SCANNING OUR FUTURE: INITIAL EXPLORATION OF TECHNOLOGICAL DEVELOPMENTS AND RESILIENCE IMPACTS

Jeremy Green and Fred Barker, January 2018

Introduction

The mission of the Scanning our Future (SOF) project is to provide a connection between future possibilities and the abilities and capacities of people to cope with change. The aim is to provide material and resources to people who are working to build resilience that makes and maintains this connection.

One of the key dimensions around which SOF intends to deliver resources is "harnessing technologies – tailoring [them] to real human needs, and handling its pressures".

The SOF project has commissioned this initial exploration of technological developments to provide a "starting point" for developing awareness of what technology changes are happening and are likely to arise, and an understanding of the opportunities and challenges associated with those changes.

To meet these requirements, this initial exploration has focused on providing a structured, consistent and accessible approach to identifying and communicating the key characteristics of specific technological developments, and for making initial judgements on their potential resilience impacts. In doing so, the exploration has sought to lay the foundations for more detailed assessment and subsequent phases of the SOF project.

The rest of this report consists of the following main sections:

- Approach
- Caveats
- Headline Findings
- Annex: Technology-specific detailed findings

Approach

This initial exploration has addressed a substantive number of significant technological developments. These are:

- Artificial intelligence and automation
- Augmented reality
- Connected objects
- Cryptocurrencies
- Distributed manufacture
- Drones
- Gene editing
- Green chemistry
- Smart drugs
- The Hidden Web
- Video analytics

For each of these technological developments, we have applied two main stages of assessment:

- **Identification of key characteristics**: this includes definition, drivers, barriers, readiness assessment, core functions and concerns. The findings are set out in an 'evaluation table' for each technological development (see the Annex). Where appropriate, the tables also include a reference to 'influencers' and further reading.

- **Identification of potential resilience impacts**: this is based on initial judgements of whether technology specific core functions and concerns (identified in stage one) are likely to have, respectively, positive and negative impacts against a series of generic resilience qualities. These initial judgements are set out in a 'resilience impact grid' for each technological development (also contained in the Annex). The main findings from each technology specific resilience grid are then summarised in bullet point form in the appropriate 'evaluation table' (under 'Resilience Impacts').

For the purposes of initial assessment, we have identified resilience 'qualities' from the literature which we consider appropriate for use as follows:

- **Individual** - personal capacities to adapt or transform in response to challenges[1]
    - awareness of and connection to the natural and human-made systems that support our daily well-being
    - sense of own agency
    - sense of belonging to a group or community (social cohesion)

- **Group** (including front line service providers)[2]
    - Reflectiveness – the ability to learn from experience or new evidence
    - Resourcefulness – the ability to find different ways to do things
    - Robustness – being well conceived, constructed and managed
    - Redundancy – having intentional spare capacity (includes having diverse ways to do something)
    - Flexibility – the ability to evolve or change
    - Inclusiveness – positive engagement with all people regardless of gender, sexual preference, race or class
    - Integration – across sectors and scales

- Additional **super-resilience** qualities (from project brief)
    - Ability to anticipate futures (including being attuned to weak and early signals of possible change)
    - Transformative potential (the capacity to identify and move to new development pathways)

Caveats

We would like to point to a number of caveats that arise from the initial exploration, so that they can be taken explicitly into account in discussions about how to move forward with more detailed assessment and subsequent phases of the SOF project.

---

[1] Ziervogal G et al, 'Moving from Adaptive to Transformative Capacity: Building Foundations for Inclusive, Thriving, and Regenerative Urban Settlements', Sustainability 2016, 8, 955; doi:10.3390/su8090955.

[2] These group qualities are based on the desirable characteristics of resilient systems as set out in https://assets.rockefellerfoundation.org/app/uploads/20140410162455/City-Resilience-Framework-2015.pdf.

These caveats relate to:

- **Coverage of technology developments** - we have provided an initial assessment of eleven technology developments, derived from those listed in the project brief. This coverage includes a wide range of technology types, at various stages of readiness, and with a wide variety of functions, concerns and impacts. Nonetheless, the coverage is not comprehensive: indeed, at a number of points in the assessment (see the evaluation tables) we have indicated how a chosen technological development is a forerunner of, or related to, other technological developments (including, for example, autonomous things, brain-computer interfaces and synthetic biology).

- **Fluidity of technology boundaries** – choosing the subjects of our initial assessment has also involved judgements about 'how to cut the cloth' in terms of the focus for assessment. Sometimes the focus is on a specific technological application which relies on a number of underlying technological developments. Examples include cryptocurrencies and distributed manufacture, where it would have been possible to have adopted different (but related) central foci, for example, block chain technology or 3-D printing. In our initial exploration, these technologies are considered as part of the assessment of cryptocurrencies and distributed manufacture.

- **Choice of resilience qualities** – our initial exploration of resilience impacts is based on a set of resilience qualities that we consider to be 'fit for purpose'. However, the resilience research literature contains numerous other suggestions for resilience qualities, and as we understand it the wider SOF project has not yet identified agreed resilience qualities for subsequent phases of assessment. There is therefore time to take stock and reflect before our chosen resilience qualities become embedded in further detailed assessment.

- **Resilience impact assessments** – as explained above, the assessment grids contain our initial judgements about the likely positive and negative resilience impacts of each of our chosen technological developments. We think that this approach provides: a reasonable indication of main potential impacts; a useful basis for comparison of impacts across technological developments; and an initial 'point of entry' into which functions and uses of which technologies are likely to deliver positive or negative impacts across specific resilience qualities (see further discussion of the latter under 'headline findings'). To build on this start, we think that the initial judgements would benefit from review and further discussion.

Headline Findings

As stated above, the detailed findings of our initial explorations are set out in evaluation tables and resilience impact grids in the Annex to this report.

Looking across the tables and grids in the Annex, our headline findings are:

- **Drivers of technological developments** – there are a very wide range of drivers. Some of the drivers are common to many of the technological developments. In particular, market opportunity and technical drivers are common to most of the developments. Some drivers – including military, regulatory and supplier push – are common to 3-4 developments. Others are unique to a specific development, for example, criminal activity for cryptocurrencies, enthusiasts scaling up for distributed manufacture and food security for gene editing.

- **Barriers to technological developments** – there are also a wide range of barriers to technological developments. Again, some of the barriers are common to many of these developments. In particular, regulatory and technical barriers are common to around half of the developments considered. There is also a broad grouping of barriers around cultural, ethical and social acceptability that impact on some technologies, including augmented reality, gene editing, green chemicals, and smart drugs. Other barriers are unique to a specific development, for example, moral censure for the hidden internet, volatility for cryptocurrencies, power constraints for video analytics and vulnerability to countermeasures for drones.

- **Readiness assessment** – six of the technological developments considered in this initial exploration have 'actual systems proven in operational environments', which corresponds to level 9 on the EU Horizon 2020 definition of readiness[3]. Of the others: one corresponds to level 8 (smart drugs – 'system complete and qualified', but not proven); one to level 7 (distributed manufacture - system prototype demonstration in operational environment); one lies between levels 6-9 dependent on use cases and deployment scenarios (video analytics - from technology demonstrated in relevant environment upwards); one is difficult to allocate but probably lies between levels 6-8 (gene editing – from technology demonstrated in relevant environment upwards); and one lies between levels 3 and 9, depending on the specific technologies considered (AI and automation – from experimental proof of concept upwards). As we note at various points in evaluation tables, allocating a readiness level does not tell the whole story. For example, although the 'readiness' of connected objects corresponds to level 9, the potential to connect more objects is much greater than has currently been realised. It is also the case that most of the developments represent the deployment of technologies invented some time ago: in a very real sense, 'the future is already here, but not evenly distributed'.

- **Patterns of resilience impacts –** as set out in the resilience grids and judged against our initial set of individual, group and super resilience qualities, each technological development has its own distinctive pattern of positive and negative resilience impacts. These patterns can be used to compare impacts across technological developments. It is notable that:

    - The number and breadth of impacts varies significantly across technological developments. For example, augmented reality displays a large number of positive and negative resilience impacts across a wide range of core functions and concerns. In contrast, drones and green chemistry both display a relatively small number of impacts. For drones, one core function delivers most of the positive impacts, and for green chemistry the positive impacts arise from very specific and important functions.
    - For some technologies impacts can be concentrated around specific core functions or concerns. For example, for AI and automation, the core function relating to the performance of tasks beyond current human capabilities holds promise for positive impacts across a wide range of the resilience qualities. A similar observation applies to the uses of connected objects that are enabled by tracking, monitoring and control capabilities. In other examples, a concentration of positive impacts can arise from the organisational form in which the technology is deployed. This arises with distributed manufacture (from the decentralised and small-scale function) and gene editing (from the democratisation of research function).
    - For some technologies impacts can be concentrated around specific resilience qualities. In particular, for cryptocurrencies and the hidden web, there is a concentration of potential positive impacts around the individual qualities of agency and social cohesion, and the group quality of resourcefulness.

