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Connected future

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Dear Readers,

When you think about the future, what do you see? Flying cars? Robotic nurses? Green cities that respond to our every need – maybe on Mars? While we need imagination to conceive our shared tomorrow, innovation, commercialization, and implementation are, ultimately, what get it built. It's about hitting the sweet spot between the cutting edge and what actually adds value. It's a pragmatic approach, yet it offers ample room to innovate, to set new standards, to define the future.

As in every endeavor, it helps to have a guide. Ours are five megatrends, major macroeconomic forces that are shaping our society, its needs, and, by extension our business. Key among them are urbanization, mobility, and eHealth, which will impact how we live in the future. Industry 4.0 will transform our factories, production lines, and supply chains. And, last but not least, security will be vital to enabling a sustainable and desirable digitally connected world.

In this eighth edition of our u-blox magazine, we dive into each of these megatrends, offering our unique perspective on where they are headed, and how we fit into them. In our feature interview, we explore the forces shaping our increasingly connected world and the changes they might bring. And throughout these pages, we examine many of the enabling technologies that our connected future will build on.

As the ongoing digital revolution plays out, we continually strive to maximize the value we provide our customers. This mission, a theme in this magazine, has been behind our intense R&D effort to develop our latest generation of cellular modem chipsets entirely in-house. It drove our investment into redefining IoT security with the Kudelski Group, world leader in digital security. And it motivated our recent acquisition of Rigado's Bluetooth module portfolio.

We wish you a delightful and interesting read.

Yours sincerely,

Thomas Seiler, CEO

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Creating value to accelerate the connected future

As digitalization redefines technological possibilities and customer expectations, our mission remains unchanged: driving innovation in the technologies we believe will underpin our future.

Technology and society dance a fiery tango. Feeding off each other, they step, swirl, and stop, before picking up again, fueled by society's desires, its needs, and its innovative spirit. Each successive industrial revolution accelerated the pace, with the steam engine, electrification, and telecommunications impacting every facet of society. And now the fourth, this time digital, revolution is taking the crescendo to its next climax.

But on closer observation, each revolution only becomes one in hindsight. As they play out, they are more evolutionary than revolutionary. They unfold step by step, each move setting the stage for the next, with the choreography often difficult to discern, the endpoint impossible to imagine. We see this progression play out wherever technology and society intersect as long-term megatrends that constantly transform our present and shape our future. And it's why we have decided to align our corporate strategy and research and development efforts with those that are most relevant to our business: mobility, Industry 4.0, urbanization, connected healthcare, and security.

As we move into the future, technological progress continues to forge ahead and deliver more and more possibilities. But the rapid advance of the cutting edge reveals only half of the picture. The majority of our customers tick to a different clock, with costly investments expected to return dividends before they become obsolete. Understanding that they are not after the latest hype but rather after solutions that they can depend on for a decade or more lets us live up to our key mission, which is creating extra value for our customers. Doing so requires restraint. Rather than pouncing on every new technological hype, it demands that we select the most promising and relevant technologies to develop reliable and dependable solutions that deliver long-term value.

"Understanding that customers are not after the latest hype but rather after solutions that they can depend on for a decade or more lets us live up to our key mission, which is creating extra value for them."

This market-driven demand dovetails nicely with the long-term nature of our product development process. As emerging production technologies enable ever-more-complex technological solutions, driving innovation in these competitive markets is becoming more and more demanding in terms of research and development. Still, over the past 18 months, we have announced a series of new integrated circuits that are laying a new foundation for our future. By making us independent of external suppliers and third parties, this major R&D investment will allow us to offer more value to our customers, paving the way for a better, richer and more sustainable future, for us and our customers, across all five of our guiding megatrends.

Leading in mobility

The megatrends are, of course, nothing new. Mobility, for example, has driven us throughout the lifetime of our company. Our relationship with the automotive industry, characterized by their extreme demands in terms of quality, reliability, safety, and security, as well as their long design and production cycles, played a crucial role in defining our corporate culture. By forging strong ties with them and by catering to their technical needs, we were able to grow into market leaders in satellite-based positioning receivers for automotive navigation and telematics solutions.

Today, the entire area of mobility is being shaken up by evolving societal expectations, unprecedented technological possibilities, and new business models. For the first time in decades, car ownership is in decline, with users preferring more flexible and burden-free solutions such as multi-modal transportation and on-demand ride-hailing. As the number of cars drops, the electronic content of each vehicle is on the rise, fueled largely by automation and the electric drivetrain. And with vehicles becoming more and more autonomous, they are also becoming increasingly reliant on a diverse ecosystem of mission-critical data services, from high-definition mapping to real-time traffic management to a new generation of global navigation satellite system (GNSS) correction services. This has established players and startups alike scurrying to figure out how best to tap into these new revenue streams.

In addition to positioning, which has long been our core business, connectivity is essential to enable cars to enhance their functionality. Cars can only become automated if they are able to exchange data between each other, with roadside infrastructure, and with the cloud. As a component supplier for both positioning and connectivity, this trends opens the door to a rich field of value that we can deliver to vehicles, paving the way for further growth even as growth in the number of cars declines.

Connecting the industry

In the connected industry, known as Industry 4.0, market expansion will, instead, be driven by growing volumes. While the value of individual

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connected devices will likely remain stable, the number of deployed devices has huge growth potential, as digitalization penetrates deeper and deeper into industrial systems and processes, from controlling machines to monitoring every aspect of the supply, production, and distribution chains.

The industry may, for instance, well be the first to benefit from performance enhancements offered by 5G, the next generation of mobile network technology. Advanced use cases such as ultra-reliable low-latency communication (URLLC), a facet of 5G that is particularly relevant for industrial applications, could first see the light of day in private cellular networks, owned and operated by companies themselves. Enabling everything from advanced robotic control to remote maintenance and digital twins, URLLC may offer companies sufficient benefits to justify the investment in the required proprietary cellular network infrastructure.

By designing our latest generation of 5G-ready cellular modems with the needs of the connected industry in mind, we have catapulted ourselves into a position in which we can serve the industry with a truly unique offering. Full ownership of the silicon makes us independent of third party components, guaranteeing the longevity of our solution, enabling secured data transmission, as well as best-in-class support. At the end of the day, this translates to improved value for our industrial partners and customers.

Making cities more sustainable

Cities have always played a pioneering role in the adoption of new technologies. And with the relentless increase in the world's urban population, poised to hit 70 percent by 2050 according to the UN, and the rise in the number of 10+ million inhabitant megacities expected to exceed 43 as early as 2030, leveraging the benefits of smart city technology will be key to making this urbanization trend sustainable. How? By building on the benefits of connected devices to solve key urban challenges, from managing traffic, power, and waste to improving air quality, public health, and public safety.

By leveraging wireless technology and the Internet of Things (IoT), cities can optimize the flow of people, goods, and energy, enabling intelligent infrastructure and smart services and utilities. Residents aren't the only ones to benefit from more livable cities that welcome increased public participation. By becoming more appealing on the global market, cities can attract top employers and top talent, feeding into a virtuous cycle of continual improvement.

Because smart cities will require vast ecosystems of partners and service providers to put together interoperable solutions, standards-based non-proprietary wireless communication technologies such as Bluetooth, Wi-Fi, and 5G cellular communication are likely to prevail. Over the past 10 years, we've invested in growing our product portfolio in these areas through intense research and development, acquisitions, and by participating in pilot studies.

Transforming healthcare digitally
The digital transformation promises to expand the capacity of today's overstretched healthcare systems. Arguably a human right and, in many countries, a financial quagmire, global public healthcare spending continues to grow year by year, exceeding 7.5 trillion US$ in 2017 according to WHO[1]. And that, despite technological improvements that could rein in costs, expand coverage, and, ultimately, improve patient outcomes. The combined human and financial incentives are bound to feed off each other to drive the digital transformation of healthcare over the next decades.

Wirelessly connected applications will be transformational in hospitals, where they will automatically collect an uninterrupted stream of patient data to improve patient monitoring, treatment, and recovery while reducing error rates. Tracking medical devices, infrastructure such as beds, and medical personnel will increase productivity by cutting time spent looking for them. Thanks to remote patient monitoring, doctors will be able to continuously track their patients' recovery once they are discharged from the hospital, and researchers will finally have a tool to closely assess their participants in clinical trials, improving their outcomes. And at home, the technology will help keep healthy people healthy and vulnerable people safe, through preventative care and assisted living solutions.

But healthcare transformation comes with a new set of technical requirements, in particular for security. Ensuring data privacy, confidentiality, and patient safety are critical to developing successful connected healthcare solutions. And widespread adoption will benefit from the same standards-based non-proprietary wireless technologies mentioned above, including Bluetooth, Wi-Fi, and 5G cellular communication.

Securing the digital revolution
As we transport more and more data via wireless connectivity, security is becoming an increasingly vital need in our society. Even more so as the IoT connects physical objects – vehicles, medical devices, buildings, factories – to the cloud, making them, and their users, potential targets for petty cybercriminals, organized crime units, and hostile governments. As enablers of wireless connectivity, we see it as one of our core missions to support our customers in building connected devices that are secure and create confidence with the end-user and contribute to a desirable, sustainable future.

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To meet this ambition, we partnered with Swiss-based Kudelksi, a company with three decades of experience securing over a billion dollars' worth of commercial value, to develop our latest generation of highly secure cellular modems. The UBX-R5 chipset and the SARA-R5 module that incorporates it derive their security from a highly robust root of trust (RoT) – a secure feature that uses a combination of hardware

[1] Public Spending on Health: A Closer Look at Global Trends, WHO, 2018

and software to enable a set of security-related functions and lets users trust that they are interacting with the right device at all times.

Adding value at the core

By developing secure and reliable wireless communication and positioning technology that lasts for a product lifetime, we are driving the ongoing digital transformation. But where will it take us next? Predicting the next big disruption is always difficult, in particular with all the enabling technologies that are emerging around us. Every once in a while, something will leap from the margin into the mainstream and change our lives. It's always easy to piece together a story of how it happened after the fact.

We saw this play out from up close with drones. It began by nurturing contacts with research teams and universities that were working on these flying platforms. Some eventually evolved into full-fledged companies, which, after reinventing themselves multiple times, have since become market leaders. Where might this play out next? Regardless of the precise application, what is essential is that we are prepared with solutions that help our customers to design products that work well and deliver value beyond the silicon they are built on.

Doing so requires us to stay attuned to the technological possibilities that are creating market traction and to the specifications and requirements of emerging use cases within each megatrend. Again it comes down to talking to customers, sharing ideas, incorporating their feedback into a forward-looking roadmap. By growing a portfolio of technologies that customers need to connect their products seamlessly to the cloud, we are constantly brought back to the core question: does it create value? In the end, it's up to individual customers and the market to decide which technologies become preferred and dominant solutions.

With a growing customer base now comprising close to 7000 companies, it is challenging to develop one-size-fits-all hardware solutions that meet the divergent needs of hundreds of use cases and applications. Adding value, therefore, also involves making our products versatile enough to meet the needs of a diverse set of users. Drawing on our extensive experience in offering data services for GNSS positioning, we have added enhanced security services to our baseline offering. This allows us to preserve our low cost point low for customers with standard needs while at the same time tending to the expectations of those developing highly dependable solutions.

In the end, our mission is clear. By delivering key components that package our capabilities in a broad range of specific knowledge areas in integrated circuits, we empower customers to focus their resources on the areas in which they can make the biggest difference. They say it takes two to tango. I would disagree. From the dancers to the musicians, from the composers to the audience, it takes an entire ecosystem. That's what makes it beautiful.

Thomas Seiler
CEO, u-blox

Mobility at the crossroads

Connectivity is transforming mobility as we know it. And it's about time: your phone is smart, so why settle for a dumb car?

Sometime around 2008, innovation in mobility took off. That isn't to say that there wasn't any innovation before. After all, it was the era of Segway, and a number of vehicle-sharing platforms, such as Mobility in Switzerland, already had fleets on our streets counting thousands of vehicles. By and large, however, innovation happened in the big car companies' own R&D departments. But after the financial crisis, the dam broke and mobility became a new frontier for entrepreneurs. The number of startups skyrocketed to the point that we at Emerald Technology Ventures, the clean-tech venture fund I founded, had to hire a team of mobility specialists just to keep up with the flood of mobility-related projects that were landing on our desks.

Today, a decade later, every aspect of mobility is in flux. The internal combustion engine, though still by far the dominant propulsion system on our roads, is under serious pressure from electric drivetrains, which have seen their performance increase dramatically. Value generation is migrating away from the vehicles themselves, which are becoming less and less differentiated in their mechanical performance. New business models are emerging that, instead, monetize software, services, and data, ultimately increasing the profit generated by each vehicle. Demand for passenger mobility is expected to double by 2050[1] ; meanwhile, new car ownership is on the decline, probably for the first time since the inception of the automobile, facilitated by the likes of Uber, Lyft, and other ridesharing platforms.

In addition, new forms of micro-mobility and multi-modal mobility offerings are spurring on customer expectations for smarter, more flexible mobility solutions, as is the promise of highly assisted and fully autonomous driving. Enabling these will require a whole new set of products and services on top of the car itself. It remains to be seen how the added value generated in the mobility ecosystem of the future will be divvied

"It remains to be seen how the added value generated in the mobility ecosystem of the future will be divvied up between automobile OEMs, tech giants, and startups."

