

Good morning,

There is no doubt that the technological planets are aligning - Internet of Things, Cloud computing, Robotics, Electric vehicles, Drones, Artificial Intelligence, Gene sequencing and splicing, Quantum computing and many others.

The transformational impact that these disruptive technologies will have on our lives will be highly non-linear, especially when it comes to AI and quantum computing. This means that our preparation for that impact needs to be highly non-linear too.

But one of the challenges that I believe we face, as individuals, as institutions and as a country, is that we need much much more really big, really long term and really disruptive thinking.

We rightly cherish our democracy and the values and ethics that underpin it. But there is no escaping the fact that we are at a disadvantage relative to countries such as China when it comes to thinking long term, balancing innovation with legislation, and harnessing the power of data to fuel our AI ambitions.

So given these systemic disadvantages and the asymmetry in the scale of investment, we are going to have to look for ways to play the transformation game smarter, more selectively and with greater leverage.

To support more of this big, long term disruptive thinking, we are going to need to structure ourselves to do it, create the processes and tools to support it, teach our children how to do it and nurture it when it happens. But we are also going to need an compelling vision to drive it.

The government's Industrial Strategy, and the four associated grand challenges, are for me a great step in the right direction. However if we are serious about building a truly smart and prosperous UK then I would argue that we need to think bigger, much bigger.

We need a grand vision for what a smart UK might look like and the infrastructure to support it. Here I believe government has a role to play not in terms of creating that vision but rather convening a diverse group of stakeholders to do that - putting up the Christmas tree for others to decorate, so to speak.

The same goes, albeit at a smaller scale, for the future of a smart and prosperous Hertfordshire. We need a vision for what that might look like, and how we might be a demonstrator and incubator for elements of the bigger UK wide vision.

In the time available to me today I can't possibly explore this landscape in any detail and so I am going to pick a few themes to drill into.

The first is the future of mobility, one of the four grand challenges. The technological intersection I mentioned earlier is driving the evolution of smart mobile machines, powered by clean energy, that are aware of the world around them and able to interact with it. That are able to interact with one another and with us. Machines that can collaborate and swarm like insects, sharing what they learn about their environment to harness the power of the crowd.

For me, the future of mobility is about this smart distributed interconnected ecosystem. It's about vehicles powered by electricity, hydrogen and possibly other clean fuels. It's about advances in the enabling technologies such as batteries, motors, 5G, lidar, microprocessors and many others. It's about autonomy and the basket of AI technologies that makes this possible.

But it's also about the intersection, collaboration and orchestration of all manner of different autonomous machines, including cars, delivery vehicles, drones and robots. And sitting on top of this mesh network or ecosystem of autonomy will be a host of smart services delivering the efficiency and service level gains, unlocking the network effects, disrupting traditional business models and sector silos, addressing the scaling challenges, providing monitoring and oversight, keeping us safe from accidents and other threats and so on.

Autonomous clean-energy powered vehicles are going to transform and disrupt the movement of all sort of atoms around our planet:

- Across sectors, for example in factories, hospitals, construction sites and homes.
- Across supply chains and the last mile.
- On our roads, pavements, cycle tracks, railways and under the ground too. On and under the sea. In the air and even in space.
- In cities, rural communities and extreme environments where humans would rather not tread.

But this is not just going to be a technological transformation, it's going to involve significant business model disruption too:

- Logistics companies will become taxi firms and vice versa
- Postal companies will become retailers and retailers may perform delivery and collection services on behalf of other companies.
- Car manufacturers will become internet search, entertainment and accommodation providers.
- Hotels and other businesses with inner city properties, may provide services for the storing, charging, servicing and dispatch of car-sharing and autonomous vehicles.
- Automated hubs that store customer orders close to the last mile will enable us to move from a push model where goods arrive when you are out, to a pull model where they arrive on demand, just in time, when you want them.

This will be a Russian doll model of autonomy. Planes, trains and ships will hand off to large vehicles, large vehicles to smaller ones, small vehicles to swarming vehicles or drones and the final 25 metres will become the domain of the robot, either dispatched from a swarming vehicle or robots that live in your building, that you trust and which understand the navigation of your local space.

But it's not just the machines that must get smarter about how they collaborate and play nicely with one another, so must we. We need to evolve new models for collaboration, across sectors and across missions, including between would be competitors. Because if everybody just carries on "doing their own thing", we will not make best use of our finite resources such as energy, time, land and transportation network bandwidth. At the same time we will fail to minimise the unintended consequences such as pollution, congestion, accidents and waste. Roads full of half empty single minded autonomous vehicles will not be a good outcome.

