



Fyzik ve firmě Continental Automotive

Masarykova Universita, Brno

16.11.2011

Jan.Hradil@continental-corporation.com

Continental 

Program přednášky



- ▶ Představení firmy Continental – autodíly a pneumatiky



- ▶ Které typy problémů je potřeba řešit

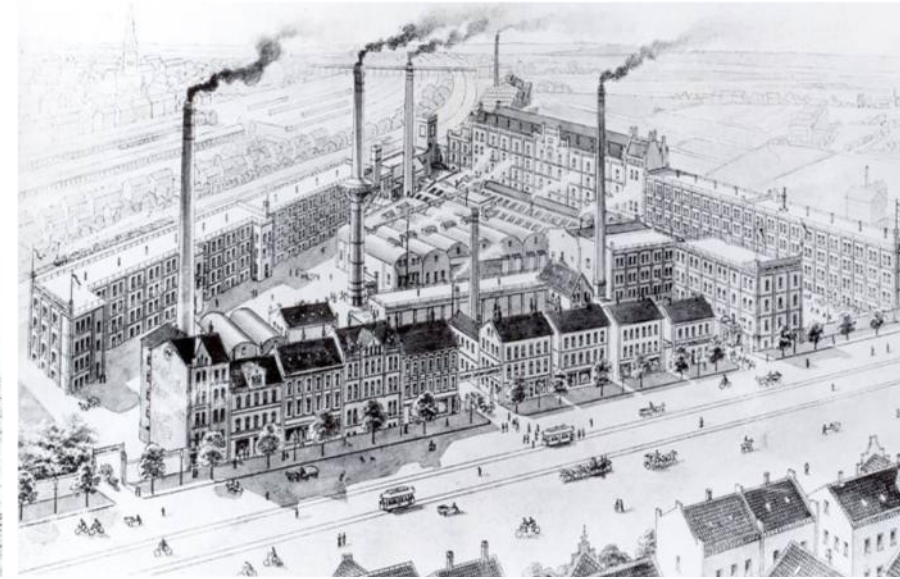
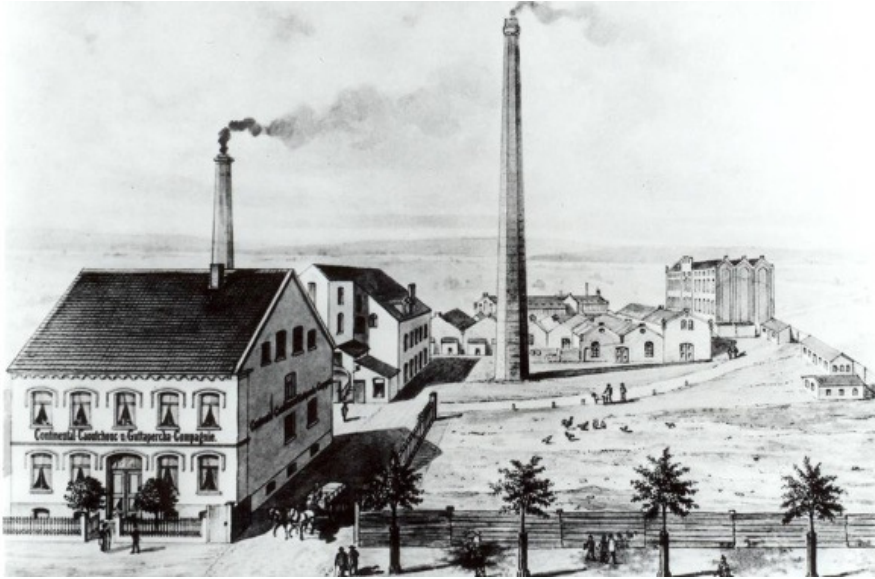


- ▶ Několik praktických příkladů



Continental Corporation

140 Years of Innovation and Progress



1871-1900

1901-1930

1931-1960

1961-1990

1991-2011

Spirit of Optimism

- ▶ Continental-Caoutchouc- & Gutta-Percha Compagnie is founded in Hanover on October 8, 1871, as a joint stock company.
- ▶ Manufacturing includes rubberized fabrics, solid tires for carriages and bicycles, as well as soft rubber products.



Continental Corporation

140 Years of Innovation and Progress



1871-1900

1901-1930

1931-1960

1961-1990

1991-2011

Inventive Spirit

- ▶ Merger with major companies of the German rubber industry to form Continental Gummi-Werke AG.
- ▶ Invention of the detachable rim and automobile tires with a patterned tread; first flight across the English Channel with a plane equipped with Continental Aeroplan material.



Continental Corporation

140 Years of Innovation and Progress



1871-1900

1901-1930

1931-1960

1961-1990

1991-2011

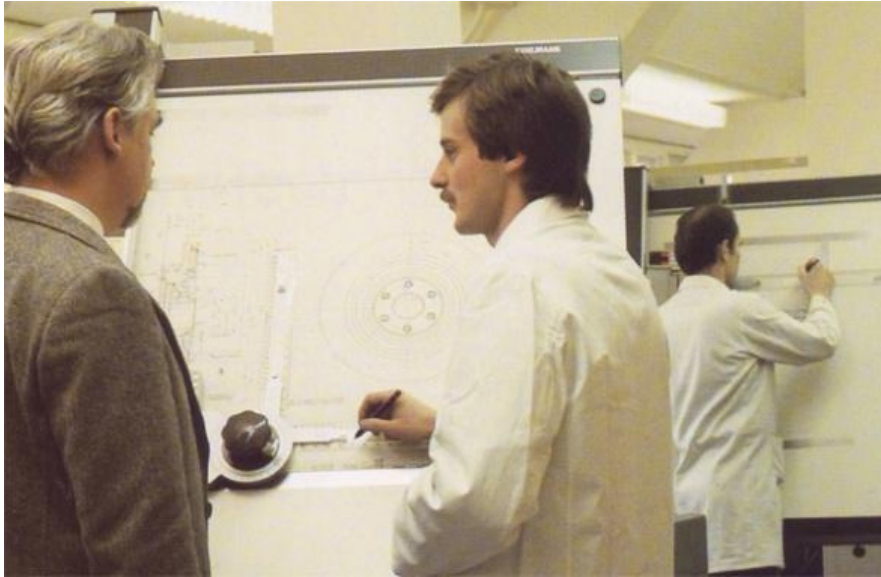
Racing Success

- ▶ Vehicles with Continental tires win numerous international races.
- ▶ Production of engine mounts, steel cord conveyor belts, air springs and radial tires begins.



Continental Corporation

140 Years of Innovation and Progress



1871-1900

1901-1930

1931-1960

1961-1990

1991-2011

Internationalization

- ▶ Business is expanded in Europe and America with acquisitions and the establishment of international joint ventures.
- ▶ The first studless winter tire is launched.
- ▶ Polyurethane gaiters and hydromounts are supplied to the automotive industry.



Continental Corporation

140 Years of Innovation and Progress

Driving safety
Driving assistance
Chassis dynamics
Systems for the powertrain
Systems for hybrid and electric drives
Infotainment and multimedia
Telematics and instrumentation
Tires and extended mobility systems
Technical elastomer products
Vibration damping and noise optimization



1871-1900

1901-1930

1931-1960

1961-1990

1991-2011

Automotive supplier

- ▶ One of the top five in the global automotive Supplier industry since 2007
 - ▶ The first environment-friendly passenger tire is launched
 - ▶ Introduction of the key technology for hybrid drive systems
-



Continental Corporation

6 Strong Divisions

Chassis & Safety	Powertrain	Interior	Passenger and Light Truck Tires	Commercial Vehicle Tires	ContiTech
Electronic Brake Systems	Engine Systems	Instrumentation & Driver HMI	Original equipment	Truck Tires, EMEA	Air Spring Systems
Hydraulic Brake Systems	Transmission	Infotainment & Connectivity	Repl. Business, EMEA	Truck Tires, The Americas	Benecke-Kaliko Group
Sensorics	Hybrid Electric Vehicle	Body & Security	Repl. Business, The Americas	Truck Tires, Asia Pacific	Conveyor Belt Group
Passive Safety & Advanced Driver Assistance Systems (PSAD)	Sensors & Actuators	Comm. Vehicles & Aftermarket	Repl. Business, Asia Pacific	Industrial Tires	Elastomer Coatings
Chassis Components	Fuel Supply		Two-Wheel Tires		Fluid Technology
					Power Transmission Group
					Vibration Control
					Other Operations

Status: December 31, 2010



Continental Corporation

193 Production and R&D Locations in 37 Countries

Europa

Austria
Belgium
Finland
France

Germany*
Greece
Italy
Portugal

Spain
Sweden
Switzerland
UK

Czech Republic
Hungary
Romania
Russia

Serbia
Slovakia
Turkey

North America

Canada
Mexico
USA

South America

Brazil
Chile
Ecuador

Asia

China
India
Japan
Malaysia
Philippines
Singapore
South Korea
Sri Lanka
Thailand

Africa South Africa
Tunesia

Australia

*Headquarters in Hanover

Status: January 1, 2011



We Shape the Megatrends in the Automotive Industry

Safety, Environment, Information, Affordable cars



Continental Corporation

Key Figures for 2010

	2010	2009
Sales	€26.0 billion	€20.1 billion
EBIT*	€1,935.2 million	-€1,040.4 million
Adjusted EBIT**	€2,516.8 million	€1,180.5 million
Employees	148,228	134,434

*Earnings before interest and taxes.

