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The Map As An Object of Service Design

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Abstract: The rapid development of ICT has led to the transformation of maps from printed paper to virtual digital publishing and three-dimensional mapping. This allows speculation to be replaced with certainty and accuracy in maps. This also allows maps to function as participatory platforms with the capacity to collect, create, store and process data through people's interaction with other individuals, the environment and cities. This has significantly changed the way that key stakeholders interact with each other through mapping and raised fundamental ontological and epistemological questions about the nature of maps and mapping. This paper reviews literature in critical cartography and map examples to see how recent technological developments relate to mapmaking. The current practice and thinking in cartography has been challenged, as cartography is traditionally considered the core mapmaking profession. When maps start to function as participatory platforms and become democratized, cartography seems to become obsolete. In light of this, we suggest that maps become the objects of service design. In this role, service designers consider maps as services and take a user-centred approach to facilitate the engagement of key stakeholders in complex systems. The key contribution of this paper lies in the fact that it initiates a discussion of the potential of service design in developing digital platforms, smart cities and public services through mapping. It suggests that future studies could contextualize the involvement of service design in this new territory and investigates its implications and limitations.

Keywords: Service Design, Digital Platform, Cartography, Big Data

1. Introduction

The emergence of Web 2.0 technologies and the increasing availability of satellite imagery have enabled the rapid growth of spatial knowledge production and dissemination (e.g. Haklay, Singleton and Parker, 2008). Mapping has evolved rapidly from paper, to GIS, to web-based mapping. In particular, the Internet and digital mapping technology allow maps to function as participatory platforms with the capacity to collect, create, store and process data through people's interactions with other individuals, the environment and cities. The recent rapid development and adoption of smart device technologies (e.g. wearable) and the Internet of Things, together with the growth in Big

Data and Volunteered Geographic Information (VGI) mapping practices, have significant implications for social relations and our everyday life (Zook and Graham 2007; Wilson and Graham, 2013). In particular, these developments have significantly changed the way that users, service providers, governments and other key stakeholders interact with each other through mapping. As recent episode of the BBC radio programme "The Forum" (2012) discussed, the fact that we are now entering a crucial moment of technological and social transformation; thereby we are now experiencing one of most complete shifts in mapping in our urban life. Lin (2015) urges that it is time "we call for more research on situating, tracing, understanding, and potentially remaking the map" (p. 43) in light of this wave of transformation.

This paper aims to understand the current status of mapping practice in relation to the rapid development of technology. It attempts to conceptualize the changing dynamics amongst stakeholders involved in mapping by:

- Reviewing literature in critical cartography to understand existing views and the knowledge gaps in the current debate;
- Reviewing map examples to understand how the recent development of technologies has changed the way maps are developed, used and disseminated.

This paper reports these findings before turning to a discussion that concludes that the nature of mapping has changed significantly as a result of the rapid development of technology. This requires a new kind of profession to facilitate collaborative mapping activities through digital platforms. It is suggested that service design, with its user-centered approach and systemic orientation, is relevant in this context.

2. Critical Cartography

2.1 A Brief Review of Critical Cartography Literature

The following table summarizes key discourses in the field of critical cartography. It appears that both the epistemological and ontological views of cartography have evolved since the start of the practice of mapping.

Table 1 Critical Cartography Characteristics (adapted from Kitchin, 2008)

early stage	Representational		post-representational	Processual
	Modern	Postmodern		
	Robinson (1952)	**Harley (1989)**	**Pickles (2004) Wood & Fels (2008)**	**Kitchin & Dodge (2007)**
Maps as wayfinding & order of society	**Maps as true representation**	**Maps as social construction**	**Maps as system of proposition**	**Mapping practices, processual**
Imagination of the knowledge, culture, speculation	Scientific effectiveness (accuracy, readability) Essentialist Objective truth; Neutral Communication focus	Expression of power/knowledge Constructed	Produce world (linking present information with past knowledge) Constructed Not representation but inscription	Context dependent of-the-moment Emergent

Early Maps. For many centuries, maps were considered to be literary metaphors and tools in analogical thinking (Harley, 1987). Early maps also dealt with natural philosophy, the description of places and people, geography, history, navigation and direction and (what we would nowadays call) methodological issues. Interestingly, because in the medieval period maps reflected dominant religious views, some maps were produced to guide behaviour in accordance with religious rituals and orders. For example, the Hereford Mappa Mundi does not only show the geographic information but also signifies religious ritual. (Figure1). These were used in a similar way as visual encyclopaedias (i.e. mappa mundi, learning and thinking tools). Those early cartographic images contained messages about how human society should be ordered as well as facts about the organization of space and how this could be communicated with people. During this era, maps were predominantly produced by cartographers. Without the support of any modern technology to produce maps and to capture the information needed for modern maps, cartographers relied largely on their knowledge, culture and speculations about the world.

Figure 1. Hereford Mappa Mundi. One of the most famous medieval maps in existence, dates from around 1300 and is kept at Hereford Cathedral in England. It was drawn on calfskin, and depicts Jerusalem as being at the centre of the world. Great Britain and Ireland are squeezed into the bottom left hand corner.

Modern Cartographic Era: The Scientific View. From the early modern cartographic era onwards, technical innovation in physical measurement and visualization skills led to the growth of statistical graphics and thematic mapping. The discussion started to be concerned with 'map effectiveness' (Robinson, 1952), which suggested that cartography's fundamental aim was to capture the abiding (inherent) truth about space and that it believed the world could be objectively known and faithfully mapped using scientific techniques that captured and displayed spatial information. This view placed great emphasis on issues such as maps' readability and accurate correspondence between physical object and graphical representation (e.g. interpretability, use of color, scale, projection, data categorization and symbology). Therefore, self-referential and technical questions were explored, and cartographers aimed to produce rules and standards to refine and improve how map representations could be designed and communicated (Kitchin, Gleeson & Dodge, 2013). Figure 2 is a map projection of a world map, which shows the entire world at once. It was specifically created in an attempt to find a good compromise to the problem of readily showing globe as a flat image.

