Monitoring

Factors Influencing Tyre Health

- Driver Behavior Monitoring
- Improper Loading of Tires
- Axel Load Monitoring
- Tire Traction Monitoring
- Tire Alignment Monitoring
- Tire Load Monitoring
- Tire Uneven Loading

Fuel Consumotion Monitoring

- Incorrect Pressure vs. Loading
- Uneven Distribution of Load
- Uneven Pressure in Gradients
- Tires with Failures
- Driving in Gradients and Bad Roads
- Engine ON During Idle

Parameter Relationship Monitoring

- Pressure vs. temperature Monitoring
- Load vs. pressure relationship Monitoring
- Tire speed vs. load Monitoring
- Tire speed vs pressure Monitoring

Tire Lifetime & Soil Outout

- Low pressure and high load
- High pressure and no load
- Soil compaction & traction
- Wear progression vs. mileage
- Early warning of failure detection

Factors Influencing Tire Wear

- Driver habits
- Incorrect pressure distribution
- Misalignment of tires
- Uneven tire loading

PTC Profile

PTC, based in Boston, is an industrial software company with more than 6,000 employees. PTC provides customers with computer-aided design (CAD), product lifecycle management (PLM), Internet of Things (IoT) and augmented reality (AR) solutions that create a digital thread of information across business units such as Engineering, Manufacturing and Service, enabling closed-loop feedback throughout the lifecycle of a product. For instance, PTC's ThingWorx IoT platform and solutions help companies connect both products and assets as they are being used or as they are being built in the factory.

Accelerating your digital transformation takes more than just the right industrial Internet of Things (IIoT) platform. You also need pragmatic applications of technology that will make an impact on your business. PTC customers use our IIoT products to address proven use cases—building a repeatable roadmap for success. With offerings for Manufacturing and Service, PTC's IIoT solutions help address a variety of concerns such as operational efficiency, workforce productivity, remote condition monitoring, and predictive maintenance.

Industrial IoT for Manufacturing: PTC's manufacturing solutions help organizations unlock new levels of innovation, productivity, and growth through various continuous improvement strategies. Keep pace with competition by reducing operational costs by up to 12%, improving asset efficiency by up to 50%, and maximizing revenue growth by cutting lead times, lot sizes, and time to market.

Industrial IoT for Service: Today, field service departments face many challenges, including increasingly difficult service level agreement terms, worker shortages, and inconsistent technician experience levels. PTC's service solutions help organizations improve first-time fix rates, reduce truck rolls, and maximize customer satisfaction – the perfect mix to reduce the cost of service and help accelerate the productivity and efficiency of service technicians.

Bosch profile

Bosch Software and Digital Solutions (Bosch SDS), a Bosch Group company, is a global provider of consulting, engineering, digital transformation, and IT services. Led by a vision of strong customer centric approach towards enterprises around the globe, Bosch SDS aims to "Accelerate the Digital World" led by themes of Building Resilient Enterprise, Scaling sustainability and Remodeling business for its customers, to achieve shorter product development cycles, improve operational and energy efficiencies, deliver greater customer experiences to their end consumers, and build new business models through our products, solutions and services.

Bosch SDS operates in the regions of North America, Europe, UK, Japan, Middle East and Asia Pacific markets through a network sales offices in the markets and on-shore, near shore and off-shore delivery centers.

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