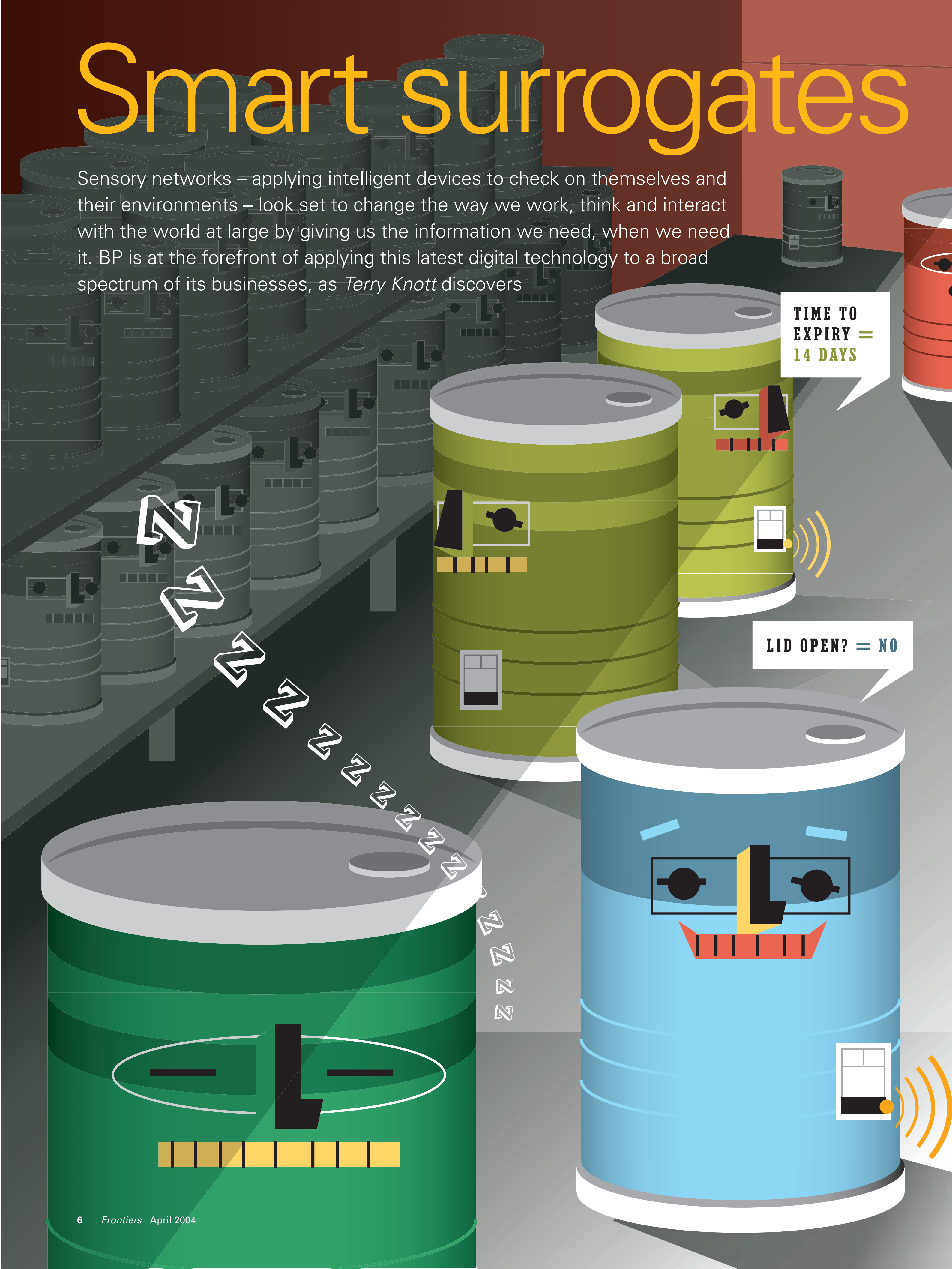
Smart surrogates

Sensory networks – applying intelligent devices to check on themselves and their environments – look set to change the way we work, think and interact with the world at large by giving us the information we need, when we need it. BP is at the forefront of applying this latest digital technology to a broad spectrum of its businesses, as *Terry Knott* discovers



In a dark, unattended warehouse, a drum of chemical product comes to life. It checks itself and the other drums nearby, interrogating them about their position and contents: Am I standing too near to a chemical I shouldn't mix with? Are there too many drums like me in this warehouse? Has anyone opened my lid? Am I getting too old to be here? If any answer is yes, the drum sends out an alert, requesting human intervention to correct the situation. If all is well, the drum goes back into hibernation, aware that its neighbours will be making their periodic checks too.

