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The Impact and Potential of the Collaborative Internet and Additive Manufacturing on the Future Economy

Robertshaw S*, Giuliano A, Achilleopoulos N, Bengtsson JE, Crehan P and Soldatos J

AcrossLimits Ltd. Triq il-Kappilan Mifsud, Hamrun, Malta

Abstract

The emergence and convergence of four key technologically enabled phenomena (Internet Collaboration, Big|Fast|Open Data, Additive Manufacturing, and Crypto-currency) prompted the Science and Technology Options Assessment panel of the European Parliament to let a contract to conduct research into the potential of these technologies and to identify any associated policy implications. The research study comprised of four phases: desk research, a workshop, a mini-foresight exercise and interviews with industrialists and academics. The data collected were analysed and a number of positive and negative policy options were identified. The issues that arose in the study are summarised and include: personal data as commodity, disintermediation, education, prosumerism and entrepreneurial innovation, pace of policy development, (and laws and regulations), borderlessness and internationalism, virtualisation of industrial infrastructure and of currency. Given the radical changes that are expected to sweep the EU and global economies in the next few years, we found there was particular interest in developing and deploying new forms of intellectual property management protocols. It was recognised that this short study was only the start of a longer process. Future investigation needs to delve deeper into the technical and social aspects of the relevant technologies and of the capability envelope they occupy, as no one can anticipate the next technology disrupter and where it will act.

Keywords: Economy; Policy; Regulation; Technology; Internet; Collaboration; Decentralisation; Disintermediation

Abbreviations: 3D: Three Dimensional; EP: European Parliament; EU: European Union; ICT: Information and Communication Technologies; IoT: Internet of Things; IP: Intellectual Property; MEP: Member of the European Parliament; PACITA: Parliaments and civil society in technology assessment; SME: Subject matter expert; STOA: Science and Technology Options Assessment; VO: Virtual organisation; VTO: Virtual trade organisation; WEF: World Economic Forum

Introduction

The European Parliament recognises that a new industrial revolution is underway, one that is led by networked digital services. Wanting to understand the implications associated with the capabilities afforded by these technologies, a short study was commissioned.

The Study Group was given four topics to investigate, both independently and in conjunction with each other. The objective was to uncover the potential positive and negative policy and regulatory implications of their widespread adoption. The topics to be studied were:

- Big | Fast | Open Data
- Crypto Currency
- Collaborative Internet Technologies
- Additive Manufacturing: including three dimensional (3D) printing

Due to the brevity of the study and the corresponding few resources to deploy, the Study Group adopted a simplified hybrid Delphi[1]/ ASHEN[2] method as the foundation of their study plan. This method was followed, to gather relevant data and analyse the collected data. It is

Important to note that the views of industry and academic thought leaders were combined in this study. All views expressed were used to develop a comprehensive set of policy options that were delivered to the STOA Unit of the EP with a final report.

This paper summarises the findings presented in the report and the accompanying Options Brief.

Background and Funding Detail

The authors are part of a consortium that, in 2013, won a Framework contract with the Science and Technology Options Assessment (STOA) unit of the European Parliament (EP) for the provision of expert advice in the Information and Communication Technologies (ICT) and related areas. Subsequently, a specialised study group was formed from a subset of this group and won a specific contract to investigate the potential impacts that the convergence of collaborative Internet and additive manufacturing technologies would make on markets and on society. In particular, policy options were called for in relation to promoting positive impacts and overcoming negative impacts.

The study was commissioned under contract: IP/G/STOA/FWC/2013-001/Lot4/C1/SC1 and ran from September 2014 and concludes, with the publication of this paper, in August 2016.

Methodology

Desk research was initially carried out to develop a background context and to identify appropriate subject matter experts (SMEs).