The key themes of this cartographic era seem to relate to the ideas of maps as truth; representation (descriptive); essentialism; maps as ontologically secure (fully formed/immutable); inherent, objective truth; and the non-ideological nature of maps (Kitchin, 2008).

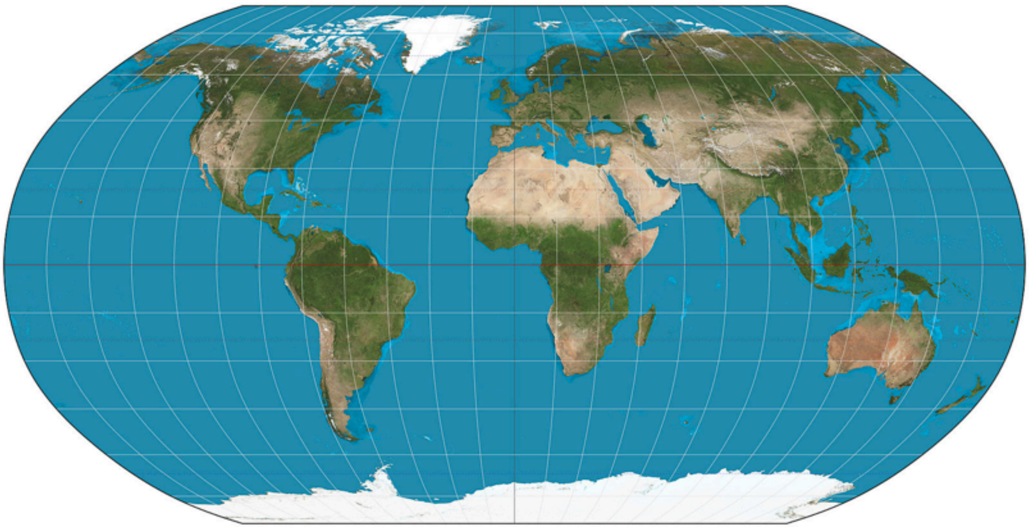

Figure 2. Robinson projection of the world. source: The New York Times November 15, 2004: About the development of the Robinson projection. 15° graticule. Imagery is a derivative of NASA's Blue Marble summer month composite with oceans lightened to enhance legibility and contrast. Image created with the Geocart map projection software.

Representational. The scientific view then developed into critical cartography, which started by focusing on the underlying notion of maps as ways of knowing about the world. Critical cartography presented this as formalized knowledge and the social construction of power (Harley, 1989). In this way, maps were defined as a set of graphical arrangements that represented human phenomena such as things, concepts, conditions, processes or events in the human world (Harley and Woodward, 1987). Therefore, in this strand of literature, maps were considered as representational. In critical cartography, "deconstruction" was the method of understanding maps within the wider context of their production, circulation and application, and of revealing the meanings, ideology and power inherent within their design, focus and presentation (Harley, 1989).

Post-representational. By contrast, the post-representational view claimed that maps had never been neutral and did not simply mirror the world; instead, each map was a dramatic reduction of the world from an extensive set of facts. Turning from the philosophy of representation to practices of interaction follows Michael Lynch's (1994, p.149) suggestion that if we wish to produce meaningful analyses of images in science, we ought to cease comparing representations with 'reality' and focus our attention on 'what people do when they engage in an activity that makes one or another "representation" perspicuous'.

The way in which unquantifiable information was abstracted, symbolized and accentuated in the best representative outcome depended largely on the choices and decisions made by mapmakers as well as on how the maps were read by users (Wood, 1992; Pickles, 2004; Dodge and Kitchin, 2000;

Wood and Fels, 2008). This view has significantly challenged the scientific (e.g. Robinson) and representational (e.g. Harley) views of maps. The core argument of this view was that the process of mapping consists of creating, rather than simply revealing, knowledge.

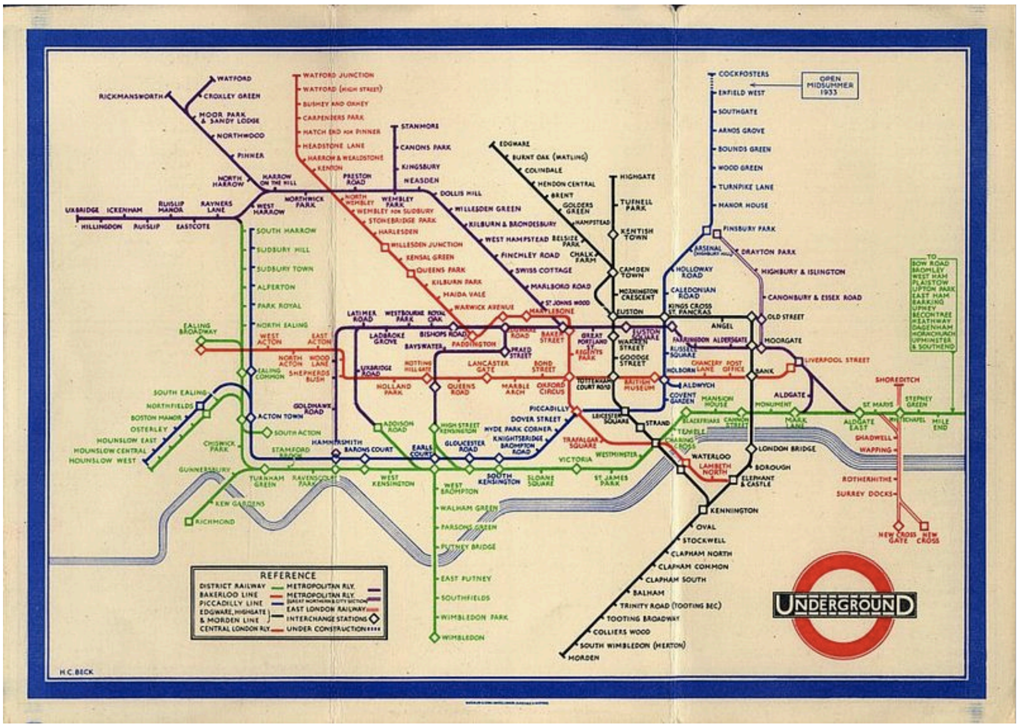

Figure 3. London Underground Map, Harry Beck, 1931.The idea of creating a full system map in colour. Beck believed that Underground passengers were not concerned with geographical accuracy and were more interested in how to get from one station to another and where to change trains. While drawing an electrical circuit diagram, he applied new idea for a map that was based upon concept rather a geographic map on which all stations were more or less equally spaced.

