“Now, with the advent of wearable sensors we have the ability to measure and monitor human reactions”

Martin Rivest, Thales Research and Technology, Canada

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Seeing it through
A new approach to digital radiography is giving the health industry an innovative way to produce high quality X-rays that is safe for both patient and clinicians alike.
We’re all connected. We’re connected to our friends and our co-workers and to people we don’t even know. We’re connected to machines — and the machines are connected to other machines. At work, at home or at school, wherever we go and whatever we do, being connected is part of our way of life.

The possibilities of connectivity seem limitless. But in this explosion of new ideas and opportunities, the only projects with a chance of survival will be the ones that create lasting value for users.

All new technology raises new questions. Just as the development of the railways in the 1830s triggered a wave of trepidation, connectivity stirs up a new set of worries and fears. How will we combat cybercrime? What if the system fails? Who owns my data? In fact, all the concerns raised by today’s connectivity revolution boil down to one thing — the need to stay in control. In practical terms, that means guaranteeing the reliability and security of the networks that form the central nervous system of society today.

As our connected objects become more autonomous, as each new technology makes our systems more sophisticated, we ourselves could become the weakest link in the chain. We humans have the potential to bring the system to its knees, unless the way we interact with our machines progresses at least as quickly as they do.

People may be the problem, but ultimately people are also the solution. They need to be at the centre of everything we do. Every dimension of the human condition, be it physical or psychological, needs to be factored into the products and systems we build.

To paraphrase Lamartine, connected objects have a soul — the soul imparted on them by their users and designers. At Thales, this is why we get customers and users involved so early in the design and development process. Connected cars, unmanned vehicles, human factors and urban sciences are just some of the subjects featured in this issue of Innovations. They show how connectivity can create real value for users — and I hope you will find them as compelling as we do at Thales!

Marko Erman
Chief technical officer, Thales
“What we are doing for cars is exactly what we did in avionics 15 years ago”

Knut Degen, CEO of Sysgo

Did you know
If you drive a car with a collision avoidance system, there’s a good chance Thales is helping to make your journeys safer. Radar components at the heart of crash avoidance systems are designed and manufactured by United Monolithic Semiconductors, a Thales joint venture. Thales is also a leader in LIDAR, a scanning technology that allows computers to “see”. LIDAR is expected to become widespread with the advent of driverless cars.
Connecting cars to data networks promises to revolutionise road travel. But could it bring new dangers as well?

The right connections

John Coutts

If the car you drive isn’t connected yet, chances are it soon will be. Technology analysts Gartner claim that one in every five cars – a quarter of a billion vehicles – will have some form of wireless network connection by 2020.

Connected cars are now one of the fastest growing manifestations of the Internet of Things (IoT). The fusion of cars, communications and data promises dramatic improvements in safety, journey times and environmental performance – paving the way for smart cities, intelligent transport systems and ultimately, driverless vehicles.

As with any disruptive technology, separating the hype from the reality is not always easy. Pivotal questions include how connectivity should be provided for connected cars and who should provide it. This is a commercially complex area, particularly for car makers.

“In the market right now, you’re talking about using narrowband connectivity for non-critical systems like phone calls and radio, and that’s about it,” says Joel Grundy, head of strategic growth opportunities in research, technical and innovation (RTI) at Thales.

Currently, built-in connected car services – such as navigation tools and stolen vehicle tracking – depend on a mobile internet connection. This is exactly the same type of connection already being used by smartphones.

But the mobile internet is too slow for the safety critical applications envisaged for the near future, such as collision warnings and traffic control. These depend on cars “talking” to other vehicles and infrastructure in real time. Short-range wireless data transceivers would be used to provide lightning-fast vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) communications.

While the car industry and government agencies are actively pursuing this technology, the costs and complexity of implementation mean that V2V and V2I are not expected to enter the mainstream for at least five years.

“What’s interesting is the immaturity of car connectivity,” observes Grundy. “If you compare cars to aircraft, for example, there’s a huge capability gap. An aircraft has multiple sets of communications systems: satcoms, radio with high levels of redundancy, cellular, data streaming and voice streaming. It’s a rich picture of connectivity. That’s not the case with cars.”

The lack of a stable business model for connectivity further complicates matters. For car makers, the prize is capturing recurring revenues through connectivity built-in to vehicles. Car buyers, though, are reluctant to be tied to manufacturers in this way. This is forcing car makers to make provision for “bring your own device” (BYOD) connectivity, with in-car systems piggybacking off of users’ smartphones.
“...it’s about the potential to give some basic human dignities and freedoms to people who have never been able to take advantage of personal transport”

Joel Grundy, head of strategic growth opportunities in research, technical and innovation (RTI) at Thales

What is a connected car?
A connected car is generally considered one in which mobile communications, hardware, software and a means of displaying information to the driver are included at the time of manufacture. Connectivity is typically provided via a built-in SIM package. Connected cars include a range of telematics functions designed to improve safety, comfort and efficiency. These include GPS-based automated journey planning with congestion warnings, stolen vehicle tracking, maintenance scheduling and remote access features such as vehicle unlocking. Automatic accident notification, which makes an SOS call in the event of a crash, will be mandatory for all new cars under the EU’s eCall programme from 2018.

In the future, the rise of V2V and V2I technology is expected to revolutionise road travel, with a range of active safety features that includes advanced crash avoidance.

Managing the risks
Connecting cars to external data networks introduces risks as well as complexity. Wireless communication links are a potential attack vector for hackers – a point underlined by several widely-publicised vehicle hacks in 2015.

Two factors put modern vehicles at particular risk. First, a growing number of cars have semi-autonomous functions such as parking assistance, lane monitoring and automatic braking. These allow a computer, rather than the driver, to take control of vital tasks such as steering and braking.

The second – bigger – problem is that electronic systems in cars are either poorly secured, or not secured at all. The risk is amplified by fragmentation: computational power in cars is seldom centralised; instead, individual functions – from instrumentation to braking – are governed by separate control modules. Modern vehicles may contain up to 70 such modules, along with millions of lines of code.

Against this background, car makers are working to centralise functions on fewer computers. But this creates its own challenges. How do you ensure safety if vital functions – such as braking – share the same computer hardware as non-vital ones like infotainment?

To answer this question, car makers have turned to the aerospace industry, which has already tackled the problem of fragmentation by adopting a solution known as Integrated Modular Avionics. This works by separating individual applications from each other by partitioning, an approach that makes it possible to run different types of software together, safely, on the same hardware.

Sygo, a Thales subsidiary based in Germany, is a pioneer in this field. The company specialises in embedded operating systems and its PikeOS solution is already proven in the safety-critical aerospace and defence markets. It’s about to make its debut on the roads: PikeOS is being adopted by Continental and Magna – leading motor industry suppliers – and is expected to start appearing in vehicles from 2017.

“What we are doing for cars is exactly what we did in avionics 15 years ago,” says Knut Degen, CEO of Sygo. “The increasing number of software applications and assistance systems means that automotive electronics require similar system architectures to those used in aviation. PikeOS is a hypervisor that can host various software packages in individual partitions and control communication and data flow between the applications and the hardware.”

As well as enabling the secure and rational use of a vehicle’s internal computing resources, PikeOS provides a defence against external threats: “For the connected car, security depends on being able to separate communications with the outside world from the inside electronics,” says Degen. “Such an architecture will be mandatory for autonomous vehicles.”

The road to autonomy
The rise of autonomous – driverless – cars is likely to intensify the focus on the role played by communications. Not only how those communications are secured, but also their purpose: if autonomous vehicles become widespread, the impetus for external monitoring, even external control, is likely to grow.

One of the factors shaping the debate is the question of liability. Deciding who’s at fault when things go wrong has long been a legal minefield and it is likely to become far more complex. This point was underlined late last year when California’s regulators announced that – for the time being – self-driving cars will still need a driver. More recently, however, the US National Highway Traffic Safety Administration has acknowledged that a computer can be identified as the driver – at least in the case of Google’s self-driving car.

The way risk is allocated will shape the evolution of vehicle autonomy, believes Grundy: “There are different implications for infrastructure control versus complete autonomy. If the world concludes that liability rests with the manufacturer, then car makers are going to bring as much assurance into cars as possible,” he says.

“The other hand, if governments decide there are areas of risk that need to be collectivised, then the ownership of the information that allows the car to make sensible decisions may rest with an infrastructure provider – the equivalent of air traffic control or rail signalling.”