[1]A strategic foresight method, developed by RAND Corp: http://www.rand.org/topics/delphi-method.html

2A knowledge elicitation technique developed by Cognitive Edge: http://cognitive-edge.com/methods/ashen/

***Corresponding author:** Robertshaw S, AcrossLimits Ltd. Triq il-Kappilan Mifsud, Hamrun, Malta, Tel: 00356 2122 4900; E-mail: steve@acrosslimits.com

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An In-depth Analysis was then developed as an introduction to the areas for those SMEs to be engaged in the study, interested Members of the European Parliament (MEPs) and members of the public.

An open meeting with invited SME speakers was arranged and conducted in the European Parliament in Brussels on

27 January 2015. The meeting was chaired by an MEP and was designed to identify important issues and open questions for further study. MEPs and members of the public were present in the audience. All participated in the discussions, which drew out a number of issues that required follow up action.

- Scenarios were created, in parallel to the meeting, using a modified Delphi study. The scenarios were used to tease out further issues.
- Between 1 February 2015 and 14 February 2015 all open issues were combined with open questions arising from the meeting and then structured following the principles embodied in the ASHEN technique to develop lines of enquiry. These lines of enquiry were followed through the development of a questionnaire and interview plans.
- Between 15 February 2015 and 10 June 2015, leading players in academia and industry were engaged to expose possible solutions and regulatory hurdles and to indicate policy related issues
- Issues were explored and options considered. Technical and operational options were aggregated and balanced to create fewer high-level policy options.
- The main findings of the study were summarised and presented to a meeting of the STOA panel at the EP in Strasbourg on 11 June 2015.
- A video clip explaining the big picture issues and aimed members of the public was created and delivered on 10 July 2015.
- Based on the findings of the study and the interviews, a detailed report was created and this was delivered on 31 August 2015, alongside a policy options brief.
- This paper represents the final output from this study.

All outputs from the study can be found in the list of supporting manuscripts at the end of this paper, where links are provided to directly access the material. Much more detail can be found in these documents and, in particular, the policy options are fully developed and linked with existing European Union (EU) policies, regulations and directives.

Main Issues Discovered

In the following discussion the subjects have been revealed through primary research, correlated and verified with independent research. The final report adopts a structure based on the four technology topics given in the project specification. This paper focuses on the wider horizontal issues uncovered during the study. The concepts associated with these horizontal issues can be summarised as:

- Personal data as commodity;
- Disintermediation;
- Education;
- Prosumerism and entrepreneurial innovation;
- Pace of policy development, (and laws and regulations);
- Borderlessness and internationalism;
- Virtualisation of industrial infrastructure;
- Virtualisation of currency

Readers interested in the detailed technical findings and policy options are welcome to download and read the full study report, which is freely available and linked in the list of supporting manuscripts at the end of this paper.

Each of these horizontal concepts is now explored more deeply and associated with a summary of its corresponding policy options.

Personal data as commodity

Personal data are currently collected and managed by companies and government organisations [1], which use them to manage customer access to services. These data have value and many current business models are predicated upon realising commercial value from manipulating and aggregating such data [2]. The current model has created the need for legislation and regulation that is very difficult to tailor to all circumstances due to the conflicting needs of protecting individuals through restricting access and usage (where companies are prevented from exploiting their customer-base and selling compiled data to third parties), and protecting society through opening up access and innovating new kinds of usage (e.g. in clinical research where aggregated patient data may reveal important new treatments).

The number of connected devices and sensors through the advent of the Internet of Things (IoT) is growing phenomenally quickly and these will massively increase the volume of personal and/or private data, within the overall concept of Big Data. In future, we anticipate that personal and private data will be owned and managed by the individuals it defines. These individuals will exchange regulated tokens relating to various aspects of their personal data-set and these will be sufficient to validate that a person is who they say they are in any transaction. This user-centric model disrupts the current business-centric model and will require other forms of value chain to emerge and evolve [3]. One such model may develop whereby owners of data agree to provide selected aspects of their personal data in exchange for service access and financial gain. It could be argued that this model is not very different from current models but the power is now in the hands of the data subject, rather than the data owner (in this case they are the same person; currently they are not). In this model, however, the owner decides which data are released, how and when they are released, how long it is available for and what can be done with it. Such transactions could easily be managed, in real time, by software entities, which respond to the data subject's requirements and current 'market conditions'. These transactions also map more effectively on to the modes of interactions that current digital citizens seem comfortable, where they willingly trade all of their personal data for access to a single service.