[3] The 'clustering' of our chosen technologies at the upper end of the 'readiness' scale might be an artefact of the selection process (i.e. our focus on technologies likely to have an impact within the purview of the project timescale lead us to select areas already well developed); or it might be a consequence of our decision to adopt the EU Horizon 2020 scale, which is aimed at identifying promising technologies for pilots and is less granular at the operational deployment stages.

- **Focusing on specific resilience qualities** – one potential use of the resilience grids is as a 'point of entry' into which functions and uses of which technologies are likely to deliver positive or negative impacts relating to specific resilience qualities. This could be helpful if there is a desire to focus on specific individual, group or super resilience qualities and to develop thinking on the contribution that technological developments can make to building up or enhancing a specific quality. For example, a look across the resilience grids indicates that;

    - The individual resilience quality of 'sense of belonging to a group or community' (social cohesion) could be impacted positively by one or more core functions of connected objects, cryptocurrencies, drones, gene editing and green chemistry, and negatively by one or more concerns associated with almost all the technologies considered.
    - The group resilience quality of 'having intentional spare and/or diverse capacity' (redundancy) could be impacted positively by one or more core functions of augmented reality, cryptocurrencies, distributed manufacture, drones and gene editing, and negatively by one or more concerns associated with AI and automation, augmented reality, connected objects, cryptocurrencies and gene editing.
    - The super resilience quality of 'the capacity to identify and move to new development pathways' (transformative potential) could be impacted positively by one or more core functions of nearly all of the technological developments considered, with the exception of drones and video analytics. However, this quality could be impacted negatively by one or more concerns associated with all the developments considered.

- **Addressing concerns and negative resilience impacts** – as should be clear, any use of the resilience grids as a 'point of entry' to help develop thinking on the contribution that specific technological developments could make to building up or enhancing specific resilience qualities, should be tempered by a parallel consideration of how the concerns and negative resilience impacts associated with a technology can be addressed. There is, unfortunately, no technological 'magic bullet' for building super resilience. Our evaluation tables do, nonetheless, contain some 'seeds' or pointers towards ways of addressing concerns and negative resilience impacts, and to organisations and groups that are seeking to influence the way specific technologies are developed. For example:

    - On an individual basis, there are actions that can be taken, ranging from exercising personal responsibility to stay within laws and regulations (e.g. not using drones for illegal activities, and not abusing access to surveillance capabilities provided by video analytics), to adopting a sustainable lifestyle (e.g. not succumbing to consumerist pitfalls associated with distributed manufacture and green chemistry).
    - On a group basis, there are various types of actions that could be taken, including: the advice and advocacy role of professional groupings (e.g. the Green Chemistry Network and the Partnership on Artificial Intelligence, or health practitioner organisations on the mental and physical health impacts of various technological developments); and consideration of the organisational and legal forms of community bodies or businesses established to apply technologies (e.g. establishing co-operatives to further the democratisation of gene editing research).
    - On a national basis, there is much that can be done on a regulatory, strategy or policy level, particularly by Government. In its recent Industrial Strategy, the UK Government acknowledged that the world is undergoing a "technological revolution" of unprecedented scale, speed and complexity, and presented a strategy for exploiting

opportunities and addressing challenges and impacts[4]. Some current Government initiatives are referred to in our technology specific evaluation tables, for example, relating to AI and automation, the Government is establishing the UK Centre for Data Ethics and Innovation, and on drones it has announced a range of measures, including a commitment to new powers and systems for registration and testing of leisure pilots.

[4] HM Government, 'Industrial Strategy: Building a Britain Fit for the Future', Cm9528, November 2017. The strategy contains a range of policies and initiatives relevant to various aspects of concerns across many technology developments. Nonetheless, there is arguably much more that should be done by Government, for example, see the references to Universal Basic Income and encouraging co-operative business models in the evaluation table relating to AI and automation.

Annex: Technology-specific detailed findings

Artificial Intelligence and Automation	
Definition Artificial intelligence (AI) is intelligence displayed by machines, in contrast with that displayed by humans and other animals. In computer science, AI is defined as the study of "intelligent agents" (any device that perceives its environment and takes actions that maximize its chance of success at some goal). Colloquially, the term "artificial intelligence" is often applied when a machine mimics cognitive functions associated with the human mind, such as "learning" and "problem solving". Automation is when technology is used to perform a process or procedure, or to improve a system, without, or with reduced, human involvement. This can be achieved by various means, often in combination (including mechanical, hydraulic, electrical and, increasingly, AI based approaches). Robotics – concerned specifically with motion and manipulation – utilises AI and is a specific form of automation. Advances in AI and associated technologies are accelerating the pace at which automation can spread, and the complexity of tasks (cognitive and physical, routine and non-routine) that can be addressed.	
Drivers	**Barriers**
• Military – early AI research was heavily funded by the US Department of Defence. Over 50 countries are now thought to be researching battlefield robotics. Another military interest is in automated monitoring, surveillance and tracking systems. • Commercial – for automation in particular, the drive to replace labour with less expensive machine processes • Technical – series of technical advances, including: in AI, machine learning (ability to learn without explicit programming), the human-machine interface (effectiveness of operation and control), and data handling (including predictive analytics using big data); and in automation, feedback control (e.g. as used in ATMs), flexibility and convertibility in reconfigurable manufacturing systems; and advances in sensing techniques (e.g in machine vision and intelligent transport systems) • Market opportunities – e.g 1980s commercial success of expert systems software; 1990s uses in logistics, data mining, medical diagnoses, and video gaming; and, more recently, energy use	• Technical – AI challenges remain around developing or refining various ‘intelligence’ functions including sensory perception, language comprehension, planning, learning, decision making, movement and manipulation, social intelligence and creativity • Costs – R&D and capital costs (e.g of new plant) can be high in relation to the short-term savings from automation • Legal and regulatory uncertainty – e.g. around accident liability for autonomous cars (note the UK Government is working on a new regulatory framework – see ‘Industrial Strategy’) • Resource use – for complex problems use of AI algorithms can require enormous computing resources

management, autonomous/self-drive vehicles, early health diagnostics and precision medicine (see 'Industrial Strategy') • Finance and economics – e.g. automated trading , fraud detection • Government - Industrial Strategy seeks to maximise the opportunities (and respond to impacts) by addressing 'Grand Challenges', including 'AI and the data-driven economy' and 'the future of mobility'	

Readiness Assessment
(based on EU Horizon 2020 definition)

Varies widely from TR3 (experimental proof of concept) to TRL 9 (actual system proven in operational environment), according to specific technologies.

It has been suggested that there is an effect called the AI Effect – as machines become increasingly capable, tasks previously considered as requiring intelligence are removed from the definition of AI. AI then becomes "whatever hasn't been done yet". However, some AI applications are well established and accepted e.g. automated parking and anti-lock braking in cars and autopilots in planes.

Core Functions and Use Cases

- To increase the throughput, productivity, efficiency or quality control of processes and systems e.g. in manufacturing, administration, retail, energy management, transport systems, the care industry and agriculture
- To replace human labour in monotonous, hard or hazardous tasks e.g. spray painting in vehicle manufacture, pipeline welding, automated mining, nuclear decommissioning, environmental decontamination, and bomb disposal.
- To perform tasks beyond current human capabilities (for e.g. speed and scale) e.g. big data analytics, industrial robotics, automated surveillance and tracking, and transhumanism

[Note that fulfilment of the 'emancipatory potential' of automation and the 'release from work' has been argued to require reorganisation of the economy (e.g. using models of co-operative and collective ownership), re-skilling and initiatives such as Universal Basis Income (see further reading).]

Concerns

- Impacts on jobs and the economy – some project a loss of 15 million jobs in the UK over the next two decades, a decreasing proportion of wealth being created through employment and an increase in the proportion generated by capital
- Impacts on *ways of living* – will we have to accommodate to automation, or can it be the other way round? (e.g. automated transport making road systems less pedestrian/cyclist friendly)
- Civil liberties and privacy – automated surveillance, tracking and ability to control
- Ethics – concerns range from in-built bias and lack of fairness in the use of algorithms and datasets e.g in recruitment, work performance and credit scores, through to the creation of artificial beings with human like intelligence (can a machine be sentient and deserve human rights?) and human enhancements (see transhumanism)

- Safety – concerns range from the failure of automation in transport (e.g, Air France Flight 447) to the dangers to humanity of 'runaway' AI improvement cycles (known as a technological singularity)
- Military and security applications – particularly around the use of robotics and autonomous weapons in combat, and security measures e.g. border controls, and applications such as tagging.

Resilience Impacts
(based on Resilience Impact Grid)

- It appears that the core functions have very limited potential for positive impact on the qualities of individual resilience. The exception is the potential for performance of tasks beyond human capabilities to impact on agency. In contrast, many of the concerns could negatively impact on both agency and social cohesion.
- Each of the core functions has uses with potential for a positive impact on one or more of the qualities of group resilience. It is particularly notable that the potential for performance of tasks beyond human capabilities could impact positively on five of the seven group resilience qualities. However, each of the concerns could negatively impact on one or more of the qualities of group resilience.
- In principle, each of the three core functions could contribute to transformative potential, and the potential for performance of tasks beyond human capabilities could contribute to anticipation of futures. However, a couple of the concerns could impact negatively on transformative potential.

