The great balancing act

Making the Important, Measurable
The word “sensor” means different things to different people.

At one end of the scale, we have this ruggedised optical instrument, that our Oil and Gas group has produced for our client.

Measures water-to-oil ratio on sea bed in 3000m deep water and is the size of an SUV – it allows well management to be optimised in real time

We used our expertise in NIR spectroscopy to develop a patentable sensing system with a 50 fold increase in accuracy. Then engineered it to work reliably in a harsh environment for 25+ years.
The unprecedented rate of progress in sensing and connectivity make this “the fourth Industrial Revolution”

**Industry 1.0**  
Mechanical production powered by water and steam

**Industry 2.0**  
Mass production based on the division of labour and powered by electrical energy

**Industry 3.0**  
Electronics and IT for a further atomization of production

**Industry 4.0**  
Cyber physical production Systems

18th Century  
20th Century  
70s  
Today
**Industrial internet**

“The world is on the threshold of a new era of innovation and change with the rise of the Industrial Internet”

- Jeff Immelt
  CEO of GE (2012)

- GE moving away from “big iron” towards intelligent connected systems to enable predictive maintenance and the provision of “thrust hours” rather than locos.

- It is taking place through the convergence of the global industrial system with the power of advanced computing, analytics, low cost sensing and new levels of connectivity permitted by the internet.

- The catchphrase he used that day, the "Industrial Internet," has by now become commonplace in technology circles, even though it has been barely realized in terms of impact.
The “Industrial Internet” is creating data more than twice as fast as any other sector.
The potential value of improved operational efficiency across the industrial sector is vast...

<table>
<thead>
<tr>
<th>INDUSTRY</th>
<th>Segment</th>
<th>Type of Savings</th>
<th>Estimated Value Over 15 Years</th>
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<tr>
<td>Aviation</td>
<td>Commercial</td>
<td>1% Fuel Savings</td>
<td>$30 billion</td>
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<tr>
<td>Power</td>
<td>Gas-fired Generation</td>
<td>1% Fuel Savings</td>
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<tr>
<td>Healthcare</td>
<td>System-wide</td>
<td>1% Reduction in System Inefficiency</td>
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<td>Rail</td>
<td>Freight</td>
<td>1% Reduction in System Inefficiency</td>
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<tr>
<td>Oil &amp; Gas</td>
<td>Exploration &amp; Development</td>
<td>1% Reduction in Capital Expenditures</td>
<td>$90 billion</td>
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Better measurement gives you better control
I’m going to start with an anecdote from my personal history, as a graduate engineer, when I first became aware of the gap between what was measurable and what was important. I’ll call this chapter:

Resist the temptation to “turn it up to eleven”
Figure 1: Simultaneous UV (210nm) and ELSD-LT chromatograms obtained for commercial Stevia product B containing erythritol, Steviol glycosides and inulin oligosaccharides.
We observed that “good” nebulisers often generated a small vacuum

Whereas “bad” ones were associated with positive pressure
An end of line test was introduced, and the vacuum levels were logged as part of the QA procedures
Vacuum = “good”

More vacuum = “better”
The effect was to make the more volatile samples undetectable…necessitating urgent repairs out in the field
Our mistake was to make the Measurable, Important

So, how to start?
There are two basic methods to approaching the challenges of “Industry 4.0” and adding intelligence to a product or service
Method 1 – the “honeypot method”…..One of the temptations to avoid is the classic “take our old product, dip it in honey and then roll it in the sensors drawer.” Wherever the sensors stick, you design them into the product and see what you can do with the data.
The current A350 model has a total of close to 6,000 sensors across the entire plane and generates 2.5 Tb of data per day, while the newer model – expected to take to the skies in 2020 – will capture more than triple that amount.

The forthcoming A380-1000 – the supersized airliner capable of carrying up to 1,000 passengers – will be equipped with 10,000 sensors in each wing.

MORE sensors – MUCH MORE data
Having collected the vast quantity of data that such a sensor network creates, this data must be analysed for patterns using modern data analytic techniques.

