

Machine Health for the Machine Maker

Ed Spence

The Machine Instrumentation Group

NIST Industry Forum

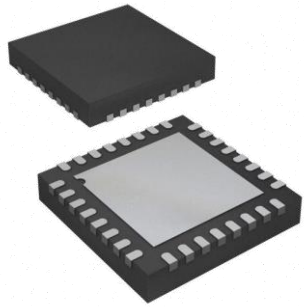
May 9th, 2018



Ed Spence is the Founder and Managing Director of The Machine Instrumentation Group, a collaborative network of CBM product and service providers helping machine makers develop their own CBM instrumentation.

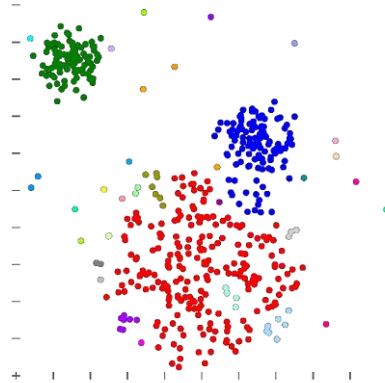
From 2008 to 2018, Ed was the Marketing Manager for Analog Devices MEMS Sensor Technology Group, where he defined the accelerometer roadmap for Condition Monitoring.

Enabling IIoT Technologies



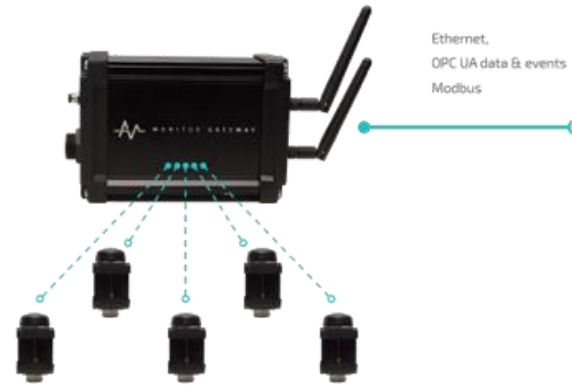
Chip Scale Sensors

MEMS accelerometers enable higher levels of integration, smaller form factors and digital interface



Predictive Analytics

Data engineering approaches improve diagnostic accuracy and add predictive insights



Wireless Networks

Lower deployment costs for on-line continuous monitoring



Data dashboards

Cloud /Web server based data visualization, distribution and analysis

Condition Monitoring Today...

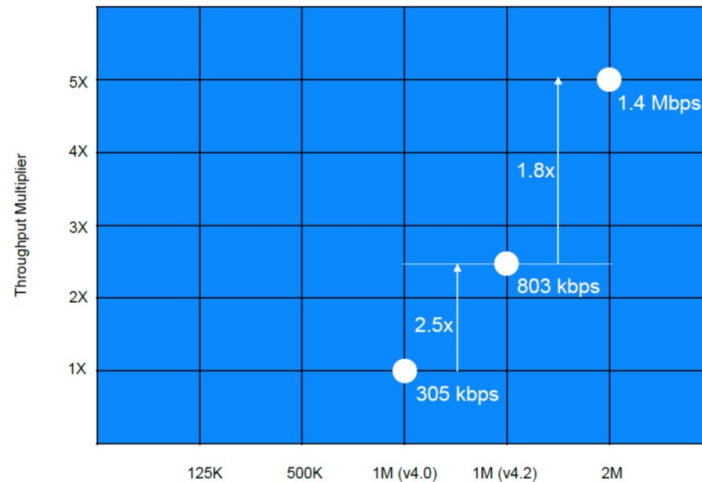


Triaxial Accelerometers



- Predominantly manual by 3rd party service providers or plant maintenance
- Low cost way to monitoring Balance-of-Plant