Influencers

Partnership on AI (to benefit people and society)
Open AI (Discovering and enacting the path to safe artificial general intelligence)
The Future of Life Institute
UK Centre for Data Ethics and Innovation (to be established)

Further Reading

'Industrial Strategy: Building a Britain Fit for the Future', CM 9528, November 2017
'Growing the AI Industry in the UK', W Hall and J Pesenti, 2017
Taylor M et al, 'Good Work', July 2017
MacDonald S, 'Broadening out an economy – making it work for all', July 2017
'Alternative Models of Ownership', Report to the Shadow Chancellor and Shadow Secretary of State, 2017.
Raworth K, 'Doughnut Economics: Seven Ways to think like a 21st Century Economist', 2017
Srnicek N and Williams A, 'Inventing the Future: Post Capitalism and a World Without Work', 2016

RESILIENCE IMPACT GRID – ARTIFICIAL INTELLIGENCE AND AUTOMATION

[Column headings are technology specific core functions and concerns. Row headings are generic resilience qualities. + represents positive impact of a use case against a resilience quality. – represents negative impact against a resilience quality.]

	To increase throughput, productivity, efficiency or quality control	To replace human labour in monotonous, hard or hazardous tasks	To perform tasks beyond human capabilities		Jobs and economy	Ways of living	Civil liberties and privacy	Ethics	Safety	Military and security		
connectedness						-						
agency			+		-	-	-		-	-		
social cohesion					-	-	-	-		-		
reflectiveness			+									
resourcefulness	+	+	+			-	-					
robustness	+	+	+		-	-			-			
redundancy					-	-						
flexibility		+	+			-	-					
inclusiveness					-		-	-		-		
integration			+									
anticipation of futures			+									
transformative potential	+	+	+			-	-					

Augmented Reality

Definition

A live real-time view of a real-world environment whose elements are "augmented" by computer-generated objects, which may be based on data that is present in or related to the real-world environment (data overlays) or entirely created (e.g. Pokémon Go). Augmented reality enhances perception of reality, whereas in contrast, virtual reality replaces the real world with a simulated one. Augmented reality is used to enhance the experienced environments or situations and to offer enriched experiences.

Drivers	Barriers
• Market opportunity – applications in training, maintenance, architecture and construction, tourism and culture, entertainment etc • Supplier push – technology providers keen to take military and specialised capability to the mass market • Competitive pressures - premium software and hardware (e.g. Apple, Google, Samsung) vendors seek differentiation and product innovation in the face of commodification and competition from low-cost suppliers (e.g. Lenovo, Xiaomi) and are investing heavily in developing AR-based products • Technical - increased capabilities of devices, displays and network bandwidth make this a possibility	• Social acceptability – nobody wants to be thought of as a 'Glasshole', the term applied to early adopters of Google Glass (terminated by the company in 2015) • Technical – performance of displays, processors and networks still falls short of acceptability for serious applications • Legal and regulatory uncertainty – where will be people be allowed to use AR and where won't they? What rules will govern the publishing etc. of AR content?

Readiness Assessment
(based on EU Horizon 2020 definition)

TRL 9 – actual system proven in operational environment (competitive manufacturing in the case of key enabling technologies; or in space)

Core Functions and Use Cases

- Simulation – e.g. use in training system operators, first responders etc in the use of complex procedures and systems, or the design of buildings, systems and products
- Data capture, visual presentation and enhancement e.g identification of objects, places and people
- Perceptual enhancement – e.g. in assistive technologies for visually impaired, elderly or other vulnerable groups
- Decision support – e.g. for front-line workers in security, emergency services, medical staff, etc; support for more informed consumer choices and ethical buying; and navigation through intuitive route guidance and location information
- Information sharing and collaboration – e.g. for professionals, communities and travellers to annotate physical environments

Concerns
• Over-reliance on fragile network-dependent technology e.g in a disasters context • Impact on skills - will pre-packaged information and decision support tools reduce individuals' ability to seek, filter and process information for themselves? • Alienation and mental pollution as technology extends further to mediate everyday interactions • Distraction and negative impacts on perception during critical tasks (e.g. from AR-based advertising) • Increased inequality – between those who are AR-enabled and those who aren't • Stigmatisation – as unchecked or contested information about individuals, neighbourhoods or communities becomes a visible dimension in the physical world • Manipulation e.g through advertising and marketing, social engineering and political campaigns
Resilience Impacts (based on Resilience Impact Grid)
• The grid indicates that AR has potential for a wide range of positive and negative impacts on resilience. • Each of the core functions has uses with potential for a positive impact on one or more of the qualities of individual resilience. It is particularly notable, for example, that agency could be enhanced through training, and social cohesion through information sharing and collaboration. On the other hand, each of the concerns could negatively impact on individual resilience, for example, connectedness could be impaired through alienation, mental pollution and distraction. • Each of the core functions has uses with potential for a positive impact on one or more of the qualities of group resilience. It is particularly notable, for example, that information sharing and collaboration related uses could enhance six of the seven group resilience qualities. However, each of the concerns could negatively impact on group resilience, for example, technical breakdown could undermine each of the qualities. • In principle, three of the core functions could contribute to transformative potential (simulation, information sharing and collaboration, and decision support). However, all of the concerns could impact negatively on this quality.
Influencers
The VR/AR Association Augmented Reality For Enterprise Alliance EuroVR (European Association for Virtual Reality and Augmented Reality)
Further Reading
Historical background here

RESILIENCE IMPACT GRID – AUGMENTED REALITY

[Column headings are technology specific core functions and concerns. Row headings are generic resilience qualities. + represents positive impact of a use case against a resilience quality. – represents negative impact against a resilience quality.]

	Simulation (training and design)	Data capture, presentation and enhancement	Perceptual enhancement	Decision support	Information sharing and collaboration	Technical break-down	De-skilling	Alienation and mental pollution	Distraction	Inequality	Stigmatisation	Manipulation
connectedness		+	+	+	+	-		-	-			
agency	+	+	+	+		-	-	-	-		-	-
social cohesion			+	+	+	-		-		-	-	-
reflectiveness	+	+		+	+	-	-	-	-	-	-	-
resourcefulness	+	+	+	+	+	-	-	-	-	-		-
robustness	+	+		+	+	-		-	-			
redundancy				+	+	-						
flexibility	+				+	-	-	-	-	-	-	-
inclusiveness	+		+		+	-		-		-	-	-
integration		+		+		-		-				
anticipation of futures		+				-						-
transformative potential	+			+	+	-	-	-	-	-	-	-

Connected Objects

Definition

The addition of connectivity (networking technology, usually wireless) to machines, often in combination with sensors and actuators (control switches) to allow those machines to be monitored and controlled at a distance, either by a human user or by an automated system (see Artificial Intelligence and Automation, above) . There are many examples already in widespread use, including wearable devices such as the Fitbit, home automation products such as the Nest thermostat, automotive products including built-in telematics boxes and after-market add-on devices, and commercial and industrial products from tractors to pipelines to aero engines.

Connected objects are part of the Internet of Things, which might also be thought of as including the networks, software and platforms used to connect, manage and control the objects themselves.

Drivers

- Technical – including miniaturisation of sensor technology, the deployment of new radio technologies, the availability of cloud services including data storage and analytics, protocols and software tools to enable application development, and the availability of smartphones as 'universal user interfaces' for a wide range of products.
- Market opportunity – to develop new kinds of product, improve existing products, and to enable new business models (especially 'servitization' - the replacement or enhancement of product sales with service contracts).
- Regulation – increasing requirements for safety, compliance and energy monitoring are pushing companies to adopt IoT technology

Barriers

- Complexity – creating internet of things services that work robustly requires multiple skills, much integration activity and interoperability across different 'layers' of the internet
- Commercial – existing business models and commercial arrangements often don't work for connected objects; for example how does a company with a history of one-off product sales make the transition to long-term support relationships and repeated billing for services?
- Legal and regulatory uncertainty – connected objects cut across existing safety, privacy and data protection laws, and this can create challenges for suppliers and potential purchasers

Readiness Assessment
(based on EU Horizon 2020 definition)

TRL 9 – connected objects are already commercially deployed in many contexts. But there is wide agreement that the potential to connect more objects is much greater than has already been realised, and that the implications of this are much deeper than current deployments allow.