Whatever model becomes dominant, cloud services and back end systems are likely to play an increasingly important role. This is already happening: functions such as theft tracking and pay-as-you-drive insurance already rely on the cloud. It’s easy to imagine a world
The development of V2I communications using high-speed wireless opens up the prospect of connected roads, with traffic and wayside systems seamlessly exchanging data about road conditions in the vicinity of vehicles. This makes it possible to warn drivers about hazards before they come in to view.

An example is providing vehicles with access to live traffic signal data known as signal phase and timing information. As well as saving fuel and improving traffic flow – imagine sailing through the city on a wave of green lights – this could lead to a reduction in the number of accidents at intersections by providing advanced warnings about upcoming red lights. Information about roadworks, data from variable messaging signs and early warnings of lane closures could all be relayed via V2I links. One of the attractions of V2I is that, in many cases, it provides a way to re-use data that is already being produced. V2I is part of the wider concept of cooperative intelligent transport systems in which vehicles communicate both with each other (V2V) and with infrastructure. The term V2X is used to describe this combination.

Are we nearly there yet?
While the shift towards autonomy is beginning to gain momentum, hurdles remain. Public attitudes are one of them. Cars have long been tied to deeply-held notions of identity, freedom and independence. By handing the steering wheel to computers, some of that freedom is sacrificed.

However, there is evidence that attitudes towards car ownership are changing. The rise of car clubs in cities and the success of taxi apps such as Uber and Hailo underline a willingness to see cars in a new light. There are also signs that the century-long love affair with the car may be losing its sparkle: research in the UK and the US suggests that young people, men in particular, are driving less.

Driverless technology has the potential to optimise the use of roads and transform safety. But ultimately, believes Grundy, the battle for hearts and minds could be won by the extent to which autonomy expands personal mobility. Currently, those who need cars most – including the young, the old and people with medical conditions – often have least access.

“This isn’t just about being able to come back from a night out in a car that drives itself – it’s about the potential to give some basic human dignities and freedoms to people who have never been able to take advantage of personal transport,” says Grundy. “I think that’s an incredibly powerful story.”

**Connected roads?**
The development of V2I communications using high-speed wireless opens up the prospect of connected roads, with traffic and wayside systems seamlessly exchanging data about road conditions in the vicinity of vehicles. This makes it possible to warn drivers about hazards before they come in to view.

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Although V2I is being widely piloted, obstacles remain. One is that vehicles are not yet equipped with the fast 802.11p wireless links that would be required for direct delivery of safety-related data, such as the status of traffic lights. Roadside equipment will need modification to handle data transmissions. And data security will also need to be addressed and questions of potential liability considered: if safety-related data relayed to your vehicle is wrong and you end up in an accident, who’s responsible?
Imagine a tired train driver ignoring a signal or an operator struggling to cope with data overload in a metro control room or a fighter pilot being distracted and missing a critical piece of information.

Understanding what factors cause stress and how they affect the way we can work, learn and react could have a significant impact on how we manage individual and team effectiveness. Bio-sensors could be the key to measuring not only stress, but a range of factors that can influence safety and performance.

“We understand the value of sensors when it comes to machines – for example, they can identify anything that might affect systems in cars or planes, at any given moment, and allow people to respond accordingly,” says Martin Rivest, technology innovation lead for Thales Research and Technology (TRT) in Quebec City. “Now, with the advent of wearable sensors, we have the ability to measure and monitor human reactions, interpret them and provide the same kind of warnings of performance issues.”

In Canada, Rivest and his colleagues Daniel Lafond, François Couderc and Jean-François Gagnon are working within the Human Behavior Recording working group on a project called Sensor Hub, an innovation network that is pioneering the use of bio-sensors to measure a range of factors that can affect performance.

In turn, they are working with psychologists, behavioral scientists, biomedical experts and software engineers to produce a system that monitors operators in order to spot where performance levels are beginning to slip.

Rivest explains that, while monitoring biological indicators is nothing new, “within this system, we can create a more detailed picture of an operator’s mental and emotional state. By integrating data gathered from sensors – heart rate, respiration, skin conductance, pupil dilation, muscle tension and so on – the system is able to map a comprehensive picture of a subject’s likelihood of performing in a normal or sub-normal capacity.”

Lafond points out that developing new sensors is not the point of the research. Instead, the big step forward is the ability to integrate and interpret the data both in real time and in the actual operational context of the customers.

“Before we had this technology, when we wanted to measure stress in a particular situation we would have to rely on a questionnaire – ‘How stressed are you, on a scale of one to five?’ and so on,” he says. “That’s fine, but it’s not real time and is not realistic during actual work. Having unobtrusive biological sensors that can measure these inputs in the background while you do your job is a great leap forward.”
The AVS/CKT Innovation Hub design team is working on the integration of TRT Canada's technology in a new in-flight training assistant that would monitor the trainee's parameters and help the trainer design, manage and enhance the session.

The key is having a compact and sensible monitoring system easily installed on board and used in flight to demonstrate the value of this concept to US Air Force flight schools. This isn't about replacing trainers, but giving them more feedback and management tools with which they can fine-tune their deployment and evaluation of the session.

“TRT Canada’s operator functional state model is a very effective building block for the design of our concept,” says Sylvain Hourlier, human factors senior expert with Thales in Canada.
Signals and interference
Kees Nieuwenhuis, human factors and cognition specialist with Thales Research & Technology in the Netherlands, says there are, broadly, three main aspects that have to be covered when deploying sensors that measure humans in real time to give an integrated picture of human performance.

The first is interference – the more the sensors pick up, the greater the likelihood of confusion. “It’s signal versus noise,” he says. “Using several infrared-type sensors in a closed cockpit environment, for example, can cause the sensors to actually influence each other’s readings. If you have more than one source tracking the same object, you risk disrupting the signal of every one of those sources.”

The second – and perhaps most challenging – part is understanding what a clean signal means, in terms of the parameter of mental state that you are interested in, in relation to the information being delivered by the sensors.

“You can say, ‘I’m looking for stress’ but that means you have to know how stress actually affects a human. What are the measurable signals? And what do they reveal about someone’s stress levels or their emotional state?” says Nieuwenhuis.

“And then we have to go beyond a single data source. We have to map two or more data streams simultaneously and understand what their fusion tells us.”

And these additional data streams could be anything, from facial recognition software designed to determine what each expression means, to testing for specific elements in the blood – such as a specific hormone that acts as an indicator of agitation.

The fusion is necessary to develop models that code for the parameters that express fatigue, stress, vigilance, attention, mental workload, cognitive control and so on.

And then the final challenge lies in understanding how such parameters relate to improved or less than adequate performance. For example, what if being a little bit stressed in a job has a positive influence on overall alertness and responsiveness? How advantageous is a relaxed demeanour when operating a complex system? What qualifies as “good” stress? Does lower vigilance affect a pilot’s performance in all the different phases of flight?

Finding answers to these questions will involve working with external partners – the aviation industry, or a rail transportation client, for instance – to better understand how subjects react under different conditions and how that then feeds into performance. It also means working closely with medical and psychological experts.

“We need to identify if an operator is capable of carrying out tasks,” Nieuwenhuis says. “It’s one thing to be tired, but to be stressed as well, and then overloaded – we need to knit that all together to understand the inputs and their effects.”

The team is working with experts across a range of disciplines: from behavioral science and human cognition experts designing high-quality experiments necessary for collecting data, to machine learning experts developing models that fully exploit the information provided by the sensors.

“There is a lot of work to be done on nailing down the specifics of the indicators and what they tell us about the human state,” says Rivest. “It’s hard to obtain the right signals and to understand what they mean.”

Portability is also a hurdle: “Typically, these studies have used sensors that can’t go mobile – they couldn’t be deployed on a soldier moving through the battlefield, for instance,” says Gagnon. “But if we look at some of the working areas where this could be useful – police, first responders, soldiers and so on – then the next frontier will be to design and build a mobile system.”
Building an automated crew member

Helen Muncie, a psychologist based at the Thales Innovation Hub in the UK, is attacking the problem of understanding the performance of the human component in any system from a different and complementary angle.

Her research focuses on understanding mechanisms of attention and cognitive control when people interact with autonomous systems. The idea is to develop an automated crew member that can monitor human operational performance, learn habits and support decision-making within complex systems.

Part of that involves using the results of sensor readings, to be able to make predictions on the momentary mental state of a human operator. But it also involves learning from human heuristics and recognising situations where the automation should interfere and, perhaps more importantly, when not.

“The sensor technology is already groundbreaking as it is, but the vision we have is to develop an artificial intelligence, decision-making automated crew member to work within a team. Think back to your favourite sci-fi movies, they’ve got people interacting with R2-D2 or C-3PO: little helpful droids that are really useful, but don’t take the place of a person. Basically, they do the things that a machine is good at.”