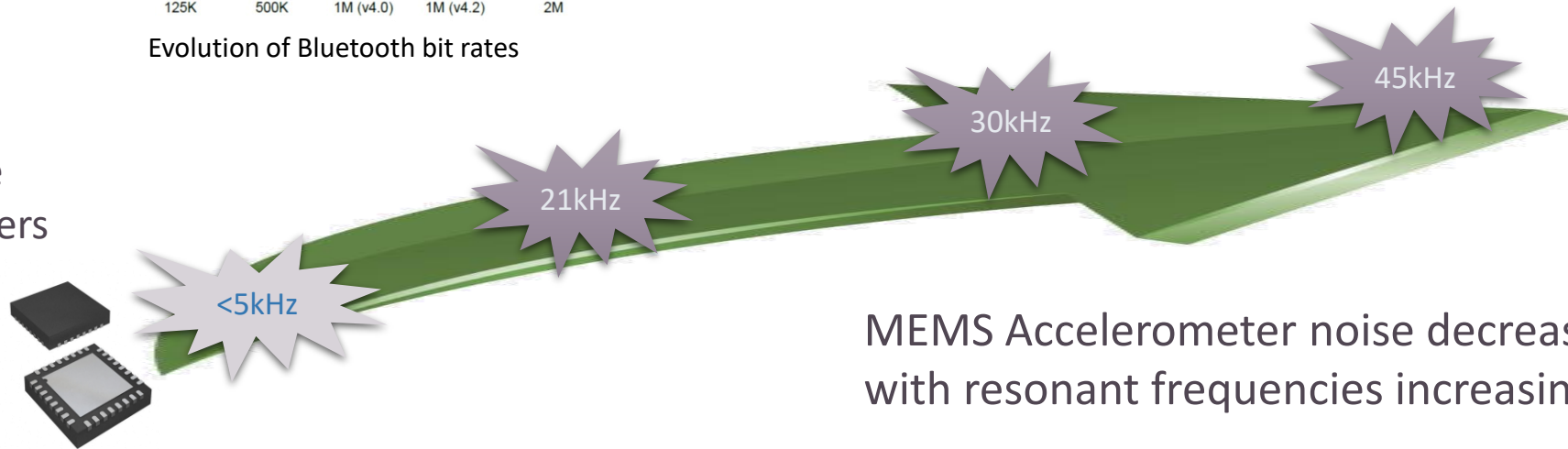
The Transformational Semiconductor Industry...



