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Coordination and Support Actions

SOcietal Needs aNalysis and Emerging Technologies in the public Sector

Deliverable D3.2

Emerging ICTs and Innovation Potential for the Public Sector – 1st Version

Workpackage	WP3 – Identification of Emerging Technologies and Innovation Identification Framework
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Abstract:	This deliverable provides an initial list of emerging technologies and trends and can be seen as a handbook that explains novel ICTs which could be useful to the Public Sector

Document Revision History

Version	Date	Modifications Introduced	
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v1.0	24/01/2017	Final document to be submitted to the EC	NTUA

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Definitions, Acronyms and Abbreviations

Acronym	Title
AI	Artificial Intelligence
API	Application Programming Interface
AR	Augmented Reality
BFSI	Banking, Financial Services and Insurance
BI	Business Intelligence
CAGR	Compound Annual Growth Rate
CEO	Chief Executive Officer
CIO	Chief Information Officer
CSCW	Computer Supported Cooperative Work
eIC	Electronic Identification Card
eID	Electronic Identification
EU	European Commission
GIS	Geographical Information Systems
IaaS	Infrastructure as a Service
ICT	Information and Communication Technologies
IDC	International Data Corporation
IoA	Internet of Anything
IoT	Internet of Things
IT	Information Technology
IVAs	Intelligent Virtual Assistants
MbaaS	Mobile "backend" as a Service
NLP	Natural Language Processing
OCR	Optical Character Recognition
PaaS	Platform as a Service
SaaS	Software as a Service
SOA	Service Oriented Architecture
TE	Technology
TT	Technological Trend
USD	US Dollar
VPAs	Virtual Personal Assistants
VR	Virtual Reality
VPN	Virtual Private Network
WBAN	Wireless Body Area Network

SONNETS

Acronym	Title
WP	Work Package
WPAN	Wireless Personal Area Network
WWW	World Wide Web

Table 1: Definitions, Acronyms and Abbreviations

Executive Summary

SONNETS aims at providing the guidelines and a methodological process that will help to reshape and **reform** the **public sector** into a **technology leader** and **innovation breeding carrier**. With this goal, the project includes the development of an ever-evolving methodological framework, backed up by an active community, driven forward by renowned experts and interested public sector officials and practitioners, for the rapid porting of emerging technologies into public sector services and into policy domains where innovation co-exists with increased effectiveness and efficiency.

A key component in the SONNETS work plan is the identification and analysis of these emerging technologies and trends and the assessment of their innovation potential for the public sector. In this context, the SONNETS consortium has developed an innovative methodological framework that targets to support and accelerate the transformation of the public sector into an innovation breeding carrier (namely, the "SONNETS Innovation Identification Framework for The Public Sector"). The Framework encompasses in particular six logical steps or phases as follows:

    i) Needs Identification
    ii) Technology Identification
    iii) Technology Pre-selection and Analysis
    iv) Technology Assessment
    v) Innovation Potential Identification
    vi) Scenario Building
    vii) Results Validation

This document goes into detail for the ii-iii-iv phases. From a methodological point of view, "**Technology Identification**" (step (ii)) took place by means of desk-based research. "**Technology Pre-selection and Analysis**" on the other hand involved the organisation of a focus group with the members of the SONNETS Experts Committee and the conduction of interviews with IT experts. The analysis of the produced short list of technologies and trends took then place, leveraging both the materials collected through desk-based research, as well as side stream information, collected in the margin of interviews and focus groups/workshops. Finally, the "**Technology Assessment**" (step iv) process took place by additional rounds of desk-based research for each of the technologies and trends under investigation, extensive study of the materials collected, as well as brainstorming activities within the consortium.)

As a result of step ii, a long list of technologies and trends was elicited from the initial pool of material. This list was refined through step iii. Finally step iv aimed at supporting the conduction of an adapted SWOT analysis, which targeted on the one side to assess the impact of the identified technologies and trends in the domains originally met, and to point out, on the other, opportunities for their adoption, usage and promotion by the public sector as well as potentially involved challenges and threats. Additionally, these activities further targeted to support the interlinking of the identified technologies with specific needs and existing or new applications and services. In this respect, the SONNETS consortium also leveraged the judgements and the suggestions of the stakeholders involved during the interviews and the focus groups/local workshops already conducted.