Corresponding policy options

Remove laws that currently limit what someone can do with their own data.

Disintermediation: Disintermediation is not a not a new concept; it has been observed and understood in the context of eCommerce for over 15 years [4] It refers to the removal of some human skill or service within a process and which maybe replaced either by an automated component or by the extension of the adjoining components

with automation, thus allowing direct connection. In the short term, disintermediation has reduced staff levels in the older version of the industrial sector it was impacting but as the deployment of the innovation grew, the employment levels returned but with higher skilled jobs. Importantly, it has been in industrial and blue-collar types of employment that the effects of disintermediation have, so far, been felt. However, the next industrial revolution looks set to bring with it a form of disintermediation that will affect white collar and professional jobs.

All economic revolutions, industrial, agrarian or otherwise, have resulted in disintermediation. Historically, the introduction of steam looms removed the need to employ skilled hand-weavers and more recently, the advent of online shops removed or reduced the need for retail premises on the high street and their dependency upon sales staff. The subtle difference in this manifestation of disintermediation is that many of the technologies under investigation, and especially their convergence, will displace white-collar jobs and professional services [5], rather than the industrial and manual services of past instances [6]. For example, blockchain[3] contracts have the potential to displace lawyers; 3D printing may disrupt conventional manufacturing and completely undermine current logistics networks through the establishment of local "job shops". Virtual crypto currencies may displace bankers and disrupt conventional banking systems and possibly even (conventional) politicians and regulators who will no longer be able to control money flows, manipulate exchange rates, or repackage debts, etc.

On-line collaboration services (in conjunction with other digital technologies e.g. recording) are already showing signs of devastating much of the music and entertainment industry [7]. and it is anticipated that this may continue to expand into other professional and white-collar areas of endeavour.

Corresponding policy options: Disintermediation and decentralisation will have profound effects upon society and market structures. Imagine and develop (radically) new ways of policy making, policy deployment and regulation.

Education: The needs of the economy are changing. In the past the transition from agrarian to industrial economies required a new class of educated people to operate machines. A fact-based education was given to a level that enabled workers to oversee mechanical devices safely and efficiently. Higher levels of education remained to be reserved for the elites. However, the next industrial revolution removes most worker activities away from actual machines when creating economic value. Therefore, new skills closer to and in many cases exceeding those of the conventional elites will be required of all workers.

The next industrial revolution presents a change in the nature of how work will be organised and how it will contribute to an economy. Consequently there will be challenging demands to be faced in the educational sector, where traditionally there has been a focus on the accumulation of technical knowledge in various domains across the arts, humanities and sciences. These subjects are taught in manner that makes a student's progress relatively easy to measure objectively.

In order to meet then needs of future employment, new educational aims and structures are required. Early signs of the demands of this new reality are already being presented by employers in the hi-tech sector, where the current output of education systems around the world are described as inadequate [8]. The emerging reality of future education has been recognised and is being promoted by the World Economic Forum (WEF), which made it the focus of the January 2016 meeting in Davos. In a major Insight Report, the WEF describes how new kinds of education are needed. These new styles will need to embrace a much greater range of "soft skills", such as: Complex Problem Solving Skills, Resource Management Skills, Social Skills and Systems Skills [9]. Importantly, these new skills requirements are additional to the technical skills that are already taught and which remain important. Therefore, forms of education that are more immersive and engaging are required. The limitations of current delivery mechanisms (schools, classes, lessons, etc.) are unlikely to be able to adapt to the new reality of flexible students, so a means of educational delivery that can be personalised to the needs of the student will need to be developed. This new mode of education will likely enable students to interactively participate in their education through new forms of technology dependent learning. There are examples of interactive technology being used as a conduit of education as well as the subject of the lesson, especially in the 3D printing sector [10] where students are able to download specifications for devices which they print themselves in order to use them later in their lessons. In order to succeed in this endeavour, they remotely collaborate with other students and plan their own "lessons", making progress at their own pace and learning in their preferred mode. As such, these educational tools become part of the technical economy, where makers engage in making their own educational equipment as part of the on-going evolution of education.