**Before amortization of intangible assets from PPA, changes in the scope of consolidation, and special effects.



Powertrain Division

Lower emissions. More driving pleasure.



Business Unit Sensors & Actuators

Customers Portfolio: Automotive Manufacturers



Continental Frenštát pod Radhoštěm

senzory – výroba / vývoj

▶ Vyrábí jak elektroniku pro automobily (např. řídicí jednotky),
tak i senzory, především:

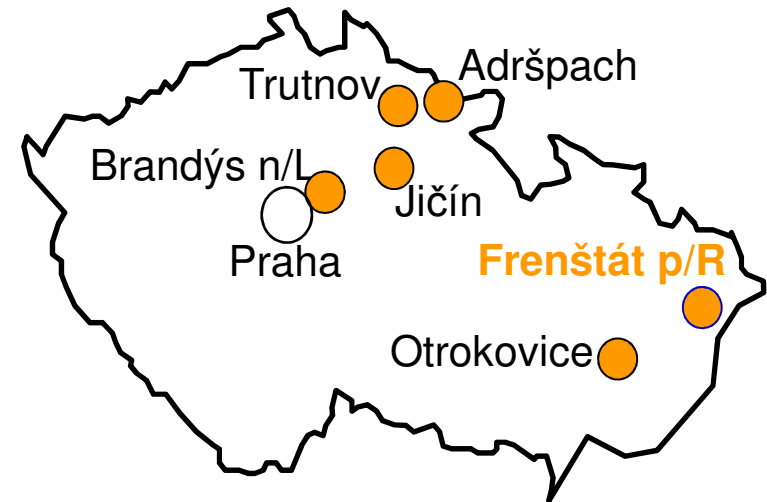
▶ Hladinové senzory

▶ Teplotní senzory

▶ Rychlostní senzory

▶ Připravuje se výroba tlakových senzorů

▶ Některé typy senzorů se ve Frenštátě p. R. i vyvíjí



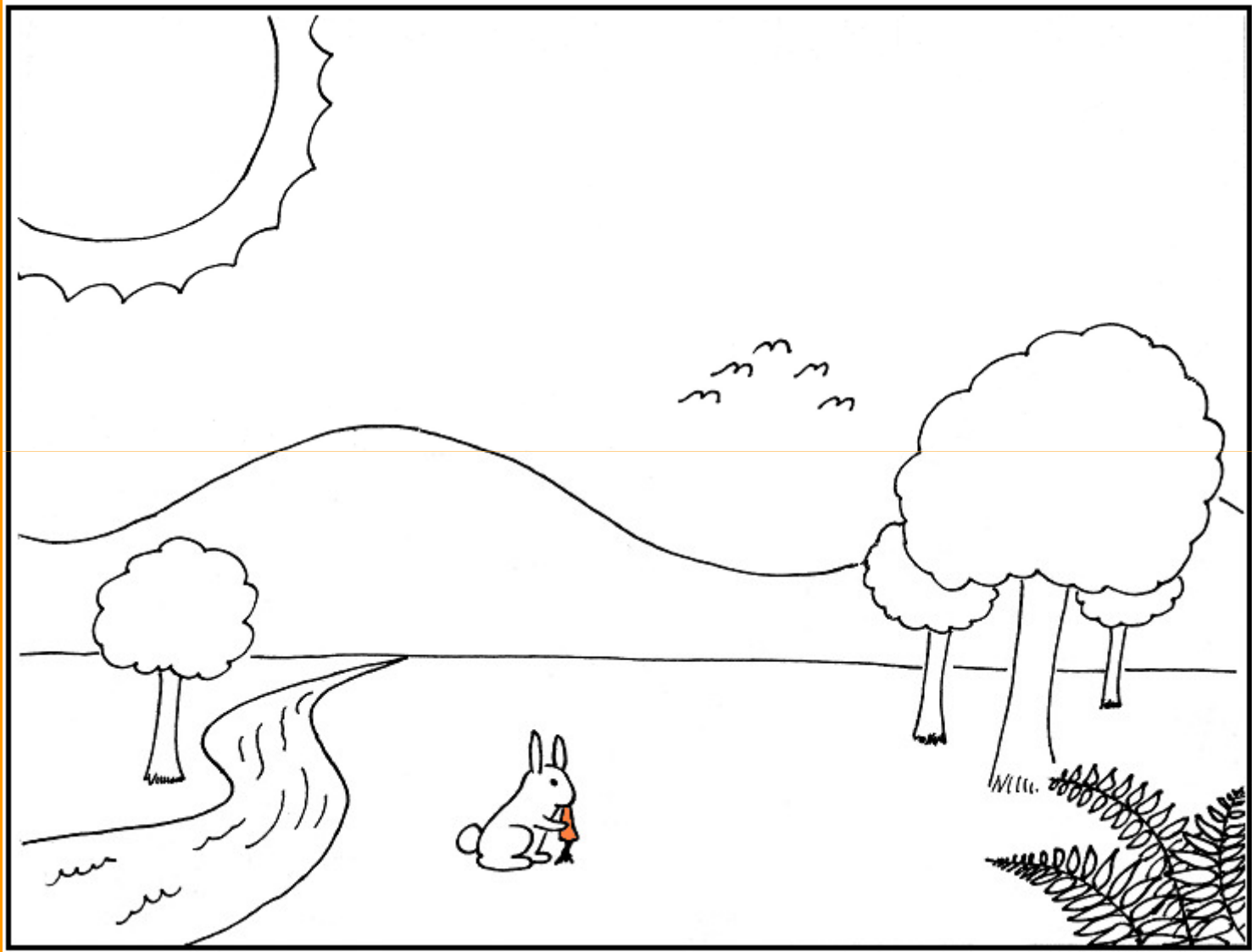
Něco o mně

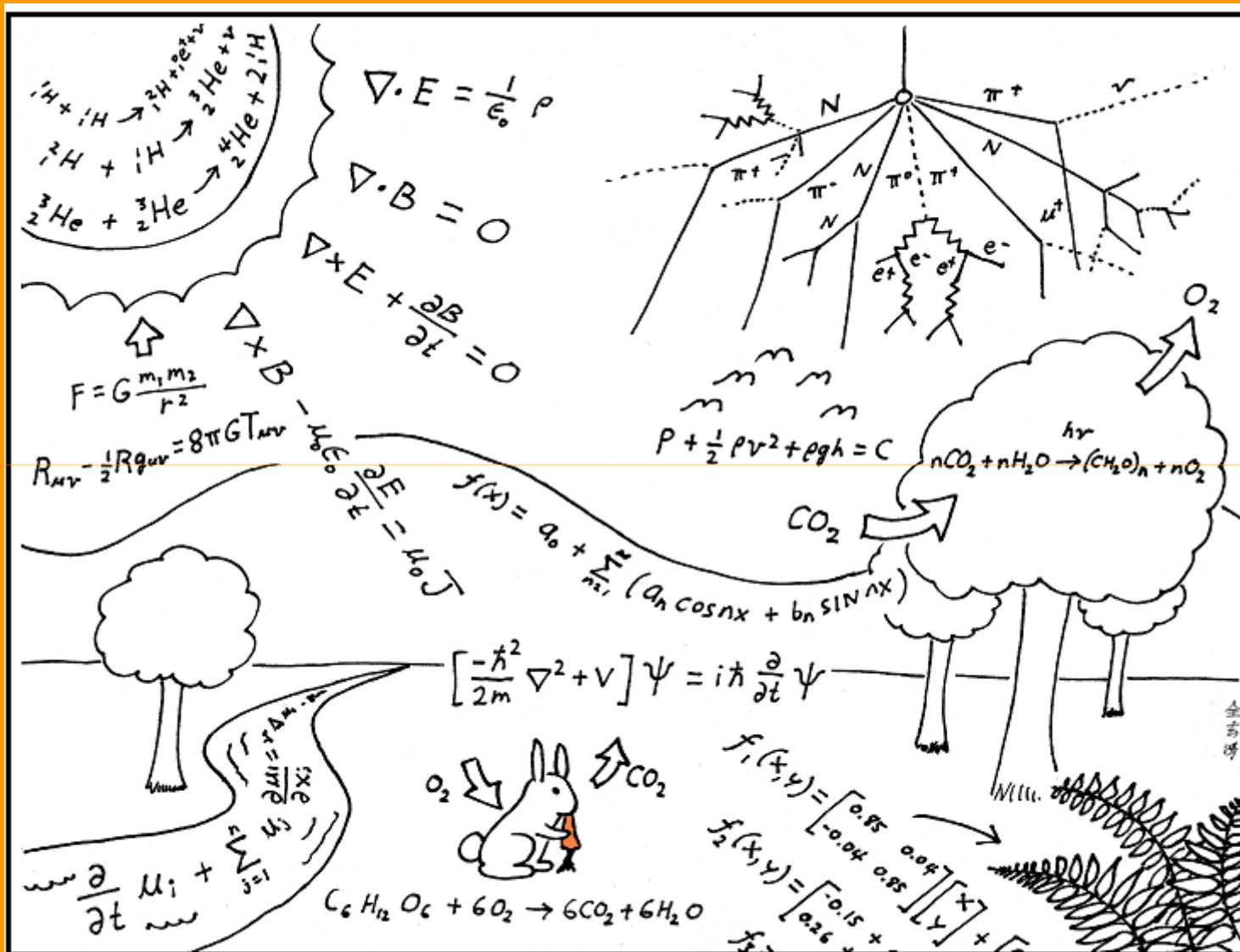
- ▶ Jaroška – olympiády, semináře
- ▶ Matfyz – odborná fyzika, polovodiče, ultrarychlé lasery (ns, fs), Fykos
- ▶ Postgraduál v Dublinu, Irsko – senzory, biosenzory, oxygen senzory a aplikace (spojité měření tlaku a teploty na křídlech letadel)
- ▶ **Vývoj hladinových senzorů**, Continental Automotive Systems Czech Republic s.r.o., Frenštát p.R.