From the analysis of all these sources and as indirect implication of the roadmap recommendations and technology maturity levels, it can be outlined that technology adoption and utilisation, especially in the case of the Public Sector, is highly related with a time horizon that demonstrates the maturity and

applicability of technologies over different domains. However when talking about the public sector it is imperative to understand that such innovations could only be realised and sustained if there exists a common and well defined technology uptake strategy that would make sure that mature technologies are already present in an organisation's body.

1 Introduction

1.1 Purpose and Scope

SONNETS is guided by the vision to provide the guidelines and a methodological process that will help to reshape and reform the public sector into a technology leader and innovation breeding carrier, playing a key role in technology development and showcasing. In this respect, the project targets the development of an ever-evolving methodological framework, backed up by an active community, driven forward by renowned experts and interested public sector officials and practitioners, for the rapid porting of emerging technologies into public sector services and into policy domains where innovation co-exists with increased effectiveness and efficiency. Thereby, a key component in the SONNETS work plan is the identification and analysis of emerging technologies and trends and the assessment of their innovation potential for the public sector. At this point, attention is drawn to the fact that in the context of the SONNETS project and the present deliverable, the terms "technologies" and trends refer exclusively to emerging ICTs and ICT trends respectively.

The present deliverable is released within the context of Work Package 3 "Identification of Emerging Technologies and Innovation Identification Framework" and is in particularly associated with Tasks 3.2 "Identification of emerging technologies" and 3.3 "Potential applications and services for the public sector". The former task deals with the sole identification and analysis of emerging technologies, whereas the latter attempts a more in-depth analysis of the impact and suitability of these technologies for the public sector. In particular, Task 3.2 targets the identification and analysis of emerging technology trends and ICTs that make a difference today in other domains and sectors and that could potentially be considered for adoption by the public sector as well, while Task 3.3, being also the core task of WP3, focuses on the application of the SONNETS Innovation Identification Framework (generated through Task 3.1) on the results of Task 3.2 and the insights related to societal challenges and needs, acquired within WP2. In this context, Task 3.3 attempts to identify:

- The impacts that emerging ICTs have in the domains that they originated from or to other domains applied.
- The relevance of these ICTs to the different policy domains and the public sector in general.
- The potential innovations that these technologies could bring in the public sector.
- A link between these ICTs and the needs of the public sector and of the society as well, by identifying what kind of applications or services could benefit from their adoption and further evolution under the public sectors' umbrella.

The present deliverable documents the outcomes of both the aforementioned tasks. An updated version of these outcomes, along with the updated and validated version of the SONNETS Innovation Identification framework are to be

provided in deliverable "D3.3 - Emerging ICTs and Innovation Potential for the Public Sector – Final Version" of WP3.

Overall, the present deliverable is intended to act as a handbook, providing an introduction to technologies and trends that could be useful for the public sector. The contents of the deliverable are expected to aspire as the creation of a knowledge base on technologies that could help the Public Sector innovate, and will be constantly updated during the course of the project though the establishment of an online infrastructure that will host the contents of this deliverable and will act as a "live" document.

