While you're waiting for your webinar to begin…

What is your involvement with energy harvesting/ wireless sensors?

a. Device supplier/ developer (e.g. TEG developer, low power electronics, piezo harvesters, etc.)
b. Wireless sensor network developer
c. System integrator
d. Existing adopter
e. Potential end-user
f. Other (please specify)

Send your answer to this question through the webinar's questions box

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- These slides will be made available to all attendees after the end of the webinar

Energy Harvesting, Wireless Sensors & Wireless Sensor Networks :

What can they do for you?

Dr Harry Zervos

Technology Analyst, IDTechEx

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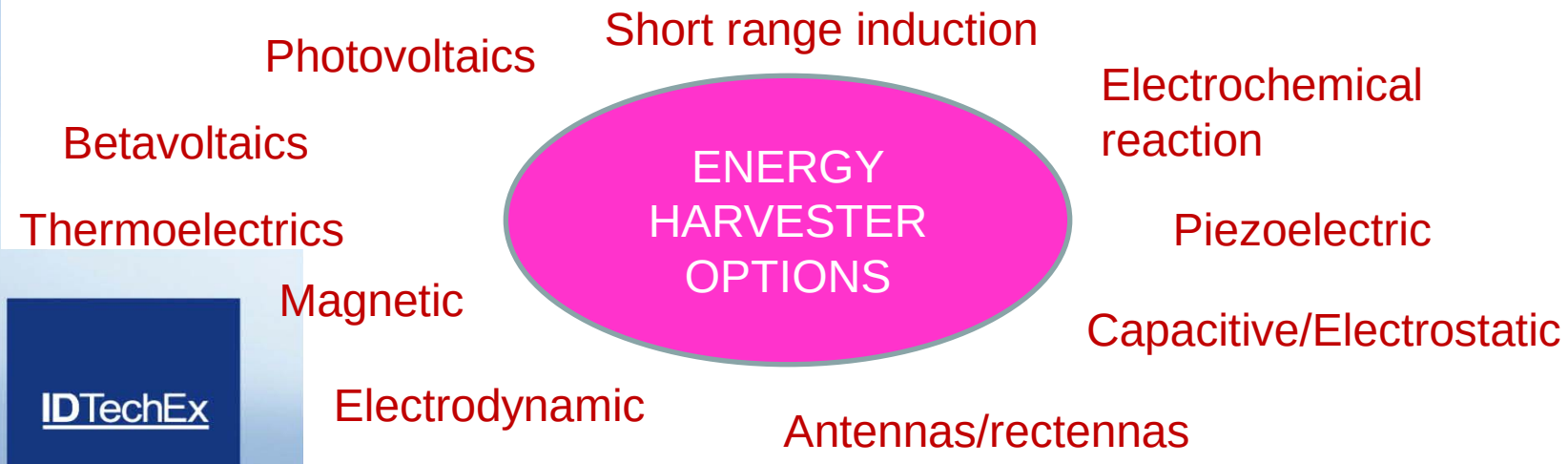
Why energy harvesting?

Conversion of ambient energy to electricity to power small electric and electronic devices. Ambient energy includes vibration, light, heat, movement etc.

- Wireless Sensor Networks (built environment, oil & gas, agriculture…)
- Consumer electronics (cell phones, radios, torches, remote controller…)
- Transport (land, sea, air vehicles – private and public…)
- Military and aerospace (satellites, soldier systems…)
- Healthcare (convenience, safety, keeping people in their homes for longer…)



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Four main components in an energy harvesting device

Energy harvesting element
Photovoltaics
Boeing Spectrolab
Electrodynamics
Kinetron,
Perpetuum
Piezoelectrics
PulseSwitch
Microstrain
Thermovoltaics
GreenTEG
Nextreme

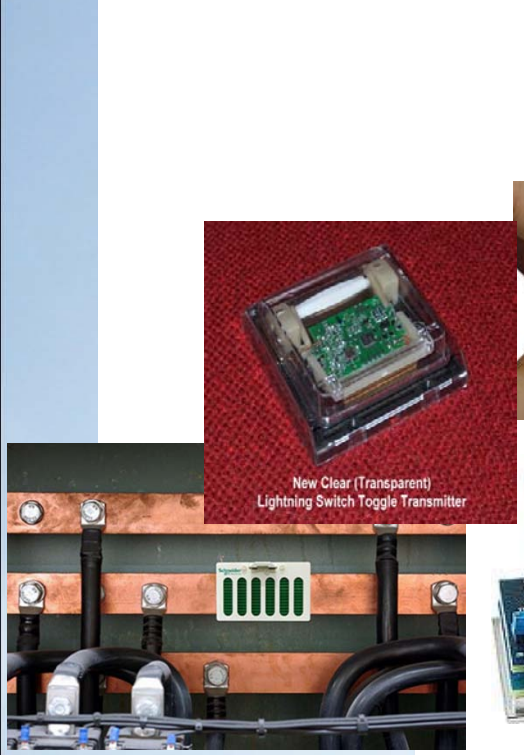
Energy Storage Component, stores and smoothes energy
Battery
Panasonic
IPS
Super capacitor
CapXX

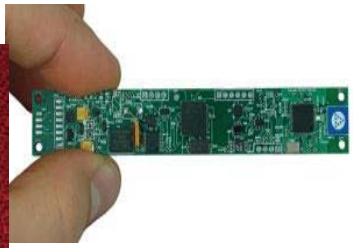
Interfacing electronics creates the right voltage, current etc to drive an electronic or electric device
Often the company making the element

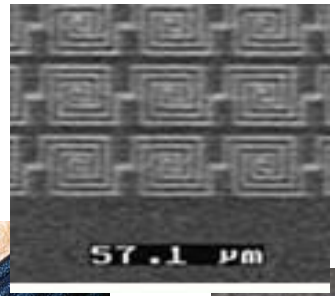
Harvesting tolerant electronics eg
Ultra low power electronic devices eg
ULP Radio Transmitter
TI
Microchip
Intel
Microsemi