[1] A.D. Little, The Future of Mobility 3.0, Reinventing mobility in the era of disruption and creativity, 2018

up between automobile OEMs, tech giants, and startups. One thing seems clear: car manufacturers won't willingly outsource control of the vehicle itself, and they certainly don't want the tech giants to control their future. Still, that leaves plenty of room to reshuffle the business.

Safety in the driver's seat

Passenger safety has long been a key driver for innovation in the automotive industry. Yet while the industry has made tremendous progress in increasing safety, its efforts have been frustrated by the fact that the weakest element has remained out of their control: the human driver. In a survey, the National Motor Vehicle Crash Causation Survey 2005-2007 found that 94% of car crashes were due to human error in the US alone. The US Department of Transportation estimates that fully autonomous vehicles could reduce road fatalities by the same percentage.

But as our vehicles transition to higher levels of driver assistance, we are becoming increasingly aware of the challenges of full autonomy. Today's most advanced autonomous vehicles have driven millions of miles in controlled areas such as highways while letting the driver let go of the wheel for short periods with remarkably few (but highly mediatized) accidents. Extending this to less predictable areas such as urban centers and suburbs where pedestrians or other traffic participants can interfere unexpectedly will be challenging at best.

Regardless of when and whether our cars lose their steering wheels, each incremental step leading down that path is making driving safer, cleaner, and more efficient. A key enabler of advanced driving automation systems is vehicle-to-everything, or V2X, communication. V2X uses wireless technologies to let vehicles communicate with each other, with the roadside infrastructure, and with other traffic

"Regardless of when and whether our cars lose their steering wheels, each incremental step leading down that path is making driving safer, cleaner, and more efficient."

65%

Reduction in air pollution

Source: A.D. Little

participants, including pedestrians. As a result, vehicles have a more complete picture of the surroundings, even beyond line of sight. There's little doubt that early warning of oncoming vehicles, congestion, and other obstacles will increase road safety even before cars become fully autonomous.

By connecting vehicles digitally into a network, V2X also provides a means to better coordinate traffic flow, reducing congestion and increasing road capacity by up to 80 to 270 percent, according to estimates.[2] There are environmental benefits as well, as smoother traffic flow also means less braking and accelerating, and, consequently, a decrease in noise, and an up to 65 percent reduction in air pollution.[3]

From sales to services

If there's one thing that carmakers excel at, it's at making, marketing, and selling cars. Increasing passenger safety by improving the car itself was right down their alley. Until recently, this gave them full control of a large part of the personal mobility market. But with today's cars generating incredible amounts of data – about twice as much as humans, the times are changing. Organizing, accessing, and monetizing the oodles of vehicle-generated data is simply not in today's automotive industry's DNA. As a result, much of its value has remained untapped. This has caught the attention of the big tech companies that pioneered many of today's data and service-based business models, and of startups eager to settle into new, lucrative niches. It's a clash of the worlds that has left the established automotive industry in the defensive.

To fend off efforts by tech giants to take over the most lucrative parts of the value chain, the automotive industry has seen a surge in partnerships, investments, and acquisitions over the past years. In 2015, for instance, a group of German automakers acquired HERE, a digital mapping company. In 2016 GM acquired Sidecar, a failed Uber competitor, as well as autonomous car developer Cruise. Toyota, Daimler, Volkswagen, and others have partnered with

[2] A.D. Little, The Future of Mobility 3.0, Reinventing mobility in the era of disruption and creativity, 2018

[3] Ibid.

chipmaker Nvidia, while all of the big ridesharing companies – Uber, Lyft, Gett, etc. – count one or more major automakers as partners or investors.

This reshaping of the ecosystem has not just been about acquiring hard skills in artificial intelligence, sensor fusion, and business models. Carmakers have understood that they need to ride the trend of the new way of working to enter these emerging spaces, where they are confronted with a younger generation of workers with new expectations. Corporate venture funding has become a mainstay as many automakers choose to focus on their strengths and rely on partners to provide the missing components. Incidentally, at Emerald Technology Ventures, all investors in our fund are large industrial corporations seeking to tap into and facilitate innovation outside their own four walls.

"Corporate venture funding has become a mainstay as many automakers choose to focus on their strengths and rely on partners to provide the missing components."

Ultimately, strength will come from diverse, complementary ecosystems, in which incumbents do much of the capital-intensive and quality-sensitive heavy lifting, such as developing functionally safe sensing and communication systems, while innovation, for instance in advanced sensor fusion or machine learning, is relegated to the more dynamic startups at the periphery of the network.

The other half of the picture

But focusing entirely on cars misses half the picture. In addition to the conventional and increasingly connected vehicles that crowd our streets, and the technological ecosystem needed to keep traffic flowing smoothly and safely, old ways to get from A to B are getting a digital facelift. Multi-modal mobility, much discussed, combines cars, public transport, and new, softer forms of micro-mobility such as shared bikes, e-scooters, and walking to offer flexible, affordable, and low impact mobility in urban areas in particular. Fully aware of what is technologically possible after having grown up with a smartphone, today's younger generation expects to be able to seamlessly jump from one mode to the other without being confronted with the hassles of complicated ticketing and, God forbid, standing in line. Now the race is on to develop smart pricing and ticketing platforms that bring together a diverse set of service providers to make multi-modal mobility as easy as hailing an Uber.

And then there is air, maritime, and heavy ground transportation. We're seeing increasing efforts to electrify short distance air travel; taxi drones are being developed in the United Arab Emirates, while drone delivery has already been deployed in Rwanda to deliver blood transfusions to remote villages. Electrification is also transforming marine mobility, notably cruise ships; Norway has decreed that its UNESCO world heritage labeled fjords be cruise ship emission-free by 2029, and already has a 500-passenger hybrid cruise ship sailing the fjords for Hurtigruten. And on the roads, the first pilot tests have been carried out on groups of trucks that semi-autonomously follow a pilot truck in platoons to optimize fuel consumption, saving operational costs and protecting the environment.

A matter of implementation

It's safe to say that the essential technologies needed to turn the page in this mobility revolution are there. Reluctance on the part of the public to adopt connected vehicles and other forms of smart mobility is also unlikely to be the showstopper it is often made out to be. When technologies effectively enhance safety, reduce hassle, or offer improved customer experience, the public has a record of taking them up, often even enthusiastically. You won't see people cheer for seatbelts or power steering, but no one is taking them out of their cars. On the other hand, drivers have been quite eager to let go of the wheel of their Teslas to see what hands-free driving might one day feel like. The mobility revolution will likely only feel like one in hindsight. In reality, it will be more of a gradual transition, as features slowly evolve from being options to the new standard.

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At this point, it's a question of incentivizing implementation through smart regulation. The sooner we get serious about decarbonizing our economies, the sooner governments will step in to promote more expensive solutions if they are better for the environment. Subsidies and incentives to promote electric taxi fleets in cities such as New York and London, and the above-mentioned plans to protect the Norwegian fjords are all early steps in the right direction. ■

Gina Domanig
Managing Partner, Emerald Technology Ventures and Head of Nomination and Compensation Committee, u-blox

Digitalizing the industry will be a long-term undertaking

More and more companies are embracing the benefits of the fourth industrial revolution, with automotive players leading the charge. But moving to smarter systems for sourcing, production, and distribution will keep the industry and technology vendors like ourselves busy for decades.

When the first mass-market vehicles rolled off Henry Ford's production lines at the turn of the last century, choice was not big on people's minds. It was the Model T or a horse. Later, emerging technological possibilities and the need for car brands to differentiate themselves from their competition expanded the palette of vehicles people could pick from. To the point that, today, dozens of carmakers offer a catalog of configuration options so varied that every single driver could be behind the wheel of a truly one-of-a-kind ride. Managing the complex logistics required to bring together the right components for each individual vehicle from myriad suppliers, assemble them correctly, and deliver the right final product to the right end-customer only recently became possible, largely thanks to the fourth industrial revolution.

With information at its core and sensing, connectivity, and data analytics and storage as key enablers, the fourth industrial revolution is already delivering on its promise to increase industrial efficiencies at all levels. In addition to the auto industry's product customization down the individual unit, companies as diverse as Boss, the fashion label, and Pirelli, the tire brand, have embraced Industry 4.0 to improve every stage of the value chain, from incoming orders to raw material flows to distribution. Lufthansa, the airline, optimizes material flows at all their global bases using location-based services.

“With information at its core and sensing, connectivity, and data analytics and storage as key enablers, the fourth industrial revolution is already delivering on its promise to increase industrial efficiencies at all levels.”

While there are several early adopters, Industry 4.0 is a very long-term trend. The reasons are pragmatic. Uprooting established industrial processes is always related to big investments. Consequently, it tends to be a process of continuous retrofitting over years, if not decades, starting where it adds most value, and penetrating deeper and deeper into existing process landscapes as new needs emerge.

Take goods tracking. Today, tracking resolution typically stops at the container level, which is quite easy to implement. Now, technology is bringing the resolution down to the individual parcel level. In the future, the resolution might extend all the way down to the individual piece.

Getting there will involve overcoming a number of challenges. One is scaling up from tracking a single container to the often hundreds or thousands of individual objects it holds. Another is delivering positions that are accurate enough to locate them. Ideally indoors, outdoors, at every step of the process. It’s just a matter of time before these challenges find solutions.

The logical consequence of this wave of digital integration are digital twins: cloud-based digital representations of all the material flows, processes, and machines that make up the industrial process. By tracking “everything,” operations can be optimized at the system level to increase resource efficiency, product quality, and supply chain and distribution transparency. Digital twins of industrial machines would help reduce downtime by predicting failures ahead of time and scheduling maintenance operations rather than being caught by surprise. And they offer operators a platform to test process changes before they are implemented on the factory floor.

And as these digital platforms become more relied upon, users will expect them to become ever closer representations of the physical world they are modeling. Achieving this will require more stringent demands on the data communication – such as higher data rates and lower latencies, or lower data rates but increased coverage and power autonomy – driving the need for newer, higher performance communication technologies. These requirements have already found their way into the specifications of the next generation of wireless technologies, from Bluetooth 5 to Wi-Fi 6 (and 7) to 5G, the latest generation of cellular communication technology.

What, when, where

Answering the three most important questions in the Industrial Internet of Things (IIoT) – what, where, when – requires small, reliable, and low-cost global positioning devices, as well as low power, wide area and short range communication technologies. But serving industrial customers isn't just about developing and selling silicon. Industrial modems have average lifetimes of a decade. During this time, a lot can and will happen. Customers expect these needs to be taken seriously to ensure not only that devices go the distance, but also that they evolve to optimize their performance and adapt to new standards and security requirements.

"Answering the three most important questions in the Industrial Internet of Things (IIoT) – what, where, when – requires small, reliable, and low-cost global positioning devices, as well as low power, wide area and short range communication technologies. "

At u-blox, we are driving the expansion of the IIoT through our chipset development in the cellular domain with precisely these needs in mind. Over the past years, we have developed cellular modems for 4G LTE Cat 1, LTE-M, and NB-IoT applications, starting from scratch and tailoring our hardware to the requirements of industrial end-users, including robustness, longevity, and security aspects that come with the long intended lifetimes of deployed products. Throughout the process, we leveraged our deep experience gained working with industrial and automotive partners in the industrial environment, where we have long been present with our global navigation satellite system-based positioning receivers as well are our short range and cellular module portfolio.

5G for the next wave of cellular applications

There have been promising developments in the specifications of cellular communication technology for Industrial IoT, driven by the 3GPP consortium, responsible for defining global cellular communication standards. The focus there has been on LTE Cat 1 to Cat 4, which are the appropriate technologies for applications that require high definition audio and video streaming, as well as the communication of other measurement data. In the coming years, our task will be to extend this to the 5G domain.

An important development under the 5G umbrella will be the emergence of ultra-reliable low latency communication (URLLC), a technology that we will likely see roll out first in private (non-public) networks run by individual companies according to higher performance specs before it is taken up by mobile network operators serving the broader public. Having full control over the backend of the network will also make it easier to guarantee end-to-end security. And there are plenty of companies that are getting prepared to help set up private cellular networks for these high performance use cases, from the established base station providers like Nokia and Ericsson to a new cohort of smaller players that are taking advantage of the fact that modern base stations are little more than PCs running a specific software with an RF head.

But with all the hype surrounding 5G, it's easy to get carried away. Most standardization bodies are focused on developing massive broadband for new record-breaking data rates, more relevant for consumer applications than for the industry. The other parts of the standard, in particular those that are relevant for industrial and automotive use cases, are lagging far behind. What that means is that we still have quite a lot of mileage to go with 4G technology, which continues to see new use cases emerge.

"We still have quite a lot of mileage to go with 4G technology, which continues to see new use cases emerge."

Now that low power wide area (LPWA) networks – targeting power-constrained applications with high coverage and low data throughput requirements – have been deployed in most global markets, the number of solutions leveraging these networks will pick up rapidly. And the expectation that they will serve their customers for close to a decade means that upcoming developments will be incremental rather than disruptive. Meanwhile, 4G private networks will allow users to push their communication infrastructure towards higher quality of service, lower latency, and higher data rates, simply by optimizing their systems via the backend of their infrastructure.

Start where it creates value

Change is in the air, and Industry 4.0 promises huge gains in efficiency, transparency, product quality, and reliability. Opting for wireless connectivity over today's wired Ethernet reduces investment costs needed to sense higher quality information and improve operator safety while being quick to implement, highly flexible, and massively scalable. On top of that, because cables can be physically damaged, in particular near the plugs, wireless connections are more robust in the long run.