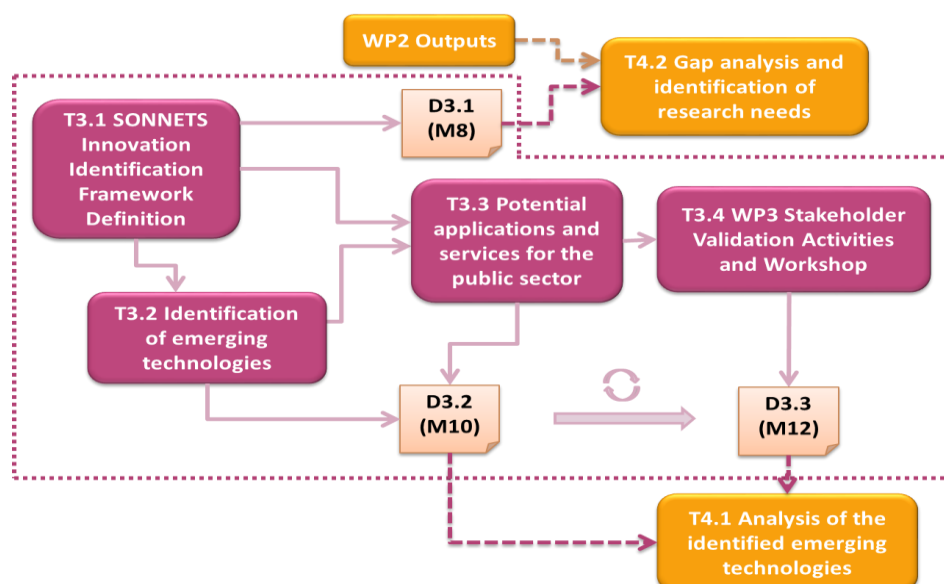## 1.2 Approach for the Work Package and Relation to Other Work Packages

Work package 3 concerns, as already explained in Section 1.1, the development of the Innovation Identification Framework, and the identification of emerging technologies. It is a component of the project, active from the start of SONNETS until M12 that enumerates four interdependent tasks and is intended to produce three deliverables, as illustrated in Figure 1.

Task 3.1 was the introductory task to WP3, and specified through deliverable D3.1 the activities to take place during the next tasks of the WP.

Tasks 3.2 and 3.3 are concerned with the actual identification of emerging technologies and their analysis and impact assessment respectively, with their outcomes being compiled in deliverable D3.2 (document at hand), which stands as the first version of the list of emerging technologies and applications that could prove useful for the public sector.

Finally, Task 3.4 pursues the validation and updating of these outcomes with the engagement of the targeted stakeholders, the results of this process being reported in deliverable D3.3.

Figure 1 below further illustrates Work Package 3 dependencies to the rest of SONNETS WPs. These include the use of deliverable D3.1, namely the Innovation Identification Framework as the means to couple WP2 and WP3 results both in the context of Task 3.3 on the identification of potential applications and services for the public sector and of their innovation potential for the latter, as well as within the frame of the gap analysis to be conducted in Task 4.2. They further include feeding Task 3.4 outputs, and thereby deliverable D3.3, to WP4 and its first task (Task 4.1) on the analysis of the most promising technologies.

Figure 1: WP3 structure and dependencies with other WPs/tasks

1.3 Structure of the Document

The rest of the document at hand is structured as follows:

- Section 2 pursues to create common grounds of understanding with regard to the contents of this deliverable. To this end, it provides definitions of key terms, i.e. "technology", "emerging technology", "technological trend", etc. It further exposes the steps and activities performed so far.

- Section 3 provides the list of emerging technologies and trends identified through desk-based research and refined by means of interviews with IT experts and workshops/focus groups.

- Section 4 aggregates the results of the analysis of the selected technologies and trends, while

- Section 5 presents accordingly the outcomes of their impact assessment.

- Section 6 showcases in a schematic fashion some of the results identified in the previous sectors.

- Finally, Section 7 summarises the contents of the deliverable and reports relevant conclusions.

- Appendix A incorporates the initial pool (long list) of technologies and

- Appendix B summarizes the results of the interviews conducted with IT experts by all partners of the SONNETS consortium.

2 Background

2.1 Introduction

This section attempts to create a common basis of understanding with regard to the work that is intended to be carried out within WP3 as well as with regard to the contents of this deliverable. Thus, is provides brief definitions or explanations of related concepts and terms, i.e. those of "technology", "emerging technology", "technological convergence", "technological trend", and "disruptive technology" and the debate that surrounds them.

2.2 Definitions

It is generally accepted that the term *technology* stands for the collection of techniques, skills, methods and processes used in the production of goods or services or in the accomplishment of objectives, such as those of scientific investigation. It can reflect both the knowledge of techniques, processes, etc., as well as be embedded in machines, computers, devices and factories, which can be operated by individuals without detailed knowledge of the workings of such things [1].