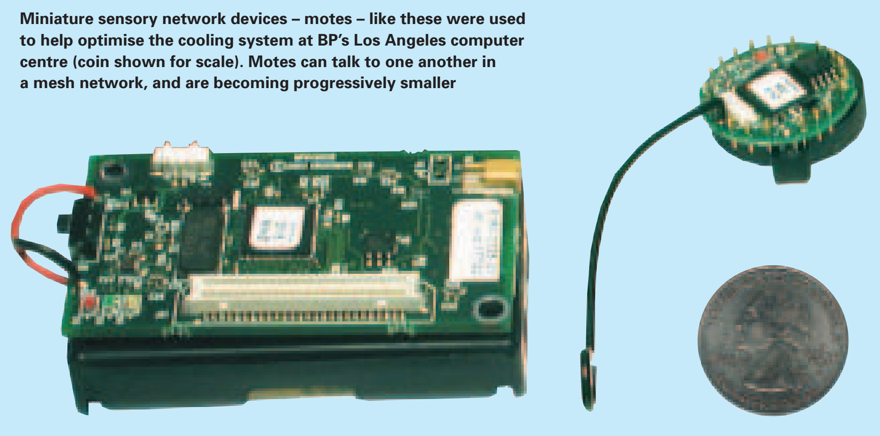
Giving 'intelligence' to inanimate objects is not new in itself, but being able to do this at a cost which enables many millions of diverse and widespread assets to generate business advantage from their continuous data output is the latest twist in the digital revolution. In technology terms, the chemical drum story is just around the corner. Many others like it are already with us. As a group of applications, they are known generically as 'sensory networks'.

'The best way to explain the concept of sensory networks is to imagine a company expert with a clipboard standing next to an asset,' says Ken Douglas of BP's digital and communications technology (DCT) function. 'The expert monitors the asset – be it an item of equipment, a product, a worker – checking on how it got there and its current condition. Then he relays this information to a central control point where it is compared with a multitude of data from all the other clipboard experts tending the myriad assets in the company. And that tells the managers what the business is doing and the moves to make next.

Sensory networks are being trialled by BP in supply chain logistics, asset management and many other areas

'Clearly this is neither practical nor economical, but we are able to imagine it. But now sensory networks are letting our imaginations become reality and are beginning to let us do just this. You could say sensory networks are our technical surrogates.'

As director of mobile and wireless applications in the chief technology office (CTO) of DCT, Douglas and his team are responsible for smoothing the introduction of new digital technologies into BP's business units, scanning the horizon for new ideas and solutions that can be applied to the company's operations. Sensory networks are currently at the top of the agenda. >>



Miniature sensory network devices – motes – like these were used to help optimise the cooling system at BP's Los Angeles computer centre (coin shown for scale). Motes can talk to one another in a mesh network, and are becoming progressively smaller

>> 'What's driving the upsurge in sensory networks is the convergence of three technologies,' Douglas explains. 'Computing power is becoming small and inexpensive enough to add it to almost any object. Wireless networks, such as mobile phones, Bluetooth and low earth orbit satellites, are becoming ubiquitous. And at the sharp end, the sensors themselves are fast becoming very tiny at near disposable cost levels, and are capable of a vast range of measurements. Integrating these gives you the power to know what is happening in the real world, at a distance, when you want to know it.'

Across BP's businesses, various types of sensory networks are being trialled – and in some cases are in commercial use already – with applications in supply chain logistics, asset management, health and safety, and retail operations, to name but some. Douglas notes there are around 45 potential applications under consideration, with new opportunities being identified all the time.