Emergent Cartography. As mapping is about creating knowledge, it was argued that maps should be understood as "processual" (Kitchin & Dodge, 2007; Mackenzie, 2003). This means that the important question is not what a map is, nor what a map does, but "how the map emerges through contingent, relational, context-embedded practices to solve relation problems (their ability to make a difference to the world); to move from essentialist and constructivist cartography to what we term emergent cartography" (Kitchin & Dodge, 2007, 342). Therefore, the practice of cartography and the theoretical analysis of cartography are both processual in nature. In this way, "cartography shifts from being ontical in status, wherein the ontological assumptions about how the world can be known and measured are implicitly secure, to an ontological project that questions more fully the work maps do in the world" (Kitchin & Dodge, 2007, 343).

2.2 Challenges to Critical Cartography

The recent shift of ontological assumptions toward emergent cartography means that there have been significant challenges to what we know about maps and how maps nowadays are related to the world through the process of mapping. It is also unclear where emergent cartography leads the argument. If the question is no longer about "what a map is" or "what a map does," but "how a map emerges and makes a difference to the world," there is a significant gap in our knowledge.

3. Technology and Mapmaking

The shift of ontological assumptions is also closely aligned with the recent development and wide usage of advanced technologies in every aspect of our lives. The future of cartography has become a widely discussed topic in the field of Geography like Human Geography and Critical Geography. For example, Kitchin, Perkins & Dodge (2009) suggest that the cartographic communication model as an organizing framework for academic research was beginning to wane by the mid-1980s. They describe the impact of technological changes in the following way:

> "Technological changes rendered problematic a single authoritative view of the world at a time when data were becoming much more readily available, and when technologies for the manipulation and dissemination of mapping were also being significantly changed. Users could become mappers and many possible mappings could be made. Digital mapping technologies separated display from printing and removed the constraint of fixed specifications. GIS increasingly supplanted many technical aspects of cartographic compilation and production. Digital position, elevation and attribute data could be captured from remotely sensed sources, and easily stored and manipulated in a digital form. Imagery could be generated to provide frequent updates of changing contexts. Maps could become animated. From the late 1990s the Internet has allowed maps to be evermore widely shared and disseminated at low cost. Mapping needed to be understood as much more of a process than was possible in communication models." (Kitchin et al., 2009, p. 7)

Jelfs, Cartwright & Pupedis (2014) further suggest that the future of cartography and new representations of geography will continue to be influenced by the outcomes of explorations of the available data and the creation of innovative, technologically produced and technologically delivered products. Wood (2003) takes a critical view of the future of cartography and asserts that "cartography is dead": mapmaking became too universal and thus eventually lost its professionalism with the march of technological innovation.

The following section investigates how mapping has been influenced by these technologies. The paper then turns to a review of map examples in order to understand "how maps emerge" in relation to the current state of technological development.

3.1 The Traditional Mapping Process and Technology

Technology has always been recognized as an essential part of mapmaking and an important driver in changing both the practice and the analysis of it. In order to understand how technology interacts with the process of mapmaking, Ackoff's (1989) framework of Knowledge Hierarchy (shown in Diagram 1) is used as the basis for understanding the flow of information represented in the process of mapmaking.

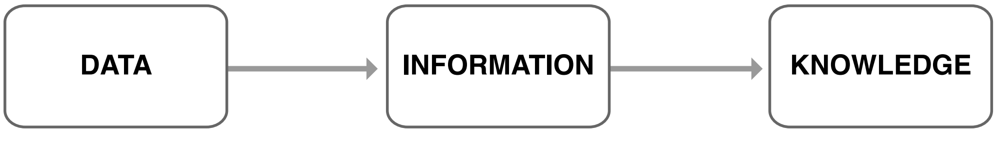

Diagram 1. Ackoff's Knowledge Hierarchy

Ackoff's framework contextualizes data, information and knowledge (and sometimes wisdom) with respect to one another so as to identify and describe the processes involved in the transformation of an entity at a lower level in the hierarchy (e.g. data) into an entity at a higher level in the hierarchy (e.g. information). This hierarchy is considered a central model of information management, information systems and knowledge management (Rowley, 2007). In this model, Data are merely symbols that we associate with specific features in the outside world, information is contextualised data that allows us to answer questions, knowledge is proceduralised information that allows us to act on and solve problems, and wisdom is knowing under which situations to act (Ackoff, 1989).

Based on the assumption that the flow of knowledge and information represents the process of mapmaking, Diagram 2 illustrates this process. From the original data to the final usage of maps, there are at least three areas that technology may be essential: technology to gather data (including both the geographic or special data and other layers of data in some maps), technology to make maps (e.g. print technology) and technology to disseminate (e.g. the map media). Conventionally, cartographers play an essential role in processing these steps by innovating and applying different types of technology. In history, we have seen that breakthrough technology has been one of the key drivers in changing the practice of cartography. For example, the modern print technology started in the nineteenth century shifted mapmaking from manuscripts to mass print production, allowing maps to be widely disseminated and to become an important part of our everyday lives.

In this process, there is a clear boundary between map production and consumption, as widely recognized in literature (Dodge & Kitchin, 2013). Maps are the interface between the professionals who produce maps and the users who use them. The skills and knowledge essential for producing maps underpin the professionalism of cartographers in many ways. Key stakeholders, e.g. users and map producers, are clearly defined based on how they interact in the process.