Evolution of Bluetooth bit rates

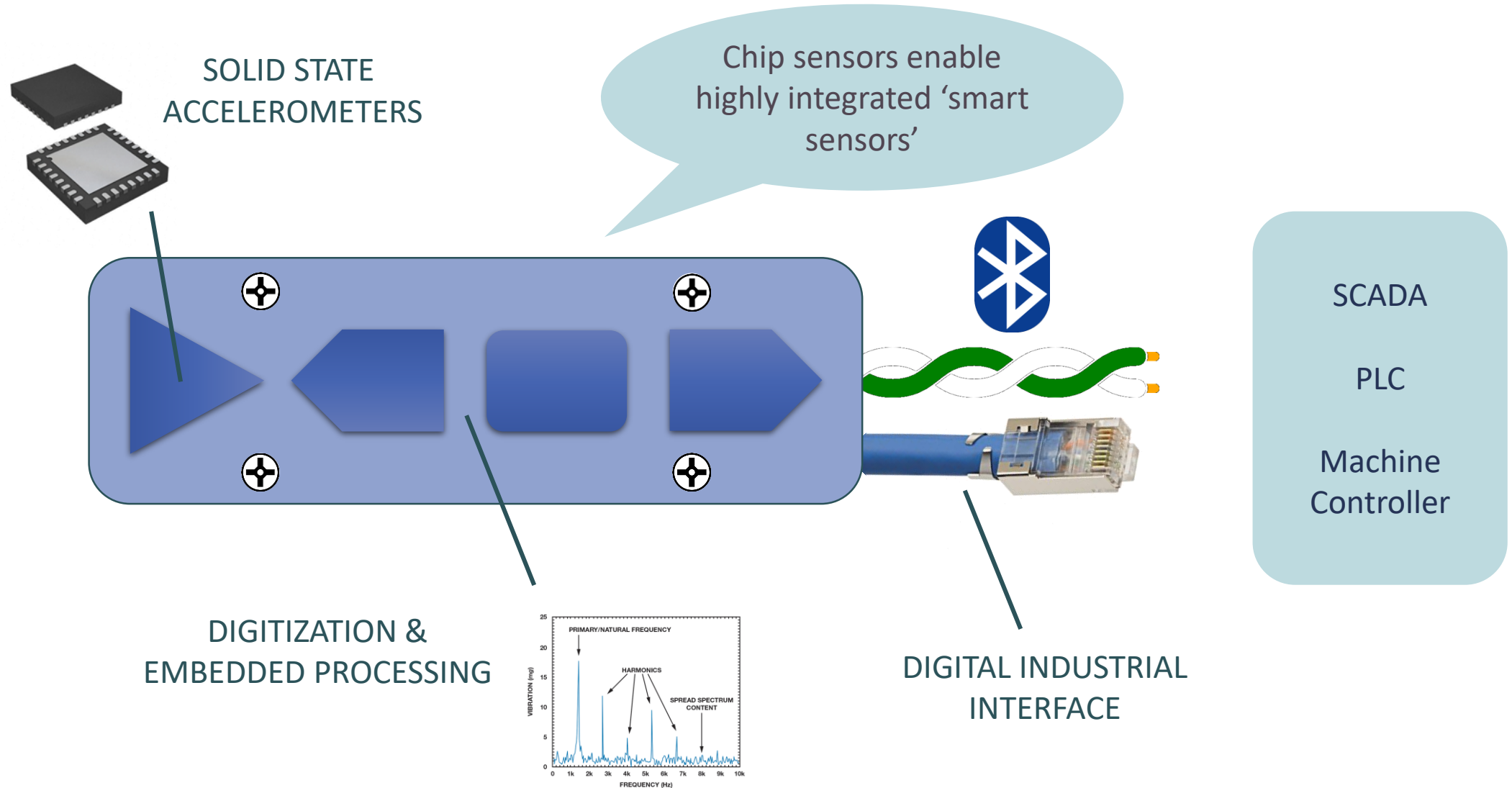
- Low power, low cost radios
- Chip antennas
- Micro-power controllers and processors

Solid State Accelerometers



MEMS Accelerometer noise decreasing with resonant frequencies increasing

The *Digital* Condition Monitoring Sensor...



Accelerometer 3dB Bandwidth



2010

MEMS

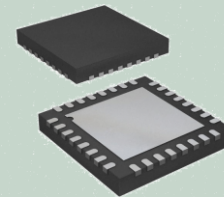
2017

The OEM /Machine Maker Opportunity...

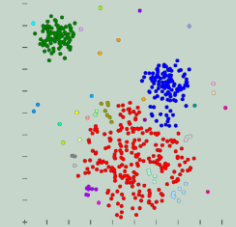
CBM value capture

- Embedded CBM sensors
- Digital interface to local controller
- Customized health indicators
- Automate 'tribal knowledge'
- Service based revenue

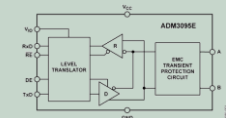
Monitoring
Software & Services



Integrated
sensors



Domain
knowledge



Digital
interfaces

OEM Incentives to Provide Prognostics / Monitoring

- Value proposition – condition monitoring services
- Workforce changes
 - Senior/Experienced users continue to retire
- Leaner maintenance
 - No time to become HW specific experts, busy running the plant
- Technology has evolved enabling cost effective solutions
 - Sensing / communications / embedded solutions / etc
- Smart Phone Culture
 - People are becoming used to having access to information
- Expanding the universe of equipment monitored
- Expanded fault coverage