But rather than diving into a full digital overhaul of an entire production facility, a more piecemeal approach focusing on those specific application areas that help create value is likely to be better in the long run. Industrial sites are often full of processes that have been refined over years. Changing everything overnight risks undermining those hard-earned refinements. By starting where it creates value, gaining experiences working within this new digital ecosystem, and continuously optimizing and improving from there, any pains from the transition will easily be offset by productivity gains it delivers. ■

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Connected future

Smart city, sustainable city

Smart cities and the wireless connected systems that underlie them hold the promise to make the places we live better serve our needs. They're also a powerful engine for value creation.

Around the world, cities are experimenting with what it means to be smart. Confronted with an unprecedented wave of urbanization, most pronounced in developing regions with poor infrastructure, they are turning to technology to mitigate problems caused by their ballooning populations. And as cities compete on the global market to attract top employers and top talent, smartness and the gains in quality of living it promises are becoming key differentiators.

Urbanization didn't exactly sneak up on us. It's been a megatrend for decades and shows little signs of slowing. By 2050, the UN foresees that 68 percent of the global population will live in urban areas.[1] For context, while urbanites make up over 82 percent of the population in North America, that figure is far lower in Asia, at around 50 percent, as well as in Africa, at around 42 percent. And as urban populations grow, ten more cities will graduate to megacities, cities that are home to over ten million inhabitants, by around 2030.

Megacities amplify urban challenges that we are all familiar with. Saturated traffic networks, insufficient parking spaces, and over-crowded public transport lead to accidents, air pollution, and long commutes. Inadequate energy management leads to grid failures, limits the potential for renewable energy, and lets losses go undetected. Outdated and poorly monitored infrastructure restricts the flow of resources, goods, or people. It wastes resources, and,

[1] https://www.un.org/development/desa/en/news/population/2018-revision-of-world-urbanization-prospects.html

sometimes, fails catastrophically. And, home to dense populations with pronounced economic inequalities, megacities are often fertile breeding ground for crime.

Increasing the sustainability of both mega- and ordinary cities means finding ways to address all of these challenges. By tackling them using a holistic approach, smart cities and the wireless connected systems that underlie them hold the promise to make the places we live better serve our needs, increasing our overall comfort, wellbeing, and security.

"Smart cities and the wireless connected systems that underlie them hold the promise to make the places we live better serve our needs, increasing our overall comfort, wellbeing, and security."

A digital nervous system in the making

Ultimately, smart cities are all about making better use of resources to optimize their residents' lives. Smart traffic management and parking schemes save time and protect the air. Smart metering infrastructure saves electricity, gas, and, water. Smart health helps increase the capacity of an already overstretched healthcare system. Smart policing can increase public safety and help rein in crime. And smart initiatives to engage with the community can encourage public participation, fostering a stronger sense of belonging and being heard.

These may sound like utopian ideals, but, in fact, the impact smart city technologies can have is far from cosmetic. A study by McKinsey found that they could reduce fatalities by 8-10 percent, accelerate emergency response times by 20-35 percent, cut the average commute by 15-20 percent, lower the disease burden by 8-15 percent, and cut greenhouse gas emissions by 10-15 percent.[2]

It turns out that we already have all the technologies these interventions would require at our disposal. Wireless connectivity – a combination of cellular 4G, and soon 5G, Bluetooth, and Wi-Fi – is prepared to connect a gargantuan web of distributed sensors to the cloud, relaying real-time data on the urban environment as well as people, material, and resource flows through the city. Cloud computing platforms are in place to manage, monitor, and analyze that data. In other words, the time has come to implement useful solutions and integrate them into a smart city platform.

Solutions serving specific verticals prove this point. Large-scale smart metering solutions are rolling out in several countries including Norway and Spain, while Italy and Sweden are already on their second generation of the technology. Cities like Ann Harbor in the US have been successfully piloting smart traffic management systems. Smart streetlights are increasing their footprint in metropolitan areas around the world to improve public safety while reducing power consumption and light pollution. Cities like San Diego, also in the US, are equipping the lampposts with microphones to accurately locate gunshots to cut the time it takes law enforcement to reach the scene of the crime. And the possibilities go further still, with companies such as Tvilight[3] offering a smart lighting-based platform to track traffic, monitor the weather, and provide a connectivity hub for third party smart city applications.

[2] McKinsey Global Institute, Smart cities: Digital solutions for a more livable future, June 2018

[3] www.tvilight.com

Despite these applications, McKinsey found that even today's most advanced smart cities are only scratching the surface in terms of their potential. So what is holding them back? Leadership is important, a city's political framework alone does not determine its smartness. Unsurprisingly, wealthy cities tend to lead the pack, as they are best able to support the deployment of the required sensing and communication networks and open data portals. But key to success is public awareness and uptake of the technologies, most prevalent in Asian cities heavily populated by young digital natives.

With that in mind, smart cities should address the needs of their residents and engage with them early on, empowering them to participate in the city's decision-making process. It's an iterative process, and as more and more cities embark on this journey, a shared set of best practices will emerge as citizens come to expect their cities to be as intelligent as many of the online platforms they engage with.

"As more and more cities embark on this journey, a shared set of best practices will emerge as citizens come to expect their cities to be as intelligent as many of the online platforms they engage with."

A powerful engine for value creation

Smart cities are powerful engines for value creation with benefits for stakeholders at all levels. Residents reap the fruits of smart city technology in the form of improved life quality, an increasingly transparent and participatory government, and new value-added services and mobile applications. By making cities economically attractive to businesses, they benefit from high-quality job opportunities. Municipal governments, on the other hand, can benefit from increased tax revenues as well as considerable savings, due both to the more efficient use of inputs as well as from increased capacity of existing infrastructure, from roads and utility networks to hospitals and police forces.

We're seeing the X-as-a-Service (XaaS) model be welcomed by smart cities. For one, it lets cities shift expenses from capital expenditures to operational expenditures. It also lets municipal authorities tap into external pools of talent and expertise, rather than requiring a new team of in-house experts to re-invent recurrent needs in each city. And in some cases, the savings that accrue year by year using smart technology are sufficient to finance the investment required and the service fees.

However they are financed, smart cities are likely to continue to grow incrementally, as new use cases latch onto the evolving smart city platform. To make it easier for cities to source their technology from a patchwork of hardware suppliers, we expect standardized technologies such as 4G LTE and 5G cellular networks as well as Bluetooth and Wi-Fi to make up the communication backbone of smart cities rather than proprietary ones. Similarly, standardized interfaces and APIs will be crucial in getting the components to "speak the same language."

For technology vendors like ourselves, smart cities present an exciting and rapidly growing market that much of our product portfolio is well-tailored to serve. Our satellite-based positioning solutions featuring dead reckoning deliver accurate positioning information to cars deep inside urban canyons. Our short range wireless communication portfolio covering Wi-Fi, Bluetooth low energy, Bluetooth mesh, and Bluetooth 5 meets the requirements to connect the smart buildings that make up the smart city and enable a broad range of smart city use cases. Our vehicle-to-everything (V2X) chipset will play an integral role in enabling smart traffic management and advanced driver assistance schemes in urban environments. And our range of cellular technologies, in particular in the low power wide area segment, is a perfect fit to securely and reliably connect the web of distributed wireless sensors that underlies every smart city.

That said, many new frontiers remain to be explored. Many smart city applications, such as smart parking, would benefit from “fit and forget” technologies that, once deployed, remain operational for decades without requiring any maintenance. Today’s low power, wide area (LPWA) networks have set a new bar in terms of increasing the longevity of wirelessly connected devices. Pushing it even further will require tapping into small but steady power sources that the devices are exposed to once in the field using energy harvesting. Extending the scope of positioning technologies will require developing seamless indoor-outdoor positioning solutions. And dealing with the abundance of data these sensors generate will demand endowing the devices at the edge of the smart city network with some degree of analytical intelligence to process the raw data and limit power-hungry data transmission to those bits and bytes that deliver relevant insights.

The rural impact of urbanization

While cities are clearly the nexus of the ongoing wave of urbanization, the flow of people moving away from rural areas also impacts them and their ability to provide the societal services expected of them. Nowhere is this more obvious than in farming, where the rising demand for agricultural produce, include grains, meat, and dairy, is running into a dwindling number of farms and agricultural workers. It probably won’t surprise you that there’s an IoT based solution to this as well. It’s one that we’ve covered in a previous edition of our u-blox magazine. Follow the QR code below to learn more.

Costas Meimetis
Senior Principal, Corporate Strategy, u-blox

When the prescription says "IoT"

Connected health applications can transform our understanding of sickness and health, extend our autonomy by years, and take the pressure off our healthcare systems. For that, they need to be secure, dependable, and cost effective.

How long did you sleep last night? Eight hours? Seven? Six? Today's society is sleep deprived, and that sleep deprivation has real-world consequences. Studies have found that four consecutive nights of four to five hours of sleep leaves individuals with the decision-making faculties they'd have after enjoying a glass of wine. That may not be an insurmountable obstacle to worldly success. But making it the rule, rather the exception, is unlikely to be a good recipe for a thriving society.

Sleep epitomizes the potential and the perils of a connected society. It also points at some ways these perils can be overcome. Let's face it, the connected society is one of the reasons why we're getting so little sleep in the first place. From social media to on-demand movies, our screens and the content they bring us are either keeping us awake longer and longer or driving us to do more, travel more, at an ever increasing pace.

And as we cut back on sleep, we deprive ourselves of its many benefits that are only now coming to light. Whether the lack of sleep is caused by a medical condition such as sleep apnea, or self-induced, it keeps the immune system from performing at peak performance. Sleep literally helps us stay alive longer. It's the brain's janitor, flushing out harmful residual products that accumulate throughout the day, such as amyloid plaques, linked with the development of Alzheimer's disease.

Monitoring activity, and sleep, 24/7

So how is connectivity helping us confront this silent epidemic? First, by offering tools to revolutionize our understanding of sleep. Sleep labs are costly, scarce, and just don't feel like home. As a result, the data they produce are costly, scarce, and somewhat flawed. Wirelessly connected sleep monitoring equipment that test subjects and patients can take home with them is transforming research, increasing the quantity and the quality of data available to scientists.

Rather than studying patients during a brief checkup or, in the best case, over a single night, mobile health technologies help doctors get their hands on a continuous data record spanning days or weeks to accurately diagnose disease. Armed with new insights they glean, it's only a matter of time before new apps come out to nudge us into making healthier lifestyle choices.

Continuous monitoring using connected technology is set to have similar effects on a variety of non-communicable diseases plaguing our society, from diabetes to Alzheimer's and Parkinson's. With one billion people globally affected by hypertension, and 17 million people dying from cardiovascular problems each year, monitoring patients continuously or over extended periods of time could provide insights transforming our understanding of these and other diseases. Not only that, they may also offer a means of early diagnosis, and, for patients that are already living with the diseases, a convenient way to connect with their doctors.

Taking healthcare out of overdrive

Healthcare is expensive. According to the World Economic Forum, by 2030 the world will lose around 30 trillion US$ in the treatment of the abovementioned non-communicable diseases alone. And just about everywhere, healthcare systems are under tremendous pressure, financially, and in terms of capacity.

"Connected healthcare devices represent a valuable toolkit to increase the capacity of the world's healthcare systems."

Connected healthcare devices represent a valuable toolkit to increase the capacity of the world's healthcare systems. Gathering patient data prior to seeing a GP, for instance, means that the doctor's visit can be dedicated to discussing

treatment options rather than attempting a high-quality on-the-spot diagnosis. Adopting electronic health record systems can then ensure that patient data gets past through the continuum of care intact and unmodified. And, when possible, connected outpatient monitoring could let patients move out of intensive care units faster and return home earlier, while still benefiting from sufficient monitoring.

Outside the clinic, our aging society is also creating problems that we have not been confronted with before. The possibility of sending the elderly to institutions where they can receive quality care is running into a cost barrier. As a result of this, and of the widespread malaise associated with elderly care homes, assisted living solutions are becoming increasingly widespread, allowing elderly people to stay home and live autonomously for longer.

In addition to enabling remote medical monitoring of elderly individuals, these solutions can make it easier for them to interact with their homes, monitoring air quality and in- and outdoor security. Ambient assisted living solutions can also connect them to family members, caregivers, medical professionals, and emergency services. And they make financial sense as well: remote monitoring could reduce elderly care expenditures in rural regions by one quarter.

Finding the hypodermic needle in the haystack

It isn't just about patient monitoring. Hospitals are fast-paced environments in which minutes wasted to find misplaced equipment can have dire consequences. According to estimates by ABI Research, looking for lost equipment could consume hundreds of hours per month in a single hospital. These hours are, therefore, not available to deliver high quality and potentially life-saving medical services to patients. Additionally, quickly and efficiently locating patients, visitors, and medical staff can increase the quality of service and safety.

Many of these challenges can be overcome through the deployment of real-time indoor positioning systems. By leveraging Bluetooth or Wi-Fi signals from a network of beacons or routers, for instance, battery-powered trackers can continuously ping their position to an asset tracking system, making the management of people and equipment much more straightforward. Seamless indoor and outdoor positioning solutions integrating satellite-based positioning could extend their reach further, for instance enabling emergency rescue services that operate outside the confines of the hospital.