We need to learn what role smart infrastructure may play in this future. Imagine walking around an airport you have never visited before which has had all the signs removed. You probably could find your departure gate eventually but clearly the signage really helps. Similarly, a little bit of smart infrastructure may make autonomous vehicles cheaper, safer and more efficient.

This infrastructure, and the associated core services and interfaces, are definitely areas where diversity will not be our friend. It's really great what Transport for London and others are doing to open up their interfaces and data but we need common standards across the whole country so that solutions we build can be rolled out everywhere. For example pay per use parking spaces for the increasing number of online delivery vehicles, priority lanes on motorways to incentivise companies to use the bandwidth more effectively, smart scheduling of electrical charging points, support for platooning of LGVs and so on.

To answer these questions, we need to get the learning going now. Learning about the intersection of autonomous vehicles, drones, smart infrastructure, robotics and smart services. Learning about the interaction of people with these technologies. Learning what it takes to make a smart automated city really hum.

That's what Google decided to do when it came up with the concept for Sidewalk Labs in Toronto, which I visited last month. This is a bold plan to create an incubator for innovation within smart communities and cities in order to kick-start the learning and share the outcomes with the rest of the world. For example affordable housing, sustainable living and a stronger sense of community, all supported by sensing, data and smart services. But we need to create these living labs in the UK too and Ocado is working on some exciting plans to make that happen across the country including in Hertfordshire.

As I have said already, the vision needs to be much bigger than just the future of mobility of people, it's the future mobility of all sorts of atoms around our planet in clean, efficient and sustainable ways.

For example, our supply chains are currently fragmented and inefficient. We need a vision for creating an internet of freight. First we need a shared digital internet for atoms to provide shared frameworks for governance, traceability, regulation, security, monitoring, standards, interfaces and so on. The need for this digital public cloud for freight will become even more important in the light of Brexit.

Then we need a physical internet for atoms to provide a rapid transit network for freight, in order to get that traffic off our roads. Here other moonshots such as Hyperloop One could be important pieces of the puzzle and Ocado is part of the Magway consortium working on a similar solution but for freight.

The second theme I want to focus is infrastructure. Here I want to explore two examples of infrastructure that I believe we are going to need at a county and a national level. To bring these to light, I want to use an analogy from the construction industry.

Just imagine you were going to erect a building such as the Shard - a highly smart and complex building using lots of new technologies. How would you go about it? Well obviously you would invite a group of builders to the site, draw a picture of the building you want and then ask them to get stuck in. Obviously that would be a complete disaster.

What you would actually do is create a detailed project plan and a set of drawings such as architectural, engineering, electrical, plumbing, HVAC, networking, building management and so on.

These drawings perform many purposes including:

- Transforming the high level vision of the architect into something that can actually be constructed.
- Facilitating collaboration between all the different stakeholders and their teams who will deliver the final build.
- Enforcing building standards and best practices.
- By splitting the drawings into separate layers, helping those constructing the building to manage the complexity by seeing just the layers that matter to them.
- After the building has been built and handed over, providing the information required for its subsequent maintenance and evolution.

Well guess what, we are not just trying to construct a smart building without such drawings, we are trying to build and operate a smart country without them!

We need layered maps of the UK to:

- Enable people understand the bigger vision and how the different pieces fit together.
- Enable people navigate around institutions and government which are often impenetrable to those on the outside.
- Enable people to understand the mesh network of stakeholders, relationships, technologies and so on, in order to foster better collaboration and faster innovation.
- Enforce standards and interfaces.
- Enable a diverse population of contributors to crowdsource ideas for improving the maps or filling in the missing pieces.
- Via change control and versioning, capture the historical evolution of the maps as a document of record.

Without such maps, it's hard for people to navigate successfully around the territory and you also end up reinventing the wheel because they don't know who else is interested in the idea of a wheel or indeed already has one they might be willing to share.

In order to create these crowdsourced maps, we need a shared common digital collaboration tool along the lines of commercial mind mapping or whiteboarding tools but obviously at a much bigger scale. The chosen tool must also be able to support the requirements for layered focus, access, privacy and security.

The second infrastructure example I believe we will need is a digital twin of the entire UK that would:

- Be a composite of thousands of separate crowd sourced simulations.
- Have a layered granular structure in terms of the focus and purpose of the simulations.
- Have the necessary controls in terms of access, change control, security and so on.
- Have common standards for things like interfaces, verification, analytics, reporting, visualisation and so on.
- Avoid the need to reinvent the wheel by building all elements of a model from scratch or alternatively missing out elements that might be important in order to simplify the process of creating the model.

Such a digital twin would:

- Help de-risk big projects by making it easier to undertake the modelling up front and at reduced cost.
- Help generate data for the training and testing of machine learning models before the real data exists.