Core Functions and Use Cases

- More efficient use of resources and increased productivity – reduced energy consumption (e.g. not heating empty rooms), energy microgeneration (e.g. smart grids), more effective sharing of equipment (e.g. shared cars), road pricing, reduced road usage through optimized transport and logistics, reduced inventory in manufacturing, reduced water and fuel consumption in precision agriculture

- Behaviour change – enabled by tracking, monitoring and control e.g. more fuel-efficient driving style, usage-based insurance to reward safer driving, reduced home energy consumption through visualisation of energy use, automated routines and greater control for users, encouragement of healthy lifestyle through monitoring of activity and exercise
- Environmental protection, safety and security – also enabled by tracking, monitoring and control e.g. independent living for elderly and disabled people through monitoring, automatic crash notification for cars, child tracking, early warnings from infrastructure, environment and equipment monitoring

Concerns

- Data privacy and civil liberties – monitoring and tracking creates new kinds of data for which ownership/rights precedents are unclear, compromises personal data, and provides incentives for commoditization of personal data through new marketing paradigms
- Safety – compromised through potential for malicious hacking of personal and public connected objects and technical failures in connectedness
- Disempowerment – the IoT holds out the prospect of extending the 'end of ownership', from digital goods to physical goods (like tractors), and enabling greater control over people by monitoring them as 'things'
- Economic concentration – as small producers are squeezed out by inability to participate in markets increasingly dominated by complex technology

Resilience Impacts
(based on Resilience Impact Grid)

- Each of the core functions has uses with potential for a positive impact on two or three of the qualities of individual resilience. In particular, connectedness and agency could be enhanced by each of the core functions. On the other hand, all of the concerns could impact negatively on agency, and economic concentration could impact negatively on social cohesion.
- Each of the core functions has uses with potential for a positive impact on three or more of the qualities of group resilience. It is particularly notable, for example, that the environmental protection, safety and security uses enabled by tracking, monitoring and control functions could enhance six of the seven group resilience qualities. However, each of the concerns could negatively impact on two or three group resilience qualities.
- In principle, two of the core functions could impact positively on anticipation of futures, and all three of the core functions could contribute to transformative potential. However, two of the concerns – data privacy and civil liberties, and disempowerment - could impact negatively on this latter quality.

Influencers

The Industrial Internet Council
The World Wide Web Consortium (W3C)
GSMA
IET

Further Reading

https://www.postscapes.com/internet-of-things-handbook/

RESILIENCE IMPACT GRID – CONNECTED OBJECTS

[Column headings are technology specific core functions and concerns. Row headings are generic resilience qualities. + represents positive impact of a use case against a resilience quality. – represents negative impact against a resilience quality.]

	Resource efficiency and productivity	Behaviour change	Environmental protection, safety and security		Data privacy and civil liberties	Safety	Disempowerment	Economic concentration				
connectedness	+	+	+									
agency	+	+	+		-	-	-	-				
social cohesion		+	+					-				
reflectiveness		+	+									
resourcefulness	+	+	+				-					
robustness	+	+	+			-		-				
redundancy						-		-				
flexibility		+	+		-		-					
inclusiveness			+		-		-	-				
integration	+		+									
anticipation of futures		+	+									
transformative potential	+	+	+		-		-					

Cryptocurrencies

Definition

A digital asset designed to work as a medium of exchange that uses cryptography to secure its transactions, to control the creation of additional units, and to verify the transfer of assets. [Cryptocurrencies are classified as a subset of digital currencies and are also classified as a subset of alternative currencies and virtual currencies.]

Bitcoin, created in 2009, was the first decentralized cryptocurrency. Since then, numerous cryptocurrencies have been created. These are frequently called altcoins, as a blend of bitcoin alternatives.

[Bitcoin and its derivatives use decentralized control as opposed to centralized electronic money/central banking systems. The decentralized control is related to the use of bitcoin's blockchain transaction database in the role of a distributed ledger. Not all the enthusiasm for cryptocurrencies comes from their potential to support illegal transactions, though that is certainly a key use case (see The Hidden Internet, below). Distributed ledgers in general, and the blockchain in particular, are also proposed as transformative technologies in other deployments separate from their use as a mechanism for cryptocurrencies – e.g. as a tool for reorganising national land registries)

Drivers	Barriers
• Technical - advances in computing power, computer science and cryptography • Criminal activity - the emergence of internet-based 'dark markets' in which illegal products (e.g. drugs) can be purchased anonymously, creating the need for an anonymous digital currency • Regulation - controls on money transfers through other legitimate and semi-legitimate mechanisms (e.g. hawala) • Market opportunity - Speculative financial opportunity, but also opportunities to use distributed ledgers across a range of financial and legal applications • Engagement by rogue states and rogue elites with a need for money transfer	• Regulatory control (e.g. Know Your Customer) – this prevents legitimate banks involvement in cryptocurrency • Volatility – undermines use of cryptocurrencies for transactions • Fear of prosecution and association with illegality • Energy consumption – process of mining Bitcoin (most popular cryptocurrency) is very energy intensive • Technical - limits on the scalability of the underlying system (at least in the case of Bitcoin)

Readiness Assessment
(based on EU Horizon 2020 definition)

TRL 9 – actual system proven in operational environment (competitive manufacturing in the case of key enabling technologies; or in space).

Bitcoin and the blockchain are functioning technologies in full commercial use. Other applications of blockchain, and distributed ledgers, are still emerging, and the full implications of cryptocurrencies are still to be assimilated.

Core Functions and Use Cases

- Private (anonymous/pseudo-anonymous) financial transactions:
  - Individual use to bypass repressive/corrupt government
  - Use to evade government controls in supporting civil society etc. organisations in repressive states
- Secure financial transactions (distributed ledgers - the underlying technology - can be more secure than centrally controlled databases):
  - Provide safer money transfer for refugees and unbanked migrants
  - A shelter against hyperinflation and economic collapse
- Decentralisation – (with blockchain there is no central server, but a shared and synchronised database across networks):
  - Use as a mechanism for community currency – e.g. Faircoin, Yetta, Scotcoin
  - Tracking aid payments in e.g. for disaster relief
  - Use of blockchain for sustainability purposes eg identifying and tracking emissions, peer-to-peer energy transfers, and impacts across supply chains

Concerns

- Criminal use - enables criminal activity, transfer of profits from corruption and extortion, etc (but see this).
- Financial vulnerability – even more than government-backed currencies, cryptocurrencies are based on trust and belief. It's not hard to imagine a scenario in which trust in Bitcoin collapsed.
- Loss of Government control - reduces tax revenues, and applicability of government fiscal policy by taking liquidity outside regulatory control – for some advocates this is the main purpose of cryptocurrencies, that it takes control of money away from government (see also this proposal to use Bitcoin for welfare payments)
- Scalability - technical limits on the scalability of the underlying system (at least in the case of Bitcoin)
- Unsustainable - process of mining Bitcoin (most popular cryptocurrency) is very energy intensive

The Resilience Impacts
(based on Resilience Impact Grid)

- For individual resilience, the core functions have potential for positive impact on agency and social cohesion. Loss of Government control (and income) could impact negatively on social cohesion.
- For group resilience, there is potential for positive impact on reflectiveness, resourcefulness, robustness and redundancy. However, a range of concerns have potential to impact negatively, particularly on robustness (criminal activity, financial vulnerability and unsustainability) and integration (loss of Government control and scalability).
- The core functions also hold promise for positive impacts on transformative potential, but some concerns could impact negatively on this quality.

Influencers

https://www.imperial.ac.uk/cryptocurrency

Further Reading

This collection of largely positive articles is one way in to the subject area: https://www.nateliason.com/bitcoin-crypto-reading-list/ . This paper on the potential resilience impacts of Bitcoin as a global currency is very technical (economics) but important http://www.bankofcanada.ca/wp-content/uploads/2016/03/swp2016-14.pdf

RESILIENCE IMPACT GRID - CRYPTOCURRENCIES

[Column headings are technology specific core functions and concerns. Row headings are generic resilience qualities. + represents positive impact of a use case against a resilience quality. - represents negative impact against a resilience quality.]

	Private financial transactions	Secure financial transactions	Decentralisation		Criminal activity	Financial vulnerability	Loss of Government control	Scalability	Unsustainability			
connectedness												
agency	+	+	+									
social cohesion	+	+	+				-					
reflectiveness			+									
resourcefulness	+	+	+									
robustness	+	+	+		-	-			-			
redundancy	+	+	+			-						
flexibility												
inclusiveness					-		-					
integration							-	-				
anticipation of futures												
transformative potential	+	+	+		-	-						

Distributed Manufacturing

Definition

A form of decentralized manufacturing based on a network of geographically dispersed manufacturing facilities that are coordinated using information technology, and making use of scaled-down versions of new and not-so-new technologies such as 3D printing, CNC (computer numerical control) tools and CAD/CAM software. Variants include business-oriented cloud manufacturing, and the 'maker' movement (including both hobbyists and those with a vision for 'homebrew' manufacturing as an agent of social, industrial and environmental transformation).