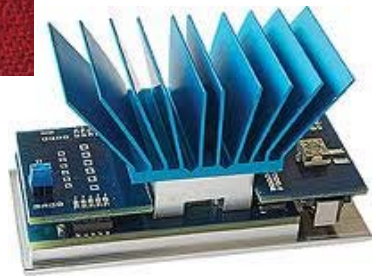
Energy Harvester Development

Several hundred developers of energy harvesters, suitable storage, low power ICs









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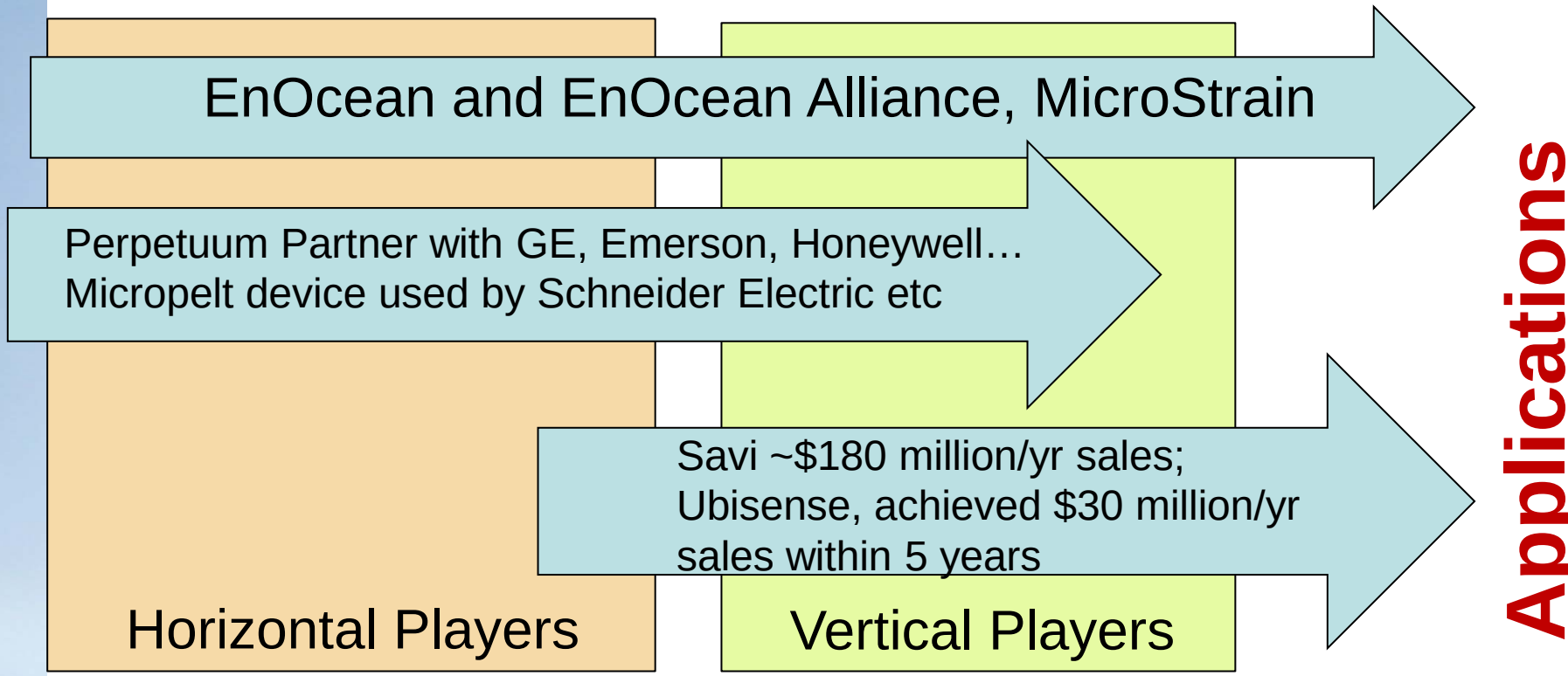
Strategies for Success



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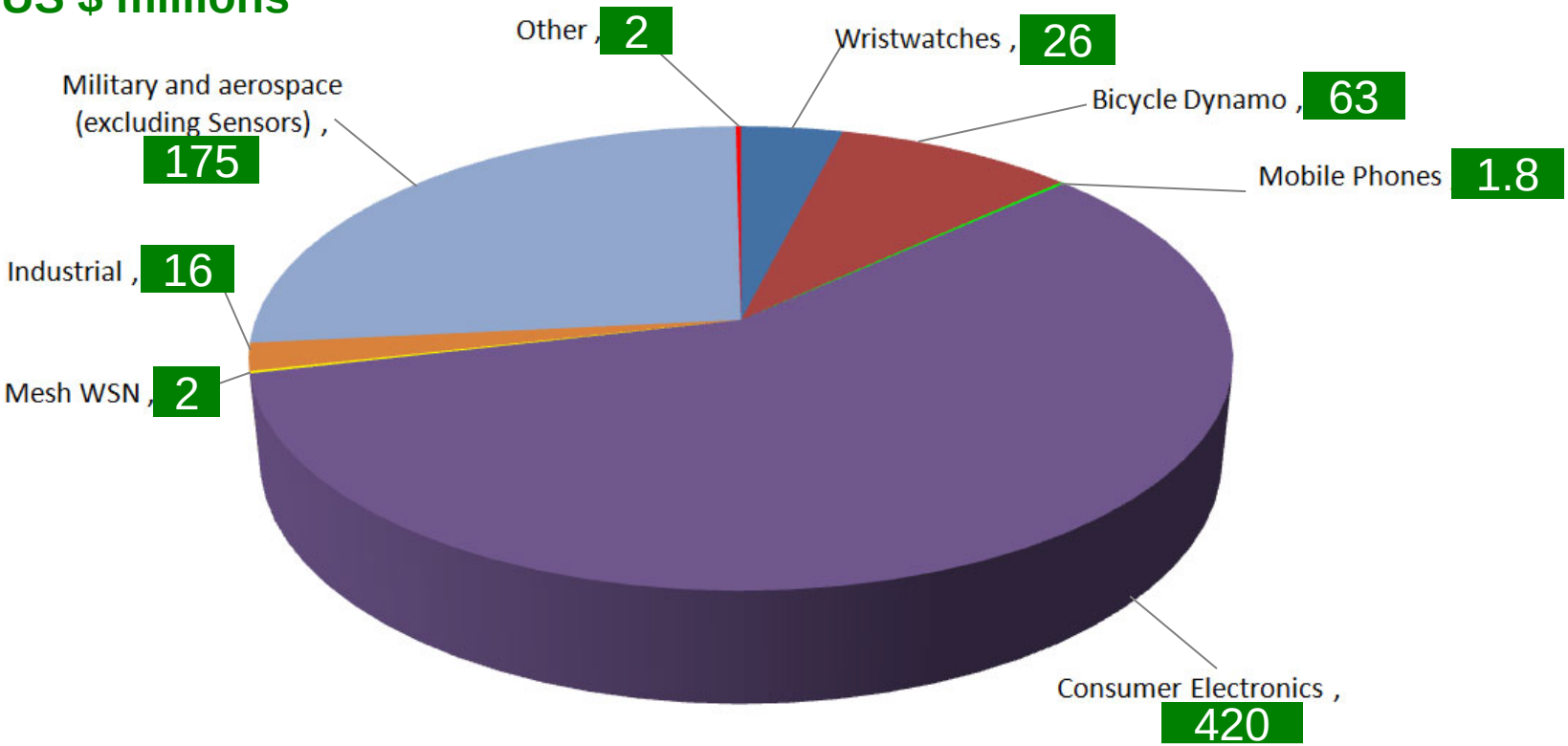
The Energy Harvesting Market in 2012: $0.7Bn

