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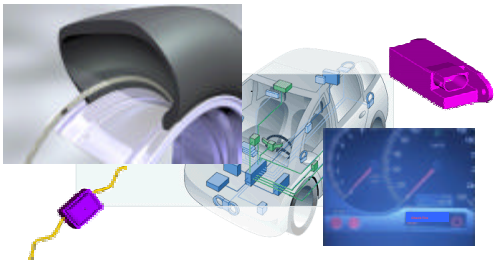
Tireguard 2nd Generation
or
Talking Tires - the basis for tire diagnostic systems



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Tireguard 2nd Generation
Agenda

- The need for tire pressure monitoring systems
- Overview tire pressure monitoring systems
- Requirements for 2nd generation systems
- Realization: Tireguard 2nd Generation / Tire IQ
- Development status

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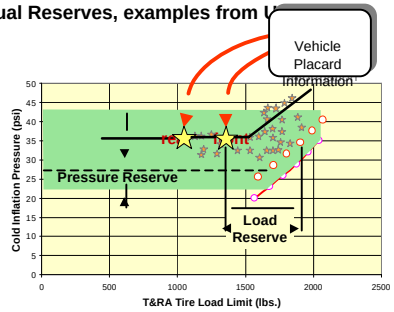
Need for Tire Pressure Monitoring Systems
Actual Reserves, examples from U



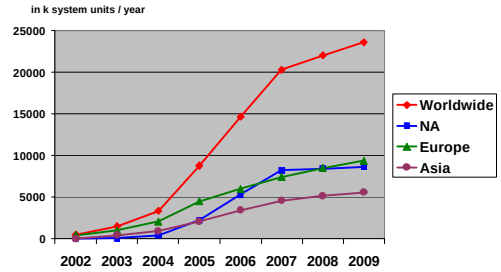
Source: Goodyear Tire and Rubber Company

Need for Tire Pressure Monitoring Systems
No more feeling for tire pressure loss

Loss of feedback from tires due to

- High quality suspension systems
- Application of “Runflat” tires

Need for TPMS Worldwide and Regional Systems Market



Source: Strategy Analytics

Realization of tire pressure monitoring systems

Indirect measuring systems

- ABS based systems

Direct measuring active systems

- Energy “on board” (e.g. battery)
- Valve or rim mounted

Direct measuring passive systems

- Batteryless
- Tire or rim/valve mounted

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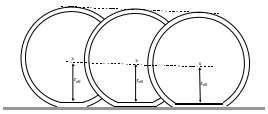
Indirect Tire Pressure Monitoring Systems

ABS based systems



- Uses ABS wheelsensor signals
- Evaluates the differencies in effective tire radius
- No effect if pressure loss is the same at all 4 tires
- Needs re-calibration after tire change or after inflation
- Low cost at low accuracy

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Direct Tire Pressure Monitoring Systems Active system

Example for valve mounted system

- Battery integrated
- Activated by accelaration sensor
- Periodical transmission of tire pressure and temperature
- Tire localization needs additional HW

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Direct Tire Pressure Monitoring Systems Passive system

Example for passive tire mounted system

- Batteryless
- Data query on demand
- Bi-directional communication
- 360° read, parking mode
- Storage of data in tire, tire history

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System requirements
1st generation (Active) and 2nd generation (Passive)

- Tire pressure and temperature measurement
- Tire localization
- Tire identification - RFID
- Easy system mounting at OEM
- Easy system initialization
- Reading / writing of data in any wheel position and at every speed
- Special functions
- Open standard - competitors should be able to deliver components

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System requirements
1st generation (Active) and 2nd generation (Passive)

- **Tire pressure and temperature measurement**

Pressure measurement	
• **range:**	1.0 ... 7.0 bar
• **accuracy:** (0°-50°C range:	+/- 150mbar +/- 75mbar)

Temperature measurement	
• **range:**	-40°...+125°C
• **accuracy:**	+/- 3K

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System requirements
1st vs. 2nd generation

- Tire pressure and temperature measurement
- **Tire localization**

1st generation	2nd generation
• **Additional LF hardware for wheel unit inquiry** • **Evaluation of RF field strength due to wheel positioning**	• **implicit localization due to individual tire interrogation**

System requirements
1st vs. 2nd generation

- Tire pressure and temperature measurement
- Tire localization
- **Tire identification - RFID**

Storing and reading of tire specific data

1st generation	2nd generation
• **Not possible, sensor is fixed on valve or rim**	• **always assured (Tire Tag is part of the tire)**