Drivers	Barriers
• Lean production – conventional manufacturing companies seeking to reduce transport and distribution costs, including the cost of holding inventory and employing workers • Decentralization – manufacturers seeking to reduce dependence on a few big factories • Customisation - Small scale enables conventional manufacturers to segment and tailor products to customer requirements • Competition – opportunities for new entrants to offer new products and business models • Scaling up – by enthusiasts and maker hobbyists • Emerging market complements - Open source software, P2P architectures and cloud platforms such as Thingverse (and others) enable design sharing and community co-creation • Miniaturisation – this enables scaling down and domestication of industrial technology • Regional development opportunity – manufacturing can be sited in less developed or depressed regions to facilitate economic development	• Poor fit with current hub and spoke model of supply chain and distribution • Skills in short supply - geeks know about software, not CNC lathes and routers • Production technologies still too difficult for everyday users compared to consumer-friendly technologies like smartphones, laptops etc. • Absence of appropriate business models and protection for intellectual property against piracy and informal distribution • Unsuitable product designs – few mainstream products are designed around user-serviceable components and parts that could be locally manufactured (but see Ackurat as an example of what might be possible)

Readiness Assessment
(based on EU Horizon 2020 definition)

TRL 7 – system prototype demonstration in operational environment (in the case of key enabling technologies)
Techologies are mainly mature and commercially available, but their assimilation and deployment in a holistic system is work in progress.

Core Functions and Use Cases

- Decentralised and small scale production:
    - enables manufacturing in depressed or less developed regions

- enables local ownership - including small-scale entrepreneurs, community and co-operatively owned workshops, etc
- potential for sustainable production and circular economy practices
- reduces dependence on distribution models that are potentially vulnerable to disruptive shocks

- Open source production - transfers the co-production and sharing aspects of open source digital goods to physical goods, including collaboration, sharing of designs, etc

Concerns

- Consumerism and waste - reduced barriers to making could lead to much more stuff
- Criminal activity - e.g manufacture of guns
- Inequality - new digital rights management could increase the gap between intellectual property owners and everyone else
- Jobs – potential losses across manufacturing, distribution and retail – and consequent impact on tax revenues
- Liability issues – around property damage, injury, and cyber and intellectual property - ill-defined regulatory and liability framework
- Safety – harder to regulate against the production of poor designs, and in unsafe workshops
- Technological vulnerability – increased dependence on an incomprehensible (compared to simpler hand and power tools) and potentially vulnerable technology vs. conventional manufacturing

Resilience Impacts
(based on Resilience Impact Grid)

- For individual resilience, the core functions have potential for positive impact on connectedness, agency and social cohesion. However, concerns around inequality and job losses have potential to impact negatively on social cohesion.
- For group resilience, there is potential for positive impact across a range of resilience qualities, particularly on resourcefulness, flexibility and inclusiveness. However, a range of concerns have potential to impact negatively, particularly on robustness. Technological vulnerability could impact negatively on reflectiveness, resourcefulness and robustness.
- The core functions also hold promise for positive impacts on transformative potential, but consumerism, waste and inequality could impact negatively on this quality.

Influencers

Institute for Manufacturing Centre for Distributed Automation and Control
Re-Distributed Manufacturing and the Resilient, Sustainable City (ReDReSC)

Further Reading

For an enthusiastic account of the potential of this group of technologies see 'THE HOMEBREW INDUSTRIAL REVOLUTION By Kevin A. Carson'

RESILIENCE IMPACT GRID – DISTRIBUTED MANUFACTURE

[Column headings are technology specific core functions and concerns. Row headings are generic resilience qualities. + represents positive impact of a use case against a resilience quality. – represents negative impact against a resilience quality.]

	Decentralised and small-scale production	Open source production		Consumerism and waste	Criminal activity	Inequality	Jobs	Liability	Safety	Technological vulnerability		
connectedness	+	+		-								
agency	+	+										
social cohesion	+					-	-					
reflectiveness		+								-		
resourcefulness	+	+		-						-		
robustness	+			-	-		-	-	-	-		
redundancy	+											
flexibility	+	+										
inclusiveness	+	+			-	-	-					
integration												
anticipation of futures												
transformative potential	+	+		-		-						

Drones

Definition

A drone – or unmanned aerial vehicle (UAV) - is an aircraft without a human pilot aboard. UAVs are a component of an unmanned aircraft system (UAS), which can include a ground-based controller and a system of communications between the drone and controller. UAVs may be operated with various degrees of autonomy, including remote control by a human operator or autonomously by on board computers. For remote human control, drones almost always have a camera and video link, and use radio-transmitted digital commands. Drones can also carry a wide range of sensor equipment. Drones can be categorised by range/altitude (from 600m/2km to orbital), weight (micro < 1kg, miniature < 25kg or heavier), or use (hobbyist, commercial or military.

[Autonomous drones can be seen as an early commercial application of Autonomous Things.]

Drivers

- Military use – particularly through Vietnam and Middle Eastern wars for missions too dirty or dangerous for humans (including greater 'political acceptability' of 'drone kill')
- Technical – maturing and miniaturising computer technologies and development of a range of sensor technologies
- Supplier push – technology providers keen to take military and specialised capability to mass markets
- Market opportunities – including scientific, commercial, emergency services and recreational
- Cost reductions – accessible to hobbyist market

Barriers

- Regulatory uncertainty – including inadequate registration and testing of leisure users, use near airports, and inadequate powers of law enforcement (now being addressed in UK – see further reading comment below)
- Vulnerability to countermeasures – eg electronic jamming, attack from birds of prey
- Competition – e.g. through alternative use of video and sensor equipment (e.g. on street lamps) and sentiment analysis

Readiness Assessment
(based on EU Horizon 2020 definition)

TRL 9 – actual system proven in operational environment (competitive manufacturing in the case of key enabling technologies; or in space)

Core Functions and Use Cases

- Aerial data and image gathering enables a range of uses:
  - Detection – eg of illegal hunting/poaching, illegal landfill, border crossing
  - Inspection and investigation – eg structural safety checks, accident investigation
  - Mapping and surveying – eg disaster prevention, geophysical exploration, landmine clearance, crop surveys, participatory mapping
  - Monitoring – eg pollution, plumes, forest fires
  - News gathering
  - Photography and film making
  - Pursuit – eg of criminals
  - Search and rescue – eg disaster recovery, lost people
  - Surveillance- eg crowds, events, traffic, police activity (System 77)

• Cargo delivery, including medical supplies and commercial deliveries (note the interest in this taken by Google and Amazon) • Passenger drones
Concerns • Advertising – potentially unregulated use of aerial advertising • Civil liberties/privacy – state or corporate monitoring of individuals or groups • Criminal/malicious use – e.g. data/video feed hacking, smuggling drugs into prisons, counter-surveillance of police by crime gangs, drones loaded with dangerous payloads crashed into vulnerable targets, illicit monitoring of sensitive sites • Inequality – increasing the gap between the 'haves and the have nots' e.g. affordability of passenger drones • Privacy – data or image gathering of private/confidential information e.g. 'nosy neighbours' or tabloid journalism • Safety – particularly for air traffic where risks include unintentional collisions, aircraft interference, deliberate attacks or by distracting pilots or flight controllers
Resilience Impacts **(based on Resilience Impact Grid)** • The grid indicates that drones have relatively modest potential for positive and negative impacts on resilience (compared, for example, with AR) • For individual resilience, aerial data and image gathering has potential for positive impact on connectedness. On the other hand, civil liberty and privacy concerns could impact negatively on agency. • For group resilience, aerial data and image gathering provides a strong cluster of potential positive impacts around reflectiveness, resourcefulness and robustness. However, criminal/malicious acts and accidents could impact negatively on robustness, and civil liberty and privacy concerns on inclusiveness. • It appears that none of the core functions hold promise for positive impacts on transformative potential. Civil liberty and crime/malicious acts could impact negatively on this quality.
Influencers The Association of Remotely Piloted Aircraft Systems ARPAS The Civil Aviation Authority CAA – response for regulating commercial use National Police Chiefs Council NPCC The European Aviation Safety Agency The US Federal Aviation Administration
Further Reading In the UK, concerns that public acceptability and regulatory uncertainty could impact on commercial development led the Government to establish a 'Public Dialogue' and consultation on Drones. This is likely to result in: new powers and systems for registration and testing of leisure pilots; and police powers to require drone users to produce registration documents on request, ground a drone safely in certain circumstances, and seize and retain a drone's components if there is reasonable suspicion of it having been involved in an offence. It may also result in: restrictions on drone use above 400ft and in proximity to airports; and the mandatory use of safety and airspace awareness apps. See the recent Government press release, the Report of the Public Dialogue on Drones and the Government response to consultation. For a European perspective see http://dronerules.eu//en/

RESILIENCE IMPACT GRID - DRONES

[Column headings are technology specific core functions and concerns. Row headings are generic resilience qualities. + represents positive impact of a use case against a resilience quality. – represents negative impact against a resilience quality.]