Being as broad, as to cover the conversion of natural resources into simple tools by the human species during the prehistoric times, discoveries, such as the printing press and the telephone in historic times, as well as more recent developments, such as the internet and mobile communications in modern times, the use of the term "technology" has changed significantly over the last 200 years.

Being basically associated to the description and study of the "useful arts" and craftsmanship [2], yet still uncommon at the dawn of the 20th century, the term rose to prominence in connection with the Second Industrial Revolution, to denote by the 1930s the study of industrial arts, but also the industrial arts themselves [3]. In 1937, the American sociologist Read Bain wrote that "technology includes all tools, machines, utensils, weapons, instruments, housing, clothing, communicating and transporting devices and the skills by which we produce and use them" [4]. Although, Bain's definition remains common among social scientists today, several definitions have emerged since then, each denoting technology in a different way. A typical definition is that provided by the Merriam-Webster Dictionary, which defines technology as "the practical application of knowledge especially in a particular area" and "a capability given by the practical application of knowledge" [5].

Technology can further be more broadly defined as the entities, both material and immaterial, created by the application of mental and physical effort in order to achieve some value. This definition of technology may well include simple tools, such as a crowbar or wooden spoon, and more complex machines, such as a space station or particle accelerator, whereas it reveals that tools may not necessarily be material [1].

The word "technology" can also be used to refer to a collection of techniques. In this context, it refers to the current state of humanity's knowledge of how to combine resources to produce desired products, to solve problems, fulfil needs, or satisfy wants, while it includes technical methods, skills, processes, techniques, tools and raw materials [1]. Especially, when combined with a specific scientific field, i.e. indicatively "information technology", the term reflects the state of the respective field's knowledge and tools.

What is important though is that technology can be viewed as an activity that forms or changes culture [6], yet not always in a positive way, thus rising philosophical debates over whether technology improves or worsens quality of life.

More recently coined terms are those of "emerging technology", "technological trend" and "disruptive technology". According to Wikipedia [7], an "emerging technology" is a technology that is perceived as capable of changing the status quo. Emerging technologies are characterised by radical novelty, relatively fast growth, coherence, prominent impact, and uncertainty and ambiguity. In fact, based on the more formal definition by Rotolo et al. [8], an emerging technology can be defined as *"a radically novel and relatively fast growing technology characterised by a certain degree of coherence persisting over time and with the potential to exert a considerable impact on the socio-economic domain(s) which is observed in terms of the composition of actors, institutions and patterns of interactions among those, along with the associated knowledge production processes. Its most prominent impact, however, lies in the future and so in the emergence phase is still somewhat uncertain and ambiguous"*.

The former definition becomes more comprehensible, if one considers the individual defining properties of emerging technologies, one by one. In this respect, *novelty*, the first defining attribute, may take the form of "discontinuous innovations derived from radical innovations" [9] and may appear either in the method or the function of the technology. Novelty is not only a characteristic of technologies deriving from technical revolutions, i.e. technologies with relatively limited prior developments, but it may also be generated by putting an existing technology into a new use. The evolutionary theory of technological change views this as the speciation process of technology that is the process of applying an existing technology from one domain to another domain or 'niche' [10], and implies thereby that 'evolutionary technology' (i.e. technology not characterised by revolutionary technical developments) can also be radically novel in domains of application, different from those where the technology was initially developed.

The second defining attribute of emerging technologies is that of *fast growth*. Growth may be observed against a number of dimensions, such as the number of actors involved (scientists, universities, firms, users), public and private funding, knowledge outputs produced (e.g. publications, patents), prototypes, products, services etc. [8].

On the other hand, the property of *coherence* pertains to the role of an expert community of practice that adopts and iterates the concepts or constructs underlying the specific emerging technology and suggests thereby that both a number of people and a professional connection between those people are

necessary [11]. This attribute further implies that the emerging technology must detach from its technological 'parents' to some degree to merit a separate identity and stay detached for some period of time to be seen as self-sustaining [8].