> **"If connected healthcare solutions have an Achilles heel, it's concerns over safety, privacy, and confidentiality."**

Tackling the Achilles heel of trust

If connected healthcare solutions have an Achilles heel, it's concerns over safety, privacy, and confidentiality. Connected medical devices, from dialysis machines to cardiac pacemakers, are potentially exposed to malevolent hackers who, by controlling the devices, could put patients at risk. Others might set out to interfere with connected hospital management systems just for the sake of it. For all the improvements they offer, electronic medical records are exposed to far more bad actors than conventional paper records. There are countless ways that such data can be misappropriated for financial gain. Fears over privacy breaches raise demands for high levels of confidentiality.

For the connected healthcare industry to be broadly adopted, applications will, therefore, require extremely high levels of digital security. Whether devices are connected to the cloud via a short range gateway or directly over cellular communication, applications have to be designed to perform securely throughout their entire lifetime. In addition to highly robust data encryption, the devices need to be continuously kept up to date against emerging threats, often over the air and under tight power constraints. This calls for highly scalable, lightweight, and reliable device management.

The right kind of connectivity

Connected health devices designed for global markets need to operate in extremely diverse settings to easily connect to a large number of clinical, proprietary, or national patient databases. Non-proprietary technologies such as Bluetooth, Wi-Fi, and cellular communication, well-established and highly interoperable communication protocols such as TCP, UDP, and HTTPS, and the likes of MQTT, CoAP, LwM2M, specifically designed for power-efficient and resource-constrained IoT devices, are, therefore, likely to remain prevalent in medical applications.

A common network topology for wearable medical devices uses two hops to transmit physiological sensor data to the cloud. In hop one, an implanted or wearable device transmits sensed to a gateway using a short range technology (typically Bluetooth). The gateway, which could be a phone, a smartwatch, or some other device, then sends that data to the cloud, either via a router using Wi-Fi, or directly using cellular communication. This approach is particularly common for highly power-constrained medical devices that achieve long battery-lives by transmitting data via Bluetooth.

But with the increasing popularity of cellular 4G low power, wide area (LPWA) networks such as LTE-M and NB-IoT, highly power-optimized cellular devices can transmit health data to the internet in a single hop. Leveraging increased power-autonomy - rivaling that of power-optimized short range technologies - and enhanced coverage compared to the 4G technology our smartphones use can enable scenarios such as alert systems that need coverage in critical situations. And with 5G cellular technology in the making, we're likely to see a whole suite of new use cases emerge, taking advantage of the higher bandwidths, the higher device densities, or the lower latencies that the technology enables.

Ultimately, the transformational impact of digitalizing the healthcare system will be driven by cost reductions, the need for increased capacity, and improved services. It promises to take research and drug development to the next level. If, on top of that, it nudges us to add a few more hours of sleep to our nights, who's to complain? ■

André Müller
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IoT security for the connected future

For the connected future to live up to its promise, security needs to be put front and center – in our devices and our minds.

5G, the Internet of Things, ubiquitous sensing, artificial intelligence, mixed reality, virtual personal assistants, connected cars, digital twins, blockchains, the cloud... The technological lineup promising to usher in a connected future is impressive, even more so considering that many of these terms that are now household names were largely unknown just a decade ago. Equally impressive is the list of benefits we expect the merging of the physical and digital worlds to deliver: safer, less congested streets, cleaner, more productive industries, smarter, more sustainable cities, longer, healthier lives.

Enabling this fully integrated, wirelessly connected digital future will require that data and the entire IoT ecosystem become as trusted as money and the financial system we rely upon every day. Today, systems are in place that let you go to a store almost anywhere in the world with nothing but a credit card and buy whatever you'd like. The levels of seamlessness and security that this requires are quite a feat, and they're one that we will have to transpose to the IoT for it to live up to its potential. Getting there will require tackling the juggernaut of IoT security.

You might be thinking that IoT security is more or less the same thing as IT security – after all, how much difference can a single o make. It isn't. To put it bluntly, failing to sufficiently secure IT systems might get you fired. Failing to secure IoT devices could land you in jail. It may sound extreme, but there's a reason for it. Because they bridge the digital and physical worlds, compromised IoT systems often represent a threat to people's physical safety. Examples abound, from connected insulin pumps to perishable goods trackers that hackers could seek to manipulate.

In either case, the consequences of poor IoT security can be severe, and not just for the direct victims who might suffer physical harm. Device manufacturers can also see their business threatened by lost revenues as customers stop paying for affected services. At the same time,

> **"Security is both a prerequisite for sustainable business and an insurance policy of sorts, reducing the risk of being hacked."**

costs associated with upgrading or replacing sold products, lost brand reputation, and customers switching to the competition can hit their bottom line. IoT security is both a prerequisite for sustainable business and an insurance policy of sorts, reducing the risk of being hacked.

Trust and control

At its core, IoT security is about trust and control. As a user, you want to be sure that the data and the devices you rely on can be trusted, and that they remain under your control. It begins by ensuring that each individual device has an immutable identity, and that the firmware running on it is authentic and can be securely upgraded. Communications to and from the device have to be secure to keep them from being intercepted or manipulated in transit. All interfaces to the device need to be secured to limit device control to authorized users. And finally, the software running on the device needs to be robust enough to resist the attempts of hackers seeking to expose and exploit vulnerabilities.

And while all IoT applications should share a common baseline level of security, requirements vary case by case. A temperature reading from

"At its core, IoT security is about trust and control."

an environmental sensor deployed on a farm doesn't need the same level of security as a temperature reading from connected vital data sensor in an intensive care unit (ICU). In the first use case, you'd want to know that the data is coming from the right sensor and that it has not been fiddled with; you probably are less worried about someone seeing the data on its way to the cloud. The situation is different in the ICU, where data breaches can lead to false diagnoses, poorly informed medical procedures, and can expose confidential patient data.

Where IoT security matters most

Let's stay in the hospital for a minute. Imagine that you're hooked up to a smart perfusion pump delivering drugs in response to wirelessly collected vital data. The last thing you'd want as a patient is for someone to feed the perfusion pump false data, causing it to deliver too much or too little medication, or to switch it off completely. Because they are so invasive, futuristic developments such as remote surgery raise the stakes further still. And as we saw earlier, such scenarios can bring on huge financial, reputational damage, and potential legal responsibilities to the developers of the compromised devices and to the hospital as a whole.

Switching to another IoT use-case, auto insurers offering reduced rates to customers with good driving habits, assessed using a black box, face a different set of threats. Customers might try to jam the positioning system to conceal illicit behavior. They might seek to tamper with the device to make it report false data to the cloud, allowing them to save fees. Or they might sue their insurers if hackers access and exploit personal data gathered by the black boxes. Insurance companies that fail to sufficiently secure their devices could suffer financially dealing with the aftermath. At the same time, the manufacturers of the black boxes might face extra costs to replace or upgrade vulnerable devices. Worse still, a hacker could find an exploitable vulnerability, replicate the devices, and sell them on the black market, syphoning off the auto insurers' revenues while helping their customers save fees.

With stakes already high and set to rise further still, it may be reassuring to know that IoT security has finally landed on the radars of OEMs delivering IoT solutions to a wide range of verticals. Our internal market surveys have shown that big end-brands are passing down a new set of IoT security requirements to their suppliers. Because most device makers have little expertise in IoT security, they are looking to their trusted strategic component suppliers to fill the void.

The next level of IoT security

Recognizing the importance that IoT security will play in protecting people, assets, and our customers, as well as in scaling up the globally deployed IoT, we at u-blox have committed to raising the bar on IoT security. We see it as a matter of corporate responsibility to release only products that comply with a demanding set of baseline security requirements. And by delivering components offering best-in-class IoT security, we hope to enable the expansion of the IoT into increasingly challenging use cases, from connected cars and smart buildings to connected health and advanced industrial applications.

"We see it as a matter of corporate responsibility to release only products that comply with a demanding set of baseline security requirements."

Of course you can't have security without a rock solid foundation to build on. That rock solid foundation is what we refer to as the root of trust (RoT). At its most basic level, a root of trust offers a trusted set of advanced security functionality through a combination of a unique and immutable device identity and the hardware and software capabilities required to enable trusted functions. Put more simply, it lets you trust that you are interacting with the right device, and that your data will remain secure.

50 shades of RoT

Just as every car has an engine, secure IoT chipsets all have some kind of a root of trust. But not all engines are created equal, and the same is true for roots of trust. The security they provide depends on a number of factors, including where, how, and by whom they are implemented. While they offer the same overall functionality whether they reside in the software, inside a trusted execution environment, or inside a secure element, potentially one containing an eSIM, their ability to withstand attacks increases in that same order.

But even when IoT chipsets share a common security architecture, the level of security they provide can vary dramatically. Ultimately, it can come down to the robustness of the code that implements the secure libraries used to generate the crypto functions and keys needed to securely connect devices to the cloud. To offer our customers best-in-class IoT security, we partnered with Kudelski, a world leader in securing digital content. This allowed us to leverage their decades-long of experience protecting connected devices against criminal and state-sponsored attacks.

Optimized for the IoT

In addition to their commercially hardened root of trust, our latest generation of secure cellular

IoT modem chipsets and modules leverage Kudelski's proven and massively scalable key management system to derive security keys in devices and in the cloud. The result is superior encryption tailored to the needs of power- and data-constrained IoT applications in which millions of devices need to be managed simultaneously. Interoperability is another key requirement for successful IoT applications. By working with Mocana's best-in-class transport layer security (TLS) stack to ensure data authenticity, confidentiality, and integrity, our hardware can securely interact with servers around the world. And finally, our components include hardware-based crypto-accelerators that make encryption faster, better, and more efficient.

From security to services

Businesses have more to gain from implementing robust security than protecting their revenues (top line) or their final financial result (bottom line). Security is also a fundamental enabler of service-based business models in which customers can subscribe to additional functionality on top of the base functionality their solutions provide.

Consider a versatile connected sensor targeting a wide range of applications, from monitoring the urban environment to tracking sensitive industrial processes. With a service-based offering, device manufacturers can let end-customers decide what level of security they are willing to pay for considering the potential consequences of hackers tampering with the data and services they are seeking to protect. Without robust IoT security, hackers could potentially switch on higher-level security features that would otherwise be sold as a service on top of the device itself, thereby robbing device developers of service fees.

At the end of the day, we are convinced that device developers targeting automotive, industrial, connected health, and many segments of consumer markets are looking for hardware suppliers that help them achieve a high level of IoT security without sacrificing time to market, product performance, and device longevity.
By putting IoT security front and center in our devices and our minds, we are pioneering technology that will enable the connected future to live up to its promise. ■

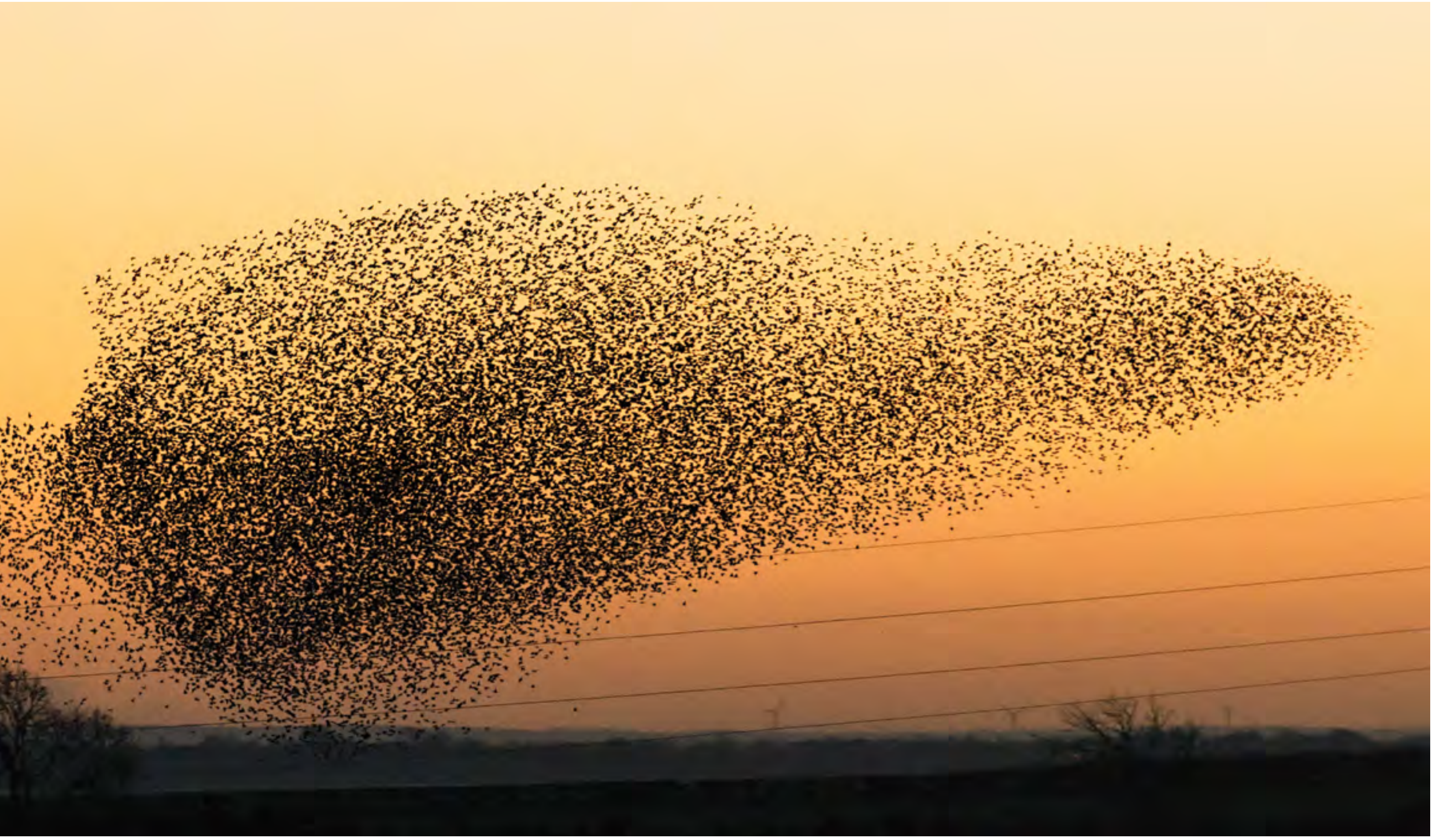
Learn more:
www.u-blox.com/publication/white-paper/four-steps-iot-security
www.u-blox.com/product/sara-r5-series

Eric Heiser
Head of Services, Product Center Cellular, u-blox

Enabling technologies

Setting up the next perfect storm

The intersection of enabling technologies and evolving expectations are a fertile breeding ground for disruptive innovation.