	Aerial data and image gathering	Cargo delivery	Passenger drones		Advertising*	Civil liberties	Crime and malicious acts	Inequality	Privacy	Safety		
connectedness	+											
agency						-			-			
social cohesion	+							-				
reflectiveness	+											
resourcefulness	+	+										
robustness	+						-			-		
redundancy		+	+									
flexibility						-						
inclusiveness						-		-	-			
integration												
anticipation of futures												
transformative potential						-	-					

Gene Editing

Definition

Gene editing (or, more correctly, genome editing or engineering) is a type of genetic engineering in which DNA is inserted, deleted or replaced in the genome of a living organism using engineered nucleases (enzymes), or "molecular scissors". These nucleases create site-specific double strand breaks at desired locations in the genome. The induced double-strand breaks are 'repaired' through gene editing techniques, resulting in targeted mutations, known as 'edits'. As of 2015 four families of engineered nucleases were being used primarily for research purposes, including the most accessible, CRISPR-Cas9.

Gene editing is set to be a significant contributor to another group of emerging technologies around 'synthetic biology', involving artificial biological systems with potentially multiple uses.

Drivers	Barriers
• Technical – simplified processes, and greater precision and control, than earlier genetic engineering techniques • Knowledge – furthering understanding of gene functions in plants and animals • Treatment and eradication of diseases – see core functions (note health service funding of gene therapy) • Food security – potential for genetically modifying plants and animals e.g to increase yield, resistance to diseases, and tolerance to pesticides and a changing climate • Market opportunities – potentially in health, energy, chemical and agricultural industries (including creation of SME spin-outs from research establishments) • Military – range of potential uses e.g amongst others, enhanced healing mechanisms and ability to cope with a warfare environment	• Technical uncertainties – varying degrees of predictability, precision and efficiency amongst the families of nucleases • Risks of unintended consequences – from 'off target' strand breaks and 'edits' (but less risks than earlier techniques) • Cost and duration of trials and evaluation processes e.g to demonstrate only desired edits made • Delivery challenges – e.g around scaling up from laboratory to commercial scale • Regulatory uncertainty – although a range of conventions and regulations apply, there is contention about the applicability of GMO legislation (an EU interpretative document is promised) • Ethical concerns – what genome edits are morally acceptable and what are not (see further reading)?

Readiness Assessment
(based on EU Horizon 2020 definition)

TRL 6-8

As of 2012 efficient genome editing had been developed for a wide range of experimental systems ranging from plants to animals, often beyond clinical interest, and was becoming a standard experimental strategy in research labs. In 2016, the Nuffield Council on Bioethics reported the rapid diffusion of genome editing across biological research (see further reading).

Core Functions and Use Cases

- Knowledge generation – about gene functions and embryo development
- Treatment and eradication of diseases – e.g addressing immunodeficiency, control of viruses, disease resistant cells, treating blood cancers, and suppressing vector (e.g mosquito) abilities to carry disease

- Genetic modifications for food security – research into plant and animal traits e.g. nutritional enhancement, pest resilience, drought resistance and food storage times
- Human 'enhancement' – note forerunner technique (pre-implantation genetic diagnosis) enables embryo screening to select for desirable traits ('designer babies'). Potential advances might enable range of 'enhancements' using synthetic genes or animal genes e.g. resilience to more hostile environments, disease resistance, night vision, enhanced sense of smell, height, propensity to fatness etc
- Democratisation of biological research – some techniques accessible to those outside science institutions ('DIY' biologists), see 'biohackers'

Concerns

- Safety risks – still potential for unintended consequences arising from unpredictability of 'off target' effects and potential impacts on plants and animals, including subsequent generations
- Vulnerability of eco-system integrity to impacts of genetic modifications – eco-system risk assessment is complex – difficult to predict and control changes e.g. 'new' organisms may have unpredictable impacts on eco-systems
- Vulnerability of food supply to over-reliance on high tech approaches and reduced genetic diversity – modified crops could perform well in controlled environments but may be less well adapted to variable environments. Is high tech intensification sustainable?
- Impact on agricultural communities and associated economies, especially peasant farmers – as a result of increasing yield disparities between 'natural' and 'engineered' varieties, or need to rely on bought rather than retained seeds
- Malicious acts - the intelligence community is concerned about the production and use of harmful biological agents or products by 'bioterrorists' as processes become simpler and cheaper (see weapons of mass destruction)
- Ethics – issues around the inequality and social divisiveness of potential human 'enhancements ('neo-eugenics'), increases in the use of animal experiments, acceptability of using human embryos in research and, ultimately, potential reduction in human genetic diversity.

Resilience Impacts
(based on Resilience Impact Grid)

- For individual resilience, the democratisation of biological research has potential to impact positively on connectedness, agency and social cohesion for those involved. In principle, human 'enhancements' could also impact positively on agency. The potential negative impact is on social cohesion, through the iniquity and social decisiveness of human 'enhancements'.
- For group resilience, there is potential for positive impact, particularly on reflectiveness, resourcefulness and robustness, and to a lesser extent on flexibility and inclusiveness. However various concerns have potential to impact negatively, particularly on reflectiveness, robustness, redundancy and inclusiveness.
- Core functions also hold promise for positive impacts on transformative potential, but several of the concerns could impact negatively on this quality.

Influencers

The American Society of Human Genetics
European Academies Science Advisory Council (EASAC)

Further Reading

Nuffield Council on Bioethics, 'Genome Editing: an Ethical Review', September 2016.
https://www.newscientist.com/round-up/crispr-gene-editing/
EASAC, Genome editing: scientific opportunities, public interests and policy options in the European Union

RESILIENCE IMPACT GRID – GENE EDITING

[Column headings are technology specific core functions and concerns. Row headings are generic resilience qualities. + represents positive impact of a use case against a resilience quality. – represents negative impact against a resilience quality.]

	Knowledge generation	Treatment and eradication of disease	Food security	Human 'enhancements'	Democratisation of biological research		Safety risks	Eco-system vulnerability	Food supply vulnerability	Impact on agricultural communities	Malicious acts	Ethics
connectedness					+							
agency				+	+					-		
social cohesion					+					-		-
reflectiveness	+			+	+		-	-			-	
resourcefulness	+		+	+	+							
robustness		+	+	+			-	-	-		-	
redundancy					+				-	-		
flexibility	+				+						-	
inclusiveness		+								-		-
integration												
anticipation of futures												
transformative potential	+		+	+	+		-	-	-		-	

Green Chemistry

Definition

Green chemistry is about the design of products and processes that minimize the use and generation of hazardous substances, and reduce consumption of non-renewable resources. As a Royal Society review elaborates, green chemistry "efficiently utilizes (preferably renewable) resources, eliminates waste and avoids the use of toxic and/or hazardous reagents and solvents in the manufacture and application of chemical products. The guiding principle is benign by design, that is, the design of environmentally benign chemical products and processes." Nonetheless, it is also argued that there are ambiguities in the definition – that "what is green" can be open to debate.

Drivers

- Regulatory approach - in the late 80s/early 90s a shift from 'end of pipe' pollution control to pollution prevention e.g the 1990 US Pollution Prevention Act.
- EU regulation – the REACH regulation (2006) seeks to improve the protection of human health and the environment through identification of the properties of chemicals (see impacts).
- Scientist push – e.g. from 1998, the Green Chemistry Network has promoted education, training and practice in industry, government, academia and schools
- Climate change and resource depletion – focusing scientific effort on replacing fossil fuels and on circular design (and here)

Barriers

- Commercial – including the cost of development, uncertainty of future benefits and reluctance to abandon sunk costs (in existing processes and products)
- Technical – including the challenge of developing substitutes for problematic processes and lack of chemists with appropriate training
- Organisational – including lack of support at executive level and conflicts between divisions/plants
- Cultural – including insufficient awareness in chemical community and negative connotations with "green" (more expensive, less effective)

Readiness Assessment
(based on EU Horizon 2020 definition)

TRL 9 – actual system proven in operational environment (competitive manufacturing in the case of key enabling technologies; or in space)

It has been suggested, for example, that "Over the last two decades the concepts of green chemistry and sustainable technologies, and the underpinning metrics, atom economy and the E factor [amount of waste formed per kg of product], have been widely embraced by industry and academia worldwide. It has been a gradual process, which is by no means complete, but much progress has been made …"

Core Functions and Use Cases

- Environmentally benign chemical processes and techniques – e.g. metathesis, bio-engineering and biocatalysis
- Environmentally benign products - e.g. new proteins/enzymes, green solvents, green nanotechnology, green agro-chemicals and bio-fuels (plus here)
- Renewable biomass - substitution of non-renewable fossil resources by renewable biomass as a sustainable feedstock for the manufacture of chemicals, liquid fuels and other products (and potential for community projects)

- Evaluation of environmental impacts e.g. see metrics overview, waste arisings, and effectiveness of a synthetic reactions through the Eco-scale

Concerns

- Greenwash – where companies make unwarranted or overblown claims of sustainability or environmental friendliness
- Greening production without addressing over-consumption
- Competition with food production – first generation biomass (corn, oil seeds) competes with food production (prompting a focus on use of waste biomass)

Resilience Impacts
(based on Resilience Impact Grid)

- For individual resilience, the evaluation of environmental impacts has potential for positive impact on connectedness. Community-led biomass projects could have a potential positive impact on social cohesion. Greenwash and over-consumption could impact negatively on connectedness and agency.
- For group resilience, there is potential for the core functions to have positive impact, particularly on resourcefulness and robustness. Evaluation of environmental impacts can inform reflectiveness. However, greenwash, in particular, has potential to impact negatively, particularly on reflectiveness, resourcefulness and robustness.
- The core functions also hold promise for positive impacts on transformative potential, but the concerns could impact negatively on this quality.