Tire ID Data Storage

- Identification numbers: tag, tire, and vehicle
- Tire data: DOT, ECE, Size, Symmetry, profile code, tire type, convenience data (load rating, speed rating, …
- Customer Part number: tire index, rim index, TPWS/TPMS index

- ROM area
- Read/Write memory area
  Volatile and Non-volatile memory area on tire tag - data can be overwritten
- Flexible arrangement of tire data
- Data can be written by Read/Write devices in production process or by base stations of vehicle

Generation 2 system is optimized for
“On - Vehicle - Read” of tire identification data

- Tag ID Read/Write provided through vehicle system
- Tire / vehicle association possible on assembly line
- No additional reader needed

- Tire tag Read Write possible through non vehicle readers
- Unmounted tire have much longer range
- ID only mode will conform to the data standard developed for tire RFID

System requirements
1st vs. 2nd generation

- Tire pressure and temperature measurement
- Tire localization
- Tire identification - RFID
- **Easy system mounting at OEM**

1st generation	2nd generation
• Sensor has to be mounted by OEM on valve or rim • Logistic and quality challenge	• As sensor is part of the tire, no mounting process at OEM

System requirements
1st vs. 2nd generation

- Tire pressure and temperature measurement
- Tire localization
- Tire identification - RFID
- Easy system mounting at OEM
- **Easy system initialization**

1st generation	2nd generation
• Barcode or LF initialization at EOL • Sensor ID provided by system supplier	• ECU controlled automatic initialization at end of vehicle production line

System requirements
1st vs. 2nd generation

1st generation	2nd generation
• **Writing is not implemented** • **Additional hardware needed to read pressure when vehicle is parked**	• **Implemented** • **Data query on demand, ECU and driver controllable**

- **Reading / writing of data in any wheel position and at every speed**
- Special functions
- Open standard - competitors should be able to deliver components

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System requirements 1st vs. 2nd generation

Only 2nd generation

- **Battery less = passive system**
- **Read / write on demand**
- **Storage of vehicle specific data**
- **Tire Service History**
- **Run Flat surveillance**

- Reading / writing of data in any wheel position and at every speed
- **Special functions**
- Open standard - competitors should be able to deliver components

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System requirements 1st vs. 2nd generation

Standardization of

- LF physical layer
- ECU - transceiver interface
- data protocol
- Tire Ident storage

- Reading / writing of data in any wheel position and at every speed
- Special functions
- **Open standard - competitors should be able to deliver components**

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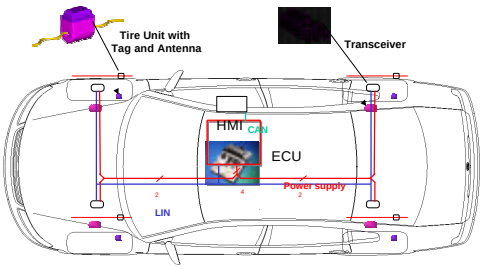
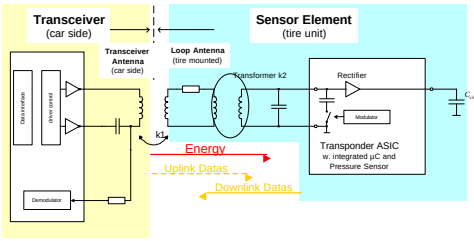
System overview



One system consists of 4 Tire Units, 4 Transceivers and interface to existing ECU

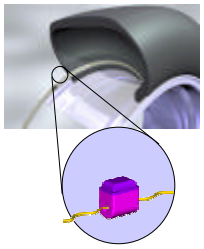
Communication Principle



- Reliable Transponder technology used for bi-directional communication
- Additional transformer needed to ensure communication under all conditions

Tire IQ Tag
Sensors as integral part of the tire

- Mounting before or after curing
- Designed for extreme mechanical stress and hostile environment
- Designed to accommodate production electronics



Weight of Tire Tag
approx. 6g

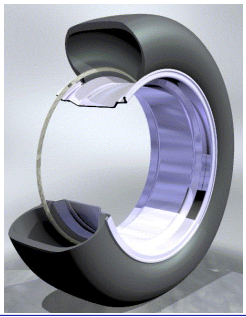
Tire IQ technology: antenna

360 Degree Antenna

Dictated by system requirements:

- Power-on read in any wheel position
- Continuous power and read in-service (speed independent)

Durable tire compatible materials



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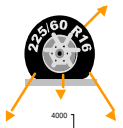
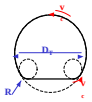
Acceleration on the Tire surface