Just over a decade ago, the Internet of Things (IoT) was little more than a term that came up in universities and R&D departments. Sure, machines communicated with each other, but back then we called it machine-to-machine communication, or M2M. And we watched it evolve, incrementally, step by step, taking on increasingly complex roles in industrial settings.

Then things changed when in 2010 Ericsson released its foundational report on the Internet of Things. It predicted tens of billions of connected “things” beyond industrial machines by 2020. Not just phones, but all sorts of inanimate devices, as radios became cheaper, smaller, and more accessible. Suddenly everyone started talking about the IoT and how it was poised to change the world.

Fast forward to today and the IoT is a mature ecosystem. While Ericsson’s initial predictions proved to be overly optimistic, there’s hardly any area of our lives today that the IoT cannot somehow improve, optimize, or gamify by

“There’s hardly any area of our lives today that the IoT cannot somehow improve, optimize, or gamify by connecting us, our homes, our vehicles, and just about anything else wirelessly to the internet.”

connecting us, our homes, our vehicles, and just about anything else wirelessly to the internet. And far from slowing down, the pace at which it is evolving and permeating our lives keeps picking up.

It took a perfect storm of enabling technologies for the IoT to take off. First, Moore’s Law, the long-standing trend towards ever-smaller integrated circuits, kicked off the digital revolution. Then came the internet, which enabled massive and affordable data processing power

and storage on the cloud. And, finally, it took near-ubiquitous wireless connectivity to make the IoT what it is today.

Artificial intelligence – from hype to hope
Artificial intelligence (AI) followed a similar path, combining a collection of enabling technologies only to become an enabling technology itself. Leveraging the rise in computing power, new generations of algorithms, and crucially, huge data sets made accessible via the internet, AI has matured into one of today's essential technologies. Aside from beating masters at Go, and world champions at video games, AI is assisting humans in a growing number of tasks, from diagnosing cancer and programming software to optimizing power grids and supply chains.

There's a reason why AI continues to live up to its hype: it's simply too big for the world's largest tech firms – and nations - to overlook. Amazon, Google, Facebook, Apple, Microsoft are all competing for technological leadership, while national governments lock horns over who's on top in AI, now considered to be crucial for national security. As a result, billions of dollars are being funneled into AI research and development, driving the technology forward.

AI's openness further fuels its innovative potential. Today, anyone with a bit of background can download advanced algorithms to solve problems that used to be extremely challenging, such as image recognition and language understanding. Contrast that to the wave of innovation that came out of the space race. Cordless devices and adjustable smoke detectors did eventually enrich our lives, but the trickle-down took years if not decades.

What the IoT and AI have in common is that they are the outcome of a confluence of rapidly evolving underlying technologies in data sensing, processing, communication, and storage. Which new disruptive technology will come out of the next perfect storm is anyone's guess. But it's

"Today, anyone with a bit of background can download advanced algorithms to solve problems that used to be extremely challenging, such as image recognition and language understanding."

safe to say that those that stay abreast of these underlying technologies – in sensing, communication, and data processing – will be the first out of the starting blocks when it emerges.

The next wave in connectivity

One of these key technologies is wireless connectivity. And 5G is, rightly, front and center on everyone's minds. Taking cues from its industrial members, the international standards organization 3GPP is currently leading the charge in driving the next wave of innovation in cellular communication. The fifth generation of mobile communication technology, 5G, extends the scope from predominantly consumer-focused applications that were served by 3G and 4G to a broad range of new use cases.

Like its predecessors, 5G promises significant improvements in bandwidth and data rates, making high definition video and other data-intensive applications a cakewalk for cellular networks. Additionally, it will continue 4G's course in low power, wide area (LPWA) technologies, designed specifically for battery-powered, low data rate communications. Smart meters, asset trackers, alarm systems, and environmental sensors are just a few applications that these low data rate technologies address.

Where 5G will truly break new ground, eventually, is in the rise of ultra-reliable, low-latency (URLLC) wireless communication between devices. It's still unclear just what applications virtually real-time communication with near-zero message losses will lead to. Whether it will in fact bring us remote surgery, the media's favorite URLLC use case along with cloud-based gaming, remains to be seen. But by offering hitherto unavailable functionality, there's a chance that it might play a key role in a coming perfect storm.

Paired with AI and new cellular network infrastructure, this wave of innovation could breathe new life into an idea that's been around since the 1990s: cognitive radio. Today our cellphones independently select the most appropriate cellular technology to use to communicate over at any given time – 3G (EDGE, HDMA, CDMA) or 4G – with no involvement from the user. A cognitive radio would take this even further by autonomously selecting the best mix of communication channels for any given task, for example increasing reliability, mobility, or coverage.

As wireless data traffic increases, context-aware cognitive radios could become an essential tool to optimize performance while hiding

“The release of Bluetooth's direction finding feature is taking the performance of its indoor tracking and positioning capabilities to a new level.”

the complexity of the solution. After all, what matters to you as an end-user is that your data makes it from device A to device B, intact and on time. You might not be as interested in how precisely it does it.

Enabling tech in positioning

A similar trend is likely to unfold in positioning, where satellite-based positioning – the only globally available source of absolute position – has made considerable performance improvements over the last decade. Just a few years ago, global navigation satellite system (GNSS) receivers targeting the mass market achieved position accuracies on the order of 5-10 meters by tracking a single satellite constellation in a single frequency band.

The technology has since come a long way, with the latest receivers capable of delivering centimeter-level accuracies by concurrently tracking multiple constellations on multiple frequency bands, applying new algorithms, and leveraging GNSS correction services. By incorporating inertial sensors such as gyroscopes and accelerometers, they can maintain this level of performance even when signals are briefly interrupted.

GNSS signals are so weak that other technologies are required to take positioning indoors. Cellular modems, for instance, can derive a coarse position estimate using signals emitted from nearby base stations. Fingerprinting Wi-Fi signals is another way to get a position estimate, as long as the Wi-Fi networks are localized and collected in an open database.

Bluetooth is already widely used to localize trackers indoors. While ultra-wideband (UWB) positioning systems offer the highest level of indoor positioning performance today, the release of Bluetooth’s direction-finding capabilities standard early in 2019 is taking the performance of its indoor tracking and positioning capabilities to a new level, offering down to centimeter-level accuracies.

Eventually, end-users will come to expect their positioning solutions to perform optimally all the time, everywhere, without having to deal with the intricacies of the individual technologies used. This expectation will drive the demand for a seamless multi-sensory positioning solution that, much like the cognitive radio mentioned earlier, automatically selects the most appropriate positioning technology to meet context-dependent performance requirements.

Emerging applications

There’s a story to tell in every industry vertical about how it will be impacted by specific emerging technologies. We explore many of these in this magazine. But then there are other emerging technologies and applications that are likely to be widely adopted across all verticals, once they are deemed sufficiently mature, reliable, and easy to use by their end-users.

IoT security is one of these. Often considered an unnecessary cost that people are unwilling to pay, privacy and cyber-security concerns will continue to grow as stories involving hackers, industrial espionage, and ransomware continue to make headlines. Once the true cost of neglecting security becomes apparent, we expect it to become a key differentiator as a prerequisite for highly sensitive and mission-critical use cases.

“Eventually, end-users will come to expect their positioning solutions to perform optimally all the time, everywhere, without having to deal with the intricacies of the individual technologies used. ”

Broad adoption of IoT technology will lead naturally to the emergence of digital twins. Already in use in several industries, digital twins offer a real-time digital representation of assets, machines, flows, and processes in complex systems, from factories, cities, mobility networks, and, one day, perhaps even people. In addition to centralizing and visualizing collected data, digital twins will be used to monitor processes, detect failures before they occur, and even test solutions virtually before applying them to the physical system.

Then there is the rise of the virtual assistant, which already today can accomplish quite complicated tasks, from reserving a table for dinner to pulling up information from the internet. But within the next decade, virtual assistants will likely become much more capable of handling the subtleties of a request. And with Google's personal assistant competing for your attention with Amazon's Alexa, Apple's Siri, and others, someone just might develop a virtual assistant that deals with each of these for you, again hiding the complexity of the inevitable technological patchwork that will emerge around your life.

And remember Pokémon Go? For several reasons, the type of augmented reality (AR) that enabled it never really took off, but it still could. Almost all the ingredients are there, from the AI to the computing power to the wireless connectivity to the cloud. The only thing that's missing is an efficient and societally acceptable technology to project the image onto your retina. With it, AR would become the Holy Grail: not only would you control your virtual assistant; you'd control the reality you experience as well. This could be as transformational at home as it could be at work.

The seeds for the technologies that will come together to, once again, disrupt the way we do things have already been sown. We will, however, have to wait and see to find out how precisely the usual suspects of ubiquitous sensing, artificial intelligence, cognitive hardware, wireless communication, human-machine interfaces, etc. will combine to scratch an itch that is shared by many.

Paul Gough
Principal, Corporate Strategy,
u-blox

Peering into the connected future with…

Interview between Sven Etzold, Senior Marketing Director, u-blox, and Michael Peeters, Program Director Connectivity, imec

Data, technology, and machines are playing an ever-increasing role in our lives, as a wave of digitalization promises to transform our lives for the better. But what are the technological and societal bottlenecks that need be overcome to get us there? And how will individuals, societies, and businesses adapt to a world in which machines take on more decision-making responsibility?

Michael Peeters
Program Director Connectivity, imec

Michael, at imec you say that technology has the power to improve lives. How do you choose which technologies to focus on?

Michael Peeters – There are two ways to look at how technology can improve lives. One way, looking at large challenges like urbanization, longevity and so on, is to go talk and work with the people looking at challenges in the street. We're doing this in the Smart City of Things[1], with the city of Antwerp, where we are really co-designing with the people in the city to figure out what the problems are, and then looking for technologies that could solve those problems.

The other approach is to grow basic technologies to a level where they are sufficiently mature to be deployed in the real world. At imec, we're tackling this both ways. We have the smart electronics and applications that focus on the challenges out there. And we have the core technologies – process technologies, silicon technologies – that we try to grow and mature to solve those problems. When the two intersect, you have real disruptions, you can really improve people's lives.

What about you Sven?

Sven Etzold – Yes, you're right. I think in general technology means improvement, and we also see it from two sides. On one side, you have engineers who try to make things smaller, faster, better. You can see it with the chip size improvements where you have much smaller chips with much more processing power. That's the part driving technology.

The other part is people themselves, and people are lazy. They want to get things done in the easiest way, and technology can help them. These two sides together, the laziness of people and technological improvement, create innovation and technology that really improve lives.

[1] https://www.imec-int.com/en/cityofthings

This edition of the u-blox magazine focuses on some of the megatrends shaping our world. Do you see technology as a primary driver behind megatrends, or rather as a solution to the inevitable evolution of our world?

M.P. – I see the big megatrends that we have as three distinct groups. The first is driven by societal problems, such as urbanization, mobility, dense city centers. There, technology is an enabler that helps solve problems created by those societal trends.

The second are those that are driven by technology, for example eHealth, IIoT. We know what the solutions look like, we have the technology, but actually implementing them in the real world needs solutions in society. How do you cover eHealth? How do you take care of medical patient data? What happens when everything is automated? What happens to the nature of work, to people on the factory floor? There, society has to provide the solution, and technology is the driver.

Then the third block of megatrends is related to security and privacy. Here, society and technology are creating problems that are moving faster than either of them can solve. Privacy is a perfect example, but also cybersecurity, encryption, and hackable self-driving cars. The solutions are both technological and societal.

S.E. – The megatrends themselves are not a new phenomenon. They have been in existence as long as mankind. For example, the megatrend of mobility has different characteristics today than 30 years ago. Today we talk of autonomous cars. 30 years ago we might have talked about the possibility for everyone to own a car. Both drivers – technology and society – inspire each other to keep pushing limits. A megatrend cannot reach its vision without technology. On the other hand, technology is meaningless without the vision to reach something, to make something better.