Corresponding policy options

Modify education policies to ensure that a wider range of relevant skills is in place when they are needed.

Prosumerism and Entrepreneurial Innovation: In a market associated with an industrial society, producers produce and consumers consume. Logistic services take products from producers to the consumer through different types of supply chain. However, disintermediation is already breaking the conventional supply chain and the increasing uptake of 3D printing is set to increase this trend. Moreover, through online collaboration tools, it is now possible for producers to engage with consumers directly and interactively: e.g. for the purposes of customer satisfaction management and market analysis. However, some first steps from mere engagement towards other forms of collaboration are already observed in the current market. This evolution is set to continue and lead to a completely new market structure where consumers will be involved in the production process to some degree [11]. Conventional manufactures are already able to offer bespoke products to individual clients, bespoke jeans [12]. Other industries will involve customers in the prototyping of new products and services. Finally, producers and consumers will collaborate in the development and promotion of new products and services as equal partners in the process. These new market actors extend Toffler's notion of a prosumer [13] from someone who mixes work and social life into one who combines activities connected with the production of the goods and services they consume. This will lead to the situation where conventional Intellectual Property (IP) management techniques will become redundant. New mechanisms to manage IP in the potential new model of consumer entrepreneurialism and joint innovation will need to be established. Such issues are recognised as drivers of commercial growth by some forward-looking companies [14] but there is no current understanding of issues related to IP management.

[3]An artifact associated with the current generation of crypto currency, which records transactions associated with the token embodying it and effectively forms a contract that is immune to attempts of repudiation. It is currently being explored in the wider banking sector for use as a digital ledger and looks set to become a standard in that context.

Corresponding policy options

Create clear new EU-wide IP rules that reflect the emerging capabilities and propagate them on the global stage.

Pace of policy development, (and laws and regulations): Technological innovation is generating social and economic change at ever increasing rates and creating churn at the same time. Policy makers typically have spent a lot of time consulting widely when framing new policy but this approach is increasingly seen as unfit for purpose when the technologies being addressed by a policy have been superseded several times before a final version of the policy is enacted into law.

An unfortunate side effect of recent attempts to legislate and regulate in some of the more complex areas of modern technology is the creation of unintended consequences, especially in relation to how data are managed. This is especially notable in the protection of personal data and the ownership rights associated with creative data products. In a complex area such as data in a digital environment there are many aspects and contexts to consider. If these are not comprehensively addressed and balanced in relation to personal protection versus public good then the consequences can be dire. For example: the laudable desire

- To prevent an individual's personal data from being abused by third parties, the current legislation makes it very difficult for clinical researchers to create databases that may benefit society through the discovery of important new treatments [15].
- To ensure that the creative rights of an artist are respected and their ability to economically operate make it likely that significant valuable functions of web search engines will have to be turned off [16]. Initial notification even produced scares about holiday photography being outlawed outside landmark buildings [17].

In parallel with the increasing rate of technical change there is a corresponding change in social attitudes to those technologies and the capabilities they afford. It is often that case that younger generations are not so troubled by issues associated with technologies as the older generations. It is the case that young people are happy to make many personal details available in public environments, just for the pleasure of sharing as well as for fun. Potentially harmful details aside, who is right? What is acceptable is an ever-shifting social and cultural norm. It is not set in concrete. It is likely that next generation policies will be derived through new mechanisms and are likely to radically shift the emphasis of protection away from 'what can be done' into 'what cannot be done' with personal data.