The basis of this is simple: machines are good at some things and people are really good at others. It’s about getting the balance right. Sometimes a person needs more control, sometimes they need less. At the moment, the systems in place are static and designed at a particular level of autonomy.

“We want to design them so they adapt to the needs of the operator,” says Muncie. “The computer can take data from multiple sources, so if we get the information that the sensors can provide and feed that into the cognitive engine - the brain, if you like - of the automated crew member, it can make assumptions about what’s going on with the person, make predictions about what might happen next, and take action.”

At the moment, this largely involves a warning of the type you might see in car technology: sounding an alarm if it senses that you’re dropping off to sleep. What the car doesn’t do is take over and drive that car so you don’t crash into a ditch.

The automated crew member would be able to learn about people over time, in the same way that a human would. It’s then a question of how it can use that data in a useful way to help the person.

“We want to use the computer’s ability to analyse lots of data to make some meaningful sense of what the operator is doing,” says Muncie. “That means developing the machine’s ability to take in historical data - bearing in mind machines don’t forget - to build a pattern of behaviour, and respond accordingly.”

The Human Behavior Recording working group’s activities and the automated crew member activity are the two most forward-looking human factors topics on the research and technology agenda in Thales today. Both involve teams of research engineers from across the company and are firmly connected to future needs.

For now, static, closed office/lab-based systems are the focus. Nieuwenhuis can see the potential applications across a range of projects. Take Mexico City’s Ciudad Segura (safe city) project, where Thales has deployed thousands of cameras, all feeding into a central control room in order to improve car theft detection and other criminal activity.

So far the attention has focused exclusively on improving the technical aspects of the system, but Nieuwenhuis says this is precisely the type of interface where sensors can help both man and machine.

“The question we’re faced with is this: if you put human operators in a complex situation like that, how much will they pick up? How well can a human operator spot something in a video stream that may only occur for a split second, maybe a minute, before moving out of range?”

There is even evidence in literature that the human brain can pick up on some anomaly without the human operator consciously becoming aware of it. Can we use that to improve human performance?

For the research team, this is the key metric that will determine the performance of the system protecting the city.

“For that, you have to do experiments,” Nieuwenhuis says. “You have to take into account that you cannot just use your own engineers as human subjects to answer such questions: you have to factor in that you cannot just use your own engineers as human subjects to answer such questions: you have to factor in that you cannot just use your own engineers as human subjects to answer such questions: you have to factor in that you cannot just use your own engineers as human subjects to answer such questions: you have to factor in that you cannot just use your own engineers as human subjects to answer such questions: you have to factor in that you cannot just use your own engineers as human subjects to answer such questions: you have to factor in that you cannot just use your own engineers as human subjects to answer such questions: you have to factor in that you cannot just use your own engineers as human subjects to answer such questions: you have to factor in that you cannot just use your own engineers as human subjects to answer such questions: you have to factor in that you cannot just use your own engineers as human subjects to answer such questions: you have to factor in that you cannot just use your own engineers as human subjects to answer such questions: you have to factor in that you cannot just use your own engineers as human subjects to answer such questions: you have to factor in that you cannot just use your own engineers as human subjects to answer such questions: you have to factor in that you cannot just use your own engineers as human subjects to answer such questions: you have to factor in that you cannot just use your own engineers as human subjects to answer such questions: you have to factor in that you cannot just use your own engineers as human subjects to answer such questions: you have to factor in that you cannot just use your own engineers as human subjects to answer such questions: you have to factor in that you cannot just use your own engineers as human subjects to answer such questions: you have to factor in that you cannot just use your own engineers as human subjects to answer such questions: you have to factor in that you cannot just use your own engineers as human subjects to answer such questions: you have to factor in that you cannot just use your own engineers as human subjects to answer such questions: you have to factor in that you cannot just use your own engineers as human subjects to answer such questions: you have to factor in that you cannot just use your own engineers as human subjects to answer such questions: you have to factor in that you cannot just use your own engineers as human subjects to answer such questions: you have to factor in that you cannot just use your own engineers as human subjects to answer such questions: you have to factor in that you cannot just use your own engineers as human subjects to answer such questions: you have to factor in that you cannot just use your own engineers as human subjects to answer such questions: you have to factor in that you cannot just use your own engineers as human subjects to answer such questions: you have to factor in that you cannot just use your own engineers as human subjects to answer such questions: you have to factor in that you cannot just use your own engineers as human subjects to answer such questions: you have to factor in that you cannot just use your own
Growth signals

How do you adapt the world’s oldest underground rail system to meet the demands of the 21st century?

John Coutts

London’s metro network, the London Underground, handled a record-breaking 1.3 billion passenger journeys in 2015. Demand is increasing at the rate of more than 90,000 per day – enough people to fill a football stadium – and the rise is expected to continue as the city’s population surges towards a predicted 10 million by 2030.

Most of this growth will need to be accommodated within the existing network. Transport for London (TfL), the organisation responsible for transport in the UK capital, is investing in capacity enhancements, including the transition to communications-based train control (CBTC) – an advanced signalling technology that makes it possible to increase the frequency and speed of train services on existing lines.

TfL is working with Thales to implement CBTC signalling across the entire sub-surface railway – the District, Circle, Hammersmith & City and Metropolitan lines (green, yellow, pink and magenta respectively on the iconic tube map). This group of lines is considered the most complex in the world and accounts for 40 per cent of the network.

“The technology we are implementing is Thales’ SelTrac CBTC,” explains Andrew Hunter, programme system engineering manager with Thales. “This is a proven system deployed on more than 70 lines worldwide, including London Underground’s Jubilee and Northern lines.”

Smarter signalling

SelTrac CBTC underlines the way digital technologies are helping operators to get more out of existing networks. In the case of London’s sub-surface lines, the introduction of CBTC signalling will be instrumental in delivering a capacity increase of more than 30 per cent. Better signalling also means faster journey times, fewer delays and improved reliability. CBTC provides extra capacity and reliability in two main ways.

First, it reduces the gap between trains, making it possible to run more trains, safely, on any given stretch of line. This is achieved by using “moving block” technology: each train on the system knows where it is and constantly calculates the appropriate safety gap between itself and the train ahead. This flexibility differentiates moving block from traditional signalling in which separation is governed by fixed geographical blocks, regardless of how fast or slow the train is moving.

The second way in which CBTC boosts capacity is through Automatic Train Operation (ATO). Acceleration and braking are precisely controlled by computers based on the unique characteristics of each stretch of track.

“We’ve got curves of the maximum speed limits across the sub-surface lines,” says Hunter. “With a computer controlling the train rather than a person, you can

Digital technologies transform the rail industry

As is the case with the London Underground, railways across the UK have long lagged behind other industries in the technology stakes, but now they’re catching up. Initiatives such as the UK’s Digital Railway plan and the EU-backed Shift2Rail programme underline a new determination by rail operators and suppliers in Europe to drive the industry into the digital age.

“Shift2Rail represents nearly €1 billion in research and innovation paid for by the EU and the industry,” says Ben Pritchard, technical manager of technology and innovation with Thales. “Thales was a founding member and we are leading one of the five innovation programmes.”

Thales is focusing on the interconnectivity of digital systems: “This includes journey planning, passenger information, ticketing and seamless door-to-door travel. We also have a significant role in cross-cutting activities that link up areas such as infrastructure, rolling stock and freight,” says Pritchard.
“With a computer controlling the train rather than a person, you can replicate the optimum driving profile for the route every time”

Andrew Hunter, programme system engineering manager, Thales

1.3 billion
– the record-breaking number of passengers handled by London Underground in 2015
replicate the optimum driving profile for the route every time.”

Better traffic supervision will also make a difference. Under the current signalling regime, supervision is scattered across 13 control rooms. Once the new system is fully operational, a single control centre will provide London Underground with a system-wide view of the sub-surface lines for the first time. The ability to visualise and control everything from a single point matters because the four lines are highly interdependent and disruption on one line can quickly spill over onto the others.

Delivering the programme presents some unique challenges. First, there’s the sheer scale of the project. The four lines being re-signalled include some 300km of track and two of the lines – the District and Metropolitan – stretch to the edges of London and beyond. Upminster on the District Line is the most easterly of all the London Underground stations, while the Metropolitan’s terminus at Amersham 25 miles northwest of the capital is not in London, but in Buckinghamshire.

The age of the infrastructure adds to the challenge. The Metropolitan Line is the world’s oldest underground railway and the tunnels between Paddington and Farringdon first saw traffic in 1863. The current signalling is also old. At Edgware Road station, for example, more than 900 train movements a day are still controlled using a veteran mechanical lever frame housed in the station’s 90-year-old signal cabin.