M.P. – There's also the intersection between megatrends, right? You have eHealth, mobility, but today mobile eHealth is becoming important, and the intersection between those two creates even more opportunities but also challenges for technology.

"Technology is meaningless without the vision to reach something, to make something better."

S.E. – If you break it down, to a certain extent we are always talking about the same things: how to connect things to each other, how to transport information, and how to interpret the information to reach a certain goal or state. While the use cases are different for eHealth or for a smart city, the core components and technologies are always the same.

M.P. – Absolutely. But if you look at networks of the past, and those of the future, I think we're actually at a very important point of shift in their fundamental nature. Networks of the past were mostly about human communication, e.g. postal, telephone, and eventually mobile telephone networks. Then it was about entertainment. We first had traveling bars and circuses, then we built theaters, and now all of our entertainment is part of the communications with media. It's all from a human-centric perspective.

However, if you look at the future, more and more devices are coming on. You have machine learning and semi-autonomous AI. I believe that those will drive the specifications. As you said, the core stays the same, but it will be driven via AI-to-AI interactions that might have completely different specifications, requirements, not coming from a human perspective. I think that's an important thing to see when we look at networks of the future.

S.E. – Going even further, what happens if these autonomous or intelligent machines have to make decisions that we humans made before. What happens if cars become autonomous and decide which battery station they have to use to charge their batteries, at which garage to change their tires? Currently, these are things we decide.

In the future, more and more of these kinds of decisions will be taken by a machine, with another machine also the counterpart. It's a completely different way of interacting. The characteristics of the megatrends will therefore also change with time, and five years from now, mobility or urbanization will present new challenges.

M.P. – There is a paradigm shift here, when we look at technologies and at AIs that are making decisions. There used to be the concept of the Renaissance Man, right? At the time of the Renaissance, it was still possible for a single person to know all of the scientific knowledge and understand it. Then we shifted to the concept of the Internet Man, who doesn't know, but can find all of the information and understand it. Paradigm shifts are slow - industrialization, the internet - you only see them in retrospect, because the old paradigm continues to live on. William Gibson said, "The future is already here - it's just not very evenly distributed." But the next paradigm shift is that we are going towards a world where we cannot know. We cannot even find all the information. The man of the future will need to know how to trust the decisions made by machines. How do you trust decisions made by non-human entities? The understanding of trust is going to become more important than the understanding or finding of information. Which are the right decisions versus which is the right information?

Michael, you are program director for connectivity at imec. How would you define connectivity now and in the future? And you Sven, what do you think?

M.P. – Take evolution. The more complex an organism, the more communication systems it has, the better it can adapt to its environment. That's why connectivity is so important to our world, why we have edge IoT and edge AI, and why we want to disperse sensors and computational capabilities and connectivity as widely as possible. Because the better we know the world, the better we can understand, the better we can connect and communicate, the better we can adapt. That's why it's so important for connectivity to become ubiquitous, that everybody on the planet can be connected. Because otherwise, you will have pockets of people on the planet that cannot be lazy. As Sven said, essentially connectivity makes it easier to be lazy because you can get information without having to travel around. You can know what other people are doing. You can make better decisions, or some connected AI can make those decisions for you.

Sven Etzold
Senior Marketing Director, u-blox

"It won't just be the Internet of Things, but rather the Internet of Everything and Everyone."

S.E. – I think that connectivity today means having the opportunity to access an ecosystem wherever you are. When you enter a building or a certain area, you also have the possibility to access a certain ecosystem. I believe that in the future this will become a paradigm shift. Because connectivity doesn't necessarily mean that you are connected to something, but rather that you're part of the ecosystem, which is a fundamental difference. It won't just be the Internet of Things, but rather the Internet of Everything and Everyone.

M.P. – I believe that we can expect that this trend of connectivity using other entities will continue. Think of the IIoT. It's not just about factory floors. You may know that at the University of Nijmegen, with which we collaborate closely, there is a Twitter tree (@TreeWatchWUR). When it wakes up in the morning, it tweets that it drank a nice amount of water. This may seem silly, but if you think about the internet of plants, sustainable farming, and so on, everything that is agri-tech, this is going to be important as well. Can we build sensors that act as interfaces? We always think about brain-computer interfaces, which are very futuristic. But what about plant-computer interfaces? Not a sensor that measures something, but one that just acts as a translator. For a plant, there may be a way to directly reach its general wellbeing by accessing its neural system. Much like with brain-computer interfaces, we might need more biological interfaces. And that may drive in more future connectivity where truly everything is connected.

S.E. – We have a project in EMEA with some universities and industrial players, where we're working on digital twins, which are not simply a virtual representation of the original system, but a one-to-one real-time copy of this system. By running something in the original system, you're doing exactly the same thing in the second system. There is the option to play in the virtual system to figure out how the real system would behave in a certain situation.

M.P. – A digital twin of a human organ for example? One of the things we are building is electrode arrays with chips underneath. You can put a stem cell on top of it and stimulate it to grow in different ways. You could then indeed grow a virtual organ and predict what will happen, for instance, try out cures on the digital twin before you tried them on your own body. However, when it comes to digital twins for factories, and maybe for real-time maintenance to know when something might breakdown, these are one of the triggers for new specifications. In these types of use cases, it's not just about high capacity, gigabits and terabits, which remain important. It's also about reliability. If I have a digital twin that follows my equipment in real-time to correct misbehavior, the network needs to be up 99.999% for people to trust it, right? I mean right now, why should I trust my machines on a wireless connection?

What are the biggest paradigm shifts that we should expect as we move towards a more connected future? Can we expect the world to become a better place?

M.P. – I'm a techno-optimist, so I think technology will make the world a better place, even with the biggest paradigm shift of computers making decisions instead of humans. Pedro Domingo said, "People worry that computers will get too smart and take over the world, but the real problem is that they're too stupid and they've already taken over the world." A perfect example are these letters I get from the local telecoms company. If I overpaid by one cent, the automated algorithms will send me a letter to say they will refund it. The letter probably costs five euros. Hopefully, optimistically, computers will become smarter in their decisions for the better of everyone.

S.E. – I'm a little bit more realistic than optimistic. I think technology can help to make the world a better place. But there are few challenges today that are not that nice. We have global warming, refugee crises, political incidents, and a kind of instability globally, where megatrends also play a role, so we can't disconnect these kinds of things. Where I'm positive, it's because the megatrends themselves always paint a bright future.

I think what technology optimists sometimes underestimate is the human factor. I'm convinced that technology can really help in improving and in making our world a better place. However, we also have to ensure that, even if machines become smarter and make decisions, humans remain in the driver's seat, and that we also have a common sense and direction we want to go in.

M.P. – I agree 100%. I think that the biggest thing holding us back is the human factor of accepting technology. I think the key element there is trust. We are slowly getting used to the idea of having machines making decisions. Even though we don't realize it, they're already making decisions. But in many cases, and autonomous cars are a perfect example, people have unrealistic or very high expectations of technology. When there's an accident in a factory and it's somehow a nonhuman entity making decisions, there's a big question, who is responsible, which is deeply ingrained in the concept of a fair society. If something goes wrong, there is retribution, but with a machine that becomes very hard. I think the biggest thing holding us back is to connect our human nature to decisions being made by machines, and I don't think we've solved that yet.

"I think technology will make the world a better place, even with the biggest paradigm shift of computers making decisions instead of humans."

S.E. – We haven't, and this is also one of the paradigm shifts. If we look back a little, we were always looking after the reliability of systems. I think the big paradigm shift will really be when we move from reliability to secure, trustworthy systems. This is the biggest step to overcome. Once again, we need humans because they decide, do I look after reliability or do I trust something that is giving me advice or driving me from A to B?

"I think the big paradigm shift will really be when we move from reliability to secure, trustworthy systems. "

Could you dig deeper into the enabling and implemented technologies behind a connected future?

M.P. – When I think about the connectivity of the future, the big technologies fall into three categories. The first is broadband. We will continue to need evermore capacity, and technologies like millimeter-wave with better amplifiers, better networks, smaller, more power-efficient chips, multi-modes connectivity, and so on. That will be very important as we move along and that's a big chunk of technologies that most people understand: high capacity.

For future networks, there is a second set of enabling technologies, which I would call deterministic wireless networks. Reliable, on time, where we know that when we send something, it will arrive. When we make a decision and we tell the machine on the other side of the planet to do A, or on the other side of the factory to do A, it will actually move and move the right way. The protocol stacks, the software, the encryption, perhaps even the machine learning to optimize those networks, are all critical technologies for the networks of the future. We have some of them already today in advanced Wi-Fi systems, but they will become even more important in the future.

Then, the third part I would say is a sensing technology, sensitive networks that work with very low power and can live forever on a battery or no battery drives huge needs for integration. Ever smaller systems, what we call BOM-less, or bill of material-less systems, where you can integrate everything on the silicon. Perhaps they harvest energy from RF waves from the air, from movement, from the plant in which they live. Just look at Bluetooth, at GNSS receivers, the incredible improvement in power consumption over the last 10 years. I mean, you have three GNSS receivers in a single watch while you used to need a big box in your car for one. That has been incredible, and it needs to continue. I think we already know what the enabling technologies are for the network of the future, and they are probably the three big baskets of capacity, determinism, and very sensitive or very low power networks.

S.E. – There is the border between enabling technologies and implemented technologies, which is becoming blurry. Systems will become more and more integrated, so we expect that we can trust the core technology as well as the data integrity of transmitted information. What will these networks as an ecosystem really look like? We have to ensure to 100% that transmitted data cannot be manipulated. It's always the data of the sender, who might be a human or even an IoT device. Ensuring that this data which is created there and transmitted to another point, cannot be manipulated, that it's always clear, that the sender is the owner of this data - finally even this will become part of the enabling technologies.

Coming back to the laziness of people, engineers are also lazy. Sooner or later they will expect that all these functionalities are prebuilt on a single mini chip and that they can simply use it straight away.

Who are the main players shaping our future connected world? Should we talk of ecosystems of players?

M.P. – I think the ecosystem is a key term there. Because of the much tighter integration of enabling technologies, ecosystems are becoming more and more important. Frankly, in the future, it may be even likely that the competitive entity will no longer be the company or the factory, but the ecosystem. We have seen a little bit of that in the past in connectivity, right? You have the IEEE unlicensed Wi-Fi ecosystem and you have the 3GPP licensed cellular ecosystem, which to a large degree are now accessing the same space. In the future, you'll see companies like Amazon creating ecosystems around themselves, on the logistics side, on the distribution side, on the manufacturing supply chain side. Companies like Softbank investing in Uber, in Lyft, and Careem. Then they add content and cross-fertilize over that ecosystem. The same thing is also going to be key for connectivity. I think the important thing of an ecosystem is a shared vision of the future: ubiquitous sensing and connectivity built on a reliable trust base for example.

That's also why we're collaborating. imec and u-blox belong to the same ecosystem, because we build the forward-looking IP, ideas, new potential concepts, and also develop those component subsystems that engineers expect so that they don't need to think about that underlying reliable layer anymore.

S.E. – It means that for us as a player in this field, we have to be part of the ecosystem over the whole lifetime. It's really from cradle to grave, where you have to follow through delivering your expertise into the ecosystem as well as to those things or people that are using the ecosystem.

"Because of the much tighter integration of enabling technologies, ecosystems are becoming more and more important."

M.P. – The good thing about the ecosystem is, as it creates this web of interconnection, it also allows you to go for not traditional supplier/vendor business models, but business models that look more at monetization as a service, which are necessary. Because if you look at the technology that's really necessary for that ubiquitously connected future, think about high speed millimeter wave, and the number of players that can own the entire stack, there's nobody except perhaps Intel or IBM, and even then. You need all of those ecosystem players and you need to connect the end-users and how they take care of this all the way back to that fundamental technology. Because otherwise, they will be no way to pay for the continuing advance.

"I think the important thing of an ecosystem is a shared vision of the future: ubiquitous sensing and connectivity built on a reliable trust base for example."

S.E. – You mentioned one name, Amazon. I think that we can't get off of our reliance on the huge tech giants today. We have Apple, Google, Facebook, which are creating their own ecosystems. Google, for example, already around 10 years ago bought Nest, where everyone said, what the hell is a search engine doing with someone that creates tiny things for home automation? But even these tech giants can't drive it totally by themselves. They need strong collaboration, carriers, the infrastructure to drive it all, and they can't do it by themselves because this would really mean dystopia. It wouldn't be a nice looking future. I think it also wouldn't be expected. This brings us back to the trust and security issue - if everything is owned just by the master of the ecosystem.

Second, and at a higher level, political stability is important, because these systems can only be driven in a good world and will only be secure and also trustworthy for those that are part of the ecosystem.