Some preliminary steps are being explored. There have been attempts to evaluate the societal value of digital technologies through technology assessment, e.g. the Parliaments and civil society in Technology Assessment (PACITA) initiative [18]. However, this study did not consider the policy-making and regulatory aspects of those rapidly evolving technologies. Instead, it looked at technology assessment as a means of determining the value of technology for societal benefit. A focussed policy making revision study focussed on the UK energy industry has taken place and some interesting lessons have been learned [19]. There have also been some attempts to create and codify a decision-making process that is able to keep pace with rapid technology change [20]. However, the focus to date has been on business decisions, which are generally not so complex as government law-making and policy formation decisions.

In future, it seems likely that interactive citizen and industry engagement will take place on a continuing basis. This means that policy evolves in real time, with technological evolution [21]. Social media platforms are likely to be the main platforms supporting this engagement.

Corresponding policy options

Stay ahead with policy-making, create new interactive models, and do not over regulate out of fear.

Borderlessness and internationalism: The goods and services created by conventional companies are already traded across borders and successful frameworks are in place to ensure that goods and services crossing borders do so with the necessary permissions and levies in place. However, collaboration technologies and data sharing mechanisms have seen the inception of virtual organisations [22]. There is no need for these organisations to restrict the scope of their activities to a specific geographical region. The concept of transnational virtual organisation (VO) is already well understood in the scientific community [23] and they have already been established and successfully deployed to investigate many areas which have led to recent breakthroughs, notably in high energy physics. It is anticipated that this concept will break through the scientific barrier and follow the Internet and Worldwide Web out of the scientific community, transferring into commercial markets. Therefore, it is likely that in future, many goods and services will be created by transnational virtual trade organisations (VTOs). However, these VOs are not only transnational they are also ephemeral and while this nature may suit the project-focused approach found in most scientific disciplines it introduces a number of issues when the concept is transferred into commercial market places.

National laws regulate locally manufactured goods and services and producers of goods and services are held to account through a judicial system, if something goes wrong. Imports into markets are currently regulated by international agreements and are controlled at ports to enforce compliance with agreed regulation standards. In a (globally) distributed digital working environment there is no single area of regulatory jurisdiction. Therefore, in a VTO context, regulation is no longer a territorial/national in scope, it has a global scope. Agreements on standards and enforcement are required, or participation in common global regulatory initiatives has to be developed. There are notable difficulties in relation to consumer protection: especially when 3D printing is combined with the VTO concept.

Where does responsibility lay if a collaboratively designed, co-created, remotely encoded but locally printed good is defective? Is it the designers, wherever they are? Is it the remote encoders? Is it the printer manufacturer? Is it the filament manufacturer? These issues were briefly discussed in the European Parliament by the Author with Vicky Ford, MEP [24] who had then recently been involved in European Single Market talks considering these future issues. The issues were illustrated by her, considering them in the context of motorcar windscreen wiper blades, which may cause a road traffic accident and result in injury or worse. Even if a decision can be made in regard to these issues: what if the VTO responsible no longer exists? As a complement of this, how are the assets of knowledge workers in this new knowledge economy protected: will current IP rules be adequate? During the study, evidence emerged that current IP protection mechanisms actually reduced innovation potential through the defensive use of patents.

Corresponding policy options

Stimulate a free flow of co-created ideas. Create clear new fair use policies and consumer protection policies that reflect the emerging

capabilities. Create new enforceable regulations capable of supporting and protecting all stakeholders in the Collaborative Economy. Create and implement policies at the global level.

Virtualisation of the industrial infrastructure: Alongside the development of new industries and business models in the forthcoming industrial revolution it will be necessary to revise national and international infrastructures. Currently, the infrastructures we depend upon are physical or are close to physical entities and exist in two main classes. Roads, rails, seaports and airports support the transport and logistics infrastructures, which in turn support the food and resource distribution infrastructures, etc. Networks of pipes and wires support the energy distribution infrastructures, which in turn support higher-level service infrastructures, such as communications and broadcast infrastructures (which also depend upon access to the radio frequency spectrum infrastructure). Collaborative technologies provide similar categories of service as those supported by the first class of infrastructure but critically depend upon the availability of the second class for their existence.