Co tedy opravdu (občas) dělá fyzik?

- ▶ Vymýšlí nové senzory
- ▶ Hledá proč ty staré nefungují
- ▶ Hrabe se v datech a hledá souvislosti

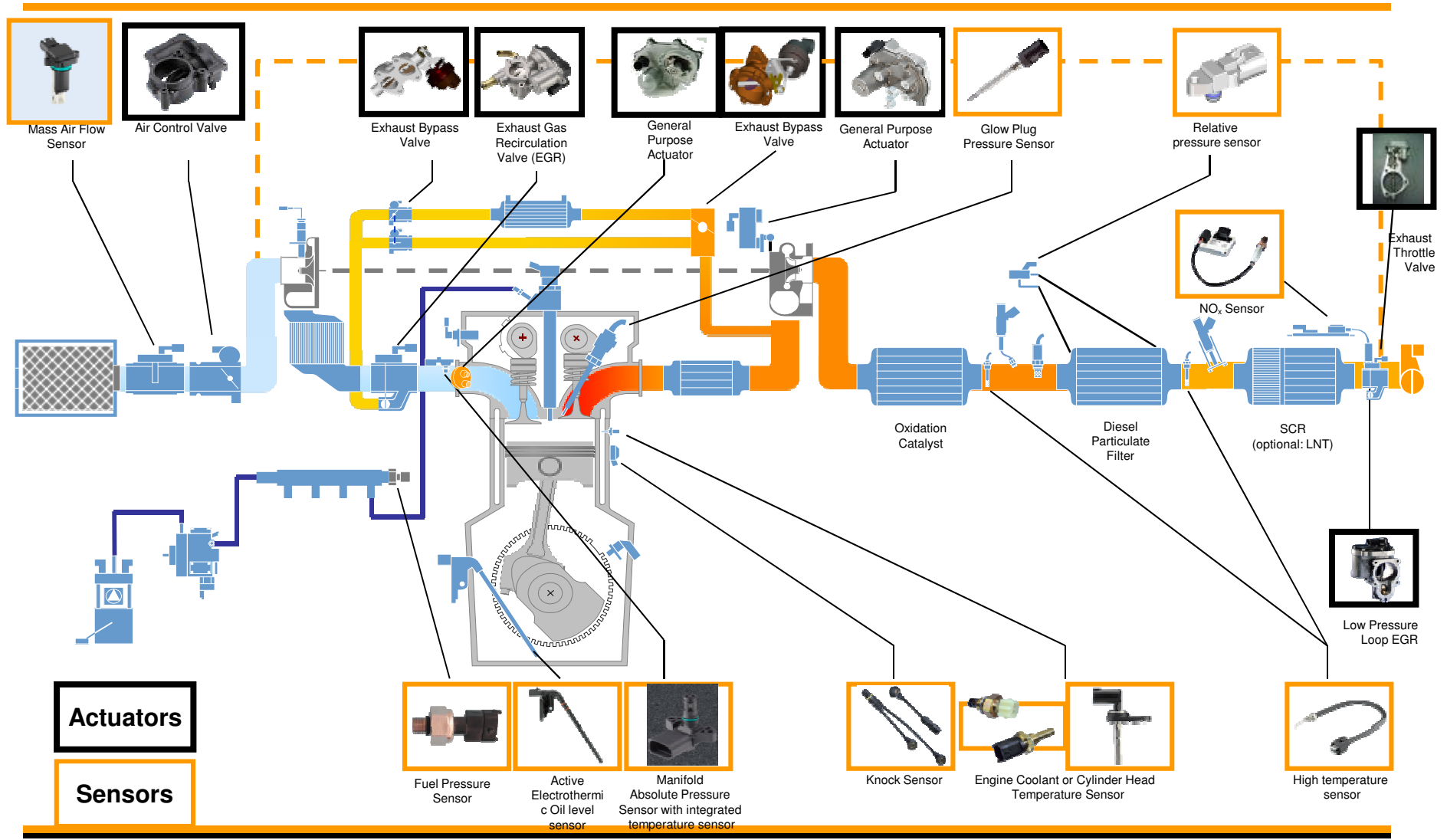




This is how scientists see the world.

Sensors & Actuators as core elements of Powertrain systems

Example: Diesel Piezo Common Rail Injection Architecture



Příklad 1 – ultrazvukový senzor hladiny oleje



- ▶ Proč měřit hladinu oleje – předvídáme katastrofy 😊



- ▶ Popis principu, základní vlastnosti

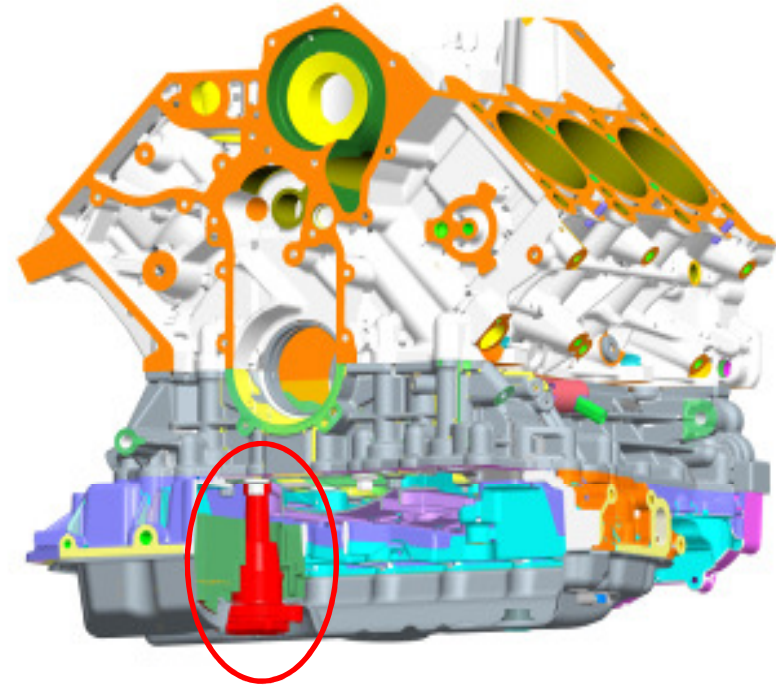


- ▶ K čemu je dobré referenční měření, a proč je reference lepší než nic



Měření oleje – proč a jak -> hladinový senzor

- ▶ Motory jsou od pradávna vybaveny olejovým **tlakovým** senzorem
 - ▶ jakmile ten hlásí nízký tlak oleje, znamená to, že se nemaže a musí se **okamžitě** do servisu
 - ▶ walk home situation = půlnoční zastávka uprostřed dálnice 500km od domova
- ▶ S **hladinovým** olejovým senzorem jde situaci předejít a **dopředu** avizovat nutnost doplnění oleje
- ▶ Metody měření
 - ▶ spojitě
 - ▶ electrothermic (vyhřívaný odporový drát)
 - ▶ ultrasonic (princip sonaru)
 - ▶ diskrétní
 - ▶ spínač (plovák, magnet, jazýčkový spínač)



Ultrasonic Level and Temperature Sensor

Best price – performance ratio



Benefits

- Replacement of oil dipstick
- Detection of low level & overflow
- Absolute measurement of oil level in static and dynamic conditions
- Stand-alone sensor with integrated electronics ("active") and ASIC
- Low power consumption
- Temperature measurement optional
- Best price - performance ratio

Technical Data

- Measuring principle: ultrasonic echo
- Measuring range: 18 mm up to 160 mm
- Interface: PWM
- First measurement available: 0.4 - 1 sec after key-on
dep. on PWM output protocol
- Measuring interval: ~ 1 sec.
- Power supply: 12V / 10mA typical
- Protection class: IP 66
- Operating temperature:
 - Level: 0°C ... +160°C
 - Temperature: -40°C ... +165°C
- Accuracy:
 - Level: ± 2mm
 - Temperature: ± 2°C (0°C ... +165°C)
± 3°C (at -40°C)