In US $ millions



Wristwatches, 33 million $26 million

Bicycle Dynamo, 6.3 million, $63 million

Mobile Phones, 0.2 million, $1.8 million

Other (including medical). 0.2 million, $2 million

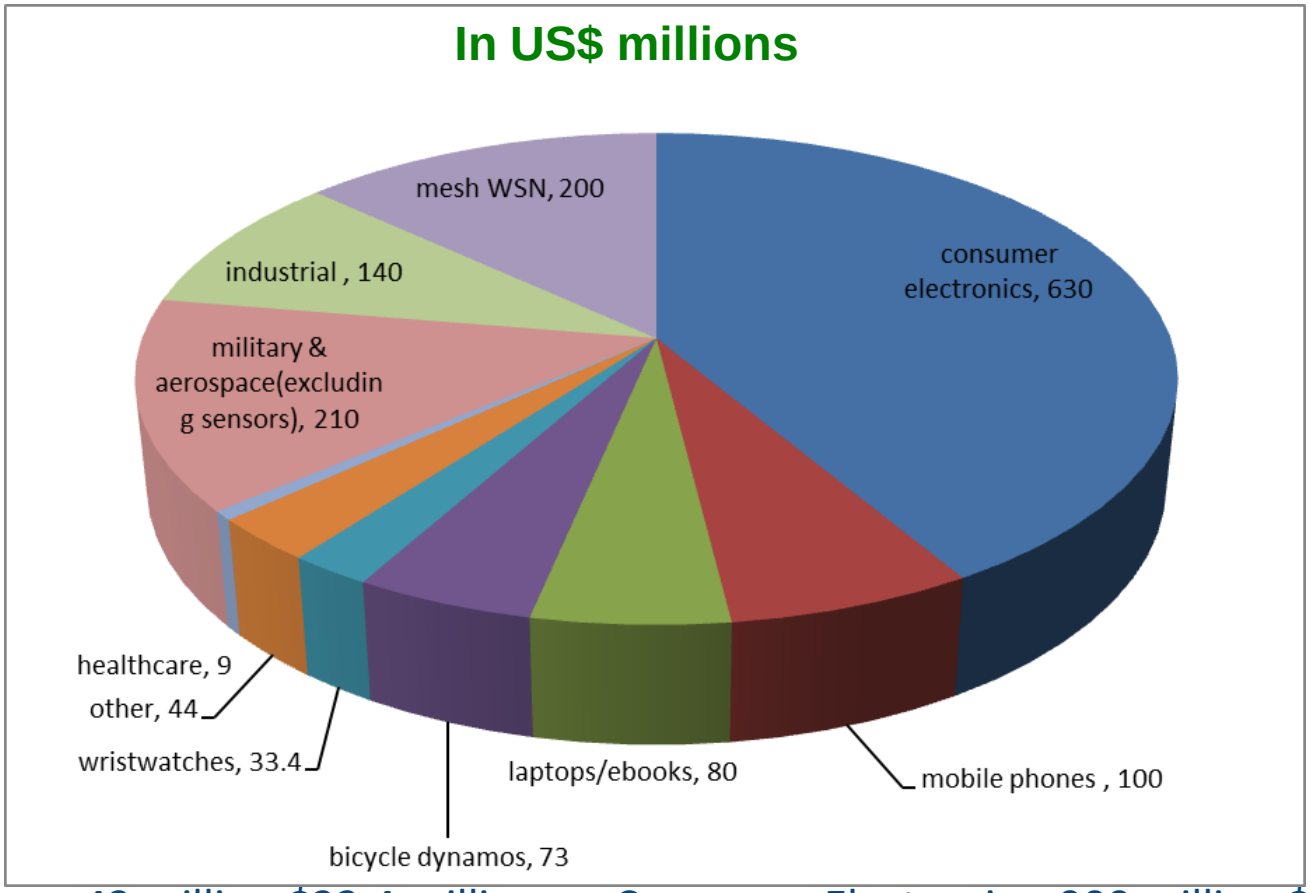
Consumer Electronics, 600 million $420 million (calculators, toys, lighters, radios…)

Wireless Mesh Networks, 0.2 million, $2 million

Industrial (non mesh), 2 million, $16 million

Military & Aerospace, 0.05 million $175 million

The Energy Harvesting Market in 2017 $1.5Bn



Wristwatches, 43 million $33.4 million

Laptops/ebooks, 5 million, $80 million

Mobile Phones, 20 million, $100 million

Healthcare, 1 million, $9 million

Consumer Electronics, 900 million $630 million

Wireless Mesh Networks, 20 million, $200 million

Industrial (non mesh), 40 million, $140 million

Military & Aerospace, 0.07 million $210 million

Timeline for widespread deployment of energy harvesting

2010	2012	2014	2020	2024
Devices where size and cost are not too demanding. There are examples within small parts of the sectors: home automation, building automation, industrial processes, medical, military, automotive, road furniture and active radio frequency identification RFID.		A high percentage of home automation, building automation, industrial processes, medical, military, automotive, electronic toys, road furniture, signage, electronic billboards and posters and active radio frequency identification RFID.		
	Integral phone, e-book and laptop chargers such as sprung rollers of photovoltaic film, extended when needed.			
		Energy harvesting e-labels and e-packaging		
			Widespread sensor networks in inaccessible places, including in people, on trees in forest fires, embedded in concrete and dropped on the moon or in battle. Energy harvesting laptops and phones widely deployed in the third world	

Energy harvesting
&
Wireless sensors
in the industrial equipment sector

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The case for wireless condition monitoring

Temperature/vibration/strain etc. condition monitoring: allowing for preventative maintenance rather than reactive maintenance, minimizing downtime, wiring costs etc.