Influencers

http://www.rsc.org/Membership/Networking/GCN/

http://g2c2.greenchemistrynetwork.org/

Further Reading

There is an introduction and extensive reading list at Environmental Health Sciences– a Primer for Green Chemists

RESILIENCE IMPACT GRID – GREEN CHEMISTRY

[Column headings are technology specific core functions and concerns. Row headings are generic resilience qualities. + represents positive impact of a use case against a resilience quality. – represents negative impact against a resilience quality.]

	Environmentally benign chemical processes	Environmentally benign products	Renewable biomass replacing fossil resources	Evaluation of environmental impacts		Greenwash	Over-consumption	Biomass competition with food production				
connectedness				+		-	-					
agency						-	-					
social cohesion			+									
reflectiveness				+		-						
resourcefulness	+	+	+	+		-						
robustness	+	+	+			-	-					
redundancy												
flexibility												
inclusiveness												
integration												
anticipation of futures												
transformative potential	+	+	+	+		-	-	-				

Smart drugs - nootropics

Definition

Nootropics, also known as smart drugs and cognition enhancers, are natural supplements or manufactured pharmaceuticals that improve cognitive function. The international sales of cognition enhancers is reported to have exceeded US$1 billion in 2015, with global demand still growing rapidly. Specialist online suppliers sell 'stacks' (combinations of nootropics) for specific enhancing purposes. Some pharmaceuticals can be purchased easily (albeit illegally) online without a prescription, often from overseas.

[Nootropics could be seen as the forerunner of a number of other cognitive enhancing 'emerging technologies', including Brain–computer interface, Cyberware and Strategies for Engineered Negligible Senescence.]

Drivers

- Military research and use – nootropics have been used to promote performance during conflict since World War II and the military (particularly in the US) continues to carry out research
- Medicinal use – for treatment of e.g. Alzheimers, Parkinsons, Huntingdons, Attention Deficit Hyperactivity Disorder (ADHD), narcolepsy and other sleep disorders
- Market opportunity – meeting pressures/desire for improved performance and success in academia or business (particularly in competitive and differentiated job markets)
- Supplier push – manufacturers keen to take supplements and pharmaceuticals to bigger markets
- Technical – development of the internet (and 'dark markets') has been an enabler

Barriers

- Social acceptability – some potential users may be put off by concerns about the ethics of use (potentially seen as akin to doping in sports)
- Safety - uncertainties in side and/or long-term effects of some nootropics where safety data is lacking
- Effectiveness - uncertainties in effectiveness (see BMA paper under 'further reading')
- Perceptions of addictiveness – but evidence shows this is fairly rare for therapeutic doses (see BMA paper)
- Legal and regulatory – sale and supply of a prescription only or unlicensed medicine is an offence
- Quality of on-line supply – risk of counterfeit, substandard or adulterated products

Readiness Assessment
(based on EU Horizon 2020 definition)

Probably equivalent to TRL 8 – system complete and 'qualified' (but not 'proven' because of a lack of data about effectiveness of various nootropics for a range of core functions).

Core Functions and Use Cases

Claimed and [actual examples] for healthy people:

- Concentration
- Creativity – enhancing the imagination, innovation and artistic expression
- Energy and motivation – ability to get tasks done (known as 'task saliency')
- Executive functions – control of complex cognitive processes e.g. decision-making, problem solving and self-control [e.g. modafinil for sleep deprived individuals]
- Memory improvement – [e.g. on spatial working memory (methylphenidate), maintaining memory in sleep deprived individuals (modafinil)]

- Wakefulness and alertness – [e.g. modafinil for sleep deprived individuals (potential including, for example, disaster workers)]

Concerns

- Adverse health impacts – from poor quality products, side effects (e.g. nausea, headaches, insomnia), overdoses or (where known) long-term impacts (e.g. decreased learning ability)
- Ethics – that it's morally wrong to use manufactured pharmaceuticals for cognitive enhancement
- Inequality – use of nootropics to succeed in exams, job interviews and work, could exacerbate the gulf between 'haves and have nots' (but note the BMA reports evidence of improvement in cognition in people at "the lower end of the spectrum" but potential impairment of those already at the "optimum level of cognitive function" – see further reading)
- Limited benefits - user expectations can greatly exceed actual enhancements
- Over-confidence – there is a risk that induced over-confidence could outweigh any performance enhancing benefit
- Potential diversion of prescription drugs for non-medicinal use – could become an issue if prescription drugs are in short supply

The Resilience Impacts
(based on Resilience Impact Grid)

- For individual resilience, all the claimed core functions have potential for positive impact on agency. However, various concerns have potential to impact negatively, particularly on social cohesion.
- For group resilience, there is potential for positive impact, particularly on resourcefulness, and to a lesser extent on reflectiveness, robustness and flexibility. However, concerns around adverse health impacts and over-confidence have potential to impact negatively across a range of resilience qualities. The quality of inclusiveness is potentially impacted negatively by a range of concerns.
- Three core functions could hold promise for positive impacts on transformative potential (creativity, energy and motivation and executive functions). Adverse health impacts and inequality could impact negatively on this quality.

Influencers

The BMA
The Medicines and Health Care Products Regulatory Agency
Various on-line promoters and suppliers.

Further Reading

See 'Cognitive Enhancing Drugs and the Workplace', BMA, August 2015, https://www.bma.org.uk, and medicine watchdog seizure.

RESILIENCE IMPACT GRID – SMART DRUGS (NOOTROPICS)

[Column headings are technology specific core functions and concerns. Row headings are generic resilience qualities. + represents positive impact of a use case against a resilience quality (based on a working assumption of efficacy). – represents negative impact against a resilience quality.]

	Concentration	Creativity	Energy and motivation	Executive functions	Memory	Wakefulness and alertness	Adverse health impacts	Ethics	Inequality	Limited benefit	Over-confidence	Potential diversion
connectedness						+	-					
agency	+	+	+	+	+	+	-			-	+/-	
social cohesion							-	-	-		-	-
reflectiveness	+			+	+	+	-				-	
resourcefulness	+	+	+	+	+	+	-					
robustness				+	+							
redundancy												
flexibility		+		+			-				-	
inclusiveness							-	-	-		-	-
integration												
anticipation of futures		+		+								
transformative potential		+	+	+			-		-			

The Hidden Internet

Definition

'Zones' within the internet not visible to search engines. Some of these are simply not indexed for public search engines but are searchable within a specific domain – an organisation's intranet, for example. Others are deliberately hidden, and of these, some are only accessible with specialist software. Terminology here is not used consistently, and there are no agreed definitions of 'deep' or 'dark' internet/web. This is confusing, perhaps deliberately, even for those with some technical knowledge. Included within the general category of the 'hidden' internet are both small closed or semi-closed peer-to-peer (P2P) networks, and larger networks such as Tor, Freenet and the Invisible Internet Project (I2P). Also included are online black markets (sometimes called 'darknet markets') such as the various incarnations of the Silk Road.

Categorisation of 'Benefits' and 'Concerns' are particularly troublesome for this area; whether something is a benefit or a dis-benefit (evading government censorship or providing untraceable email services, for example) depends on who you are and your relationship to your government.

Drivers	Barriers
• Technical – the 'arms race' between on the one hand the technological capabilities of governments (supported by mainstream internet companies and specialist suppliers) to control, block, censor and identify participants in internet activity and, on the other hand, the ingenuity of enthusiasts and independent developers, some academic researchers, and some large organisations (Tor was developed within the United States Naval Research Laboratory) to maintain privacy of communications, and anonymity for content creation and transactions. • Political – many governments identify some hidden internet activity that they regard as negative (e.g. cybercrime, coordination and mobilisation of resources for terrorism, pornography) and other kinds of activity that they regard as positive ('dissidents' in regimes they regard as repressive, civil society organisations, etc.), and may provide material and political support for the latter. • Market opportunities/criminal activities – darknets provide the mechanism for commercial transactions that governments seek to prohibit, including the sale of illegal drugs and 'research chemicals', the commissioning of illegal services, and also	• Technical – using darknet software and tools is more difficult than using packaged software aimed at mainstream users. Users need to remain engaged with the technology and to frequently reconfigure settings so as to circumvent measures intended to block or identify illegal activity. • Technical and legal uncertainty – it is not always clear whether users have genuinely achieved privacy and/or anonymity, or whether they have broken laws, or what the sanctions might be if they have. Both the law, and the technical environment, are constantly changing. Fear of being caught is a major deterrent for users considering adopting this technology. • Moral censure – in the uncertain legal environment there is considerable effort by content owners and others to characterise widely practiced darknet activity (e.g. file sharing) as associated with activities that are both criminal and widely detested – for example, the frequent assertion of links between copyright infringement ('piracy') and terrorism (an assertion contested by serious academic research)

support non-commercial activities that might elsewhere be provided by commercial market actors (e.g. the free re-distribution of copyrighted material) through file-sharing. All of these provide strong motivations for the development of software tools and services to support the operation of darknets.	