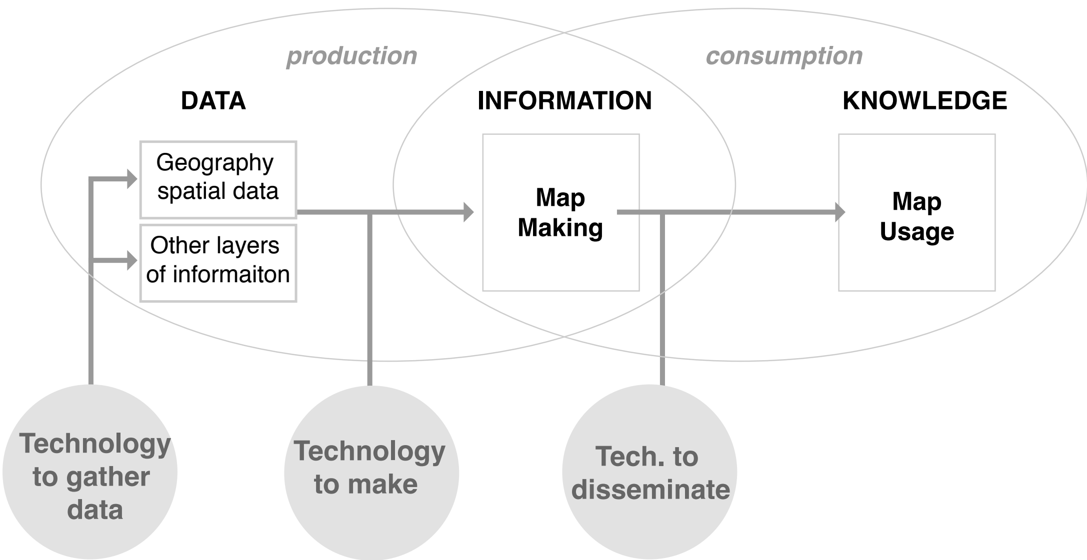

Diagram 2: The Traditional Mapping Process

3.2 The Recent Development in Technologies

In order to understand the extent to which the recent development in technologies has changed the traditional process of mapmaking and how it relates to technology, Table 2 summarizes the key technological developments (and relevant terms that summarize the application of these technologies) since the early 1990s.

Timeline	Early 1990s	2005		2010ish	
Technology	Geographic Information system (GIS) Computer system for capturing, storing, checking, and displaying data related to positions on Earth's surface	Web-based Digitial Mapping (Google Maps/OSM) Interactive display, data from different sources can be integrated and easily layered	Web 2.0 (Ajax, Web API) From static web-pages to dynamic The growth of social media	Ubiquitous Computing (Internet of Things, Wearable Devices) Internetworking with connected devices enable object to collect and exchange data through internet	Augmented Reality (AR) Computer generated sensory input
Implication	**God-like View** **Supplanter of cartographic compilation and production**	**Interactive Maps** **Data Intergration** **API**	**Platform with cost effective scalability** **Collective intelligence (i.e. Crowdsourced)** **Users as co-developer**	**Big Data generation with geographical reference**	**Combines real and virtual** **Interactive in real time** **Registers in 3D**
Map examples *	Crime Mapping, 1986 Oakland Crime Map, 2007	OpenStreetMap, 2004 Google Street Map, 2005 Google Earth, 2005 Google Sphere, 2012 Map Creator HERE, 2013 Postcode for Quick CommuteMap, 2013 Whereabout London, 2014 Manhattan Tree Map,2015 Everyvine Map, 2015 Patho Map, 2015 Health Map, 2006	LoveCleanStreet, 2009 Urban Mobs, 2009 Invisible City Map, 2011 Transportation Map, 2011 Flickr Luminous Cities, 2011 Livehoods Map, 2011 Chatty map of London, 2012 Park Life London Map, 2013 NY Sentiment Map, 2013 Sight seeing heat Map, 2014 Sentiment mapper, 2014 Scenic Route Map, 2014 Urban Mind Maps, 2015	Noise Pollution Map, 2012 London Air Pollution, 2012 OysterCard Flow Map, 2013 Boston Bus Journey speeds Map, 2013 Live bus-tracking Map, 2013 Bikeshare Map, 2014 Most Stressful Places, 2015 MindRider Map, 2015	NYC Tunnel Vision, 2014 UCL Campus Map, 2013 Continental AR HUD, 2014

* Please see appendix for more information about this map examples

Table 2: Recent Technologies and Their Implications for Mapping

GIS. A geographic information system (or GIS) is a system designed to capture, store, manipulate, analyze, manage and present spatial or geographical data. Since the late 1990s, the Internet has allowed GIS maps to be ever more widely shared and disseminated at low costs. Modern GIS and other computer mapping application assists analysis and can sow many different kinds of data on one map, such as streets, buildings and vegetation. This enables people to more sanity see analyse and understand patterns and relationship (see figure 4). GIS produces a "god-like" view (Dodge, 2008; Kitchin & Dodge, 2007) that represents the world in an objective fashion. As Cosgrove (2001, p92) puts it, data are displayed 'naturistically' as if on a planet seen from space. GIS also supplants many technical aspects of cartographic compilation, production and dissemination, allowing the development of a range of Internet mapping portals (e.g. Google Maps, OSM and other free open-source platforms). This has significantly challenged traditional cartographic communication models as well as the core theories of critical cartography.

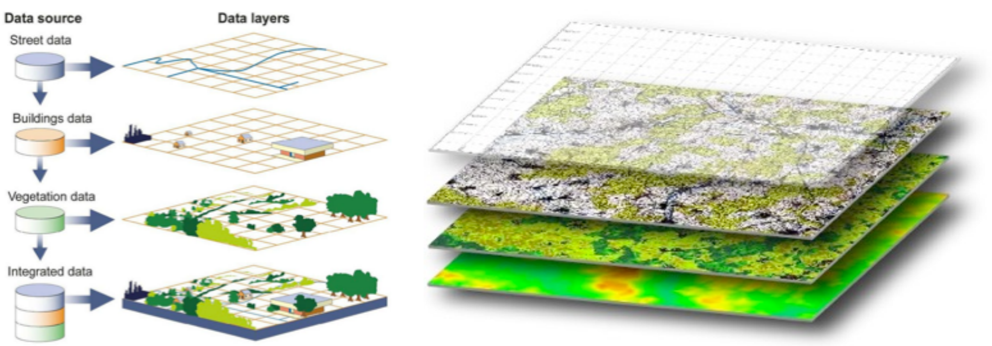

Figure 4. Illustration courtesy U.S. source: Government Accountability Office

Digital Mapping Technology. From 2000, incredibly accurate digital mapping technology and automatically rendered map representation (Google Maps, satellite imagery) has infused and almost replaced conventional mapmaking (Farman, 2010; Goodchild, 2000). These mapping portals allow users to access and interact with growing volumes of geographical data by using straightforward interfaces to produce their own maps (Crampton, 2009). Google Maps (launched in 2005) in particular—empowered by satellite images, street-level perspectives and other functions—has enabled a full spectrum of interactive mapping (See figure 5). Data from different sources can be integrated and easily layered. It also offers an API (Application Programming Interface) that allows maps to be embedded on third-party websites or applications.