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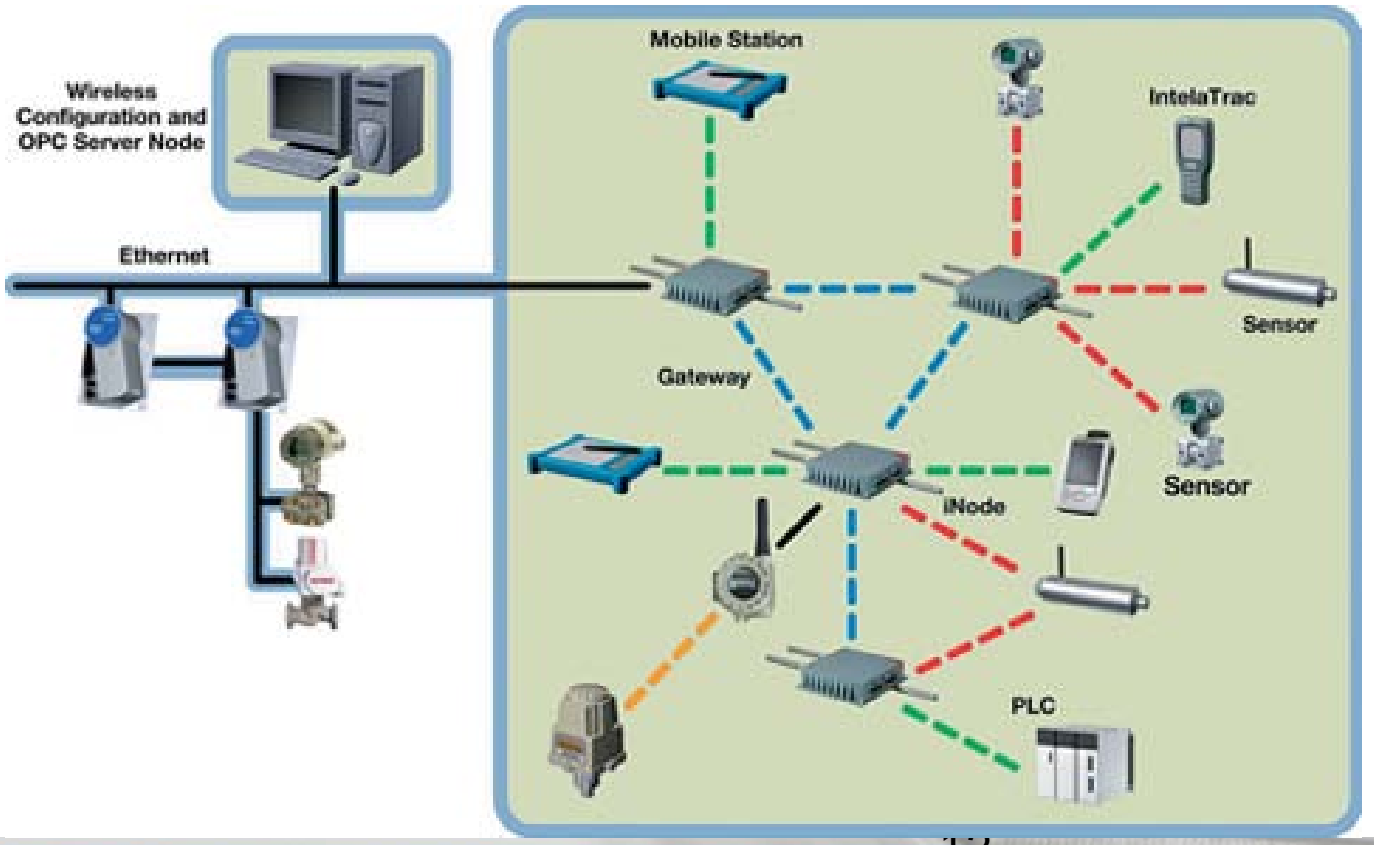
Wired nodes

Honeywell's nodes: Why go for wired nodes?

"The problem with allowing battery powered devices to relay for each other, is that their power consumption fluctuates as the data rate fluctuates, making battery life unpredictable"



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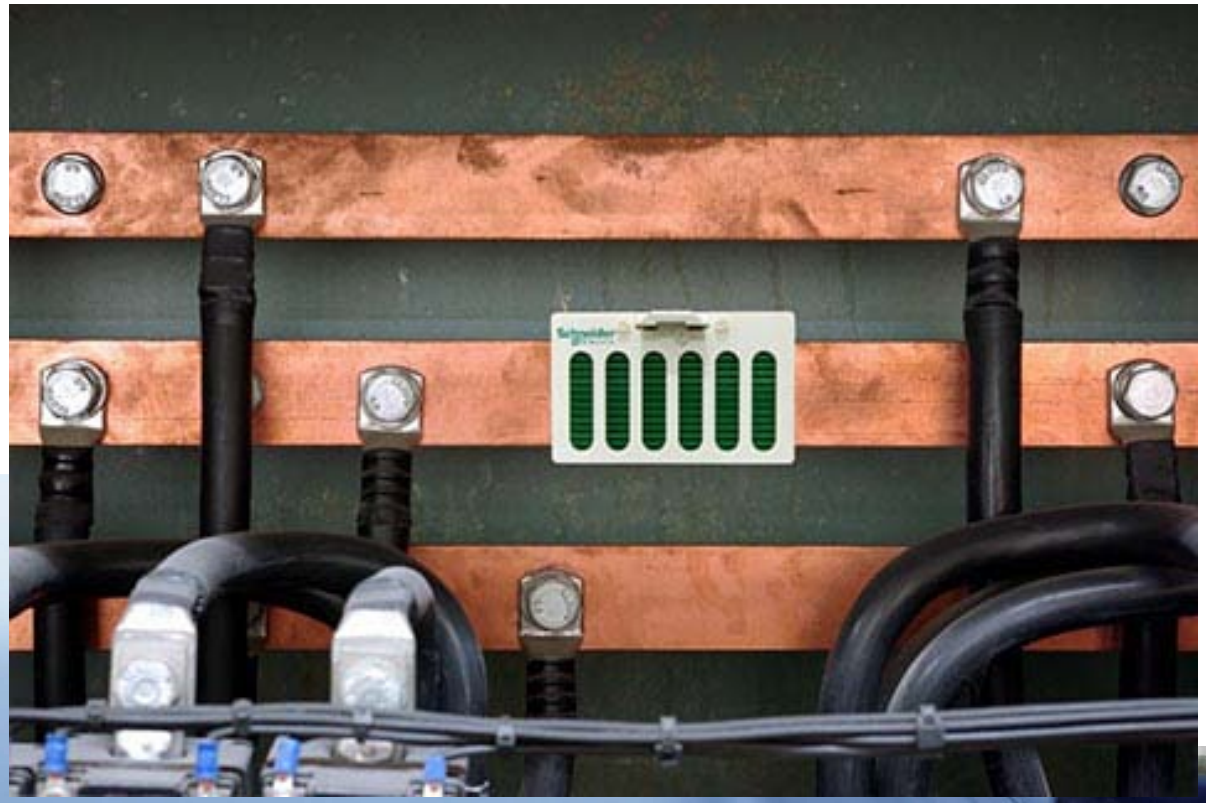
Schneider – Micropelt