The operational complexity of the network is a challenge in its own right. Although each line is operated as an independent entity, there are many places where track and signalling infrastructure are shared. The tightest parts of this knot are found in central London. Two of the busiest junctions on the sub-surface railway – Baker Street and Edgware Road – are each shared by three different lines.

The Metropolitan Line is the world’s oldest underground railway and the tunnels between Paddington and Farringdon first saw traffic in 1863.

24/7 re-signalling
Modernising the network demands not only technological but also logistical expertise. The priority is to ensure new signalling is installed safely, smoothly and with minimum disruption to passengers.

“We are migrating to the new system in 14 sections,” explains Hunter. “To simplify the logistics, we are starting close to the control centre at Hammersmith.”

As with any major infrastructure scheme, getting delivery right is a balancing act: “In the past, we’ve used weekend closures. Although highly efficient, it’s not fair or popular with the travelling public,” he says. “One objective with this project is to do more work in engineering hours – overnight – and to eliminate the need for closures as much as possible.”

Time is of the essence. While London slumbers, Thales’ teams have a window of
just four hours during the night to install and test new equipment before restoring everything to normal, ready for the morning rush hour.

The safety-critical nature of signalling means that newly installed equipment must be exhaustively tested before it can be commissioned.

“We have the ability to switch over between the existing signalling system and our SelTrac CBTC system,” explains Hunter. “We do comprehensive testing on night shifts. That way we can be confident in the trains and confident in the functionality of the system before we ‘cut over’ at our commissioning weekend.”

Having only four hours out of every 24 available for trackside work imposes obvious limitations. To speed up delivery, Thales has perfected a technique, known as performance monitoring, that enables engineers to make the most of daytime hours that would normally be lost.

“Performance monitoring has all of our new equipment powered on but not controlling the railway. This means that I can collect all the data logs from all the equipment throughout the day and isolate any problems that would cause a service-affecting failure,” explains Hunter. “Shadow-mode monitoring runs round the clock and means I can be confident about trains and trackside infrastructure working perfectly. If it’s not, I’ve got logs of that I can analyse.”

Thales pioneered this approach on the Northern Line re-signalling scheme – a project that was successfully completed six months ahead of schedule in 2012.

“What we’re delivering here is 24/7 re-signalling,” says Hunter.

“We can do significantly more testing – during the day, in the background – without any interruption to passenger service. Even compared to the Northern Line, what we’re doing here is a game changer.”

Face-to-face problem solving with the customer also helps to ensure everything runs smoothly.

“London Underground and Thales work together in a joint project office,” says Hunter. “The phrase we use is ‘one team’ and it’s highly effective. If I want to sort out a problem with my opposite number, we can meet up and solve things in 10 minutes that might otherwise have taken days.”

Engineering design for the project is now well under way and trackside work is scheduled to start shortly. The main benefits of the scheme will be delivered by 2022, when the frequency of trains running at peak periods will increase to 32 trains per hour in central London – boosting the carrying capacity of the network by an extra 36,000 passenger journeys every 60 minutes.
Partnering with top universities is an important aspect of innovation for Thales, which has created joint projects with over 50 prestigious institutions and research laboratories worldwide.
Knowledge sharing

Technology transfer has become a key ingredient for many organisations in their plans for growth, enabling them to open up new markets, forge relationships with business partners and extend their capacity to develop innovative products.

“The way we do business has changed and the way we negotiate contracts has changed,” explains Patrice Caine, chairman and CEO of Thales. In many cases, this involves a transfer of technology, something that can make some tech-driven companies nervous, but from Caine’s perspective it’s all part of the price of doing business.

“We welcome these changes – in today’s world, our clients are not looking for a simple seller-customer relationship, but a true partnership,” he says. “Transferring technologies is not a risk, as long as it’s done within the frame of international legislations, especially in the defence domain. If we want to be a major player on the global market, we have not only to accept it, but also to embrace it.”

In the 1990s, technology-based companies guarded their intellectual property like a precious jewel, reluctant to let it out of their grasp; overseas partners mostly had to make do with outmoded technology.

But there has been a significant shift in the balance of power within international markets, which has resulted in a steady relaxation of their previously iron grip on intellectual property.

In many countries, technology transfer is now enshrined in law – or, at the very least, it has become a condition of doing business. Governments require companies that wish to trade in their countries to go into partnership with local firms as prime contractors or equal partners, transferring knowledge to these joint ventures and to local research laboratories.

Often, agreements involve both government agencies and commercial companies. For example, three years ago, Thales Alenia Space began partnering with Brazilian companies Embraer and Telebras to build a telecommunications satellite.

At the same time, Thales signed a memorandum of understanding with the Brazilian Space Agency that will see the company play a major role in shaping the country’s space programme. The deal involves sharing know-how in satellite telecommunications, observation and meteorology, as well as other areas.

“There are two reasons why you transfer technology. First, when you export to another country, the government may request a technology transfer,” confirms Marko Erman, chief technology officer and senior vice president for research and technology at Thales.
All countries want more local added value and hope to develop their economy by moving up the value chain. This condition is present in the vast majority of export arrangements.

Second, we might want to transfer technology because the business case demands it. For example, it might be better to develop a product in China or India because the local competence is at the right level. It may be that a product developed for existing markets might be too sophisticated: local development would get you a better result.

Erman cites several companies that have decided to develop products that are “good enough” (i.e., in China) using a local, optimised supply chain, features and performance aligned with local constraints – low cost, ease of use, etc. But, ultimately, the product, while initially suitable for the local market, is attractive for other export markets.

“You often need to transfer technology to speed up development. It may be a condition of the deal, but it also means you can use a country as a source for new ideas,” Erman argues. And with a scarcity of skilled engineers in some parts of the world, countries with a ready supply of the right people, such as China and India, are very attractive. And while some argue that this risks cutting jobs back at home, in fact the opposite is true: when a business wins an important export contract, even one that includes a transfer of technology, it can help maintain and create new jobs in your home country.

Proceeding with caution

Some technologies are more sensitive than others. Defence sales always involve a state to state discussion before agreements between companies can be reached. Most sales require government approval before exports or technology transfer can take place.

“In the defence business, you need to have a clear assessment of the key assets that you don’t want to share with partners who may be potential competitors,” observes Martin Defour, chief technology officer of defence miss systems with Thales.

“Usually we limit the transfer of technology to development cooperation with laboratories and university departments to improve our relationships in particular countries. In India, for example, we have agreements with universities in Mumbai and New Delhi.”Partnering with top universities is an important aspect of innovation for Thales, which has created joint projects with over 50 prestigious institutions and research laboratories worldwide. Indian universities, for example, are working with Thales on military radio frequency technology for predicting the physical properties of antennae.

There are many ways of limiting the potentially adverse effects of technology transfer.

“Protecting your know-how doesn’t mean that you can’t transfer technology,” says Erman. “You need to be clear about what makes your product different from the competition, what you would like to keep for yourself and what you are ready to share. You can decide that keeping a component – a specific material or a process – is enough to protect you. For example, you can still transfer the quasi totality of the IP of a complex product, while keeping a tiny yet strategic asset that preserves your competitiveness.

“In such a way, you’re helping to build competencies in other countries, allowing them to extend their value chain, while you preserve enough differentiating elements to stay competitive on a global scale.”

The fast-changing nature of technology development also provides protection against possible negative effects of technology transfer: “The world is open so we can transfer a technology knowing that we would urgently need to develop the next one in any case,” explains Erman.

He points out that, two decades ago, US and European telecommunications companies were making older generation products in China. Now China leads with more sophisticated products than their Western rivals.

“You can’t assume the rest of the world won’t catch you up,” Erman says. “It is a rule of the game that, if you can’t accept technology transfers, you cannot export. Many people are afraid of using this model in China. Others believe that you have no choice. In non-defence, if you are not present, you are missing a major part of the market and at the end of the day you will lose out.”
Jeremy Hooper, CEO of Thales Saic Transportation Systems (TST) from 2012 to 2015 – a joint-venture between Thales and Shanghai Electric Group – has been involved in the step-by-step transfer of communications-based train control (CBTC) technology from Thales Canada and France since 2007.

“Technology transfer may be driven by regulatory requirements, but it can also produce massive benefits in operational performance,” he says. “In the case of TST, the China market is sufficiently large with a significant opportunity pipeline to support investment in local capability. The aim for TST from the outset was to build a solid competence base in China that would serve the growing Chinese market. It would also bring real expertise close to the customer and largely remove dependence on the group’s international competence centres and therefore potential international priority conflicts.”