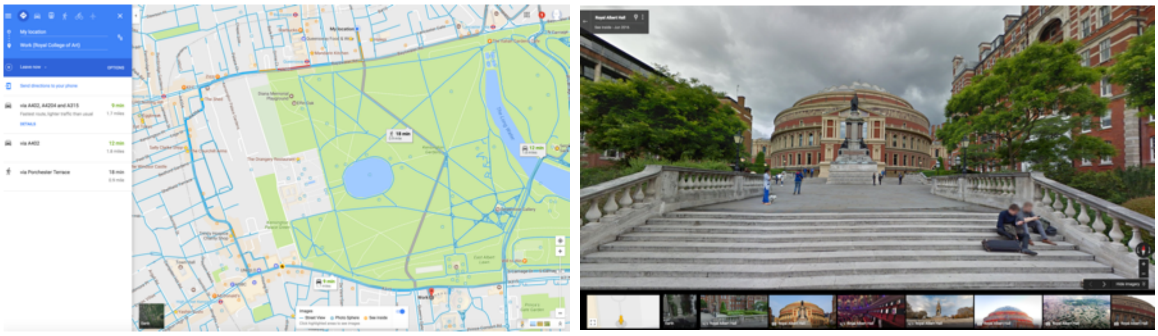

Figure 5. Google Map (2005 onwards) In April 2007, My Maps was a new feature added to Google's local search maps. My Maps lets users and businesses create their own map by positioning markers, polylines and polygons onto a map. On May 25, 2007, Google released new feature of Google Maps which provides 360° panoramic street-level views of locations.

Web 2.0 Technology. The term "Web 2.0" reflects changes in the ways that the Internet is deployed both by software developers and by end-users, changes that suggest a potentially revolutionary shift in the nature of the Internet. The core competencies of Web 2.0 include: the web as a platform with cost-effective scalability (O'Reilly, 2005), collective intelligence (O'Reilly, 2005; Allen, 2009) through user participation (Best, 2006), dynamic contents, openness and freedom (Greenemeier and Gaudin, 2008). The term Map 2.0 has been used (Gartner, 2008) to refer to Web 2.0 applications that provide suitable platforms for dynamic and interactive maps that allow everyone to produce and change their own individual maps without professional knowledge. This collaborative and social aspect of new mapping has led to democratic approaches to mapmaking and mapping. The terms Volunteered Geographical Information (VGI) (Goodchild, 2007), crowdsourcing (Dodge & Kitchin, 2013), counter-mapping and counter-knowledge (Harris & Hazen, 2006) can be understood under the umbrella term UGC (User Generated Contents).

Some argue that this means the end of traditional cartography (as in, for example, Wood's (2003) claim that "cartography is dead.") However, others (e.g. Sui, 2007) think Web 2.0 enables the integration of social and technical aspects into "wikified" models of cartographic communication or mapping (see Figure 6).

Figure 6. Panoramio Maps (2007) was geo-located tagging, photo sharing mash up owned by google.

Ubiquitous Computing (IoT & ICT). The Internet of Things (IoT) is a recent trend in the field of communications that renders the Internet a universal thing. It makes all objects connect with one another and with other physical devices—referred to as "connected devices" and "smart devices"—and other items enable these objects to collect and exchange data (Brown, 2016). The wide adoption of these technologies is driven by the declining cost of sensors and microprocessors, coupled with the increasing array of affordable connectivity technologies. These trends are driving efforts to increase access to connectivity technologies (Information and Communications Technologies for Development. i.e. ICT4D) . IoT is seen as the next frontier in information and communications technologies (ICTs). The impact of IoT on mapmaking is significant as each object can be equipped with sensors, micro-controllers and receivers for the digital communication of geographical data. GIS has an ability to gather, store, examine and manage spatial data and allow users to manage data in maps. IoT and GIS may be coupled together to provide an even better understanding of geographical data and patterns. For example, MindRider is a head-based IoT and wearable devices that tracks in real-time how user's ride, movement, and location engage with his/her mind giving new insight into riding experience without user's direct participation (see figure 7). This tie-up allows for interactive mapping that users real-time data and takes into account contextual information, including the user's particular interest that they want to address (Priya, 2016).

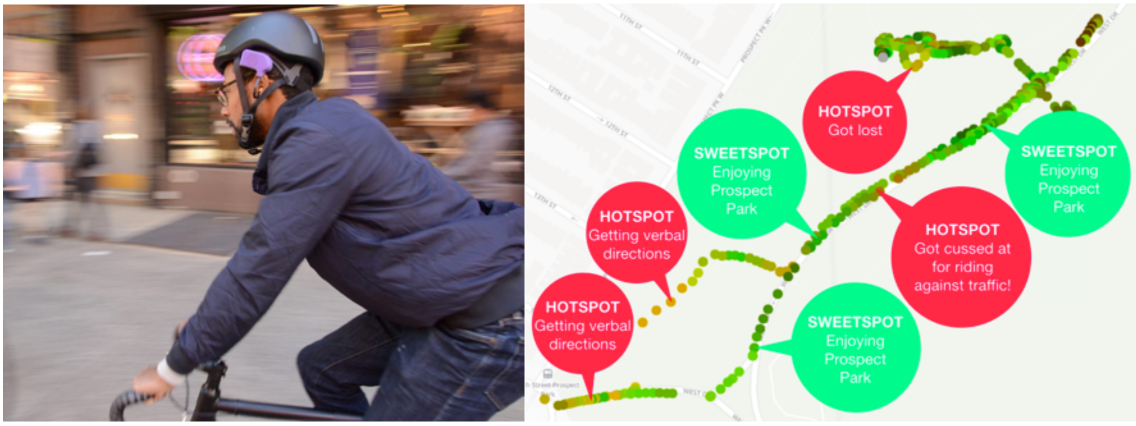

Figure7. MindRider Map (2015) is a head-based wearable that tracks, in real time, how users rides, movement, and location engage their mind that providing new insight into riding experience. It used biosensor to collect human experience data and process it in a large-scale, location-aware context.