Target Customers: All OEMs worldwide

Lead customers: 2 German OEMs

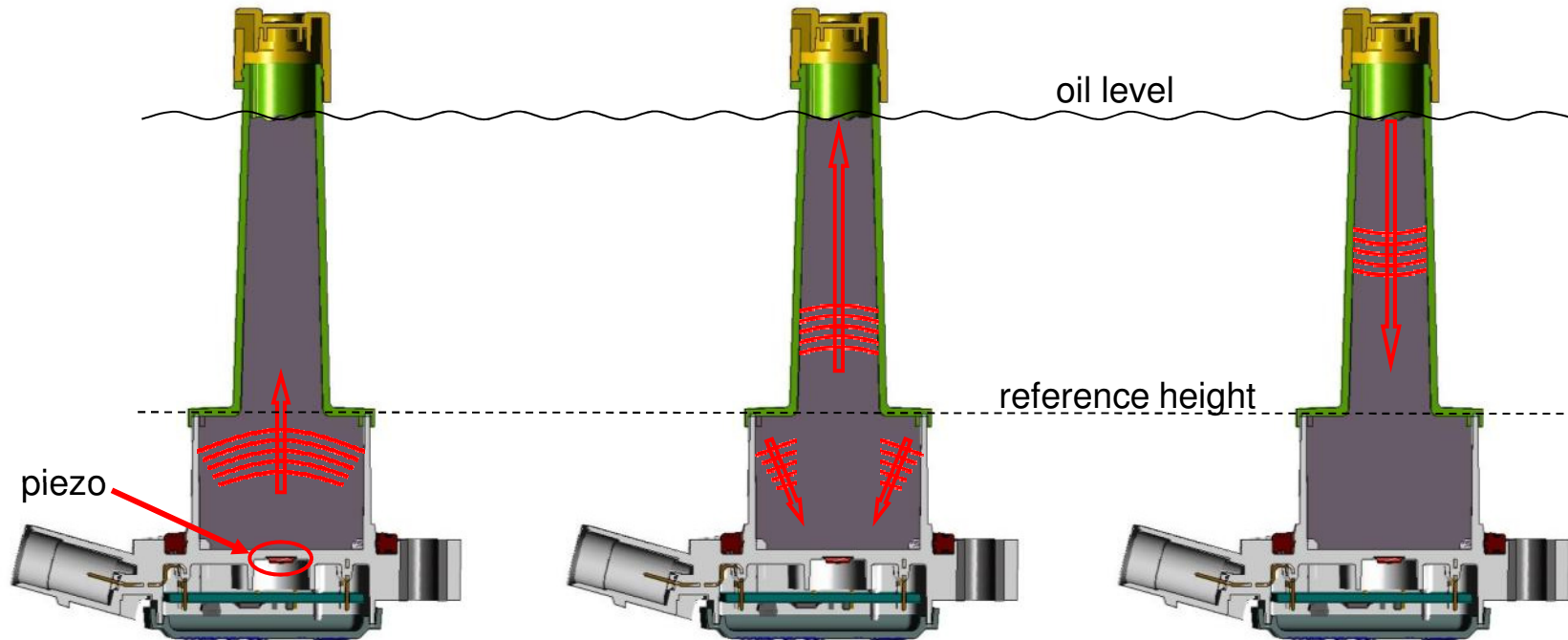
Expected SOP: 2011

Manufacturing: Frenstat (CZ)



Ultrasonic Level and Temperature Sensor

Measuring Principle



▶ Piezo emits ultrasonic pulse

▶ Part of the pulse is reflected at the reference, the other part goes to the oil surface

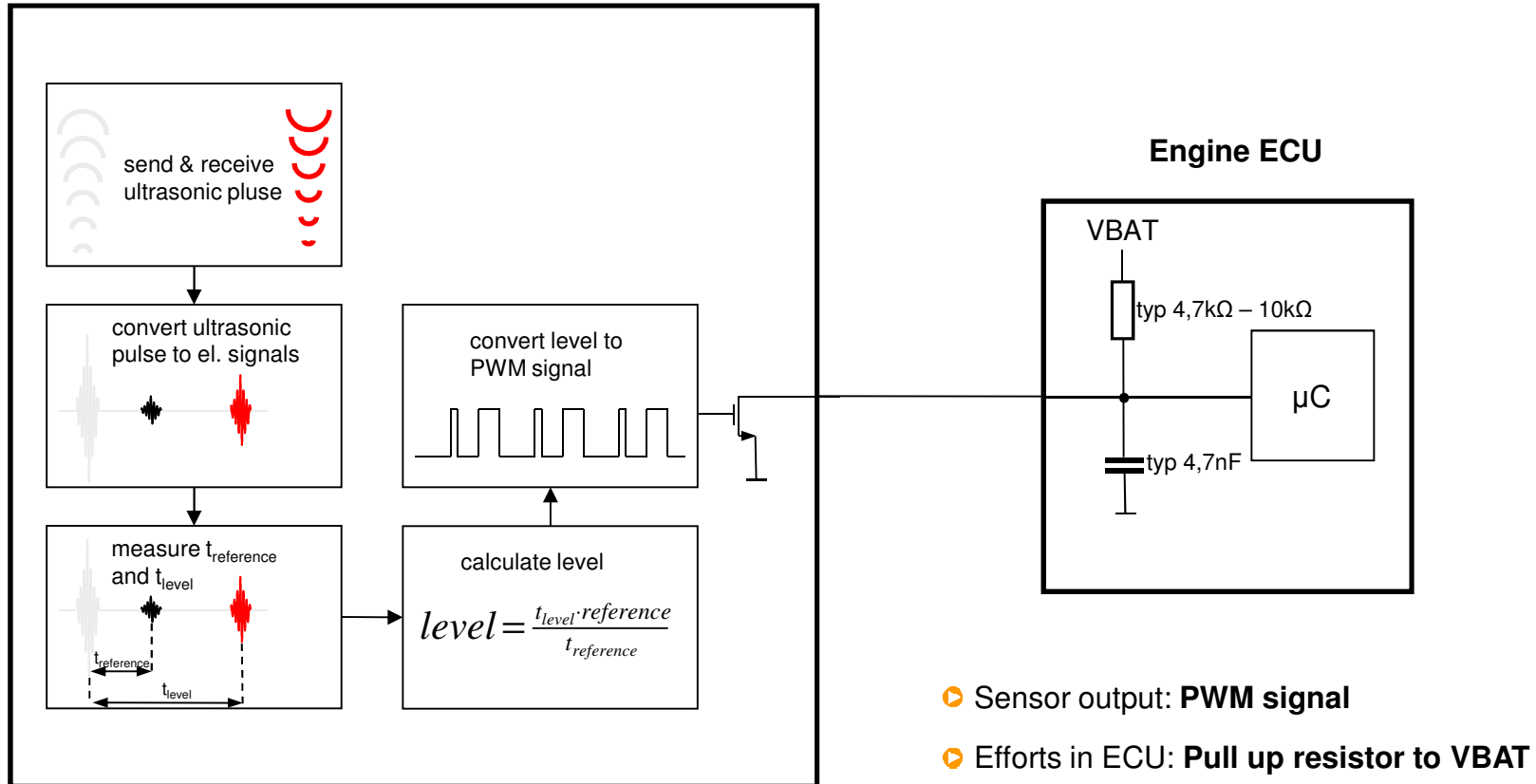
▶ The oil surface reflects the pulse and the piezo receives the echo, "Time of Flight (ToF)"

$$\text{Level} = \frac{\text{ToF(Oil-surface)}}{\text{ToF(Reference)}} \cdot \text{ReferenceDistance}$$