The transfer of technology of Thales and then TST (after its establishment in 2011) in China was carried out in a careful step-by-step approach from 2007 to 2013. It began with local management, application design, procurement, installation and commissioning, then moved on to limited software development and in-house validation, before completing the transfer by covering the full project lifecycle. The latter included more fundamental activities of system design, vital and non-vital software development, safety assessment, etc. With this strong foundation, TST moved into more detailed research and development.

“One of the success factors of the technology transfer to TST has been the fact that the technology baseline transferred was mature and already delivered in previous China projects, under export mode,” says Hooper. “Another factor was the availability of well-educated engineers in China, many of whom have very specific degrees in transportation or automation. This meant TST has been able to absorb the technology transfer and rapidly grow the size of the company in a short timeframe.

“Technology transfer is not just about transferring technology, especially in safety-critical systems. It is also about transferring a mature engineering management system, and a safety and quality culture. The SelTrac CBTC product line that forms the basis of the technology transfer has a 30-year zero-incident safety record, which is unique in the industry, but it would only take one incident to reset that clock to zero. Ensuring international levels of delivery and safety was the reason for the step-by-step transfer approach, and also the reason for our success to date.”

TST’s core business is providing CBTC technology for the China metro market but, based on the success of this approach, TST has taken the first steps to expand into tram control systems, with a first reference awarded in 2015 in Shanghai. This has triggered a new technology transfer programme from Thales Italy.
According to "The Mobile Economy", a report published in 2015 by GSMA Intelligence, the mobile industry in Sub-Saharan Africa "remains a key driver of economic growth and employment across the region." In 2014, 5.7 per cent of GDP in the region was generated by the "broader mobile ecosystem" – representing over $100 billion in revenue – and this is expected to hit 8.2 per cent of GDP by 2020.

Mobile broadband connections represent over 20 per cent of the base right now but are set to grow to almost 60 per cent by the end of the decade, according to GSMA Intelligence. This will be driven in part by more than 400 million new smartphone connections expected in that time.

Despite this optimistic outlook, the report points out that the key players – from operators to governments and regulators – will need to do whatever it takes to keep up with demand: "… more than 60 per cent of the population will still lack internet access by the end of the decade. Improving the affordability of mobile services and extending network coverage to rural areas are particular challenges, given the high levels of poverty and the large proportion of the population living in rural areas."

Operators are responding – investments in improved coverage and mobile broadband networks are expected to reach $13.6 billion (24 per cent of total revenues) by 2020, up from $9 billion in 2014.

Eutelsat Communications, working with Thales Alenia Space, will be playing an important role in this process when it launches a new high-throughput Ka-band satellite. This new addition to the firmament will help improve coverage for most of sub-Saharan Africa.

Consumers and businesses alike will benefit from the newly improved broadband services afforded by satellite dishes, from...
 Investments in improved coverage and mobile broadband networks are expected to reach $13.6 billion (24 per cent of total revenues) by 2020, up from $9 billion in 2014. 

Community networks connected to Wi-Fi hotspots to mobile phone backhauling and rural connections. Once in place, it will produce 75 gigabytes of capacity via a network of 65 spotbeams, providing internet coverage to most of the region starting in 2019. This all-electric satellite will be the first to use Thales Alenia Space’s new Spacebus Neo platform. The platform combines efficiency and light weight, and will let Eutelsat benefit from competitive launch conditions and they will also be able to upscale the satellite to significantly increase coverage.

“With the Spacebus Neo platform, we are pushing back new boundaries in high throughput satellites in order to deliver quality and affordable broadband services in the many countries in Africa where increasing internet penetration is a key priority,” says Michel de Rosen, chairman and CEO of Eutelsat.
The name Scott Swanson may not be well known to many people, but he has a notable place in history. Back in 2001, just weeks after the attacks of September 11, Swanson – then a pilot in the US Air Force – found himself part of the top secret Predator mission team, piloting a drone over Kandahar some 6,900 miles away. Swanson’s target was a pickup truck parked outside a compound thought to be hiding Mullah Omar, the supreme commander of the Taliban.

The missile missed Omar, but Swanson’s place in history was confirmed: it was the first time a US drone had fired a weapon in combat.

In the 15 years since, drones – or unmanned vehicles (UVs) as they are known – have graduated from bleeding edge military hardware to the shelves of electronics stores across the world. You can now buy a basic drone for civilian use in many countries for around $99, while the use of unmanned vehicles continues to grow in the military. Between 2010 and 2014, the US Air Force trained more UAV pilots than F-16 pilots.

For Thomas Reydellet, strategic studies and prospective director at Thales, these vehicles are now central not only to military operations across the world, but also to a growing number of civil uses. Miniaturisation of sensors, as well as major advances in software and hardware have allowed UVs to develop into far more than remote controlled flying objects.

However, for this progress to continue, future UVs need to be more autonomous, agile, mobile and interconnected with other assets and platforms, in order to take their place in the military operational loop and live up to their potential.

“They need longer endurance if they’re going to be used in the field in the long term,” Reydellet explains. “They need to be rugged and discreet, with robust communication capacities to connect with other military assets,” he explains. “To continue to be accepted by military forces, they need to deliver a measurable operational benefit compared with the use of traditional systems alone.”

“Conversely, unmanned systems have a huge number of potential missions – delivering weapons/combat, reconnaissance, logistics, surveillance, targeting, communication relay, etc – but technology, from artificial intelligence to algorithms, is still an obstacle to achieving the performance levels required. Progress is being made and you can easily imagine teams of UVs working in tandem – and some manufacturers and engineers are already working on it.”

**No limits**

While military planners are working on integrating a greater range of sophisticated UVs into their systems, civil authorities are increasingly waking up to the possibilities that UVs can provide. This include everything from delivering medicines to monitoring weather, providing traffic updates and surveying disaster zones, to clearing mines, monitoring shipping lanes or monitor crowds for any criminal activity.

And it’s not only flying UVs: unmanned surface vehicles (USVs), ground vehicles (UGVs) and...
Unmanned and ready

Unmanned vehicles have already proven their use in the battlefield and are beginning to show potential in civilian circumstances as well. But is the day coming when they’re not just unmanned but operating entirely on their own?

Christian Doherty
underwater vehicles (UUVs) are all developing at a rapid rate both within the military and beyond.

“For example, last January, armed Russian UGV units were operating in Syria,” says Reydellet. And as the technology evolves, the marketing potential is also growing: the global military UGV market will generate revenues of $412.5m in 2015, including explosive ordnance disposal; intelligence, surveillance and reconnaissance; logistics and supply; and border patrol.

Rob Hooper and his colleagues Jason Dey and Matt Hart at Thales have been working on the development of autonomous maritime systems for several years.

Thales was successful in winning the joint UK-France cooperation programme called Maritime Mine Counter Measures (MMCM), the aim of which is to develop the capabilities of a combination of different unmanned autonomous vehicles to defeat the threat of sea mines.

“This encompasses USVs and UUVs, controlled remotely from an operation centre,” says Hooper. Work on MMCM has gathered pace in the past two years, largely in response to the growth of the mine countermeasures (MCM) market across the world, where clients are seeking safe and efficient modes of operating remotely to remove mines from a variety of very different circumstances, in a reliable, cost-effective manner.

“We’ve built the Halcyon USV component of the system, and we have been operating it for the last two years,” Hooper says. “And in the process we have demonstrated, progressively, through a number of trials, increasing autonomy in terms of the operation of the Halcyon.”

Dey says increased autonomy will be a fundamental feature of the next wave of USVs: “The increasing level of environmental sensing feeds into how it can determine and process its situational awareness, more objectively and accurately, in order to be able to make decisions autonomously.”

Achieving that has involved working on the range of the vehicles, as well as developing the right operating platform. Built-in autonomy requires more sophisticated sensor technology; on Halycon, sensors range from the obvious – radar, cameras, microphones, etc – to the more advanced, such as electro-optic cameras with target tracking, sonar and LIDAR, which measures distance by illuminating a target with a laser and analysing the reflected light. These sensors equip the vehicle with far greater sentience and the ability to understand and adapt to its environment.

“Once you get to a position where that’s defined, you can go even further and start looking at some sort of heuristic capability, so it’s almost thinking for itself,” Dey explains.

But he also points out that the more the system moves in that direction, a parallel challenge emerges: “The vehicle still has to behave in a coordinated way and it has to be safe to use, so when we talk about increasing levels of autonomy, it then becomes a question of how much we can allow the vehicle to make those decisions reliably on its own, and how much control to retain.”