99.26% correlation
This can be massively insightful…but is also fraught with difficulties. Correlations are much easier to track down after events, rather than before

95.45% correlation
"There will be over 50 billion machines online by 2020. The storage space alone will be staggering. Gigabytes will be a thing of the past. Terrabytes will be a memory. Exabytes will be floating around in the every day.

By 2020, the human race will be producing over 44 zettabytes of digital data annually. That’s 44, with 21 zeros. That really is Big Data. But how will the world cope with that much information? And more importantly, how can the industry make it work for them?"

GE.
Divorce rate in Maine correlates with Per capita consumption of margarine

Correlation: 99.26% (r=0.992558)

Data sources: National Vital Statistics Reports and U.S. Department of Agriculture
US crude oil imports from Norway correlates with Drivers killed in collision with railway train

Correlation: 95.45% (r=0.954509)

Data sources: Dept. of Energy and Centers for Disease Control & Prevention
Sensors are about *information*, not data
Make the Important, Measureable
1. Consider the business case

Rather than just “adding smarts” to your old product, production line or service….consider it as part of its overall eco-system. Can you:

Make your product or service unique?

Make you better perceived by your customers?

Reduce warranty claims, materials costs or cost of ownership?
Can you generate an ROI?

Implementing a new sensor system can be expensive – it can be disruptive…

Is the potential up-side >10x the probable cost of development?

Can you pay back in 3 years…or less?
2. Get the criteria right
Consider your system in context
Consider your system in context

- Who needs the information?
  - WHEN do they need it?
    Real-time? Daily updates? Once a week?

- Who owns the problem?
  Manufacturing / Service / Customers / Operators?
  - Who is prepared to pay for it?

- How can you ensure security over your information?
  - If it has value to you, there will be hack attempts
Step 3

3. Build ‘the simplest experiment to show the hardest aspect’ then define your product architecture accordingly.
Here are some practical experiences in trying to implement a distributed sensor network for the logistics industry – one of our own developments, that I know some of you are already familiar with.

The challenge here for us is to reduce wastage of perishable goods where the temperature has to be tightly controlled.
Why do this?
The other important industry using cold chain logistics is life sciences and pharma – goods such as biological vaccines, where the efficacy of the drug is strongly determined by how it’s handled in transit.
DropTag® is a simple-to-use, low-cost condition-monitoring system, comprising smart sensor pucks, an app and a secure server.

It allows individuals and businesses to understand how goods have been treated at any given point in their journey.

- Temperature
- Humidity
- Acceleration
- Pressure
- Flight detection
Adding wireless sensing means the measurements are taken INSIDE the insulation, but can be read from OUTSIDE.

DropTag is affixed to individual cold-chain packages prior to despatch.

Critical events are logged in DropTag’s memory.
Temperature and Humidity traces provide a wealth of data…

Can see the cooling / heating cycles correlate with the vibrations seen.

When the refrigeration unit cools down the load the humidity also drops and fresh dry air supplied.
But remember – we want information, not data.

The value of this sensing system is not in the volume of data it can produce, but in the immediacy of the way it answers the question: Is this shipment OK?
Knowing AFTER the event that a shipment is damaged, or not fit for use is helpful….but is it a solution?

- The greatest benefit comes from solving the problem, not from diagnosing it.
In order to maximise the usefulness of a distributed sensor network, we must employ some localised sensor intelligence

- Distil the data into useful, actionable information
  - Learn what’s important
  - Prevent data-overload

- Urgent – provide near real-time access to the information
  - Securely, with appropriate access controlled within the relevant organisations
  - Remote access, for operators in different regions
Consider, from the beginning, the value of the information...
...and the value of the immediacy of the information

AND THE EFFECT THIS CAN HAVE ON YOUR BOTTOM LINE
Intelligent sensing is the art of measuring what’s important

This isn’t just about logistics; it could be a sensor on your production line, or on your airbus or locomotive….

No amount of data is sufficient to replace some aspects of management - but the overall task is much easier when you measure what’s important