Ultrasonic Oil Level and Temperature Sensor - schematic

Standalone Sensor with integrated electronics requires least efforts in ECU

Ultrasonic Oil Level Sensor with integrated electronics



Příklad 2 – optimalizace rychlosti odezvy teplotního senzoru



- ▶ Jak pomáhá FEA/FEM při předpovídání vlastností



- ▶ Svázání teorie a reality – nakonec je realita to co nás zajímá

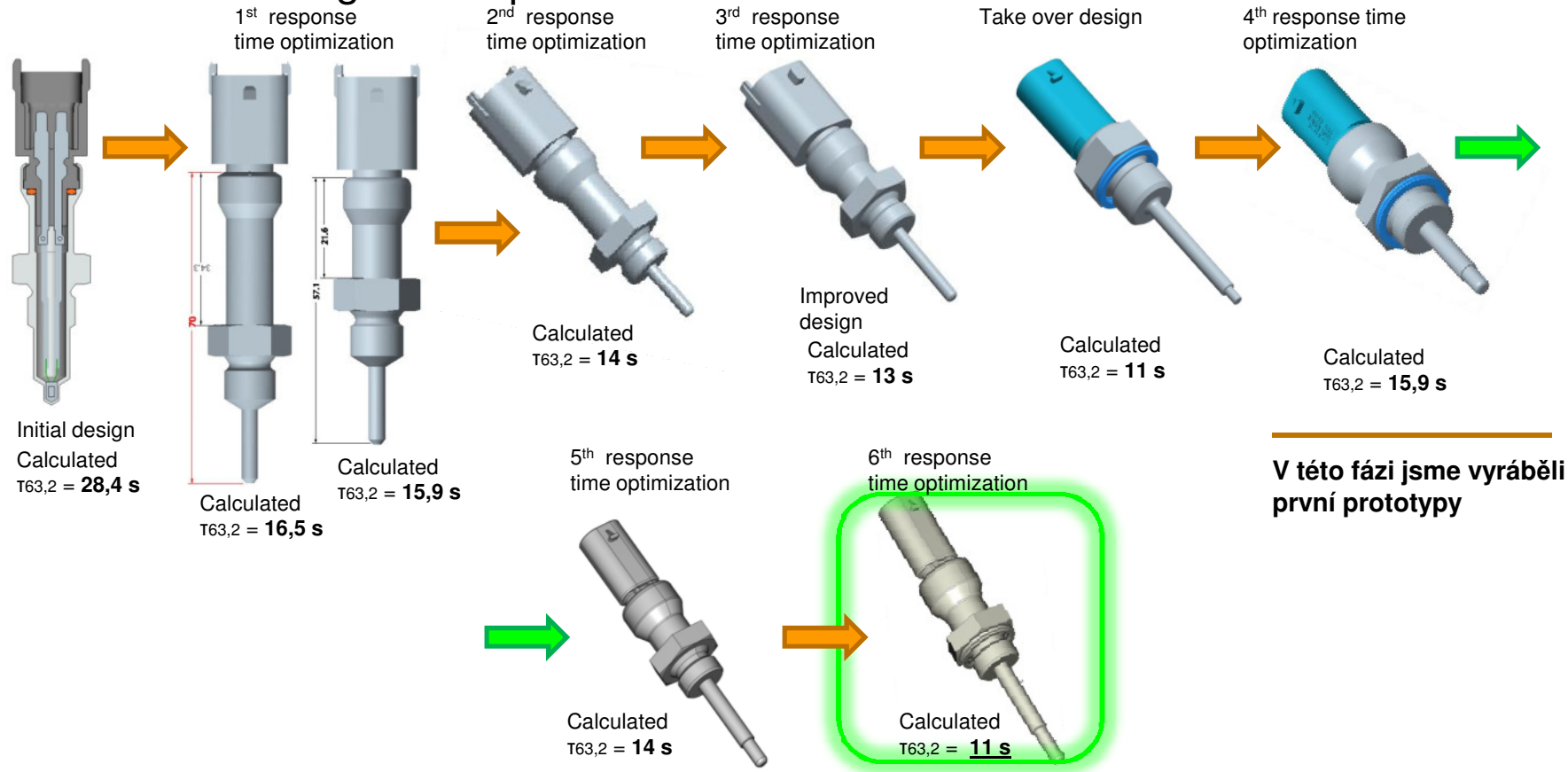


- ▶ Měření ve větrném tunelu



Příklad vývoje s pomocí matematických simulací - přehled různých historických verzí takzvaného EGR senzoru – sleduje se response time, teplota o-ringů, kontaminace venkovní teplotou

Connector design concept evolution



► Tento vývoj byl a je řízen s pomocí matematických simulací, T. Gajdarus.

Reálný příklad – dosažená přesnost response time (13.6sec vs 12.2sec)

- ▶ Náš hardware na měření response time teplotních senzorů ve vzduchu, je to v podstatě dvojitý větrný tunel.
- ▶ K danému problému máme odvozené funkční okr. podmínky.



Příklad 3 – co dělat, když senzor nepřežije testování (vibrace)



- ▶ Jak zjistit životnost senzoru (15 let) v laboratoři co nejrychleji (do 7 dnů).



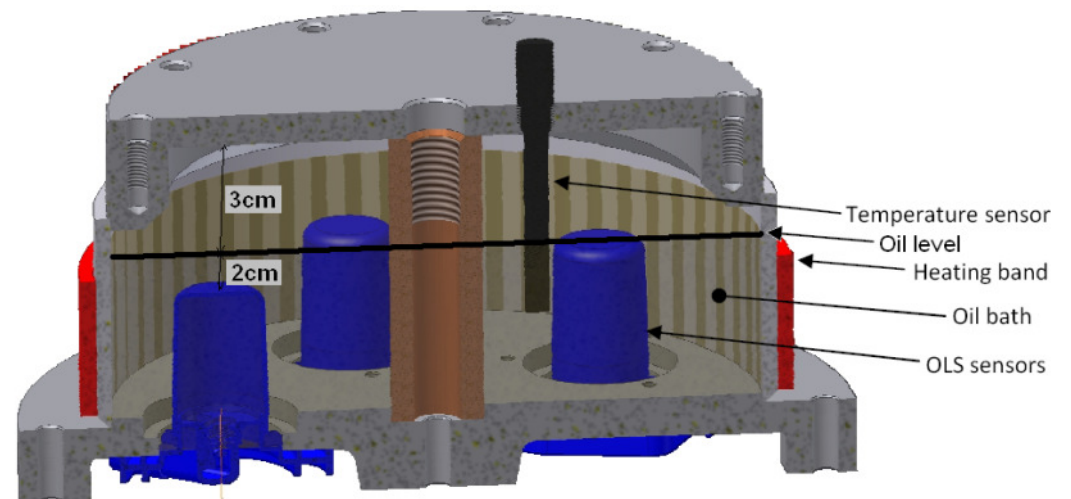
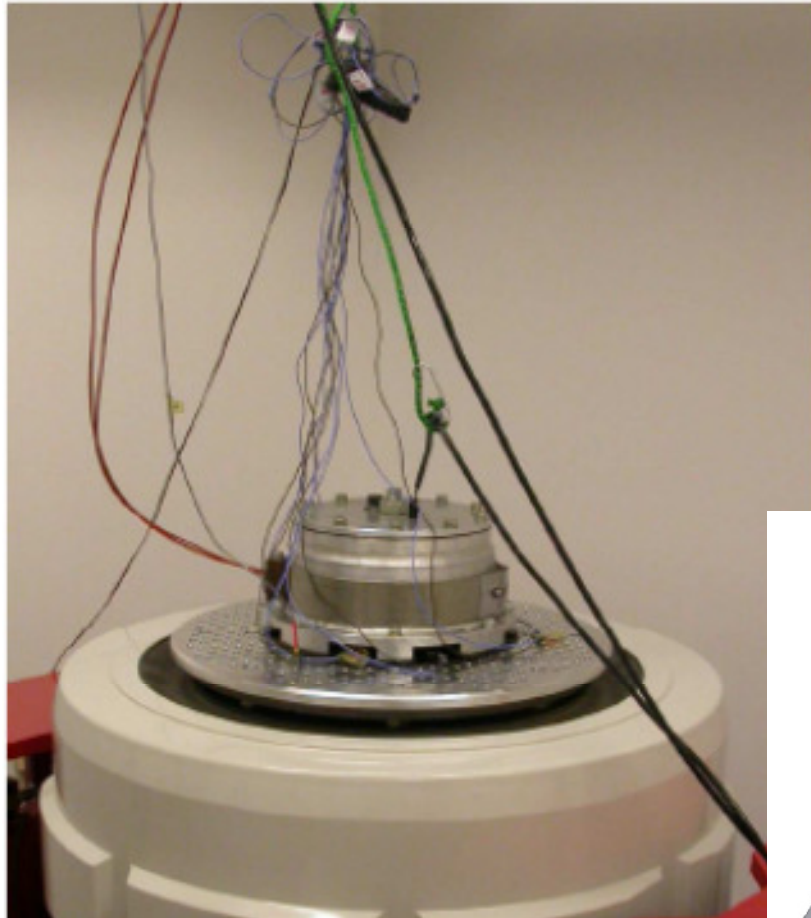
- ▶ Vlastní frekvence výrobku nemusí být příčinou. Únavový lom?!?