Keeping up with Watchkeeper

It’s a question that Barry Trimmer and his colleagues have spent the past three years puzzling over as part of Project CLAIRE, a collaborative effort between Thales, the UK’s Ministry of Defence (MOD) and National Air Traffic Systems (NATS).

“Project CLAIRE was about demonstrating that you could get a UV into unsegregated airspace – which is airspace shared with commercial traffic,” Trimmer explains. “During the first flight, we moved to shared airspace – the same airspace as airliners – under control of air traffic control, which was a real first.”

Trimmer says the next leap forward will be the safe use of “sense-and-avoid” technology, installed to allow a vehicle to safely navigate in the event that a data link is lost.

“If the link fails, you’re probably going to hit the ground at some point,” Trimmer says. “You’re going to go through what they call ‘Class G airspace’, with no connection to the ground station. In that scenario, the vehicle has to make its own decisions.”

Thales has invested in two sense-and-avoid technologies under European initiatives. One uses optical sensors to replicate visual flight rules and the other envisages a radar sensor to sense-and-avoid in low visibility conditions.

The successful deployment of sense-and-avoid technology represents a genuine sea change, and would open up the potential of UVs to a far greater range of uses.

“Sense-and-avoid is the technology you need if you’re going to...UAVs need to deliver a measurable operational benefit compared with the use of traditional systems alone”

Thomas Reydellet, strategic studies and prospective director at Thales
deploy any civil UV for any purpose at all. That includes civil surveillance or disaster response or any of those things,” Trimmer explains. Sense-and-avoid involves the kind of automation already seen in the “rules of the air” followed by any automated flight system. This is definitely credible in the short term. The technology – the UV’s “brain” – operates as a fail-safe in the event of malfunction. “For example, if we lost an engine, that would lead to the UV breaking out of controlled airspace,” says Trimmer. “UVs are expected to be safe in the event the data link is lost so that’s another really important, basic feature of UAV design – to be safe if the UV loses its control link.” In this case, breaking through into uncontrolled airspace “safely” means that the UAV will see what’s around and will take action to avoid anything nearby, without any intervention.

This is the keystone of the next phase of UV development, which will see these vehicles transform from unthinking surveillance and attack devices following automated sense-and-avoid protocols into “sentient” vehicles, with much more autonomy than current models. Reydellet, however, sounds a note of caution, especially in reference to UVs.

“To work alongside humans, military robots and unmanned systems will need to display a number of human traits, such as intelligence, mobility and discretion,” he says. “They will need to provide measurable operational benefits and remain under the direct control of their human handlers at all times.”

Clearly, the possibilities for UVs to sense and learn from their environment are enormous. However, Reydellet believes that while the current sensor technology has only just begun to show what UVs can do, we’re still a long way from fully autonomous vehicles.

“As the sensors in UVs become smarter, computation loads will need to increase, in order to achieve autonomy for a fully unmanned operation,” he says. “But no suitable onboard processing solution currently exists.” In essence, the majority of the UVs “brain” will remain in the remote control station for the time being.

The big challenge for those working on UVs now is to balance autonomy with computing efficiency – grappling with the size, weight and power restrictions that currently prevail when building a UV for both civil and military use. The next frontier is clearly visible, however – building UVs that fit comfortably into wider systems. Whether that means a surveillance drone capturing and analysing intelligence on the wing or a USV directing other nearby vehicles through mined waters, the brains of these vehicles are developing at an astonishing rate.

Thomas Reydellet, strategic studies and prospective director at Thales
The race was on. In the late 1950s, research teams across the United States were competing to develop a new technology: the laser. First to cross the finish line was engineer Theodore Harold Maiman from Hughes Research Laboratories in Malibu, California. On 16 May 1960, he fired the first working model, which used a ruby laser to concentrate the light and produced the red beam we have associated with the technology for so long.

At the time, lasers were very much confined to the lab but now they have found their way into every facet of everyday life and continuous lasers are a relatively mature technology. They are used for a variety of applications, such as marking, cutting and soldering metal for the car industry, and we take for granted that lasers both scan the barcodes on our groceries and measure the composition of rocks on Mars. Yet, even after more than five decades of research, researchers in this field see yet more potential. A pulsed laser, for example, consists of energy generated within a very short time – ie “instantaneous power” – which can be controlled very precisely.

“Lasers are still a relatively young technology,” says Christophe Simon-Boisson, chief scientist for laser at Thales. “There’s still plenty of room for improvement, specifically in two areas: power and efficiency.”

Power is the “bang for the buck” – in the form of laser light itself – while efficiency is more complicated: typically 70 per cent of the input energy used to power the laser does not find its way into the beam. Most of it is radiated away as heat, making lasers just one per cent efficient.

Waste heat can be reduced by channelling more input energy into the laser beam itself. The power of the laser can also be boosted using concentrated ultrashort bursts of output.
energy. Either way, the efficiency would rise along with the output, opening up new applications for lasers in the scientific, industrial, medical and military worlds.

**The next step**
Thales has been researching and building lasers for 30 years. In 2012, it developed and delivered the Berkeley Lab Laser Accelerator (BELLA) system in the Lawrence Berkeley National Laboratory in California. During the night of 20 July 2012, BELLA became the first laser to deliver a petawatt of power – the equivalent of one million billion watts. It was achieved by delivering all of the energy into a pulse that lasted for just a femtosecond (one millionth of a billionth of a second).

Leaping beyond this, the European research programme Extreme Light Infrastructure for Nuclear Physics (ELI-NP) has contracted Thales to provide two 10-petawatt lasers. These will underpin a new European laboratory in Bucharest, Romania, which has been launched to perform unprecedented scientific research. In one project, this exceptionally powerful laser will be used to investigate the nuclei of atoms to better understand how the chemical elements are formed inside stars.

According to Simon-Boisson, one of the ultimate scientific goals for this technology is to produce a laser with sufficient power to create a tiny spot of focused energy similar to that which encompassed the universe at the time of the Big Bang. This is many years away but, if it could be achieved, it would allow scientists to investigate the possible creation of matter out of a vacuum – the process that is thought to have happened during the formation of the universe.

But this isn’t all about scientific research and theory, of course – extreme lasers also offer practical applications far outside the lab.
Simon-Boisson draws an analogy with the car industry: "When developing new technology for Formula 1, the benefits are felt all the way down to our personal cars."

For example, in the manufacture of silicon-based electronic components, sand is heated to become glass or amorphous silicon, then heated again until it transforms into a crystalline form that can be used for electronics. This is known as “silicon annealing” and traditionally is done in a furnace but the movement of the hot air makes the process difficult to control. By using pulsed lasers – which deliver pulses that last for a nanosecond (a billionth of a second) – manufacturers could heat and transform the glass quickly, precisely and efficiently.

Another process that would be rendered easier and more precise is “peening”, where a metal sheet is strengthened by subjecting it to repeated shocks. This can be done with a hammer – but by firing a laser at a thin sheet of water running over the metal surface, the instantaneous expansion of the water into vapour acts like a mechanical blow, achieving the same results with far greater efficiency.

The faster pulsing femtosecond lasers have applications in the medical world as well, for procedures such as cauterising tissue, skin resurfacing to remove scars or tattoos, and to shrink or destroy tumours and polyps. All of these applications could benefit from more precisely controllable lasers, which would allow surgeons to more accurately perform procedures.

The generation of X-rays for medical imaging could benefit greatly. At present, they are produced using mini-particle accelerators like old fashioned television vacuum tubes. An intense laser could replace this bulky, fragile technology and be simpler to maintain, minimising life-cycle costs for the equipment.

Another natural role for lasers is to produce the isotopes. There are hundreds of applications for radio isotopes – for example, some are used by doctors for scintigraphy, where a small dose of a mildly radioactive substance is introduced in a patient’s bloodstream to identify everything from blockages to internal bleeding. A high intensity laser accelerating electron particles into atomic nuclei could be more efficient and cheaper to maintain in the long run than the existing particle accelerators used for the process.

More efficient and intense lasers could allow for the highly precise targeting of tumours in cancer patients, generating the particles needed for proton therapies. These treatments use highly focused beams of protons to target tumours while minimising any damage to nearby healthy tissue. Currently, generating protons requires a synchrotron particle accelerator, which is large and expensive. This means that, despite the therapy being well understood, only 41 centres in the world offer the treatment. Laser-accelerated protons would considerably reduce the size and cost of the necessary machinery.

Military applications

In addition to the civilian applications, there is currently a widespread interest in developing military applications for these more powerful lasers.