No wires

Although the hardware and software elements in a sensory network vary widely from one application to another, they fall into three broad categories.

Wireless telemetry is the most mature of the three, but is now finding a new lease on life as wireless connectivity has plummeted in price and can now be accessed almost anywhere. Attaching a self-powered black box to an asset in order to transmit signals about its location and condition, via a wireless local area network (LAN), cell phone network or satellites, is now both technically and economically feasible. With the exception of the north and south poles, relaying signals via commercially available satellites is possible anywhere on earth.

Next comes radio frequency identification (RFID). Sometimes known as 'smart tags' or 'radio barcodes', these small robust tags are passive devices containing a programmable silicon chip and a miniature metallic antenna, which can be embedded almost unnoticeably into textiles, packaging, plastics – just about anything. When a specific radio frequency falls on the RFID, it is activated and transmits the unique identification information on its chip back to the interrogator – no inbuilt power is required, nor indeed any maintenance.

The interrogator containing the radio transmitter can be a hand-held reading device or statically located to read tags automatically as they pass by. While this is not dissimilar to laser-read bar codes in concept, the key advantage to RFIDs is that many chips can be read in rapid succession, almost simultaneously, and no visible 'line of sight' is needed for the reader to function – open a large container and all the separate items inside can be read at once. And, most critically, the cost of manufacture is tumbling to extremely low levels.

It is expected that RFID manufacturing levels will be measured in billions in 2005 with tags costing only a few cents, to meet demand for an almost infinite number of commercial applications in everyday use. The list seems endless – major global retail chains are already beginning to require all incoming goods be tagged; airlines can use RFIDs to track passenger baggage and cargo; railways can automatically track rolling stock as it passes checkpoints; RFID-enabled security seals can alert authorities if ship-borne containers are opened illegally; even BP's staff security passes now use RFIDs. They are also very robust, for example being used in stressful environments such as in oil and gas well drilling to identify lengths of drillpipe or downhole tools; and also reliable – RFIDs can trigger perforating guns inside the wells to assure the right guns are fired, rather than rely on expensive electrical control lines.

What sets motes apart is their intelligence – they can talk to one another to set up a network

By embedding a small battery into an RFID, the tag becomes 'active' – giving the tag the ability to transmit under its own power, reporting to the interrogator over a range up to around 150m. This adds versatility to the tag in situations where access is restricted, or movements must be monitored, aiding communications between operators and control centres, or locating people in an emergency.

The third and most recent type of sensory network device is referred to as a 'mote', reflecting its small size. A mote incorporates a sensor capable of reading physical parameters such as temperature, pressure, weight, vibration, strain or speed; a small power source; a microchip giving it computing capacity; and wireless radio communications ability through a transmitter.