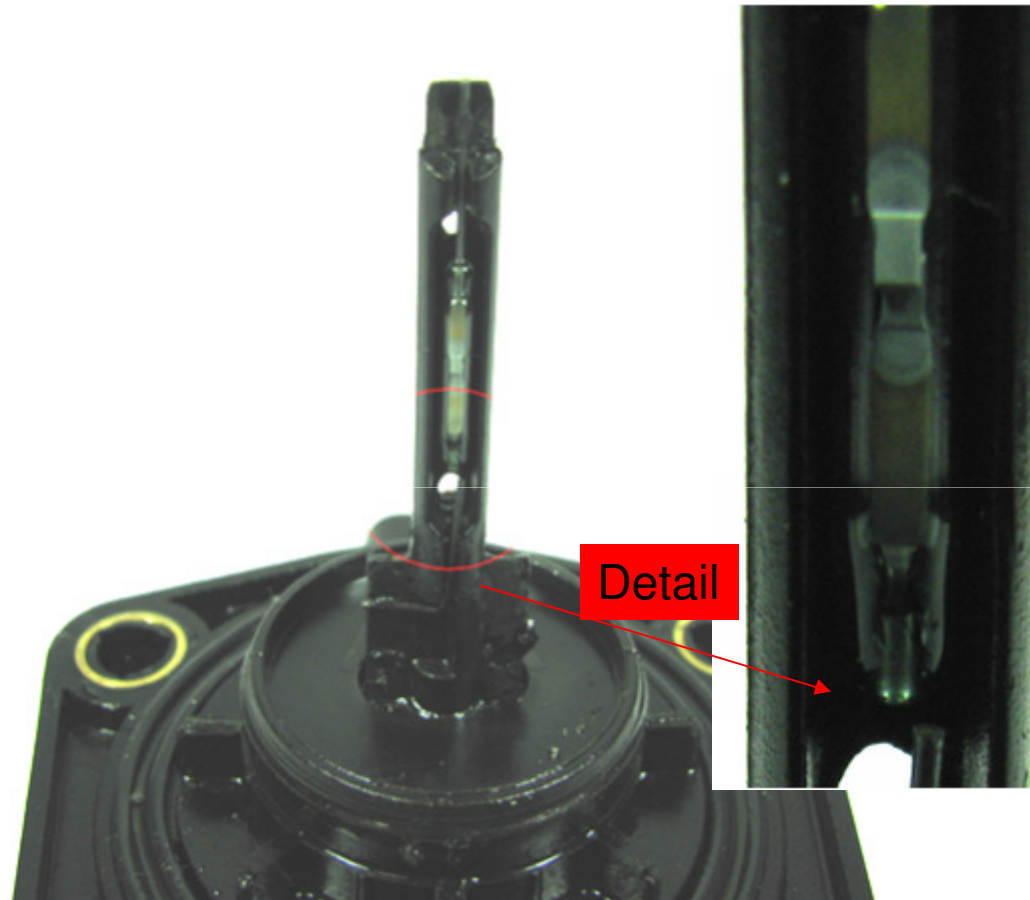
- ▶ S Wehlerovou křivkou je vysvětlení mnohem snažší a optimistické do budoucna. Chyba je na straně testu, ne výrobku.



Co přináší život...

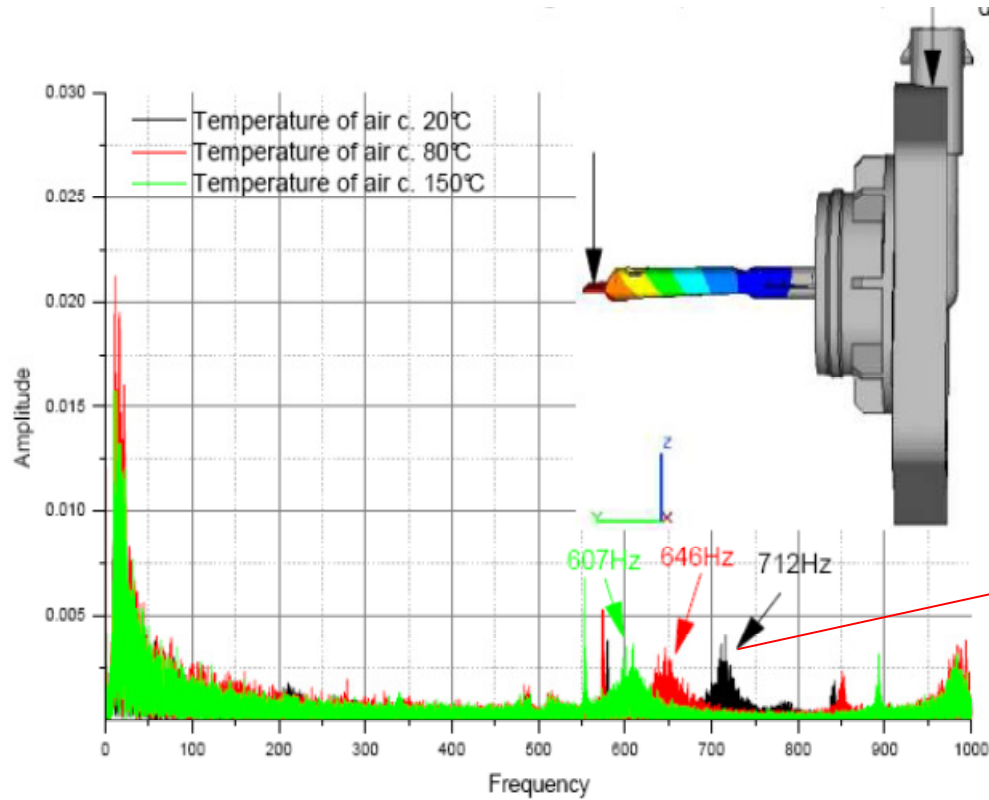


Details of fracture



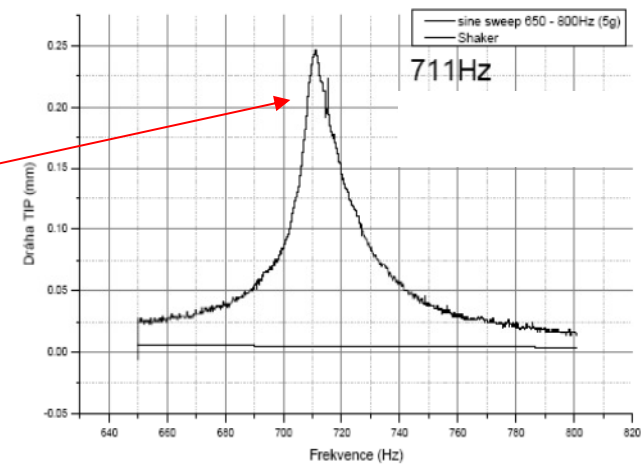
Natural frequency measurement

- ▶ Measured frequency around 600-750Hz for different temperatures



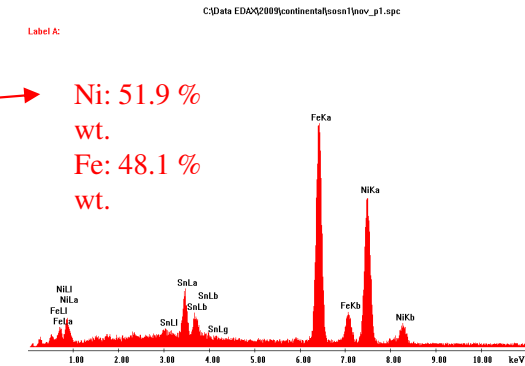
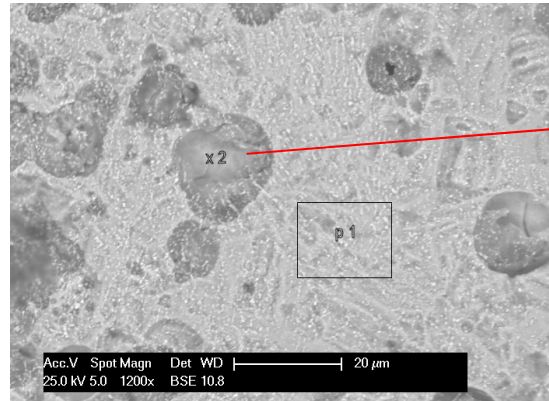
- ▶ Confirms theoretical FEM analysis of whole sensor

- ▶ BUT: sensor moves as whole, reed switch is not stressed itself!



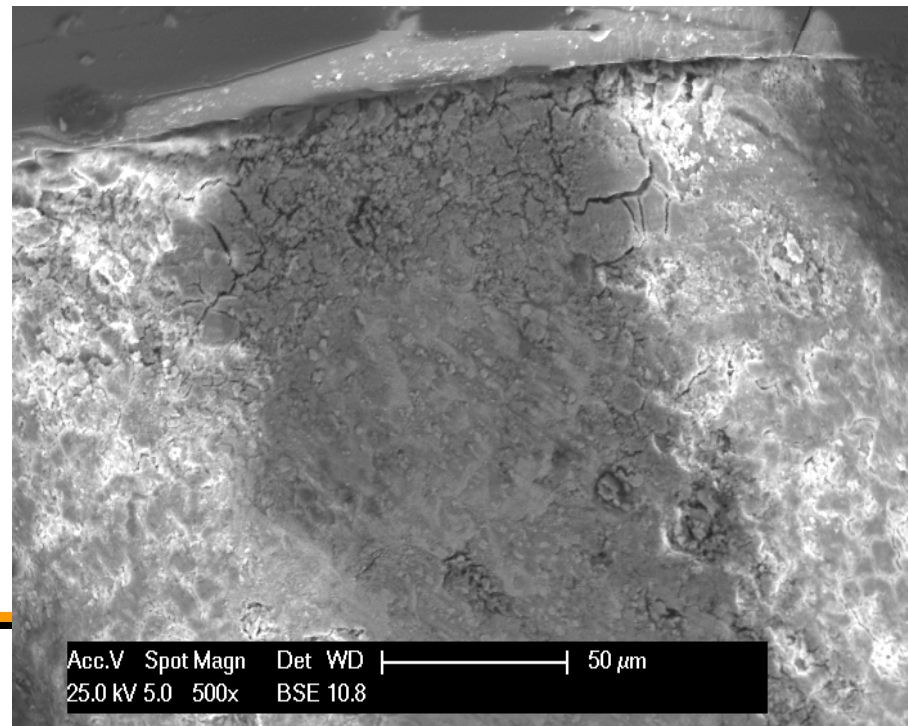
Material analysis with SEM

- ▶ SEM analysis confirms material composition of Ni52Fe48



- ▶ SEM shows on wire, which was tested under vibration test (after etching of the surface) micro-cracks at the glass-wire interface
- ▶ The cracks seems to be from fatigue fracture