Qnode. A wireless busbar monitor:

Temperature sensor, powered by temperature gradient (5 ^{o}C is adequate)



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KCF technologies

Multi-modal energy harvesting for condition monitoring:

- Piezoelectric
- Solar
- Thermoelectric

“The health and efficiency of a piece of equipment such as a compressor, chiller, generator or fan can be gauged by its amount of temperature and vibration”

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Energy harvesting
&
Wireless sensors
in the automotive sector

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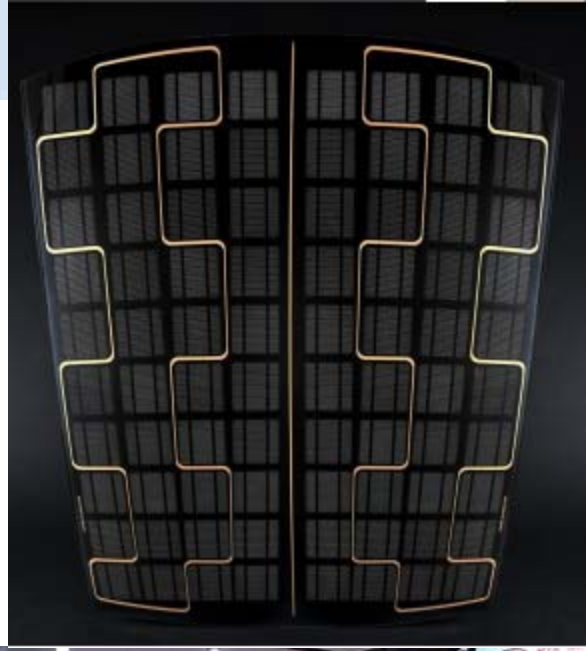
Asola - Fisker Karma

- ✓ 130 Watt Solar roof panel



Solar technologies used:

Mostly **crystalline silicon** but…

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FIAT-SolarPrint-Infineon-Webasto

- ✓ July 2010: Collaborative work with Fiat Research Centre, to develop DSSC solar roofs
- ✓ €3 Million project: DSSC cell + Lithium Ion battery to power different parts of a car.

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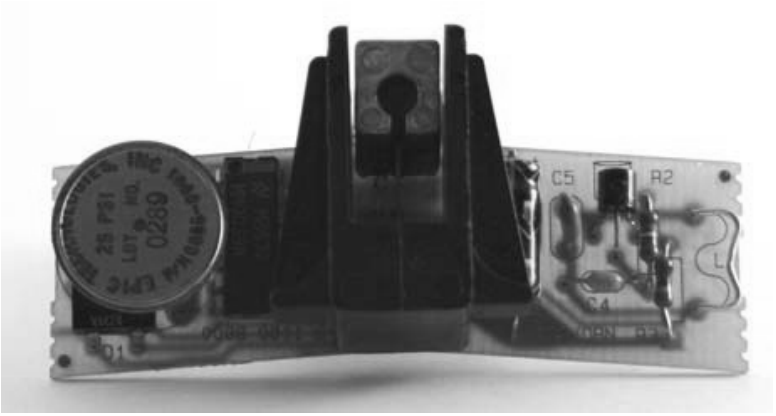
Battery operated Tyre Pressure Monitoring Systems (TPMS)

10 years is not sufficient in some cases

Car makers are concerned with warranty costs if batteries do not last as long as expected

In some usage scenarios, such as in the trucking industry, batteries last much less than 10 years.



Tire pressure sensor and energy harvester by Epic Technologies

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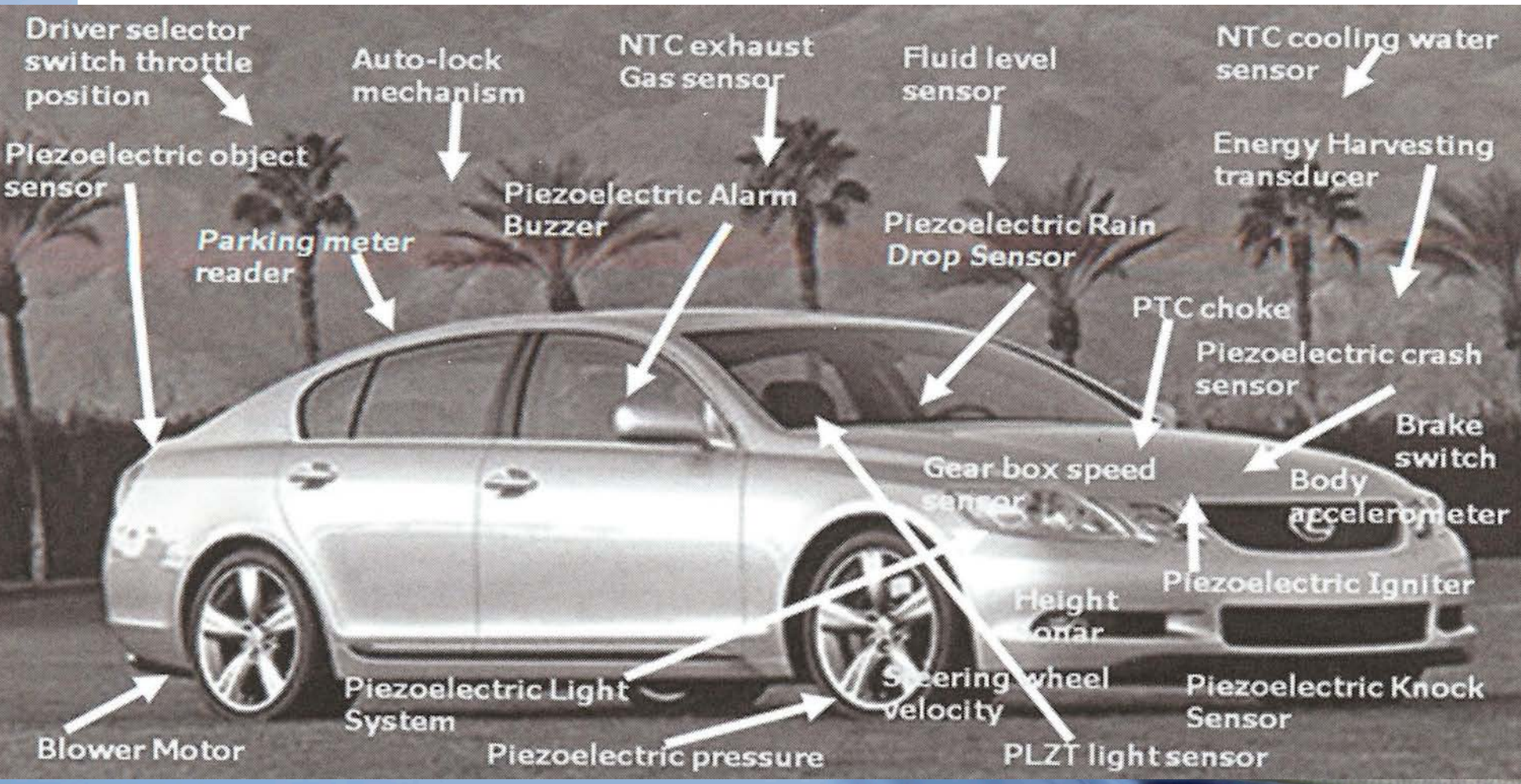
TPMS, not the only sensor…