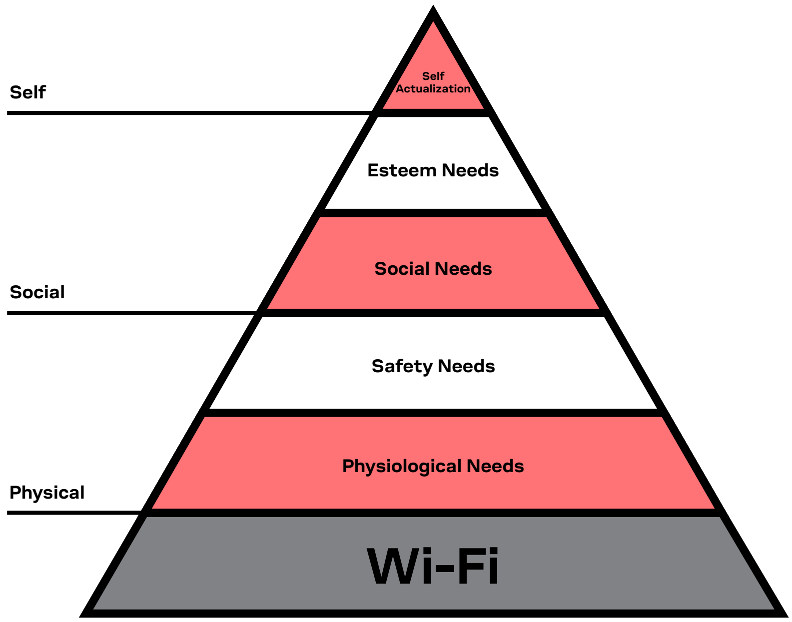
M.P. – A lot of those ecosystems are not necessarily technology or market ecosystems, but data ecosystems where everyone wants to own the data. This is where the touchpoint is with political stability, because access to certain types of data in a politically unstable context, I mean, it’s an accident waiting to happen.

What are the main obstacles that are holding back our connected future? What if they can't be overcome?

S.E. – I think the first obstacle that is really holding back more connectivity is money. Today, where everyone's talking 5G, you have lots of demos at events where you see what the future will be like with 5G, what kind of things in our life will improve by applying this technology. Reality as of today is slower than expected, and it's mainly related to the huge investments that have to be made. So money is really one thing that is holding back a totally connected future. 5G is only one example. It would be for other things related to connectivity as well. You need to invest quite a huge amount of money to come to this ideal state and reach a positive ROI to a certain extent.

The second is the need for stable political systems. Sometimes societies have the technology, the brains, in areas where technological improvement would be possible, but it’s held back by the unstable situation around. It doesn't necessarily mean only that companies are not willing to invest. It's also that people or even governments themselves don't know if they’ll be happy with their decisions two days later? This is something where I actually see these kinds of obstacles for getting more connectivity, more technology, even on a global basis.

M.P. – When 5G was being defined, there were discussions in ITU to define a number of use cases: mobile broadband, enhanced mobile broadband, ultra-reliable low latency, massive machine type communication. But people forget that there were a number of other ones as well. One of them was, for example, ubiquitous connectivity, but at a much lower bit rate, over hundreds of square kilometers. These would be ideal in developing countries, in rural communities, to bring them up to the level of having connectivity and the ability to have all of the automation improvements in efficiency. But as you said, the investment environment just isn't there today, because a lot of the connectivity is being driven by entertainment and communications. So it's mostly broadband and the other use cases get some attention, but not sufficient.



Maslow's hierarchy of needs.

S.E. – And we also have to be aware that, even as of today, as innovation cycles are getting shorter and shorter, the next innovation level might be here in two years. Where we say, okay, we haven't taken the next technological step…

M.P. – 6G, 7G, 8G.

S.E. – …yes, exactly. We have to be aware that industrial and automotive use cases have life cycles that are much longer than the next innovation cycle. So we build things to last much longer than the next technology step. But at the very end, it's expected that the next few steps, the components and the core foundation we build today, are still up to date in six or seven years. It's getting difficult for people to decide, what should I do right now? 5G is once again a perfect example with what they call massive machine type communication. In the 4G era, they called it LPWA, which is more or less the same thing. The transition will be an evolution from A to B.
But we already see the clear need and requirement from markets, from ecosystems, to say that if we decide to do LPWA today and we want to do massive machine type communication in five years, we won't want to change everything. If you don't invest today, you're just postponing the investment and you have to put the money on the table five to six years later, when really everything's available.

It seems that not everyone is equal in front of technology. Some benefit from it more than others. Should technology be a “human right”?

M.P. – You've probably seen Maslow's pyramid of needs, where the bottom layer is replaced by Wi-Fi, and communications and the ability to communicate drive evolution. So I think to the degree that you need technology and connectivity to evolve, like food, clean air, and water, it should be a right.

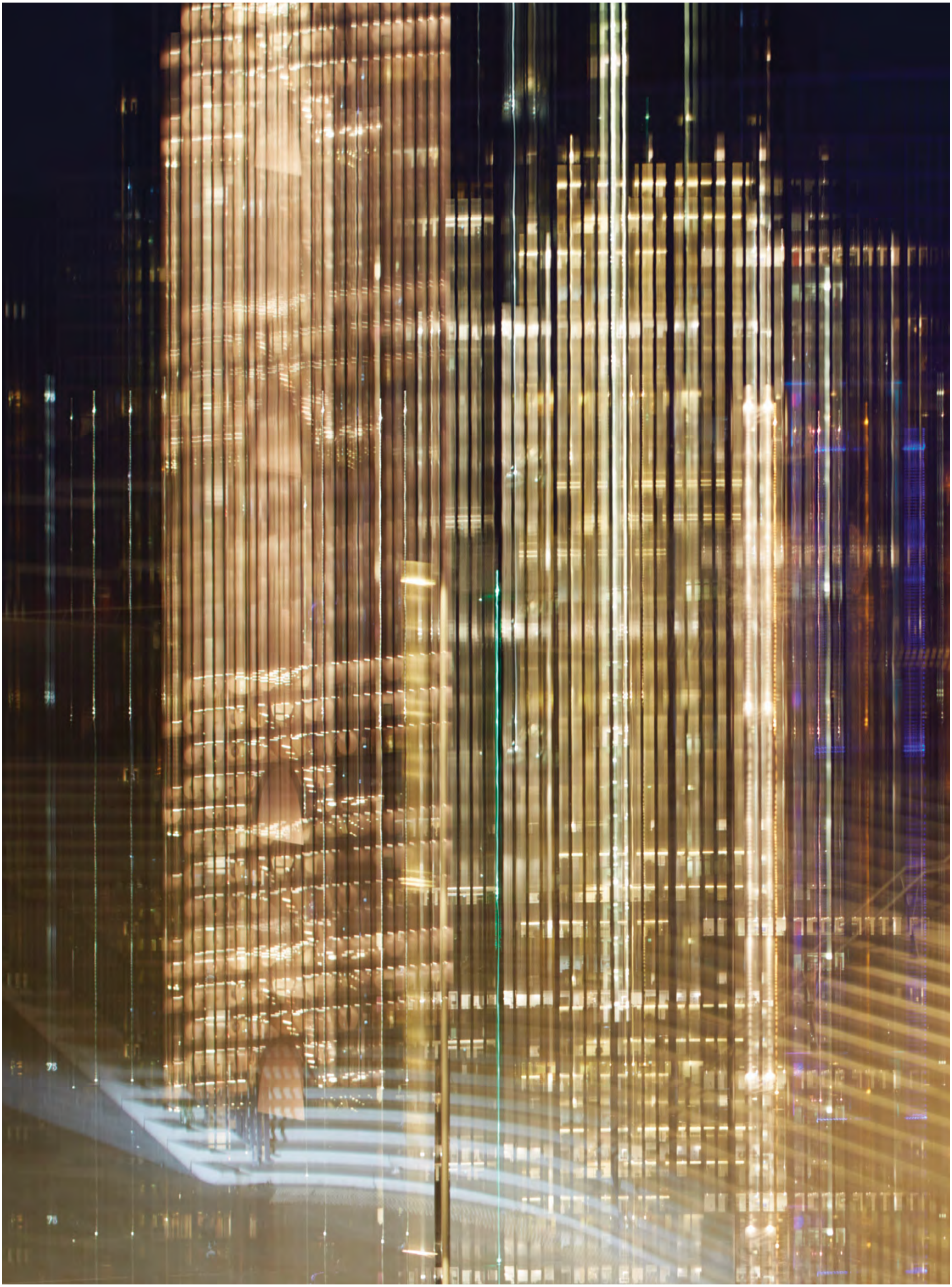
There is an inequality, but at the same time, putting my optimistic hat on, if you look at the world today, there are more people connected than ever. Healthcare across the world on average is better than ever. Access to education, on the whole, is better than ever. So while there is this digital divide and it exists, so we have to keep an eye on it.

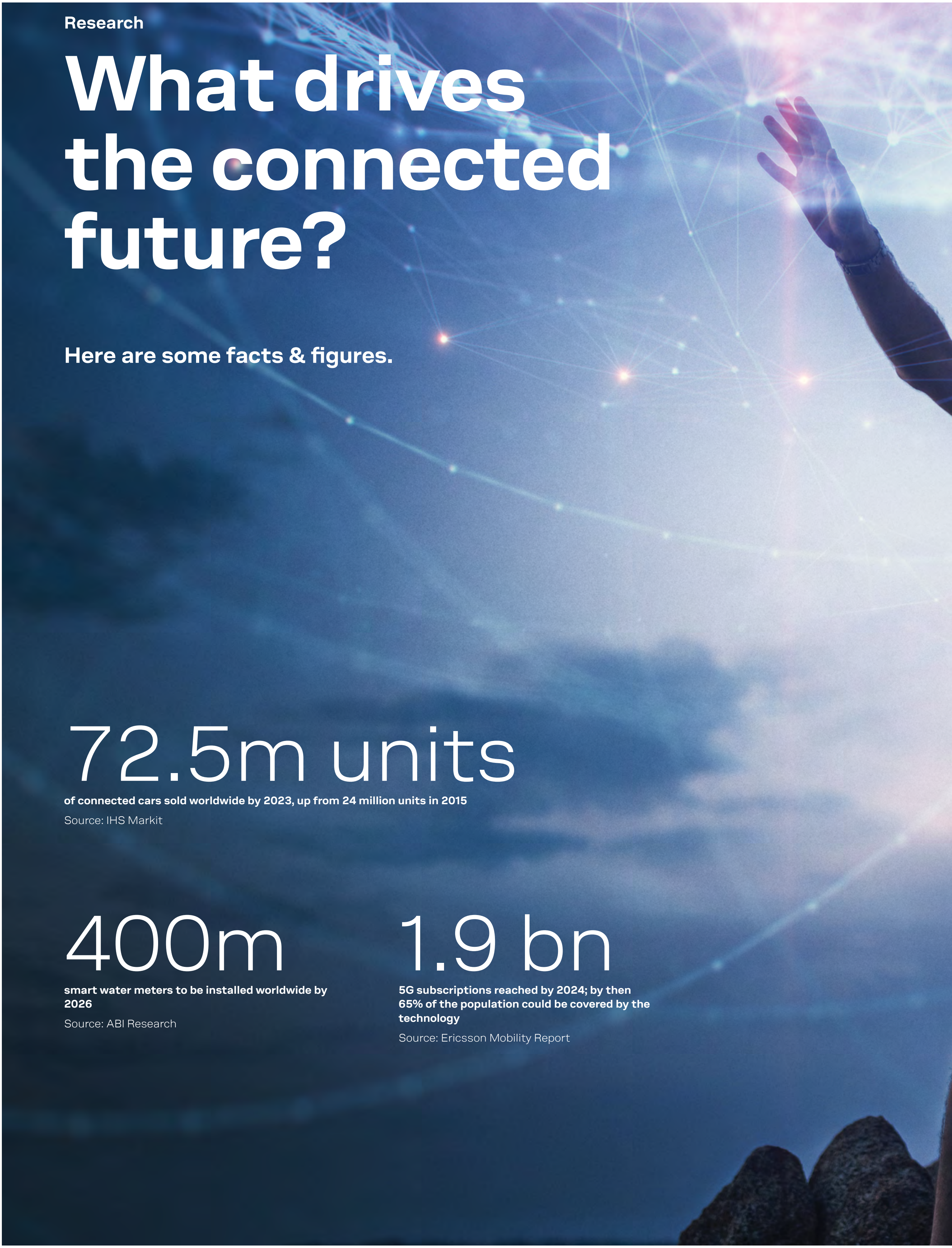
Perhaps it's not technology that's a human right, but education and understanding of the technology. Because if we go to a world where connectivity means more, and more decisions are being made by autonomous entities, if people don't understand and trust technologies, they will not implement them, and instead turn away from them like the Luddites in the 1800s.

S.E. – If technology is defined as having the right to access information I need to improve my life, I would say, yes, technology is a human right. Technology is more like the vehicle: you need to have the ability to access it to address all the other challenges. I agree that looking at Maslow's pyramid, things have changed. Access to information and the right also to spell out your own thoughts, to be able to articulate your thoughts, to participate at discussions should be there too. It's not only about surviving, it's also about becoming a vital part of a society. We in the Western world need to ensure that fundamental rights can be applied in other societies. And I think technology is a very good vehicle to help to do so, and also to raise the flag and say we should steer into another direction, rather than go in straight ahead to what you are doing right next to the wall.

M.P. – I think that's also part of the role of our ecosystem: to help people, to educate people, to help them understand what technology can and cannot do. So that people know which technologies can tackle which of the challenges you just described. ■

Watch the whole interview:





What drives the connected future?

Here are some facts & figures.