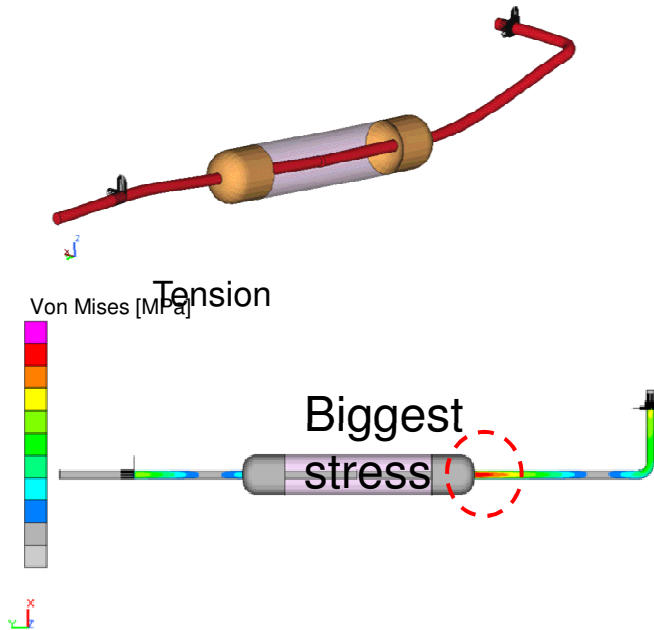
- ▶ Cycles number:
 - ▶ 1500 Hz * 3*48 hrs
 - ▶ => $8 \cdot 10^8$ Cycles



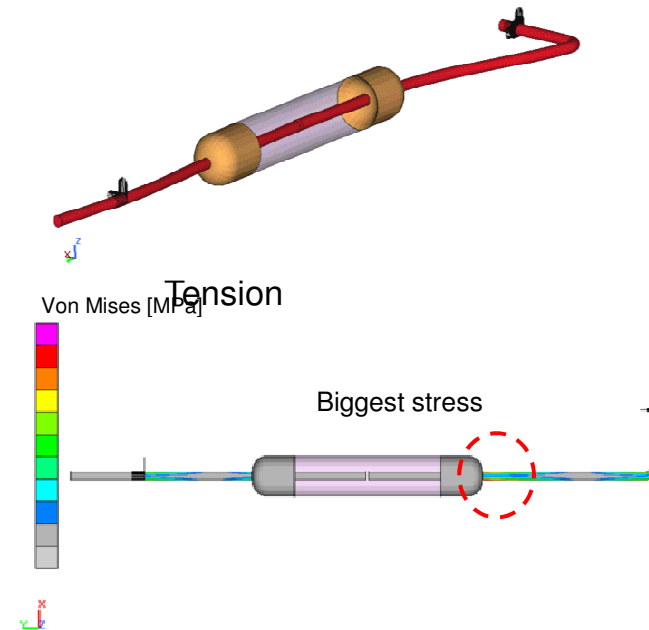
Computer simulations – modal analysis

Swell, 22.11.2011

natural shape in X



shape in Y

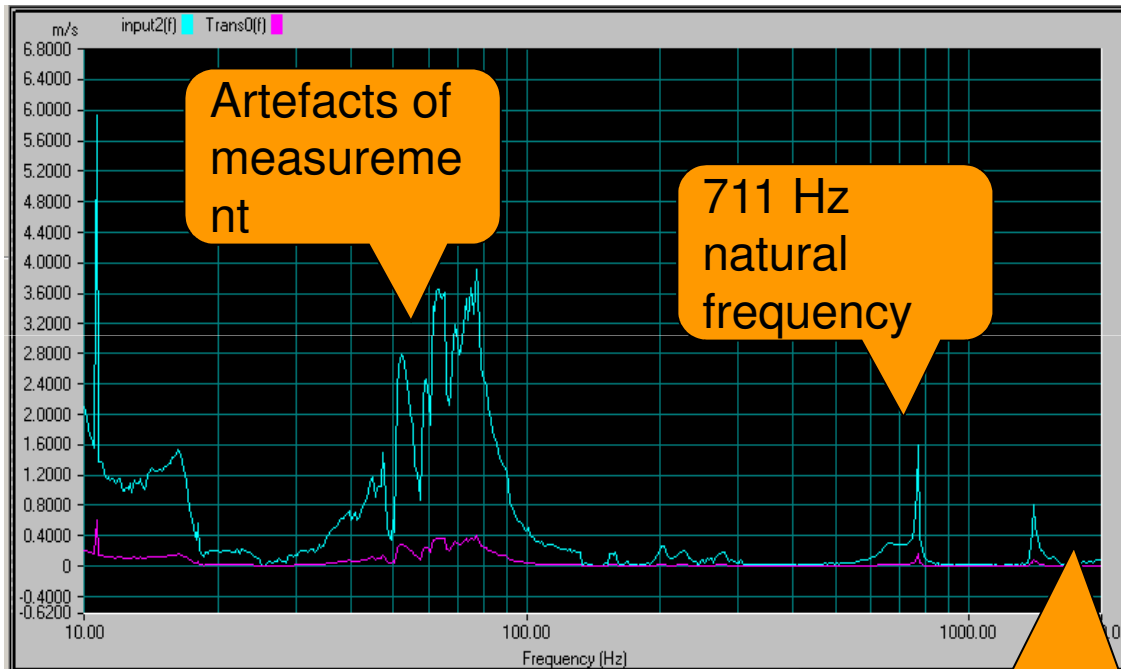


Conclusion:

Theoretical calculation predicts damage of reed switch in the same place, where damage really occurred.