"Many nations across the world are looking to develop laser defence systems. They are spending a lot of money on this," says Alan Miller, chief technologist with Thales. Defensive systems do not use pulsed lasers but rely on the continuous delivery of laser light to a target. In summer 2013, for example, declassified documents from the UK government revealed that a laser system was deployed on British ships during the Falklands war. The aim of the weapon was quite simple – to dazzle Argentine pilots who were attempting low-level bombing runs – but the technology involved had to be consistent and accurate in order to work.

In the years since, the power that can be delivered by lasers has increased to the point where they could be used to take down aircraft or destroy targets from a distance. The chief benefit from a laser system over standard projectile weaponry is that there...
are essentially no consumables; bulky shells do not need to be carried. Instead, as long as the laser has a power supply, it can continue to fire. This means that the “cost per shot” is lower than conventional weaponry.

The US Navy is already testing a laser weapon system called LaWS, while in the UK, the Royal Navy is exploring a laser-based directed-energy weapon (DEW) and hopes to have something in theatre before 2020.

The UK Government is also investing in lasers with “disruptive capability” – new technologies that have the potential to disrupt adversaries. They state that it is “high risk/high return areas of research that can deliver potentially game-changing advances.” Lasers could form a part of that although the exact role that they would play is classified for now.

Despite their potential, none of these groundbreaking applications will happen overnight, whether in the military or the medical profession. Simon-Boisson estimates that it will take 15-20 years or more for lasers to become efficient and advanced enough for their long-term potential to be realised.

But it will all be worth it, he says, especially when it comes to things like proton therapy: “If we succeed, it could be a breakthrough in the treatment of cancer.”

“Lasers are still a relatively young technology. There’s still plenty of room for improvement, specifically in two areas: power and efficiency”

Christophe Simon-Boisson, chief scientist for laser at Thales

Are there lasers on Mars?

NASA’s Mars Curiosity rover carries a laser designed and built by Thales to vaporise rocks for analysis. The ChemCam laser weighs just 5kg. It can target a piece of rock from up to seven metres away and vaporise a small quantity of it with the heat from the laser. The vapour this releases has its chemical composition read by an ultraviolet spectrometer, with the data fed back to Earth for analysis. ChemCam may be the first laser ever sent to the surface of another planet, but it won’t be the last. Thales is currently working on an improved model for NASA’s Mars 2020 rover.
The rise & rise of urban sciences

Technology shapes cities, from railways in the 19th century to cars, electricity and telephones in the 20th. In the 21st century, digital technologies such as data analytics and computer modelling are set to spark a similar transformation. How can we ensure that technological innovation benefits citizens? One city seeking an answer to this question is Quebec in Canada.

John Coutts

Quebec City’s new joint research unit in urban sciences – also known as the Unité mixte de recherche en sciences urbaines or UMRsu for short – draws on the expertise of business, academic and government stakeholders to tackle urban problems and exploit emerging opportunities.

Hosted by Thales, the 3,000 square-foot lab is fully equipped with the latest interactive technology and is the first of its kind in Canada. The project is a partnership between the Quebec City authorities, Laval University, the National Institute of Scientific Research, the Quebec Metro High Tech Park and Thales Canada, with the support of the provincial government of Quebec.
“It’s a unique collaborative ecosystem focused on research and development in urban sciences,” says Richard Grenier, director of Thales Research and Technology in Canada. “It’s oriented towards solutions that improve efficiency and fluidity in the city, whether it’s transport, governance, security, urban planning or city logistics. “UMRsu is an ecosystem that brings together industry, small enterprises, startups, local government and academia to work together to resolve some of our most pressing urban challenges,” he adds.

The new science of cities
Urban sciences represent a relatively new discipline. Unlike conventional academic approaches, which seek to describe and explain urban phenomena, urban sciences go one step further. The aim: to develop solutions using the city as an urban laboratory. “It brings together a wide range of disciplines that have so far been studied in isolation,” explains Professor Sébastien Tremblay, scientific director of UMRsu. “These include engineering, advanced mathematics, management, social sciences and planning. Together, all of these contribute to research and development to make things more efficient in cities.”

One programme that is set to benefit from this approach is “complete streets”, an initiative designed to make streets accessible for all ages, abilities and modes of travel – not just cars.

Delivering complete streets is a complex business. Schemes of this sort cut across departmental boundaries and budgets: civil engineers, urban planners and traffic managers need to collaborate, but each has different requirements that must be gathered, evaluated and reconciled. External experts – including architects, telecoms engineers and utilities – must also be brought into the equation.

“The challenge is to capture all the requirements, transform them into criteria that can be analysed and then to come up with the best possible compromise,” explains Tremblay.

This complicated juggling act is accomplished via multi-criteria analysis, using a software tool called Myriad developed by Thales. Myriad allows decision makers to take into account a huge number of variables, weigh up different options and then choose the best one.

“Thales has already developed smart tools and applications in transport, security and defence, which can be adapted to the specific requirements of smart cities, urban logistics and planning,” says Professor Tremblay.

As well as providing technology and expertise to make this possible, the lab acts as a forum where participants can work together. “One methodology we are putting in place is what we call ‘design thinking’,” says Martin Rivest, project manager and technology innovation lead for Thales Research and Technology in Quebec City.

“One methodology we are putting in place is what we call ‘design thinking’,” says Martin Rivest, project manager and technology innovation lead for Thales Research and Technology in Quebec City. “This involves multidisciplinary workshops that bring all the stakeholders together to identify and progress the most appropriate solutions. We are looking at introducing a Thales Design Centre within the UMRsu incubator to ensure design thinking plays an important part in its evolution.”

Work being carried out on multi-criteria analysis could pave the way for innovative ideas like smart city dashboards – platforms that not only improve governance and city operation,
but that also make it possible to showcase new projects and promote citizen involvement.

“That’s where Thales can draw from its expertise in our other critical domains,” says Siegfried Usal, vice president of strategy and communications with Thales in Canada. “Infrastructure projects tie in with governance, city services and citizen requirements; they also tie in with security.

“Thales helps its defence and civil customers to operate trains, metros, aircrafts, ships and satellites safely by providing them with the best possible technology and solutions, which we design jointly. This gives Thales a unique expertise in designing cyber-physical systems and deploying decision-making processes. This is a key building block of the UMRsu, to help conduct studies and develop solutions that can be later adopted by cities and citizens.”

**Serious games**

As well as engaging citizens, municipal authorities have a duty to protect the public when things go wrong. First responders and safety managers must be ready to tackle everything from crowd events to transport disasters and terrorist attacks.

To respond effectively, public authorities need to be able to practise their response to different crises. They also need to be able to choose and train the right personnel.

“Serious games” could help, by immersing users in a virtual crisis. This not only provides vital training, but also makes it possible to evaluate and improve performance. Working with Quebec’s police department, UMRsu’s Intelligent Simulation for Civil Protection Emergency Response (ISCPER) project is using SYnRGY – a tool developed by Thales – to build its own serious games, designed to replicate any incident that first responders are likely to encounter.

“SYnRGY incorporates maps and algorithms for the propagation of fire and traffic, and resources”

Professor Sébastien Tremblay, scientific director of UMRsu

and fire-fighting vehicles,” says Tremblay. “Most of the mechanics are already there.”

Critically, serious games make it possible to refine crisis management: “If a crisis is poorly managed, city officials and police officers can review what’s happened and replay the scenario to see how they should have responded,” explains Rivest. “This makes it possible to learn lessons and continuously improve emergency plans.”

The technology behind serious games could also help to improve other areas of urban security – underlining the way capabilities can be re-used between projects.

Smarter CCTV monitoring is one area that could benefit.

“In most command and control centres, there’s a wall of TV screens – but this is not the most efficient way to monitor what’s happening,” says Tremblay. “Using the R&D platform allows us to test new visualisation techniques.”

The same platform is being used to evaluate biometrics for first responders. Data gathered by wearable technology – devices that monitor variables such as respiratory frequency, skin conductance and pupil size – provide clues to the physiological and psychological state of the wearer.

“Biometric data helps us to gain insight into the operator’s functional state,” says Rivest. “This could be used both for training and for monitoring first responders working in the field. To do this, we want to leverage a technology enabler we have developed at Thales called SensorHub.”

The objective is to identify indicators that distinguish between different states of mind and body. Raw data is only a starting point, stresses Rivest: “One of the key challenges is to distinguish between stress and cognitive overload – if you only look at beats per minute, you can’t tell the difference. To understand what’s really going on, we are using models and machine learning techniques.”

Research of this sort underlines the way that “big data” – high volume, high velocity data – is helping to shine a light into phenomena that were until recently, poorly understood, or not understood at all.

“Analysis and exploitation of big data is the enabler in about 85 per cent of our projects,” says Tremblay.