Readiness Assessment
(based on EU Horizon 2020 definition)

TRL 9 – specific darknet tools and software are in constant flux (I2P is described as 'beta software since 2003') but the networks and the markets and communities they support are well established.

Core Functions and Use Cases

- Anonymous/private distribution or publication of material - e.g. whistleblowing (e.g. Wikileaks), material restricted by copyright (e.g. free and paid-for file sharing), or banned or censored content
- Secure private messaging – e.g. between members of a clandestine or suppressed organisation (a secondary function is to restrict messaging to members of a pre-defined community, thereby restricting the sending of email spam or spoof messages)
- Anonymous and private transactions – e.g. the sale of banned or illegal products or services (some with unanticipated consequences e.g. making drug dealing safer?).

Concerns

- Terrorism – e.g. coordination and mobilisation of cells and resources
- Crime - e.g. cybercrime, drug dealing, production and distribution of child pornography
- Safety – products sold anonymously can be subject to reputational scrutiny through user reviews, but this is of limited value compared to a regime of rigorous safety testing and clinical trials (e.g. so-called 'research chemicals' are developed and sold at the buyer's risk).
- Economic impact - undermining of established business models by rewarding hidden content producers and owners

Resilience Impacts
(based on Resilience Impact Grid)

- For individual resilience, on the assumption of beneficial uses, the core functions have some potential to impact positively on agency and social cohesion for those involved. There are considerable negative impacts, particularly for the victims of crime and users of risky products.
- For group resilience, there is potential for positive impact, particularly related to resourcefulness. However various concerns have potential to impact negatively, particularly on robustness and inclusiveness.
- Core functions also hold promise for positive impacts on transformative potential for dissident or suppressed groups under repressive regimes, but terrorism and crime could impact negatively on this quality in, for example, liberal democracies.

Influencers

The Darknet Research Centre
The Electronic Frontier Foundation

Further Reading

The Darknet: A Short History (http://foreignpolicy.com/2013/12/09/the-darknet-a-short-history/)

Darknet 101: An Introduction to The Darkest Places Online (https://blog.radware.com/security/2016/04/darknet-101/)

The Darknet and the Future of Content Distribution (http://web.cs.ucdavis.edu/~rogaway/classes/188/materials/darknet.pdf)

RESILIENCE IMPACT GRID – THE HIDDEN WEB

[Column headings are technology specific core functions and concerns. Row headings are generic resilience qualities. + represents positive impact of a use case against a resilience quality. – represents negative impact against a resilience quality. Note that for the hidden web we have made initial judgements about impacts on the assumption of potential beneficial uses of the three core functions i.e. that negative uses and impacts are captured under the four concerns]

	Anonymous/private distribution and publication of material	Secure private messaging	Anonymous and private transactions		Terrorism	Crime	Safety	Economic impacts				
connectedness							-					
agency	+	+	+			-	-					
social cohesion	+	+	+			-	-					
reflectiveness												
resourcefulness	+	+	+									
robustness					-	-	-	-				
redundancy												
flexibility					-							
inclusiveness					-	-		-				
integration												
anticipation of futures												
transformative potential	+	+			-	-						

Video Analytics

Definition

Video analytics (also called video content analysis or video content analytics, VCA) is the capability of automatically analysing video to detect and determine temporal and spatial events.

This technical capability is used in a wide range of domains including entertainment, health-care, retail, automotive, transport, home automation, flame and smoke detection, safety and security. The processing capability can be implemented as software or as hardware in specialized video processing units.

Video analytics can be used for simple motion detection (e.g. for a security camera), tracking of a moving object, or “egomotion” (computation of an object’s own position in and movement through an environment, e.g. for a camera-enabled robot). More sophisticated analysis can be used for identification, behaviour analysis or other forms of situation awareness.

Processing of video is often combined with enhancement technologies such as video de-noising, image stabilization, unsharp masking and super-resolution.

Video analytics is both a complement to and a substitute for other means of data acquisition such as connected objects; for example, ‘smart parking’ can be effected by in-road sensors to detect where spaces are occupied or by cameras and processing of images.

There are multiple trade-offs between image quality (and camera cost) vs. software processing, and local vs. centralised processing. (Processing video at or near to the camera means conserving network bandwidth (so using network resource less) but might cost more in terms of distributed processing resource compared to processing the video data at a central location).

Drivers	Barriers
• Technical – availability of better, cheaper, smaller video cameras; availability of better (higher-bandwidth, lower latency, cheaper) radio networks (LTE etc) for connectivity; processing power and software tools for analysis; cloud software for services • Cost reduction – automated analysis makes it possible to deploy cameras where human monitoring would be prohibitively expensive • Market opportunities – the possibility of automated services (e.g. traffic management, smart parking) that can make use of automated analysis of video feeds, often in combination with structured data • Political – increased public anxiety re crime, terrorism, border security	• Legal and regulatory uncertainty – particularly as regards privacy, ownership of images, etc. • Technical – some deployment scenarios cannot be supported in real time by currently available processing software • Power constraints – even wireless connected cameras need power, and batteries run down quickly for cameras that are always working and sending information • Network constraints – despite improvements, wireless networks are still constrained in terms of bandwidth and latency (the delay in sending data). This makes wireless connected cameras unsuitable for applications where real time information is critical

Readiness Assessment
(based on EU Horizon 2020 definition)

TRL 6 – 9; some working systems, other use cases and deployment scenarios (e.g. autonomous driving) still under development.

Core Functions and Use Cases

- Detection and identification – 'something (with pre-defined characteristics) is here', and 'the thing that is here is this kind of thing (or this individual thing/person)' - e.g. via facial recognition or automated number plate recognition
- Analysis – counting, measuring, identification of trends and patterns e.g. consumer behaviour or detection of fraud
- Egomotion – the estimation of position of a camera relative to fixed objects (e.g. in an autonomous car, or robot navigation)

Examples of uses for these functions include**:**

- Retail – to provide information and insights to retailers about footfall and behaviour of visitors, and to identify individual shoppers
- Public security and safety – information about crowd behaviour, objects left in public spaces, identification of specific individuals, temperature variations from thermal images,
- Home security, assisted living,
- Manufacturing – enabling robots in production environments
- Detection of fraud and pilfering, e.g. in logistics, distribution or retail
- Traffic and transport information – traffic densities, parking
- Autonomous and assisted driving, including driver monitoring (e.g. tiredness detection)

Concerns

- Privacy and civil liberties – automated analysis makes surveillance at scale easier to deploy. There is also scope for individual abuse of public surveillance
- Lack of transparency – who is defining what is being monitored and tracked, and to whom are they accountable?
- Increased anxiety and fear as a result of more prevalence of cameras
- More intensive marketing (and Increased consumption) through more effective retail environments

Resilience Impacts
(based on Resilience Impact Grid)

- For individual resilience, two of the core functions – detection and identification, and analysis – have uses with potential for positive impacts on connectedness and agency. However, each of the concerns could negatively impact on qualities of individual resilience. For example, agency could be impaired through each of the concerns.
- Each of the core functions has uses with potential for a positive impact on one or more of the qualities of group resilience. It is particularly notable that the analysis function could enhance four of the group resilience qualities. However, each of the concerns could negatively impact on group resilience. For example, inclusiveness could be undermined by three of the concerns.
- In principle, the analysis function could contribute to anticipation of futures. However, all of the concerns could impact negatively on transformative potential.

Influencers

Multimedia Information Group, US National Institute of Standards and Technology
Living Analytics Research Centre, Singapore Management University

European Commission project on Video Surveillance for Security of Critical Infrastructure
Further Reading An introduction to video content analysis – industry guide British Security Industry Association Introduction to video analytics – EE Times The video surveillance report 2017: Cybersecurity, open platforms, 4K, low-light cameras, video analytics and warranties Video surveillance standardisation activities, process and roadmap

RESILIENCE IMPACT GRID – VIDEO ANALYTICS

[Column headings are technology specific core functions and concerns. Row headings are generic resilience qualities. + represents positive impact of a use case against a resilience quality. – represents negative impact against a resilience quality.]

	Detection and identification	Analysis	Egomotion		Privacy and civil liberties	Lack of transparency	Anxiety and fear	Intensive marketing				
connectedness	+	+					-					
agency	+	+			-	-	-	-				
social cohesion					-		-					
reflectiveness	+	+						-				
resourcefulness		+			-			-				
robustness		+	+				-					
redundancy												
flexibility					-		-	-				
inclusiveness					-	-	-					
integration		+										
anticipation of futures		+										
transformative potential					-	-	-	-				