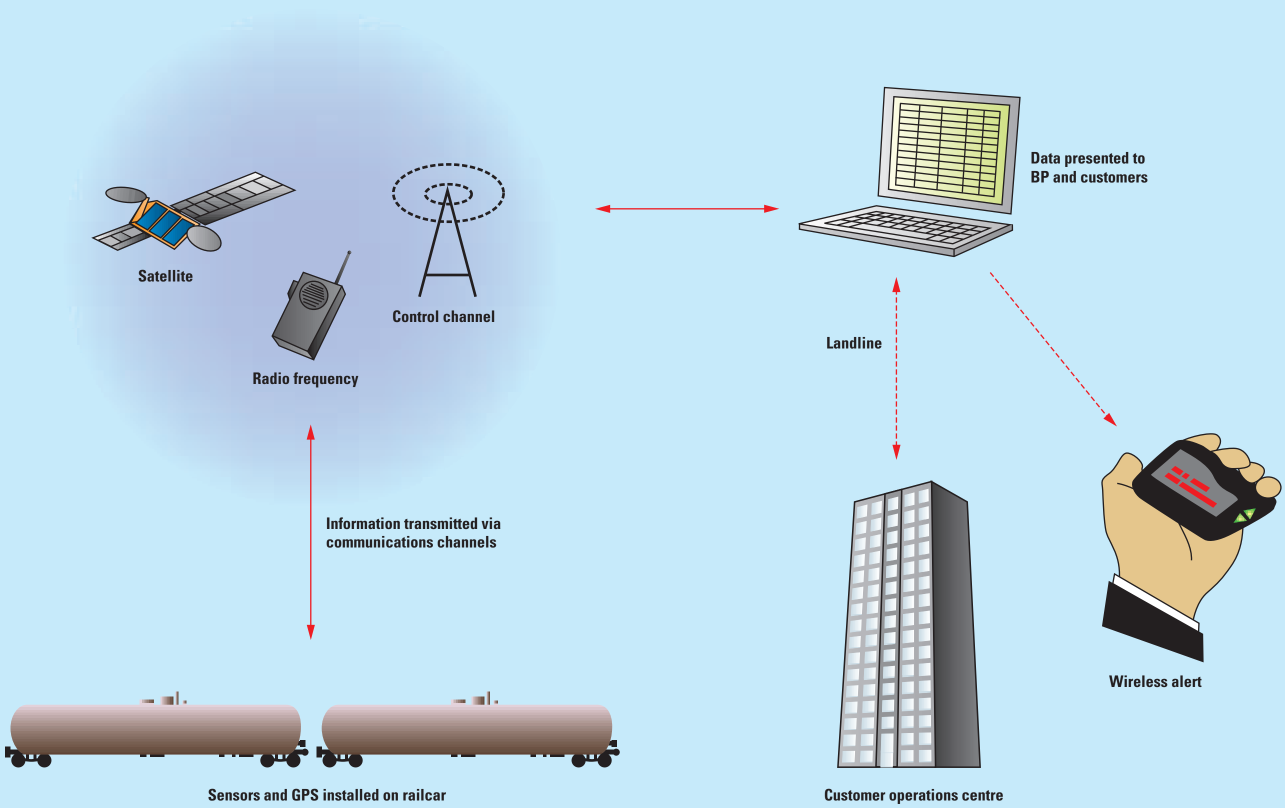
'Motes are coming into their own now,' says Harry Cassar, technology director of BP's CTO team. 'What sets them apart is the intelligence to talk to one another, to set up a mesh network. This means that if one mote goes down, the network can reform itself and remain in operation. It also means that an individual mote does not need to have a long range, and therefore the inbuilt power supply can be small.'

Motes would be the type of sensing device used in the chemical drum warehouse example, but could be applied to a vast array of situations. Currently they are around the size of a bar of soap, but in a few years' time are likely to be no larger than a medicine capsule – motes are sometimes referred to as 'smart dust', as they could in theory be scattered around by the handful.

'Among the challenges being worked on now is extending power supply life,' adds Cassar. 'Most of the power is consumed by the radio communications and can be preserved by programming the mote only to transmit when necessary. But in time it is expected that motes will scavenge energy from their environment, for example from vibrations, heat or light, and will therefore not need an inbuilt power supply.'

These and other issues – such as getting motes to be self-synchronising so that new members of the network can begin communications without special programming – are the subject of a new **>>**

Keeping tabs on BP's railcar fleet



Continuously rumbling around the railroads of North America, BP has a fleet of some 12,000 freight railcars, transporting a range of products as diverse as polypropylene and natural gas liquids. The products onboard can be liquids or solids, often as powders, other times as pellets, and are sometimes hazardous. Their journeys can be relatively short or cross-border, taking in Canada and Mexico, delivering BP's portfolio of products from its manufacturing plants and refineries to customers, and taking in fresh raw materials.

Rail is the standard mode of transport for moving bulk products throughout North America. Knowing just where any railcar is, precisely what it contains – many chemicals come in different product grades – and whether it is full or empty, presents a significant logistics challenge. Although most of the railroad system in North America has for some time operated a 'car location message' (CLM) train tracking system based on RFID tagging of individual cars and a network of trackside tag readers, this provides information only when the train is in transit – once inside a chemical plant, visibility of the car's location is lost. Furthermore, the CLM only provides a location snapshot of the railcar and does not give information about what it is carrying.