Shipping more intelligent hardware

Expanding the Application of CBM

CBM 1.0

On-Line Systems

Critical plant



CBM 2.0

Route based

Expands coverage to BoP



CBM 3.0

Wireless networks

Continuous monitoring for BoP

Expands coverage to new applications



CBM 4.0

Embedded sensors

Pre-instrumented OEM equipment

Expanding CBM coverage to new equipment



Adapting CBM to Specialized Equipment



Motor-Pump Train

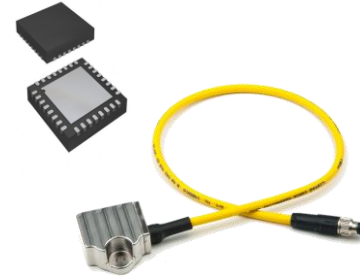
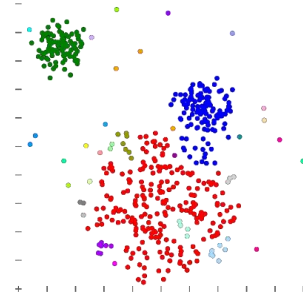
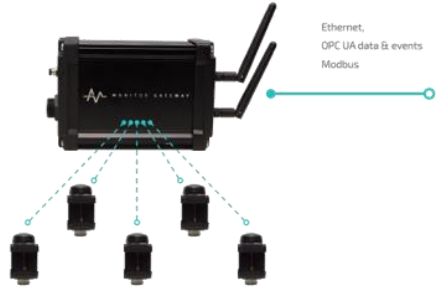
- Fixed frequency rotation
- Monitoring and diagnostic techniques well understood
- Common library of known faults



Control Valve
& Actuator

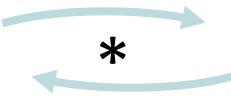
- Unique motion signatures and fault modes
- Diagnostics are visual
- Fault knowledge is 'tribal'
- Many hardware configurations

A General Process for Machine CBM Development...



Assessment
Consulting

CBM
instrumentation



Develop Health
Indicators

Add (custom)
sensors

Monitor predictive
health indicators

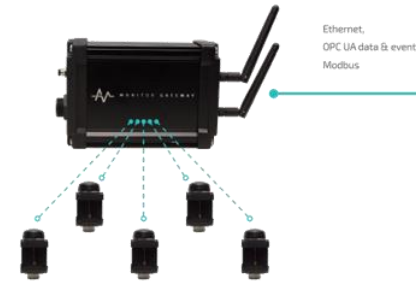


*New health indicators can often be development directly from available operational control data. An analytics pilot study can be performed before adding any new instrumentation...

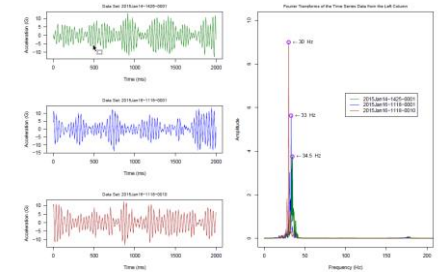
Lessons Learned so Far and Future Work...

(from an Emerson Fisher – TMIG Case Study, The Reliability Conference, Las Vegas, April 2018)

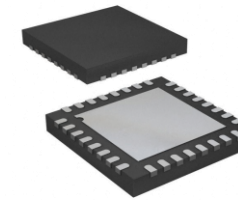
- Acquiring and evaluating new measurands requires new sensors
- Exploring techniques for expanded health monitoring is multi-faceted
 - Leverage and manage the convergence of new technologies
- Accelerating Time-to-Market
 - Force multiplier using contractors vs developing everything in-house
- Capturing domain knowledge
 - SME informed health indicators
 - Holy grail: automated CBM



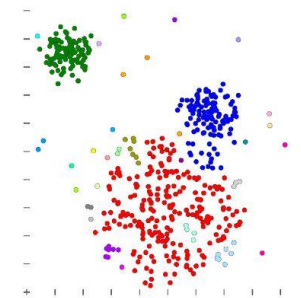
Expand Sensor Deployment



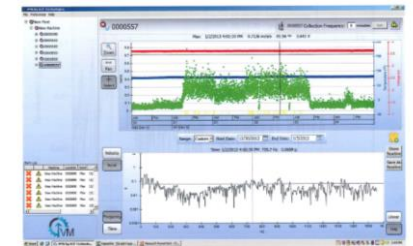
Collect More Field Data



Embed Next Generation Sensor Technologies



Improved Data Analytics – Machine Health Indicators



Prognostics Dashboard

Thank you!

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