Augmented Reality. Augmented Reality (AR) is defined as the mixture of sensory perception of the real environment and fictional visual objects (Milgram, 1994). In general terms, AR combines real and virtual reality allows interaction in real time and is registered in 3D (Azuma, 1997). AR has many applications in medicine, navigation, energy, military and data visualization. Stanek (2010) suggests that AR may be used as a graphical user interface for spatial data that enables the visualization of landscape and other cartographic objects in a flexible way. It blurs the distinction between the real world and the user interface in a way familiar from the phenomenon of ubiquitous computing (as described by Weiser (1991). While ubiquitous computing focuses on the computer becoming invisible among the objects of everyday life, AR seeks to add to the experience of reality, thereby creating new forms of interaction between humans and computers. This means that the AR helps us to add information and context to the reality that surrounds us virtually and with the user of technology (see Figure 8). Mobile computers running AR applications can provide such ubiquity. The common advantages of this type of computer environment—like user interactivity and visual and contextual variability—allow for the adaptation of maps and for enhanced geo-location support (Stanek, 2010).

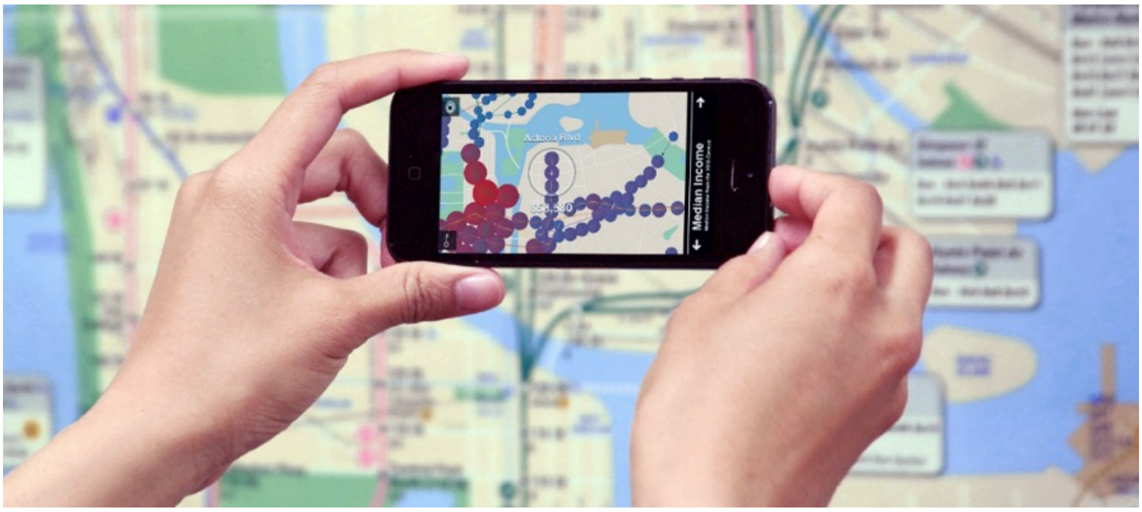

Figure 8. Augmented NYC Tunnel Vision (2014) uses the map as a platform to explore the city through data-visualization. The app pulls data from a variety of sources and seamlessly integrates them into the map by drawing over the camera feed.

3.3 Illustration of the Current Mapping Process

Based on the foregoing review of recent technological innovations, Diagram 3 integrates this technology into a depiction of the mapmaking process. First, it appears that technological innovations do not happen in one area alone but in all of the three areas that technology is relevant to mapmaking: technology to gather data, technology to make maps and technology to disseminate maps. The impact of these technologies has undoubtedly transformed the whole process. Second, the production and consumption of maps have been brought together, and the boundaries in the process have blurred. This has led to a change in the dynamics between map producers, cartographers and users. The reordering of the power structure challenges traditional mapping practices in many ways, and, at the same time, it opens up opportunities for new practices and new forms of relationship to be formed for more effective collaboration.

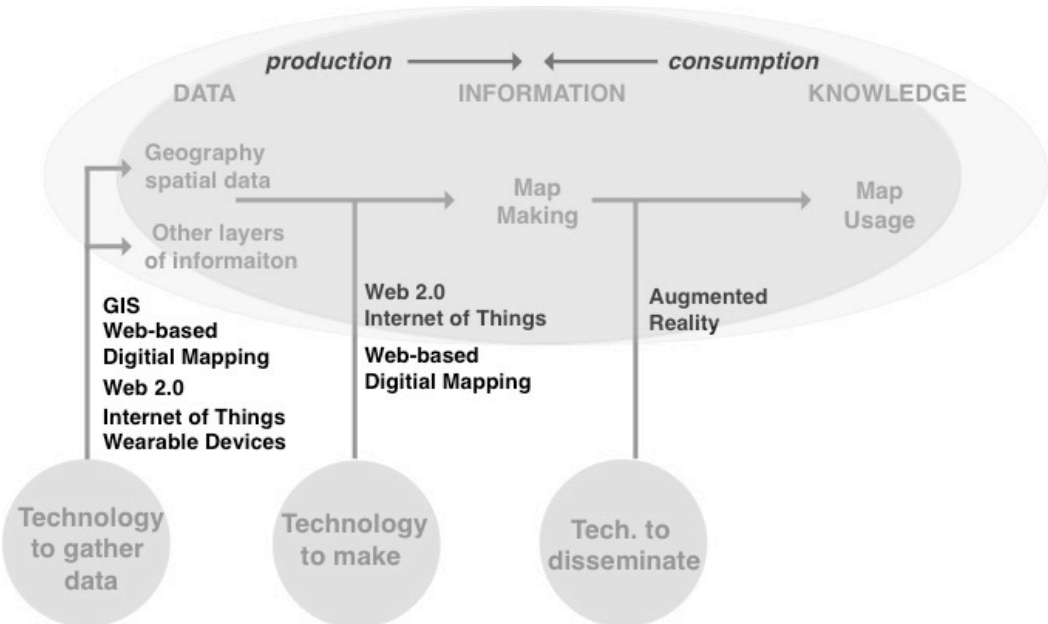

Diagram 3: Current mapping process

Some of the key challenges and opportunities include:

The ubiquity of data. The accurate geographical information and base-maps generated through GIS have made the speculation and knowledge of cartographers superfluous when it comes to the mapmaking process. Accuracy and map reliability had long been a challenge in mapmaking, but these recent developments seem to have made cartographic practice that relies on physical measurement technologies and visualization skills obsolete. The other key change is the dramatically increased complexity in the type and amount of data available for mapping. Users are involved in data generation. On the one side, users consciously layer information onto maps through social media and other tools. They voluntarily contribute, collect, clean and upload GPS tracks and add attribute data, termed Volunteered Geographic Information (Stefanidis, Crooks & Radzikowski, 2013; Dodge & Kitchin, 2013). On the other side, supported by IoT technology embedded in the system, data can be automatically generated in the form of Big Data. The data are harvested from smartphones, social media and sensors embedded in the built environment (fixed and wireless telecoms networks, digitally controlled utility services and transport infrastructure, sensor and camera networks, building management systems and so on). Data are now ubiquitous. As Graham and Shelton (2013) argue, although Big Data seems to allow for the objective measurement and mapping of the world as it actually is, and so seems to enable us to arrive at fundamental truths, it is questionable whether and in what way cartography is relevant, especially when the core argument in critical cartography seems to have pointed toward a different future.

Democratized Mapmaking. Digital mapping technology not only enhances maps in terms of their scale and resolution, but also makes this imagery in virtual space available to the public and to business through mapping platforms. This allows users easily to layer information onto the platform and customize its usage. Maps begin to function as participatory platforms; mapping becomes democratized as never before. Public- and citizen-orientated mapmaking efforts are distinct from traditional mapmaking, and this has changed the relationship between the user and the map provider/maker. Thousands of people collectively act as geographically distributed sensors; they connect to platforms socially, communicate meaningfully and contribute collectively. They voluntarily collect, clean and upload geospatial information and contribute data.

Mapping has become distributed, participatory and social. It offers a new form of mapping experience in which users can become authors and through which the content is constructed collaboratively. This collaboration is a form of so-called “crowdsourcing,” wherein many people volunteer pertinent information, usually about their local area; in this way, citizens become to be as sensors (as detailed by Goodchild (2007)

This means that the production of knowledge is in the hands of the public rather than in those of accredited and trained professionals. The shift from map user to mapmaker (Zook and Graham, 2007) is not only about blurring boundaries by letting users control geographical information, but also about counter-mapping and counter-knowledge activities (Harris and Hazen, 2006). This has led to either a de-professionalization of cartographer or a re-professionalization of map users (Crampton, 2009).

The Expanded Usage of Maps. Ever greater numbers of people are using map media to search and navigate this digital space; they produce spatial knowledge just as they consume spatial information. Nowadays, huge amounts of data are recorded, stored and analysed while we produce various kinds of spatial data in our daily lives, including travel behaviour, energy usage, noise levels and emotional attributions from crowdsourcing. As digital data have become ubiquitous, unprecedented insights produced and mapped in the form of Big Data have changed users’ perceptions and informed their knowledge of place, thus aiding them in their decision-making regarding how best to interact in the city; this is potentially producing new ways of knowing and being in the world (Batty, 2013; Graham

& Shelton, 2013). Although we still use traditional data collection methods such as surveys, interviews and questionnaires for mapmaking in the urban setting, new ways of collecting data are increasingly effective to reveal patterns in people's activity on a large scale in physical places. Describing the dynamics of cities is a crucial step in both understanding people's activity in urban environments and in planning and designing cities accordingly.

The reproduction of urban data through interconnected, map-based social media and location-aware services affords us information about the urban experience: The layers of data generated by the interaction between people and places can be understood as a description of human behavioural patterns in time and space. City planners and governments are able to look at urban data from various sources for the sake of future urban developments and for the inhabitants' benefit; they no longer have to speculate but can observe and measure behavioural patterns and harvest insights for meaningful decision-making that potentially supports the city's key stakeholders. In this respect, depicting geo-referenced data can offer new perspectives on city services and the way processes and strategies are designed and implemented (Ciuccarelli, 2014; Graham & Shelton, 2013).

4. Service Design in Mapping

All these changes challenge the traditional way of producing and thinking about maps. We argue that instead of focusing on exploring the relevance of traditional cartography practice in this space and seeking a kind of "re-professionalization," it is time to investigate and seek relevant practices and disciplines. In what follows, we explore the relevance of service design for mapmaking.

4.1 Maps as Service Ecosystems

Ostrom (2010) describes service design as "a collaborative, cross-disciplinary activity" that involves "the orchestration of clues, places, processes, and interactions that together create holistic service experience for customers, client, employee, business partner or citizen" (p. 17). In other words, service design involves a holistic approach to the design of experiences and systems that require the integration of multiple design disciplines in a systemic solution.

As we have discussed, recent technological developments have allowed for collaborative mapping activities. Users have become co-producers of maps, as have service and technology providers, governments and other stakeholders. In this way, the roles of producer and user are not distinct, which means value is co-created in interactions among entities—including map service providers, users, governments and other related entities—through the integration of resources. This parallels the discussion in "service science" of services as involving a co-productive process in which "the service is produced in a customer process where customer, company and subcontractors are actors" (Edvardsson, 1997, p. 31). This concept is further developed in the concepts of "service ecosystems" (Maglio & Spohrer, 2008; Spohrer & Maglio, 2010; Lusch & Vargo, 2009; Satish Nambisan & Lusch, 2015) or "service systems" (Maglio & Spohrer, 2008; Lusch, Vargo & Wessels, 2008). Underpinned by the fundamental concepts of service science, service design practice intends to apply a scientific understanding of services to design, improve and scale service systems for business and societal purposes (e.g. efficiency, effectiveness and sustainability) (Spohrer, Maglio, Bailey & Gruhl, 2007). Therefore, the rationale for exploring service design in mapping lies in this theoretical explanation of service and the shared meanings between mapping platforms and service systems.