Now, thanks to a tracking system being tested by BP, referred to as 'telematics', it is possible to know what is happening to the cars and their products on a continuous basis.

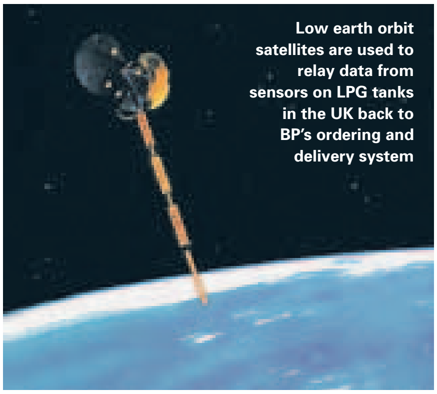
'BP's petrochemicals business needs greater visibility on their railcars throughout the use cycle,' says the manager of the telematics project, John Diendorf of BP's petrochemicals marketing, sales and logistics group, based in BP's Naperville facility in Illinois. 'We want to know when a car has arrived, when it is unloaded, reloaded, and returning. This information not only lets us improve the use of assets from a business point of view – even a small increase in railcar 'turns' adds up over such a large fleet – but together with the addition of sensors to monitor impacts and temperature, will also bring significant safety-related data with respect to hazardous cargoes. The visibility provided by telematics could transform both the petrochemical and rail industries.'

For the telematics pilot project, which began last year, 21 railcars, of both tank and hopper types, carrying six different product lines, were equipped with a wireless satellite telemetry system. In essence each car carried sensors to measure the temperature of the contents (for liquids), the weight of the load, accelerometers to record impact, and a global positioning system (GPS) transponder to give location. The equipment is battery powered and transmits radio frequency signals to a geostationary satellite, for onward relay to BP's control centre.

The trial proved very successful, each car reporting back daily and giving BP information on its precise location and status. Furthermore, by setting up a 'geofence' around the BP and customer chemical plants – an area designated by GPS co-ordinates – the system is able to report to BP if any changes to the cars' condition take place during transit, causing an alarm condition.

Compared to the conventional manual procedure of inspectors walking the line to determine if cars are full or empty – or even present – the sensory network alternative shows clear advantages. 'There were no show stoppers,' adds Diendorf.

Now the telematics trial is being expanded with technology support from Accenture to include 240 railcars, primarily from BP's acrylonitrile business unit. Under evaluation will be the use of BP solar panels to power the sensors and telemetry system, the frequency of signal transmission, a method of sensing 'hatch tampering', and the ability for authorised users in BP to 'ping' the cars – that is, interrogate them from mobile devices such as laptop computers and cell phones. Pending the outcome of the trial, it looks likely that telematics will be expanded to include more of BP's railcar fleet in North America and Europe.



Low earth orbit satellites are used to relay data from sensors on LPG tanks in the UK back to BP's ordering and delivery system

>> research programme known as CoBIs, involving businesses, universities and the European Union, in which BP is participating as the 'business test case' for field tests, presenting real problems to be solved by mote technology.

BP is already gaining practical experience of working with motes, beginning last year with the company's computer data centre in Los Angeles being selected as a trial site. An array of eight 'ready to go' mote kits, supplied by Crossbow Technology of San José, California, was employed to measure the temperature and humidity inside and outside computer server racks at various locations in the centre, in order to optimise air conditioning and the distribution of servers and racks – the existing system of a small number of hard-wired thermostats does not generate sufficient data to optimise energy consumption. The 'granular' measurement capability of the motes trial identified the cycling of hot and cold spots – from 11˚C to 29˚C – around and inside equipment, which can be used to design a more precise and thermally efficient cooling system.

Business value

Another mote application recently starting in BP is focused on monitoring of ship vibrations in harsh environments like the North Sea, while other projects under consideration include pipeline integrity monitoring and checking the quality of borehole water in connection with BP's bioremediation programme at many thousands of sites around the world. Mote technology is evolving rapidly – another idea is to use nanotechnology to engineer miniature machines such as actuators or accelerometers into mote sensors.