	1 st rez. fr.	2 nd rez. fr.
Variant A	1 839 Hz	2 253 Hz

Resonances at higher frequencies



Artefacts of measurement

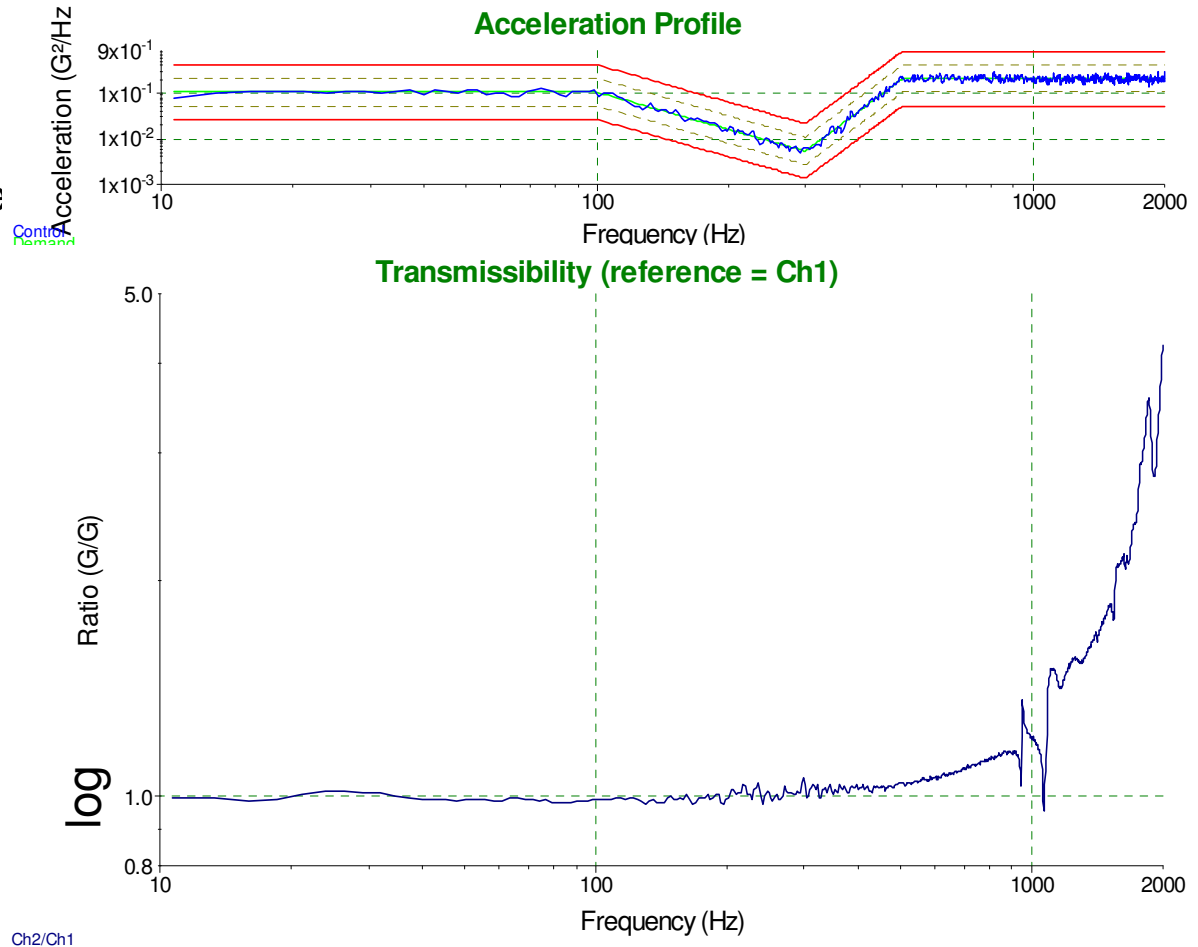
711 Hz natural frequency

~1450 Hz Reed switch natural frequency

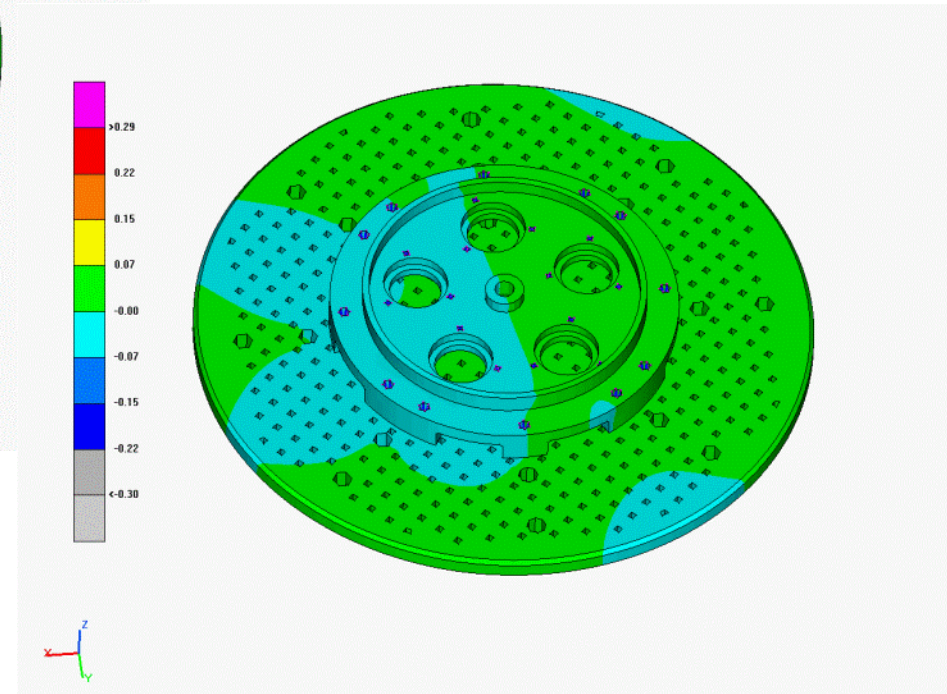
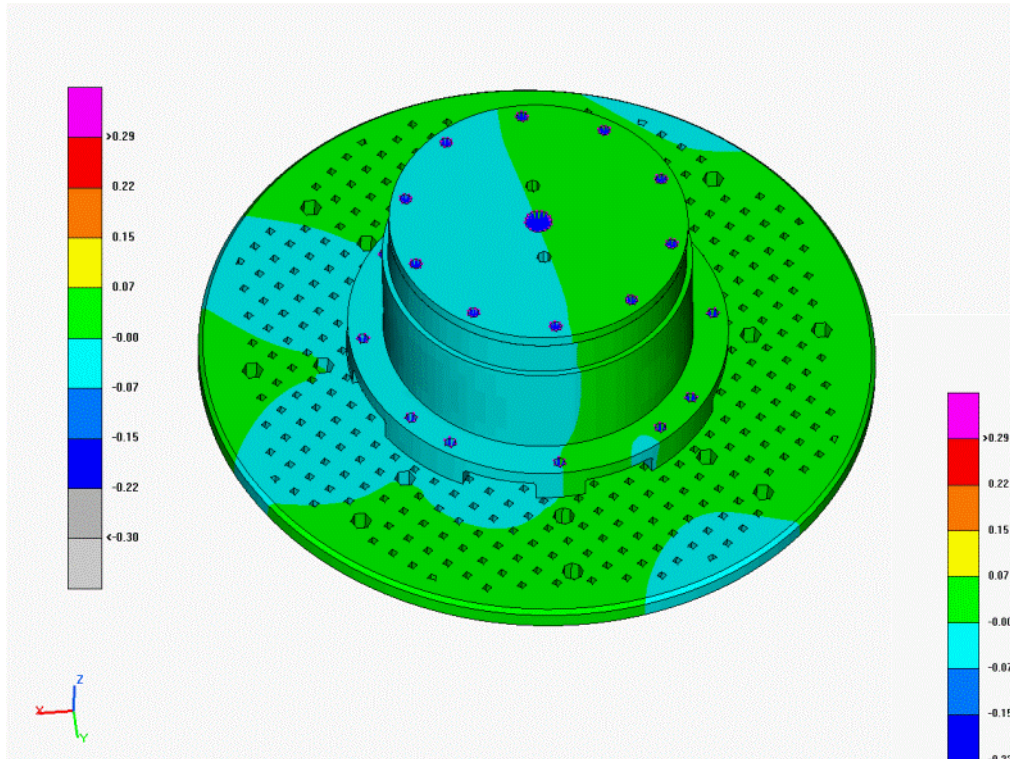


Analysis of vibration fixture

- ▶ In region above 1000 Hz (in random vibration profile) significant amplification of vibration of fixture is observe
- ▶ up to 5-times



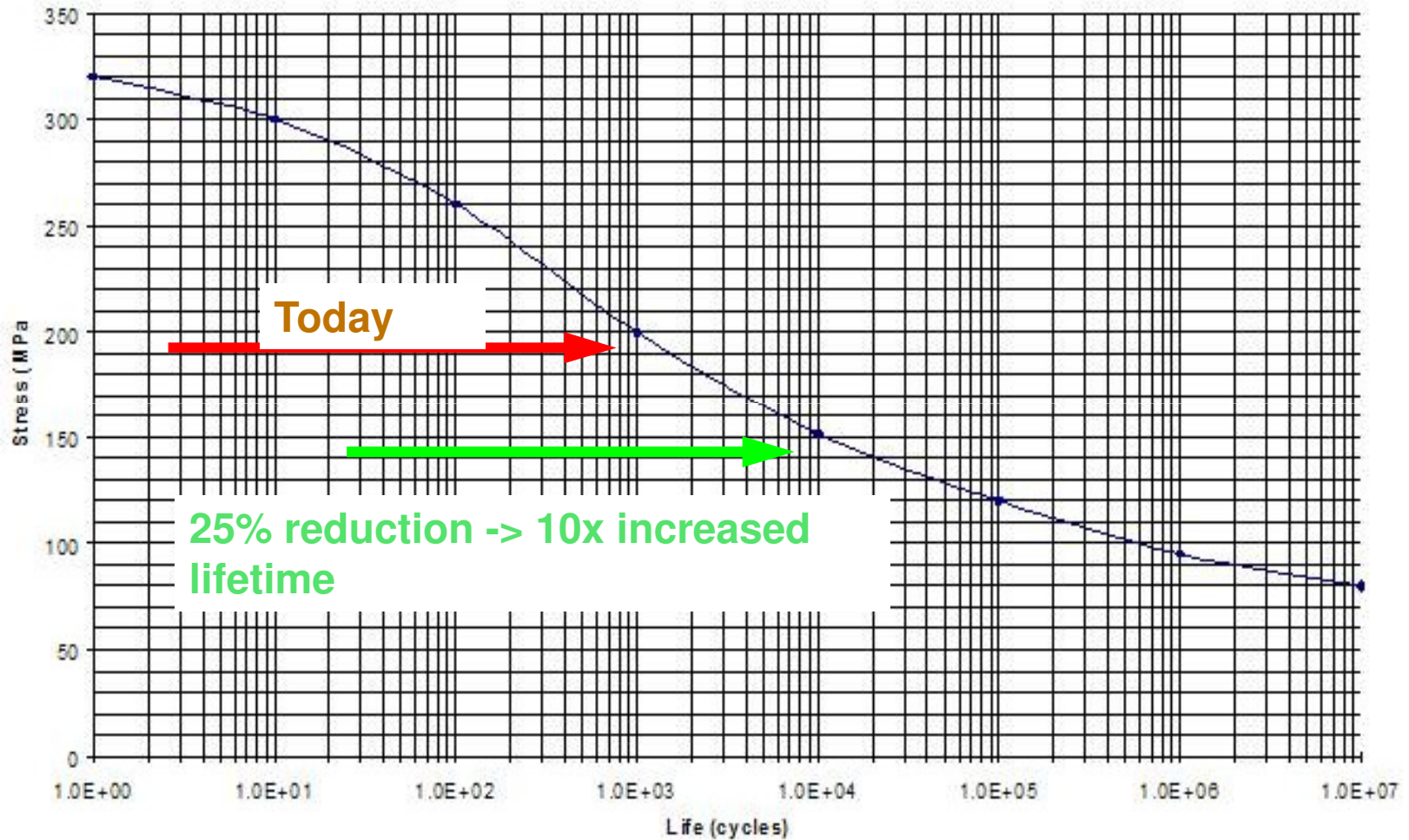
FEM analysis of vibration fixture



▶ See animation....

Wöhler curve (sample)

S-N CURVE FOR BRITTLE ALUMINUM WITH A UTS OF 320 MPa



140 Years Continental
1871 – 2011



Thank you for your attention!

Continental 