**Going with the flow**

Water management is another area where big data analytics could make a real difference. Cities depend on supplies of clean, high-quality drinking water. They also rely on
effective sewage systems and wastewater management. Tied in with this is the ability to predict and control flooding.

Managing all of this is complicated. Guaranteeing clean, consistent water supplies for citizens presents particular challenges. This is because water quality is influenced by human and natural factors that change not only week by week, but also hour by hour.

Fluctuations in water quality make it tricky to predict exactly where, when and how much treatment will be required before water can be consumed. This challenge is set against a backdrop of growing concern about pollution levels in Lac Saint-Charles, Quebec City’s main source of drinking water. UMRsu is embarking on a project using big data analytics to improve water management.

"The objective is to use water quality data from water intakes and supply systems as a decision aid in drinking water monitoring," explains Rivest.

The project taps into the wealth of historic water data accumulated by the city: "There’s about 10 years of data from different sensors that has not been exploited before," says Tremblay.

"The idea is to use this data to develop an algorithm for predictive analytics to provide an advanced warning of problems. The same kind of analytics can also be applied to wastewater."

Insights gained from the research will help managers to select water intake parameters, as well as assisting water treatment plant operators in making preventive adjustments. It will also make it possible to identify the best locations for waterworks, along with optimum times and frequencies for monitoring water quality.

Although the lab was launched less than a year ago, it is already making its mark on the international stage.

"It’s a model they want to replicate in Dubai where Thales is very engaged with its customers," points out Rivest. The lab was showcased during COP21 in Paris as an exemplar of industry, cities and academia collaborating on green solutions.

The initial project is set to run for five years, but Tremblay has his sights set on the long term.

"We are setting up something here that has great potential," he stresses. "We’re confident about the future and would like to see UMRsu become a permanent institution."

"The idea is to use this data to develop an algorithm for predictive analytics to provide an advanced warning of problems."

Professor Sébastien Tremblay, scientific director of UMRsu
Back in the 1930s, when police detective Dick Tracy first appeared in US comic strips, no-one would have believed that his iconic “2-Way Wrist Radio” wristwatch would one day become a reality. But over 80 years later, it seems an updated version of that vision could become a fact of life.

While smartphones have played a fundamental role in expanding wireless connectivity around the world over the past decade, so-called “smart watches” are still a relatively new phenomenon. But as more tech companies launch their own brands of smart watch, from Apple and Samsung to Huawei and Sony, their potential for innovation becomes increasingly clear.

A smart watch can run apps in much the same way as a smartphone, providing users with everything from heart rate monitor to barometers and geo-localisation...
6W4U

Among other things, 6W4U could be used to keep officers in touch with each other as well as providing a secure connection to their HQ.

GPS technology, but in a very compact package while keeping their hands free. And it has the added benefit of being a very familiar form – despite being groundbreaking tech, it doesn’t have a particularly steep learning curve.

Thales has created a new app called 6W4U (“6-Watch for you”) that is intended for use on different smartwatch models and designed to take full advantage of this new step in interconnected tech. The concept, produced at Thales’ Design Centre in France, was developed with the help and support of the French police force. Among other things, 6W4U could be used to keep officers in touch with each other as well as providing a secure connection to their HQ.

The app could alert law enforcement officers of any nearby dangers or a potential risk through vibrations and pictograms, quickly and simply. It could also pinpoint team members using geo-localisation which would allow the command centre to monitor how a scene is playing out and coordinate a response as needed.

“6-Watch for you” provides an intelligent link between colleagues on the ground and helps to reinforce security at a time when speed is increasingly of the essence.

The app was launched at the Milipol 2015 worldwide exhibition of internal state security, and was highlighted by French magazine L’Usine Digitale as one of the eight key innovations presented at the event. Thales plans to take the lessons learned from law enforcement agencies using this app to further develop its potential and hopefully market it to civilian customers in future.
Seeing it through: digital radiography

Is there a way to produce high quality X-rays in a way that is safe for both patient and clinicians? An innovative approach to radiography is making this look like a real possibility.

John Lamb
When it comes to medical imaging, it’s all about what you can see. The clearer and more complete the image – and the faster it is obtained – the better the opportunity for an accurate and potentially lifesaving diagnosis. But getting to that point can be a challenge.

On your computer right now – possibly on the very display where you’re reading this – you’re likely to be enjoying incredibly clear display power. The latest tablets offer 5.6 million-pixel resolution, while “ultra HD” 65-inch televisions will take that to 8.3 million in the future.

But if you head to a medical clinic or hospital, it’s a very different picture. The people most in need of fantastic detail and powerful, high-quality image resolution – doctors, surgeons, dentists and other medical consultants – seem to be living on a different planet.

There’s a noticeable gap between the power of consumer imaging and that being used in the medical profession but, until recently, there hasn’t been a cost-effective way to bring the best of the former to the latter.

The main obstacle is radiation. Medical imaging devices rely on X-rays, which pose obvious health risks with too much exposure – there is always a trade-off between dose and image quality, especially for paediatric, dental, mammography,
surgical and interventional applications and CT scan technology. X-ray technology also tends to be bulky and heavy, limiting its mobility.

Ideally, the profession needs portable X-ray detectors that can take quality images automatically, using tiny bursts of radiation, and then display them quickly at the highest possible digital resolution, so that the technician or doctor can check that the images are correct and that the radiologist can use them.

Reduce exposure
Thales is investigating the medical potential of consumer electronic technology through a number of partnerships, continuing a tradition of leading-edge work in medical imaging that dates back to the 1950s. And when it comes to making radiology better, Thales is just as likely to look for inspiration in a tablet as printed electronics.

“We are inspired by the display industry, which is transforming digital signals into an image in the best possible way in terms of resolution,” says Vincent Marfaing, director of radiology at Thales. “But we are actually doing the reverse: we’re transforming an X-ray beam into visible light, then transforming the projected image into an electronic signal.”

Doing so quickly and efficiently represents game-changing potential for those in the profession. For example, imagine a doctor or an X-ray technician being able to view a digital preview of an important medical image in real-time while standing at a patient’s bed.

Thales’ Artpix Mobile EZ2GO (“easy to go”) – an 11-inch tablet that functions as a portable digital radiography imaging sub-system – makes this possible for the first time, storing up to 50 high quality X-rays at a time. Compared to analog solutions, the system reduces radiation per shot by as much as 40 to 50 per cent to produce equivalent image quality for the radiologist. Feedback from users reveals that this one device could win back as many as 300 extra hours of potential work time for that specialist, as it saves so much time trekking back and forth in the hospital.

“We’re also seeing real potential in special image-processing software that can take a two-dimensional image and effectively generate a 3D version,” Marfaing adds. Imagine a surgeon considering a very delicate heart procedure: they need a 3D view of what’s really going on. Typically, this has been done by taking a number of radiological images – a process that involves multiple exposures to X-rays. Thales has discovered a way to build an equivalent 3D reconstruction, minimising the number of shots, based on a detailed algorithmic approach.

“We could be offering images equivalent to a CAT scan at a fraction of the dosage that would take otherwise,” he states.

Marfaing is also enthusiastic about the work being done in organic and printed electronics – technology that could produce light, robust (if not unbreakable) flat-panel detectors for the healthcare sector.

“You want a handheld X-ray detector to be as portable as possible,” says Marfaing. “You don’t want it to break when dropped or knocked into other hospital equipment. The point of possible failure here is the plate glass technology inside the detector, which is rigid.”

One workaround would be to make that rigid surface flexible: “We are investigating...
“...If we can do that – and we think we can – we really will make a difference here to healthcare”

the use of flexible foil substrate with organic printed electronics to replace traditional electronics on glass,” Marfaing explains. “This would allow us to create a device that is much lighter than the norm, making it far more transportable, and it would also be effectively unbreakable.”

A real difference
At the heart of all of this innovation is a desire to help both clinician and patient in equal measure: “We’re looking to help patients by giving the physician the best image possible to help with diagnoses, while also exposing both parties as little as possible to radiation. If we can do that – and we think we can – we really will make a difference here to healthcare.”

These first generation product and ideas sound truly transformative – but how far off is their arrival for frontline clinicians and the patients of today?

Marfaing says that this depends on the creation of a strong, deep network of industry and academic partners – something he and his team are working actively to build. This includes highly-focused niche players like ISORG/Plastic Logic, as well as the Siemens and the Philips of the world, he says, plus France’s advanced government-backed research institutes CEA.

“When it comes to the next generation of radiology functionality, it’s about maximising both image quality and safety.” Thales hopes to achieve this goal by working with the best partners and developers to bridge that gap between consumer and medical radiography functionality.