Energy waste

Energy density of Fuel 12.7 (kWh/kg)

Engine losses 62.4 % Idle losses 17.2 %

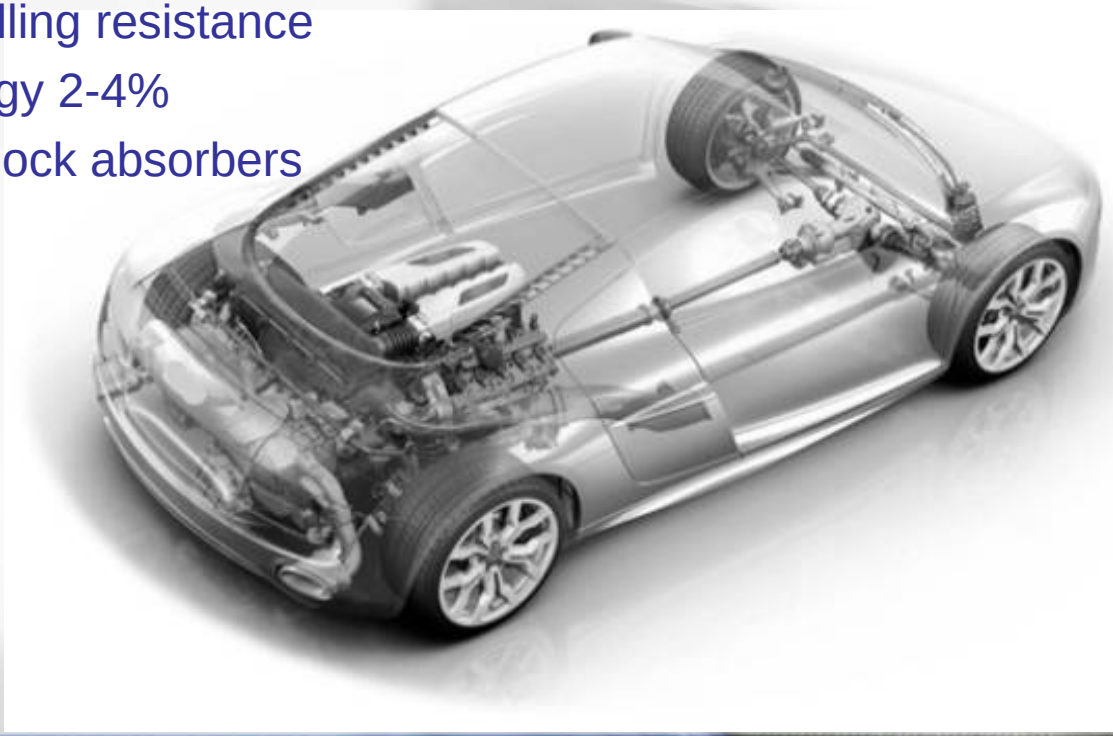
Drive line losses 5.6 % Accessory losses 2-10%

12.6% Energy left to move the car

Over 50% lost in drag & rolling resistance

Available suspension energy 2-4%

Regenerative braking – Shock absorbers



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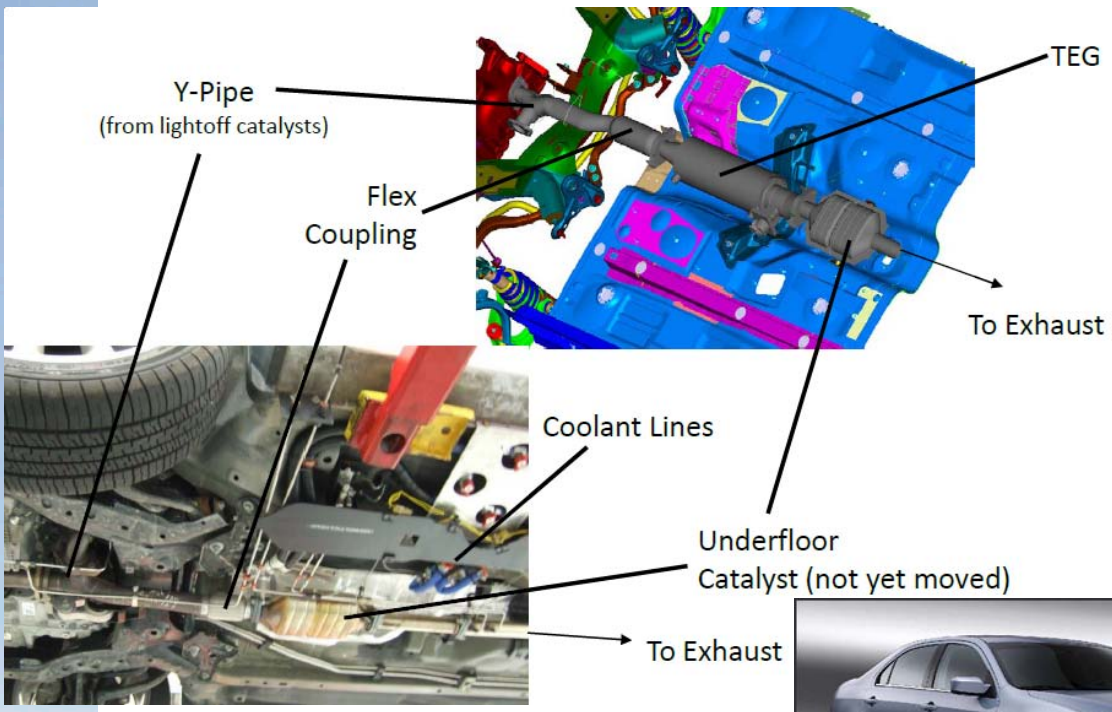
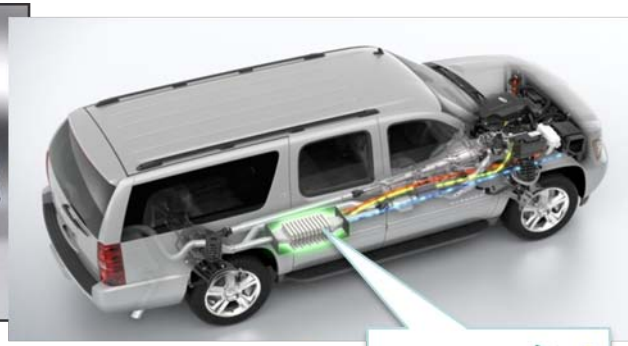
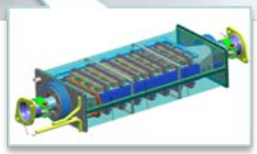
Ford, BMW, VW, GM, Volvo…