In an environment where fewer real goods need to be transported and the volume of virtual and digital goods increases, knowledge becomes a capital asset and the economy is transformed. However, for a successful knowledge economy to exist and to survive beyond the next industrial revolution, network access must be assured [25]. More specifically, where fibre and radio spectrum replace roads and rails, two critical enabling capacities are necessary:

- Dependable and resilient energy security must be achieved. Only then will it be possible to guarantee the survival of digital services. Moreover, this notion of energy security must embrace the rapidly escalating demand for electricity supplies to power the information processing needs of the hardware devices performing the computational operations. The advent of the Internet of Things has already increased the demand for electrical power to support the necessary processing. Alternatively, hardware manufactures must develop new low-power devices [26].
- Network reach has to cover all territories and regions, in fixed and mobile modes. Network access has to be available to all, wherever they are, whoever they are, and whenever they need it [27].

Recent studies [28] imply that the new industrial revolution will eventually initiate a decentralisation of current national economic power structures. This supports the model of fibre and radio spectrum replacing road and rail. New forms of localisation will emerge, where peripheral and autonomous regions will be empowered to develop local economies best suited to local needs. Federations of connected nodes will enable these peripheral regions to energise their local economies to the overall benefit of the national economy, albeit within a different structure.

Corresponding policy options

Address foundational issues of access and availability.

Virtualisation of currency: Little has been mentioned about crypto currency so far, mainly because at the transactional level it offers only another form of payment for goods and services. However, the way that it achieves this is novel and brings with it new challenges, some of which bring potential democratic costs, which are often overlooked in more common technical analyses, but which certainly need to be managed.

Crypto currencies are like other forms of currency, where value is embodied in tokens and these are transferable between actors in the economy. They are also like traditional forms of currency where economic value is associated with a unit of work and the value of this work is translated in to a token value for the purposes of engaging in transactions. What is different is that the units of work within conventional economies are associated with 'people doing things'farmers reaping crops and rearing livestock, mechanics repairing cars, etc.) these are easily observed in the 'real world'. Conversely, the units of work within a cyber economy are associated with machines solving very complex problems. The token value in crypto currencies is therefore a truly abstract entity. It exists in a virtual form inside a virtual environment and its value is derived from abstract work carried out in an automated process, which may not sit in a single physical location. The significance of this is that the creation of value can take place anywhere and is not traceable in any conventional sense associated with current economic models. It will, therefore, become possible for economies to detach themselves from nations. Cyber economic communities are already decoupled from regulatory mechanisms such as central banks and this is one of the reasons for the popularity of crypto currency for some people: the kinds of people who do not like centralised power structures. The result of these developments, when taken to a logical conclusion, implies the possibility of a national government loosing control over that part of national economic activity, which is conducted within the cyber economy by its citizens. Moreover, the loss of a government's ability to benefit from seigniorage reduces its income [29].

When taken collectively into account, there is the potential for traditional national politics to be threatened by the emergence of virtual economies, where cyber citizens may prefer (or choose) to disengage from conventional national structures and transfer citizenship into this new environment, which does not respect national borders, laws, regulations, or social constructs. Such notions are causing fear (particularly in relation to criminal use) in many quarters, from within banks themselves and also in governments.

Although disjoint from issues directly related crypto currency and the cyber economy, it is interesting to note that Estonia is the first country to partially migrate into online environments. Estonia has expanded its significant national e-citizenship programme and is offering e-residency to non-Estonian individuals and businesses, which do not need to physically relocate to the country of Estonia to benefit from their e-residency registration [30]. Is this the first step in the creation of hybrid cyber-real nation states?

Corresponding policy options

Create new enforceable regulations capable of supporting and protecting users of derivative crypto currency services growing out of the Collaborative Economy.

Establish a recognition process for crypto currencies. Objectively examine and consider the fears of criminal use in context.

Conclusions

The study focused on four emerging and potentially disruptive technologies and from this study emerged a number of cross-cutting horizontal issues, which were discussed in this paper and presented along with their associated policy options. The study objectives were very ambitious given the broad scope required and the time allowed. However, the hybrid Delphi/ASHEN method that was deployed compensated very well and a great deal of useful data were derived.