- By combining machine learning and simulation, enable machine learning to explore new paradigms, solutions and optimisations that are beyond what humans can come up with. (A great recent example of this was Deepmind's AlphaGo Zero that learnt to play Go better than humans by playing itself armed only with the rules of Go. In the process it discovered new moves and gameplay that no human had found in over 2000 years of playing the game).

At Ocado, we make significant use of simulation, emulation and visualisation to model our huge automated warehouses and other aspects of our business. Our plan for creating a living lab in Hertfordshire that I mentioned earlier, would start with crowdsourcing a digital twin of the living lab, in part to test the idea of building one at a country scale.

An important area for such modelling would be to test ideas for future proofing our housing stock as part of building smart communities and towns. For example:

- Modular configurable buildings.
- Automated hubs close to the lastmile for the consolidation of deliveries and returns.
- Integrated facilities for drones and other autonomous vehicles to perform unattended delivery and collections.
- Smart sensing to support independent living for the elderly and remote preventative medicine.
- And so on.

The last theme I want to touch on is education, because grand visions for creating this smart future will come to nothing without the people with the necessary skills to implement it.

One of the key challenges the UK faces in responding to the opportunities related to AI and robotics is the skills deficit. Data Science and AI lie at the most overheated end of the software engineering skills spectrum and there is a massive shortage of graduates and postgraduates emerging with these skills.

What is not talked about enough is the fact that these skills lie at the end of a digital literacy pipeline that stretches all the way back to primary school. There is a massive amount more that government, NGOs and business could do to help manage the flow along the entire length of this pipeline and to plug the leaks.

If we want a larger and more diverse set of graduates emerging at the end of this pipeline, then we have to do much more at the early stages. For example investing in more properly qualified teachers for these subjects, mandating schools to offer these digital literacy subjects up to A-level, and making these subjects mandatory within the curriculum at GCSE level just as we do with Maths and English. These are essential transformative skills not just for those who may go on to become software engineers but for everyone.

But true digital literacy is much more than just teaching children to code. For example we also need to teach them to be data literate. To understand how to organise and manipulate data, to gain insights from them, to visualise them, to build models from them, to understand the dangers of bias and so on. We also need to help our children understand the amazing possibilities and current limitations of technologies such as AI and robotics, the important ethical and philosophical questions around their applications, what it means to be human and so on. We need to find ways to maintain the level of interest in STEM subjects demonstrated by girls of primary school age which currently decays as they progress through the educational system. We need to be weaving this digital literacy throughout the curriculum.

However this pipeline must not stop at college or university. It needs to continue on into the workplace, and here we need to do much more to incentivise organisations to invest in continual learning, particularly when it comes to subjects such as AI. We need to fuzzi the boundary between education and work life and disrupt the current linear path: Go to school, go to college, go to work, do not repeat.

We need to prepare children for the process of continual learning and the inevitable reskilling that awaits them; we need to teach "self reinvention" as a meta skill and reframe the "mid life crisis" into an art form.

But we need to do more, much more.

Many of the skills and techniques we are currently teaching our children will be as devalued in the years to come as the encyclopaedia has been by the advent of the world wide web. Instead we need to focus on teaching enduring meta skills such as learning how to learn, collaboration, creative thinking, problem solving, intersectional thinking, mind mapping, design thinking, goal setting, innovation and entrepreneurship.

If education is all about preparing the next generation for their future life and instilling a love of learning, then I believe we are failing in terms of the structure and curriculum of our current educational system. The current relentless focus on exams, tests and the regurgitation of mark schemes is consuming all the educational oxygen, leaving teachers with little or no time for spontaneity, for sharing their love of a subject and for just pursuing the curiosity of their students to see where it might lead. If we allow education to switch our students off the joy of learning, then we will do them an incalculable disservice.

On the other hand, if we enable our children to leave school having learnt how to learn, full of curiosity, armed with a set of future proofed skills and with a joy of ongoing learning, then they will be well equipped for their life ahead.

So I believe we need to completely rethink our education system from the ground up and in so doing, future proof the underlying curriculum. This is going to be a long term game that we need to start playing now because it will take 20+ years to work its way through the educational pipeline. That's why I believe we need to follow in the footsteps of Finland and remove the educational football from the political playing field because this is a game that needs to be played in a radically different way.

As I said previously, these are just three themes within a much larger landscape that I believe we need to explore both for Hertfordshire and the UK as a whole. I am also well aware that when it comes to these sorts of challenges, there is a limit to what Hertfordshire can achieve in isolation. However I believe we need to be a voice in the lobbying of national government to exhibit political thinking and leadership that are truly holistic, agile, bold and disruptive.

Thank you.

Paul Clarke
Chief Technical Office, Ocado