Energy harvesting
&
Wireless sensors
in the build environment

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Applications in the build environment

- Monitoring buildings and infrastructure, such as, highways, bridges, subway tunnels etc.

- Wireless switches, occupancy sensors, temperature/humidity sensors, for energy efficient buildings, reducing costs of retrofitting and intrusive rewiring

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Applications in the build environment

- working with construction, infrastructure and technology firms.

Wireless sensors installed to monitor
a tunnel on
the London Underground,
where they measure changes
in inclination and cracks.

Wireless sensors installed to monitor strain on netting preventing rockfalls onto the road.

Applications in the build environment

[1] wireless switches [2] wireless outdoor light sensors [3] wireless occupancy sensor [4]wireless room temperature sensor [5] wireless climatic sensors [6] [7] wireless position sensors [8]Central control [9] Remote monitoring/control

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Energy harvesting
&
Wireless sensors
in the military/ aerospace sector

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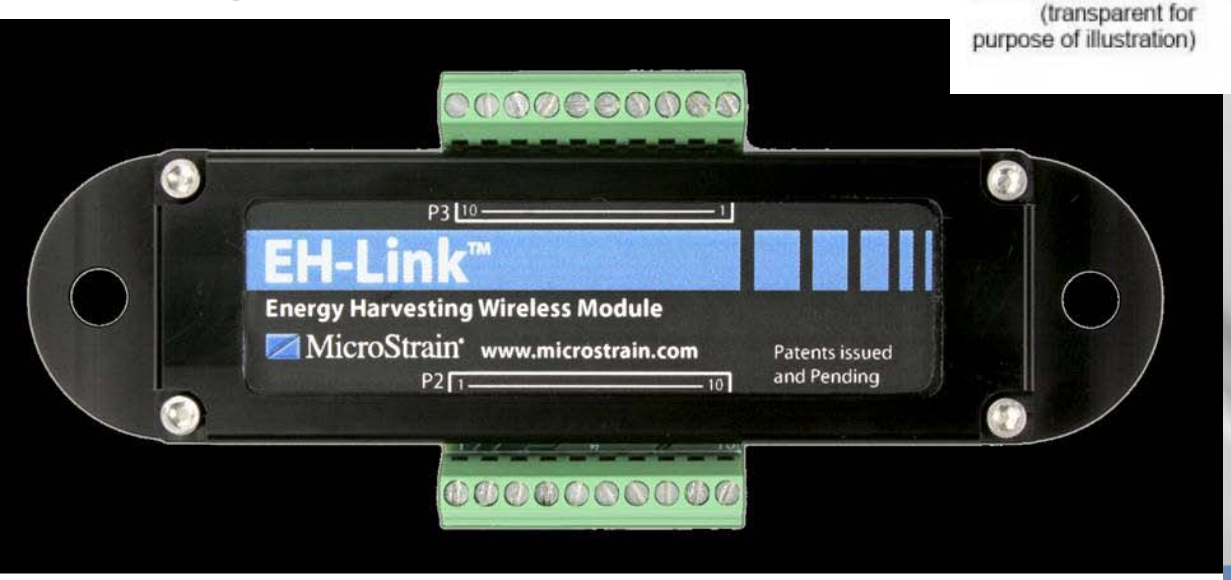
MicroStrain Solutions

Energy harvesting wireless sensor node. The node collects energy from multiple sources including strain, vibration, thermal gradients, ambient light and electromagnetic fields.

Helicopter Pitch Link w/ Energy Harvesting, Sensing, Data Storage, & Wireless Communications
(MicroStrain, Inc. patents pending)



Boeing

Key application areas:

- **Airplane systems**
- **Vehicle health monitoring**
- **Flight Test**

Minimise weight, wire use.

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Space satellites

PowerGeneration Technology for Deep Space Science Exploration

The solar array on Venus Express comprise two symmetrical wings supporting GaAs solar cells Their combined 5.7sq.m. can generate up to 1400W of power in Venus orbit

Energy harvesting & Wireless sensors in other sectors

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MSX– Micropelt

Energy reduction (~50%) in cooking, via the use of an embedded and sealed wireless sensor, powered by a thermoelectric harvester

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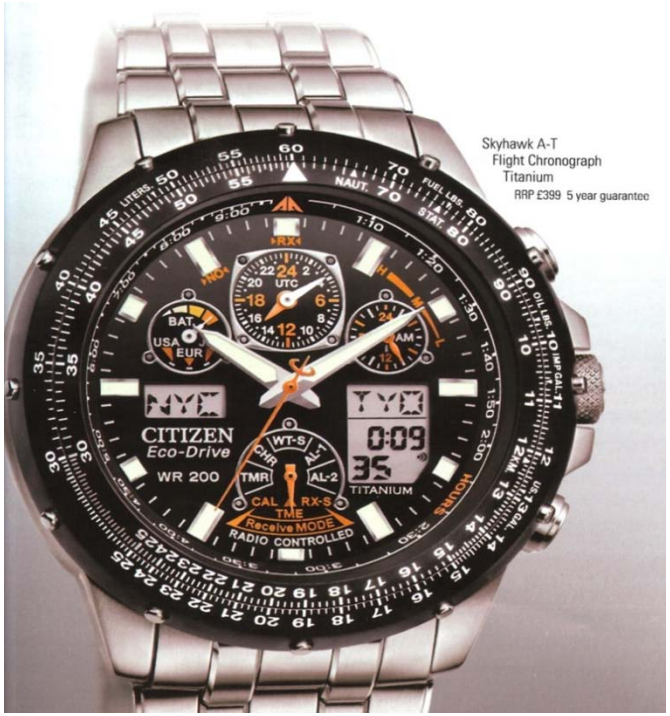
Nokia E-Cu
Concept by Patrick Hyland