But while motes are at the sharp end of sensory network technology, wireless telemetry and RFID applications are also being put through their paces at varying scales in BP.

One prominent example, already yielding cost benefits to BP, is in the monitoring and delivery of liquefied petroleum gas (LPG) across Europe. The LPG supply chain involves road tankers delivering the fuel to storage tanks at individual homes or business users. Estimating customer usage rates to time deliveries of LPG to thousands of users over a wide area inevitably results in multiple or wasted tanker journeys. To tackle this problem, BP's LPG business unit worked with DCT's CTO team on a pilot trial in the UK which began over two years ago, leading the way to a far more efficient delivery system.

Attached to each LPG tank is a small grey box containing an ultrasonic level sensor powered by a battery with a five-year life – this can be fitted by the tanker driver and entails no power connections or phone lines. This box monitors the volume of LPG inside the tank and transmits the information periodically by a simple radio signal – similar to a mobile phone text message – to a low earth orbit satellite, which then relays the data to BP's ordering and delivery systems, reporting precisely how much LPG is left in the tank to assist in planning deliveries. The remote tank monitoring (RTM) technology has been developed with UK company Andronics, and is fully operational on some 2000 tanks in the north of England.

'One of the issues we encountered prior to installation of RTM was the number of zero deliveries that impacted our delivery logistics,' recounts John Sweet, national operations manager for BP LPG. 'In many cases when the tanker arrived at site, no gas was required. With RTM we have seen a major reduction in these aborted deliveries.'

RTM has increased by more than 50 per cent the average 'drop size' of LPG deliveries, the 'holy grail' of LPG business measures, leading to a corresponding decrease in the number of deliveries required. Such is the success of the trial that further pilots are being implemented across Europe as part of the LPG business unit's 'EasyBiz' initiative, allowing BP LPG businesses in eight other countries to 'plug into' the RTM system as part of improving the service offered to customers.

Smart sensing technology is opening up our imaginations

Wireless telemetry is being evaluated in many other BP supply chains – for example in tracking railcars and their chemical contents (see panel on previous page), and may be used to assist BP's recently launched campaign to improve road safety across its global vehicle fleet. In a forthcoming long term trial, 'black boxes' will be fitted to vehicles to record vehicle speed, acceleration, deceleration and driving hours.

RFID tags are being targeted at several opportunities in BP in supply chains, asset management and in personnel tracking. Possible applications include tracking of storage drums in the lubricants market to improve the utilisation of containers and warehouse processes, and to reduce counterfeiting of products; and the tagging of a new style of LPG bottle made from composite materials rather than the conventional metal cylinders, which will enable unmanned sales and 24-hour availability for customers exchanging bottles.

In BP's refinery in Toledo, Ohio, equipment which needs regular inspection – notably that relating to safety and security – is fitted with RFID tags, ensuring that inspectors with handheld readers visit the locations at prescribed intervals. In a system closely related to RFIDs, based on wireless LANs, BP's UK chemicals facility in Hull is planning to track 'lone' personnel around the huge site, as an additional safety measure. Workers carrying handheld readers as part of their normal duty – or others wearing purpose-designed tags known as Wi-Fi tags – can be located through triangulation of signals emitted by the site's wireless LAN. Tagged mobile assets, such as compressors and cranes, can also be located in this way. This type of tagging can also provide an enhanced check on personnel during safety musters – in onshore plants or on offshore platforms – as if they fail to muster, their last position will be known.

The list of applications continues to grow. But will we become swamped with information as sensory networks pump out their information like unstoppable robots?

'We can prevent information overload by instructing sensory networks to tell us only about the exceptions to the norm, or trends that may be starting to evolve,' counters Douglas. 'Managers need more information, which they will always put to good effect, even if not immediately. We are finding that people are experiencing benefits other than the ones they first envisaged – smart sensing technology is opening up their imaginations.'

He sees a future bringing greater visibility and knowledge about the world around us, optimised in a way we have never known before. The technology is here and developing fast. The crucial task will be to make sensible use of the revelations that will surely follow from deploying our 'smart surrogates'. ■