4.2 The Facilitation of Collaborative Activities

Viewing mapping as co-creation, service design may facilitate collaborative activities because of its unique way of adapting a range of multidisciplinary tools and methods, including stakeholder mapping, user journey mapping, co-creation and blueprints. In comparison with more conventional design methods (e.g. task analysis, sketching and modelling), this set of methods facilitates user participation, interdisciplinary teamwork and creative collaboration. These methods are open, interactive and transparent. By contrast with the way these methods are used in their own fields, service designers have the ability to make them more communicable and accessible. In this new space, designers' expertise lies in their ability to empathize with people in relation to the system and to apply thinking to action. Further, participatory experience is considered "not simply a method or set of methodologies" but as "a mindset and an attitude about people" (Sanders & Rim, 2002, p. 1). In the shift, the concept of "design for people" is replaced with "design with people."

4.3 Developing Services to Explore the Usage of Maps

As service is the primary concern of service design, it aims at

> "Designing services that are useful, usable and desirable from the user perspective, and efficient, effective and different from the provider perspective. It is a strategic approach that helps providers to develop clear strategic positioning for their service offerings. Services are systems that involve many different influential factors, so service design takes holistic approach in order to get an understanding of the system and the different actors within the system." (Mager & Sung, 2011)

In the context of mapping, the central challenge has been how to exploit the opportunities provided by technology. Service design is therefore central to exploring the potential for new opportunities and for new service systems and experiences to be developed for a large variety of users (Moritz, 2005). This is particularly evident in the debate around the reform of public services, in which both organizations and citizens are asked to evolve and adapt to more collaborative service models, thereby changing their roles and interaction patterns (Parker and Parker, 2007).

5. Conclusion

This paper reviews literature in critical cartography and map examples to unpack how recent technological developments relate to mapmaking. The findings suggest that technology has significantly changed the way maps are developed, used and disseminated. The key impacts are threefold: (1) data have become ubiquitous, and now allow us to measure and map the world as it actually is and so to arrive at fundamental truths; (2) maps have become a platform and the outcome of the process of value co-creation among users and other key stakeholders, which has opened up opportunities for new services and new mapping experiences; and (3) the usage of maps has become diversified and highly personalized, and the user's experience has been significantly enhanced; this has great potential in various new areas such as city development and public service innovation.

These changes have, in turn, challenged current practices and thinking in cartography, which is traditionally considered the core mapmaking profession. When maps start to function as participatory platforms and become democratised as never before, cartography seems to become obsolete. This has led to either a de-professionalization or a re-professionalization.

In this paper, these considerations have led us to suggest redefining the designer's role as a facilitator of value co-creation through map services, in which maps are the object of service design. In this role, service designers consider maps as services and take a user-centered approach to facilitate the engagement of key stakeholders in complex systems. The key contribution of this paper lies in the fact that it initiates a discussion of the potential of service design in developing digital platforms, smart cities and public services, taking maps as the media. Future studies could contextualize the involvement of service design in this new territory and investigate its implications and limitations.

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Appendix. List of Maps in Table 2

Geographic Information system (GIS)

- Crime Mapping (1986)
- Oakland Crime Map (2007) http://tinyurl.com/475pxb

Web-based Digital Mapping (Google Maps/OSM)

- OpenStreetMap (2004) http://bit.ly/1TBmDpn
- Google Street Map (2005) http://bit.ly/18mqnSF
- Google Earth (2005) http://bit.ly/2iOOHIK
- Health Map (2006) http://bit.ly/2irQbMH
- Google Sphere (2012) http://tinyurl.com/nwjvarb
- Map Creator HERE (2013) http://tinyurl.com/nsvzhoc
- Postcode for Quick Commute Map (2013) http://tinyurl.com/q52mzwg
- Whereabout London (2014) http://tinyurl.com/ogfjqps
- Manhattan Tree Map (2015) http://bit.ly/2hCmgjK
- Everyvine Map (2015) http://tinyurl.com/o9qwmhn
- Patho Map (2015) http://bit.ly/2hVO8wW
- Urban Mind Maps (2015) http://bit.ly/2inUgij

Ubiquitous Computing (Internet of Things, Wearable Devices)

- LoveCleanStreet (2009) http://bit.ly/2hxqsOe
- Urban Mobs (2009) http://bit.ly/1z1gclg
- Invisible City Map (2011) http://tinyurl.com/pfmb5xb
- Transportation Map (2011) http://tinyurl.com/nbjmqvl
- Flickr Luminous Cities (2011) http://tinyurl.com/pv7t6j4
- Livehoods Map (2011) http://tinyurl.com/7ouaz2v
- Chatty map of London (2012) http://tinyurl.com/pgqa5dq
- Noise Pollution Map (2012) http://tinyurl.com/pc9ndep
- London Air Pollution (2012) http://tinyurl.com/6seg8d7

- UCL Campus Map (2013) http://tinyurl.com/qjr6udw
- Park Life London Map (2013) http://bit.ly/2inNNnH
- OysterCard Flow Map (2013) http://tinyurl.com/padtm4z
- Boston Bus Journey speeds Map (2013) http://tinyurl.com/ok9ul7a
- Live bus-tracking Map (2013) http://tinyurl.com/pw7neg4
- Bikeshare Map (2014) http://tinyurl.com/ntrhoo9
- Most Stressful Places (2015) http://tinyurl.com/pestjpd
- MindRider Map (2015) http://bit.ly/1c6oaMH

Augmented Reality (AR)

- NY Sentiment Map (2013) http://tinyurl.com/pan8pl9
- Sight seeing heat Map (2014) http://bit.ly/2hE69DP
- Sentiment mapper (2014) http://tinyurl.com/pan8pl9
- Scenic Route Map (2014) http://bit.ly/1z1gclg
- NYC Tunnel Vision (2014) http://bit.ly/2hE6ma5

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