Freeplay wind-up electrodynamic energy harvesting radio for Africa

energy is stored in a spring until needed

a-Si photovoltaic face and rechargeable battery for energy storage



Citizen Eco-Drive watch

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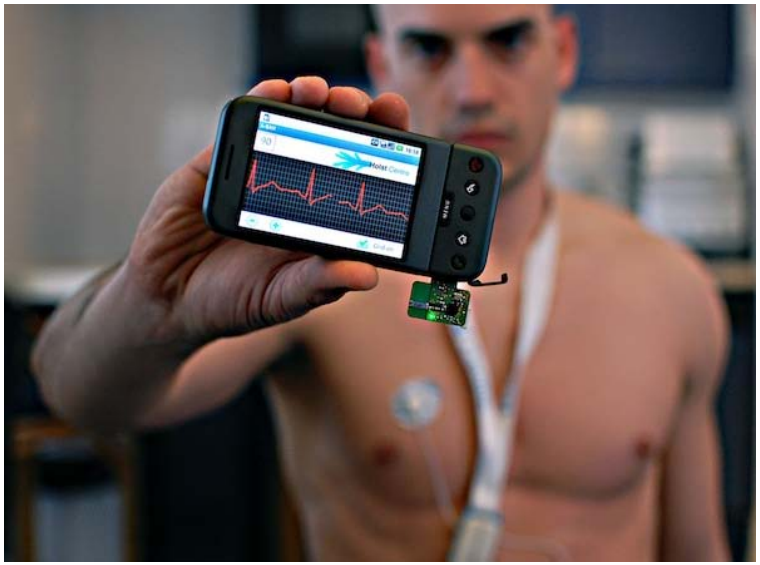
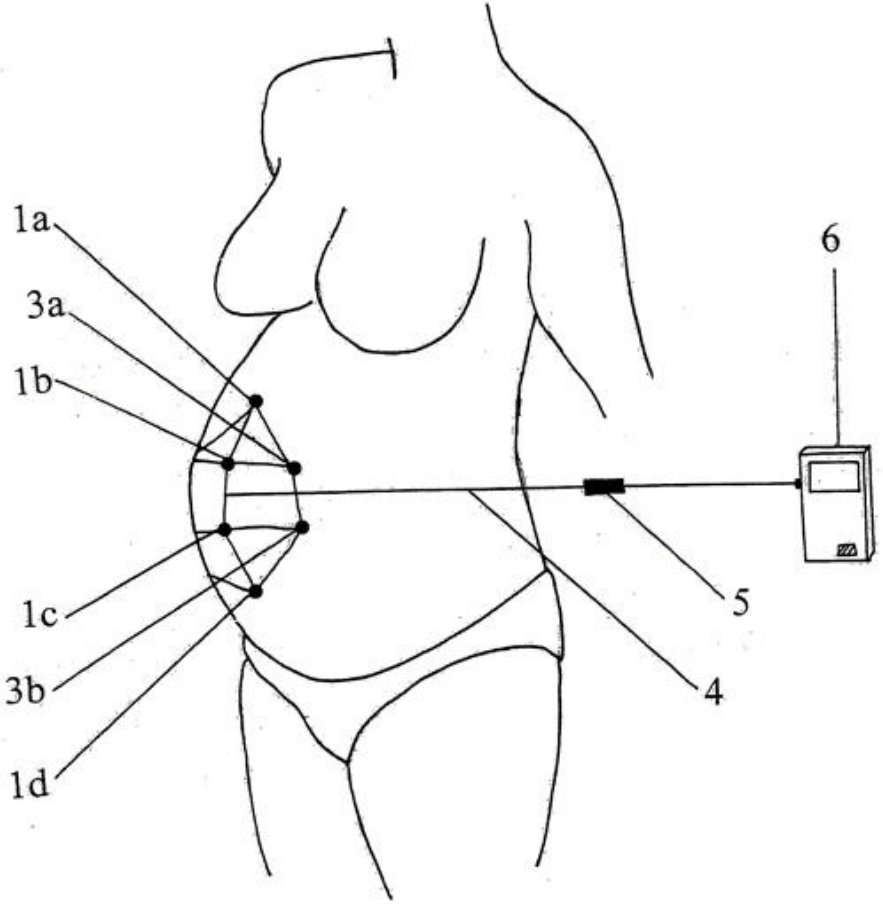
Body Area Networks



monitoring heart rate using EKG-like sensors



monitoring parameters such as the electrical activity of the muscles in the uterus to determine the strength and frequency of contractions

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Conclusions

- Large market for energy harvesting applications in many verticals for many different harvesting technologies

- Significant research and investment is still needed in the areas of cost, performance, RoHS, thermal management, systems integration, manufacturing and durability.

- Stiff competition from battery technologies, both on cost and performance, not to be ignored

-Whether you're making tvs, buttons, houses, clothes, bird-cages, roads, phones, planes, trains or automobiles…

Energy harvesting and wireless sensors should interest you

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Watch Governments

They can move more quickly as it is not all about cost but also safety, protecting the environment, efficiency etc. They can mandate things to happen:

- Smart meters (25+ million ZigBee ICs, other markets are a fraction of this combined)
- More than $1 Billion spent by the US Military on RTLS/Active RFID in the last decade
- Subsidise set up and manufacture costs, plus installation costs, of PV
- For passive RFID, Governments have mandated/paid for RFID on cattle, in passports, in transportation systems, libraries…
- Governments are increasingly legislating to have more environmental buildings, infrastructure (Smart Grid), transportation…

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- Tire pressure monitoring – US law
- CO_2 sensing in classrooms in the UK

For more information…

Energy Harvesting & WSN Europe, May 15-16, Berlin, Germany

www.idtechex.com/eh

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Thank You

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