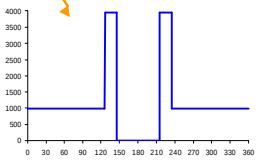
Calculation based on simplified assumptions

The circumferential speed vc has to be constant





$$g = \frac{v_c^{\,2}}{r \cdot 9{,}81}$$



Tire	195 / 65 R15			
Speed	200 km/h	= 124 mph	G-Force Tire	992
Radius	80 mm	= 3,14 inch	G-Force Radius	3933

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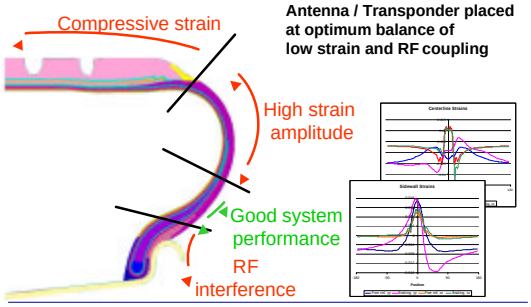
Tire antenna positioning



Antenna / Transponder placed at optimum balance of low strain and RF coupling

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IQ Tire communication

On vehicle

Off vehicle

Conveyer mounted reader

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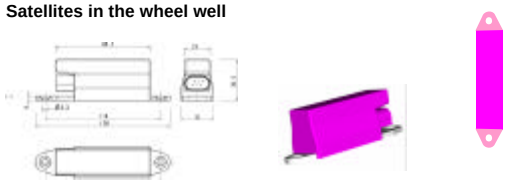
Transceiver
Satellites in the wheel well



Mechanic dimensions
Length 128mm / Width 30 / height 38,5 mm

Weight approx. 140g

- Fixed on suspension
- Watertight housing
- Integrated connector
- Generic design

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Joint Development

Targets:
- Tire IQ: Tire Guard electronics embedded in the tire
- Batteryless system
- Development of communication channel for future tire diagnostics

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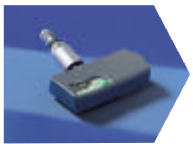
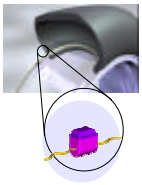


Electronic Competence



GOODYEAR

Tire Competence

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Tire IQ

RFID

LPWS

Batteryless
Standard valve
Bidirectional comm.
on demand

Tire IQ

Logistics	TREAD Act	Sensor Output	Service	Vehicle	Customer
• Inventory • Shipping • Receiving	• DOT • VIN	• Pressure • Temperature • Localization	•Runflat miles •Total mileage •Diagnostics	• Load, speed • Summer vs. Winter	TBD

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Integrated Tire Monitoring System
From *Tire Guard* to *Talking Tires*

Development Status

- **Communication principle is validated**
- **Extended tire and driving tests at Goodyear confirm mechanical concept**
- **ASIC development ongoing**
- **SOP scheduled end 2005**

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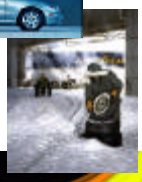
Tire testing - Tire Performance

Tire performance testing
- Ride
- Handling
- Vehicle limit handling

No reduction of tire performance



Tire uniformity testing
- High and low speed
- Radial and tangential force variation

No measurable effect

Balance
- Static
- Dynamic couple

Small effect (tag mass 6 grams)

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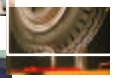
Tire testing - Tire durability

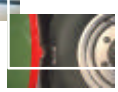
Standard tire durability tests confirm ring has no influence on durability

> 2,000,000 km of testing within the last year.



Transponder / antenna survive standard tire durability tests

Tested in conventional and EMT (self supporting runflat) tires



Tested in tires from multiple manufacturers

Tire IQ™ Validation

Full tire release testing plus ring specific tests (200 tires total)

Conventional (225/60R16), EMT (225/60R16), low aspect (225/45R17)

High mileage tests on drum and on vehicle

- 72,000 km, 36 million cycles
- Aged tire high mileage tests

– High speed test (290 km/hr), high slip angle test (10°)

– High deflection tests

- Bead durability (185% overload), beat unseat
- Limit handling on vehicle closed course
- 0 pressure runflat mileage (EMT tires)

– Impact tests

- Radial and horizontal plunger, curb scuff, cleated wheel

– Low temperature test

- Frozen to -51C, driven until warmed, repeated

– Field testing

- Mixed conditions in NA and EU

System Field Testing

Akron to Troy, reading every 2 seconds