Some of the policy options are provocative and/or contentious. This is not because the authors particularly want to cause friction but because:

- The new economic model discussed in the main report has the potential to create a truly transformative impact for the whole of Europe.
- The policy options reflect the considered opinions of the expert stakeholders who were interviewed and which were confirmed by our own research results.

In other words, the opportunity is too important for its significance to be hidden behind obscure language.

If Europe can adapt to the forthcoming changes and deploy policy and regulations suitable to support itself through the early stages of the change process, then there are very many significant benefits to be derived: social as well as economic. If Europe moves quickly and acts decisively then it can assume a leadership role and profit from the associated benefits. If Europe moves slowly, the leadership benefits will be lost and it will become part of the following herd. If Europe tries to fight against this change, it will suffer badly because the change will eventually come, whether it is wanted or not, and it will be shaped according to someone else's agenda.

This paper represents only a partial overview of the implications associated with the forthcoming changes, yet it offers an insight into this important economic and social opportunity for Europe.

We recommend that specifically targeted and more detailed work should be carried out in order to understand some of the more nuanced and subtle aspects of the potential contained within the Collaborative Economy concept and the technologies that underpin it.

Background Information

Disclosure of competing interests

The authors are independent experts in their respective technology areas and work closely with the European Commission and with national authorities around the world, in a number of advisory and expert roles. They have no competing interests in relation to the production and publication of this paper. All agree to its publication.

Author Biographical Notes and Contributions

Steve Robertshaw (Corresponding Author) is a technology strategist with expertise in high performance

computing, novel software architectures and distributed artificial intelligence. Steve focussed on extracting the cross cutting issues, edited the reports and wrote the paper.

Angele Giuliano is managing director of AcrossLimits. She is a serial entrepreneur in social and health technologies. Angele led the study.

Nick Achilleopoulos is a computer scientist specialising in education technologies and crypto currencies. Nick contributed his expertise to the crypto currency study.

Johan Bengtsson is a software engineer specialising in Internet technologies. Johan contributed his expertise to the collaboration technology study.

Patrick Crehan is a national policy and strategy advisor specialising in the future of education and in developing strategies to embrace emerging technologies. Patrick contributed his expertise to the additive and 3D manufacturing study.

John Soldatos is a computer scientist specialising in the Internet of Things and Big Data. John contributed his expertise to the Big | Fast | Open Data study.

Supporting Manuscripts Generated in the Study

Preliminary in-depth analysis

http://www.europarl.europa.eu/stoa/webdav/site/cms/shared/2_events/workshops/2015/20150127/STOA%20Workshop%20Collaborative%20internet%20-%20Indepth%20analysis.pdf

Workshop participants' booklet

http://www.europarl.europa.eu/stoa/webdav/site/cms/shared/2_events/workshops/2015/20150127/Participant's%20Booklet.pdf

Summary highlights of workshop

http://www.europarl.europa.eu/stoa/webdav/site/cms/shared/2_events/workshops/2015/20150127/Workshop-Highlights.pdf

Final report

http://www.europarl.europa.eu/RegData/etudes/STUD/2015/547425/EPRS_STU(2015)547425_EN.pdf

Options brief

http://www.europarl.europa.eu/RegData/etudes/STUD/2015/547425/EPRS_STU(2015)547425(ANN)_EN.pdf

Video clip

https://www.youtube.com/watch?v=I3kz q9lJ67E

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Chair of workshop

Virginie Rozière (MEP and STOA Panelmember)

Workshop Speakers

Prof Frank Piller (Aachen University, Germany & MIT Smart Customisation Group, USA)

Oliver Gajda (European Crowdfunding Network, Brussels)

Prof Yike Guo (Imperial College London, UK)

Tom Heath (Open Data Institute, UK)

Louis Turner (Asia Pacific Technology Network, UK & Asia)

Dr Beverley Vaughan MD (Stevenage Bioscience Catalyst, UK)

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Chair of STOA panel meeting

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