72.5m units

of connected cars sold worldwide by 2023, up from 24 million units in 2015

Source: IHS Markit

400m

smart water meters to be installed worldwide by 2026

Source: ABI Research

1.9 bn

5G subscriptions reached by 2024; by then 65% of the population could be covered by the technology

Source: Ericsson Mobility Report

14.2 bn

connected things in use this year; 25 billion by 2021

Source: Gartner

14.2 tn

US$ added to the global economy by 2030 thanks to the Industrial IoT

Source: Accenture

3.1 bn

US$ market value of the worldwide IoT security sector in 2021, up from US$1.9 billion estimated for 2019

Source: Gartner

Unleashing connected construction sites

AddMobile's comprehensive management platform, the AddMobile Toolbox, is helping make building sites safer and more efficient.

From small housing developments to large-scale infrastructure programs, construction sites are busy and potentially hazardous places. Employees and contractors are constantly coming and going. Materials arrive by the truckload. Expensive equipment gets moved around sites and beyond.

To ensure projects run safely and smoothly, it's essential that operations managers can keep track of everyone and everything at all times. And this is precisely what the AddMobile Toolbox – part of the ever-growing Industrial Internet of Things (IIoT) – helps enable.

The perfect IIoT partner
Using a blend of technologies, including standard RFID, positioning, cellular, and short range radio communication, the suite empowers those in charge of construction projects to monitor and control everything from site entry to vehicle usage and work orders. It also provides precise tracking of tools and other important equipment.

As you might have guessed, u-blox technology is at the heart of the AddMobile offering. Our MAX-M8 GNSS module, SARA-G3 GSM/GPRS cellular module, and NINA-B1 Bluetooth 5 low energy module all play essential roles.

"There are two big attractions about working with u-blox," says Bo Lyvall, Business Development Manager at AddMobile. "Our beacons and hubs rely on a combination of GNSS positioning, cellular connectivity, and Bluetooth short range radio interfaces. Firstly, u-blox provide all three technologies in one place. And secondly, they have great support engineers local to our Malmö base. This is hugely valuable in helping us use their technology to realize our vision."

Expanding possibilities
The latest addition to the AddMobile Toolbox is the AddTracker, a Bluetooth low energy tracker beacon that can be attached to any piece of portable equipment.

The beacon transmits a signal and a unique asset ID. This can be picked up by nearby AddMobile hubs, or a smartphone running the AddMobile app. These devices then use their cellular connectivity to send the asset's position to the AddMobile cloud platform. From here, operations managers and other authorized users get a snapshot of the item's features, location, and where it is on its planned maintenance schedule.

This setup gives AddMobile Toolbox customers powerful capabilities that help them run their construction projects safely and efficiently.

Fixed and moving hubs

Operations managers can track assets around construction sites, using a network of strategically located fixed hubs.

Equally importantly, they can track a kit when it's taken off-site. One way of doing this is by fitting a works vehicle with a mobile hub. This has a positioning module and cellular connection, along with a Bluetooth low energy interface in the cargo area. The hub picks up the Bluetooth signal from individual asset beacons, and sends it to the AddMobile cloud, where managers can see where their mobile workforce and assets are at any time – and ensure that individuals and teams have the right equipment with them for the jobs they're doing.

The next steps

The exciting thing about the collaboration between u-blox and AddMobile is that this is just the beginning of the journey. With the opportunities offered by longer-range Bluetooth, there are possibilities to further cut the cost of equipment tracking, particularly on big and complex sites. Another area likely to be explored is the use of cellular technologies in asset tracking.

This will mean more opportunities for us to shape the IIoT, while helping ensure that buildings and infrastructure are constructed more safely and efficiently than ever before. ■

Learn more:
www.addmobile.se/addmobile-toolbox/asset-management/?lang=en
www.u-blox.com/product/nina-b1-series
www.u-blox.com/product/sara-g3-series
www.u-blox.com/product/max-m8-series

A vertical takeoff to exciting new possibilities

Onboard Quantum-Systems' VTOL drones, the high accuracy and operational reliability of u-blox technology is showing its credentials in mission-critical UAV applications.

Unmanned aerial vehicles (UAV) are taking off, with applications as diverse as surveying, medical delivery, and search and rescue missions. That hasn't stopped Munich-based Quantum-Systems from shaking up the sector with an innovative UAV design that takes off and lands vertically like a helicopter but flies like a normal airplane once airborne. This lets it travel much further and in a more energy efficient way than conventional vertical takeoff and landing (VTOL) drones, without the need for a runway or ground infrastructure.

Attaining speeds of 80 kilometers per hour and covering distances up to 100 kilometers, the Trinity F90+ is Quantum-Systems' latest cutting-edge UAV. Intended for civilian usage, this new 2.4 meter wingspan aircraft can serve wide-ranging applications, including agricultural monitoring, pipeline inspection, and stock pile calculations. The drones are also being used to transport vital blood samples to patients in remote locations across rural Africa.

Having achieved great results with u-blox positioning technology in other UAVs in its portfolio, the engineering team at Quantum-Systems was keen to pursue this relationship on the Trinity F90+. After looking into available options, the u-blox ZED-F9P multi-band global navigation satellite system (GNSS) receiver made the cut – thanks to a compelling combination of performance and reliability at an appealing price point.

Compact, lightweight, and with minimal power needs, the ZED-F9P is highly optimized for UAV applications where there are serious size, weight, and power constraints to contend with. Its 20 hertz update rate lets it take highly dynamic maneuvers in stride, and its sub-10 second convergence times ensure that it always stays on course. .

"The primary technical challenge that our engineers had to address when embarking on the development phases of the Trinity F90+ project was ensuring that, while in flight, there

Tron F90 UAV deploying blood samples in South Africa.

would always be access to accurate enough position data," explains Dr. Michael Kriegel, CTO at Quantum-Systems. "More specifically, this would be vital to collect accurate sensor data for those use cases that rely on precise data such as vegetation mapping or stock pile calculations."

By providing an uninterrupted stream of high precision positioning data to the drone during flight, the drone can perform missions which would have been impossible in the past. This requires effectively managing GNSS correction data, using a combination of sources available to the ZED-F9P module. In the future these will also include multi-band real-time kinematic (RTK), raw code, and carrier phase data.

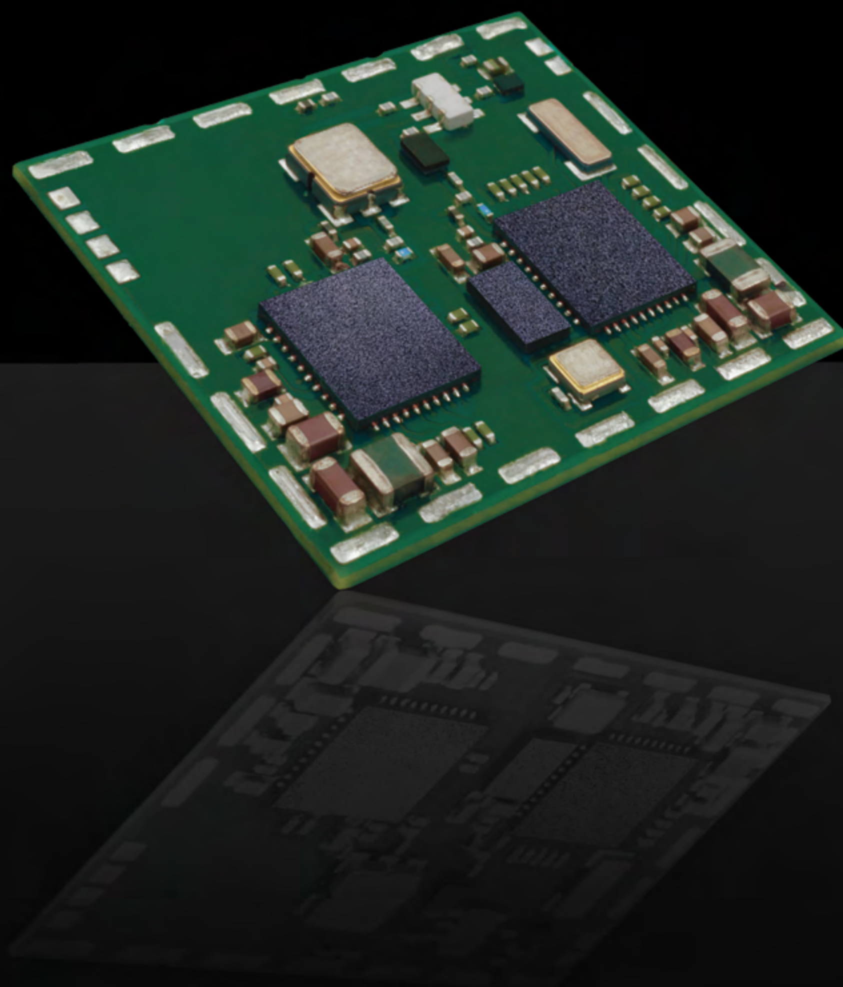
The resulting centimeter-level absolute and relative position accuracy lets Trinity F90+ pilots perform even the most demanding missions in terms of accuracy in order to save time and money. One of the most recent projects includes the automated recording of vegetation near the tracks and of storm damage along the Deutsche Bahn network with autonomously operating UAVs by Quantum-Systems.

The ZED-F9P is now being built into every UAV that Quantum-Systems produces. "Accurate, robust, power efficient, and easy to integrate, the u-blox ZED-F9P met all of our design criteria perfectly. In addition to the hardware, u-blox provided much-appreciated technical advice on this venture. Our longstanding partnership continues to get ever stronger," Dr. Kriegel concludes.

Learn more:
www.quantum-systems.com
www.u-blox.com/product/zed-f9p-module

Products

In the spotlight



The latest in positioning and wireless communication technologies

Combining industry-leading quality, robustness, sensitivity, and performance with innovative features, u-blox delivers components and solutions that meet the needs of even the most demanding designs. We focus on business-critical applications where products need to perform 24/7 with maximum reliability, handling exceptions with minimal disruption to the overall system. Our customers expect improved productivity, quick turnaround, and a head start on their competition.

Bluetooth low energy modules

With the integration of the recently acquired wireless modules from Rigado, u-blox has extended its Bluetooth low energy offerings to customers. The newly added BMD module series complements our NINA and ANNA families, allowing you to choose the solution that best fits your business. The new BMD modules all come with an open CPU, meaning customers get to build their very own software solutions, making the most of the powerful integrated MCU. Are you looking to connect your high-volume fitness equipment without sacrificing performance and reliability? Do you need compact modules to support medical applications on wearables? Look no further. Whether it is a BMD module, or NINA /ANNA module featuring our u-connect software, the new extended u-blox portfolio has the Bluetooth low energy answer you are after.

Learn more:
www.u-blox.com/short-range-radio-chips-and-modules#tab-bluetooth

SARA-R5

The SARA-R5 series of multi-band LTE-M and NB-IoT modules is based on our u-blox UBX-R5 cellular chipset and our u-blox M8 GNSS receiver chip. By bringing all technology building blocks in house and having full ownership of hardware and software, we offer our customers guaranteed long-term device availability and lifetime support of the entire platform, down to the chipset level. SARA-R5 is 5G-ready, meaning the modules can be software-upgraded to 5G LTE once networks have been rolled out, greatly improving end product scalability and lifetime. The modules also include built-in end-to-end security with a hardware-based root of trust inside a discrete secure element.

Learn more:
www.u-blox.com/product/sara-r5-series

u-blox M9

The next generation of our meter-level precision technology has finally arrived. u-blox M9 is the ultra-robust platform that caters to high performance applications in the automotive, telematics, and UAV arena. Our NEO-M9N module provides exceptional sensitivity and acquisition times for all L1 GNSS systems. Support for concurrent reception of four global navigation satellite systems maximizes the position accuracy, also in urban canyons. High update rates of up to 25 Hz as well as jamming and spoofing detection allow for dynamic applications such as unmanned aerial vehicles to receive position information with low latency, flagging any incoming security attacks.

Learn more:
www.u-blox.com/product/neo-m9n-module
www.u-blox.com/product/ubx-m9140-chip

Five new Bluetooth modules, countless new possibilities

The acquisition of Rigado's module business boosts our product portfolio and gives customers that joined us from Rigado easy access to the full range of u-blox wireless communication and positioning solutions.

On July 31, 2019, we welcomed five new modules, seven new team members, and many new customers to the u-blox family with our acquisition of Rigado's module business! By incorporating a handful of successful products developed by Rigado, an Edge-as-a-Service gateway solutions provider working out of Oregon, USA, into the u-blox product portfolio, we grew our market share, gained access to new verticals, and won precious industry expertise. Our existing customers saw new items added to our menu of short range modules, while those joining us from Rigado gained access to our full portfolio of u-blox wireless communication and positioning solutions.

Commercial complementarity was the key factor driving the acquisition. Thanks to their palette of modules optimized for cost and size, as well as strong ties to Bluetooth chip supplier Nordic Semiconductor and relevant customers, Rigado successfully built up a strong footprint in consumer-oriented markets, including the smart home, wearables, and fitness. This nicely rounds off our market presence in short range technologies, which has traditionally centered on industrial customers and their applications.

The expansion of our distribution channels was another important outcome. By leaning heavily on established electronics distributors, Rigado streamlined demand creation and procurement. It is an approach that we are transferring to all of our products.

We look forward to extending our solutions, our services, and our support to the customers that joined us through this acquisition. By offering them a single source for their wireless communication needs, we aim at simplifying their efforts to incorporate additional technologies such as Wi-Fi, NB-IoT, or LTE-M into their products. And as the line between short range communication and positioning services continues to blur with the introduction of positioning technology offered by Bluetooth 5.1, we expect to see exciting new synergies with our satellite-based positioning solutions. ■