The fourth defining property pertains to the *considerable impact* that the emerging technology may exert by crosscutting multiple levels of socio-economic system, i.e. organisations and institutions, as well as knowledge production processes and technological regimes [12]. Such impact may be exerted on the entire socio-economic system, bringing the concept of emerging technologies very close to that of general purpose technologies, or may have a more narrow scope, i.e. be exerted in specific domains [8].

The final defining attribute of emerging technologies designates that the prominent impact of the former *lies somewhere in the future*. As a result, there may be *uncertainty* around the probabilities associated with each possible outcome (e.g. potential applications of the technology, financial support for its development, standards, production costs, etc.), i.e. around the potential that emerging technologies have for changing the existing 'ways of doing things' [13]. Additionally, *ambiguity* may be existent because proposed applications are still malleable, fluid and in some cases contradictory, or because social groups may hold diverging values and ascribe different meanings to the technology [14].

Based on the former definition, it can be assumed that the term refers basically to technologies that are new; yet it may include as well older technologies that are still controversial and undeveloped in potential. Emerging technologies enumerate indicatively nanotechnology, robotics, artificial intelligence, etc.

A technology may further be self-standing or result from the technological convergence of previously distinct fields, in view of evolving towards similar goals. The combination of voice and telephony features, data and productivity applications, and video, so that they share resources and interact with each other in order to create new efficiencies constitutes an indicative example of technological convergence. In the light of this distinction, emerging technologies reflect technical innovations which represent progressive developments within a field for competitive advantage [15], whereas converging technologies represent previously separate fields which are in some way moving towards stronger inter-connection and similar goals [7]. Whether emerging or converging, the degree of the impact, status and economic viability of a technology may vary.

Relevant to the notion of emerging technologies is also the term '*technological trend'*. In its series of reports, Gartner defines a strategic technology trend as one with the potential to have significant impact on an organisation in the short-term future [16]. According to the same source, factors that denote such significant impact include a high potential for disruption to the business, end users of IT, the need for major investment or the risk of being late to adopt. Although, to the knowledge of the SONNETS consortium, there is not a more formal definition of the term "technological trend", there is an intuitive perception that the term denotes practices of growing popularity that break new grounds for the use and application of emerging or well-established technologies. So, the difference

among emerging technologies and technological trends is subtle and frequently these two terms may get confused.

Last but not least, one should consider the notion of *disruptive technology*. The latter is one that displaces an established technology and shakes up the industry or a ground-breaking product that creates a completely new industry [17]. This term has been coined by Harvard Business School professor Clayton M. Christensen. In his best-selling book, "The Innovator's Dilemma," Christensen separates new technology into sustaining technology that relies on incremental improvements to an already established technology, and disruptive technology which in turn lacks refinement, often has performance problems because it is new, appeals to a limited audience, and may not yet have a proven practical application [18]. He even points out that large corporations are designed to work with sustaining technologies and have trouble capitalizing on the potential efficiencies, cost savings or new marketing opportunities created by low-margin disruptive technologies, so that it is not unusual for them to dismiss the value of a disruptive technology, as the latter does not reinforce current company goals, only to be blindsided as the technology matures, gains a larger audience and market share and threatens the status quo.
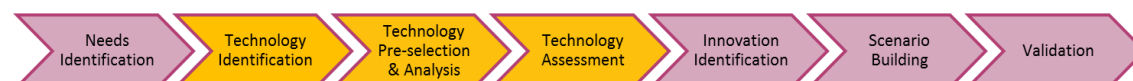
In the context of the SONNETS project, and more specifically in view of serving the vision of transforming the public sector into a technology leader and innovation breeding carrier, our interests focus exclusively on Information and Communication Technologies (ICT). In particular, under the umbrella of ICT, all emerging technology fields, disruptive technological innovations and strategic technological trends are equally considered, as long as they hold the potential to modernize the public sector and its constituent policy domains and to bring the latter at the forefront of technological developments.

2.3 D3.2 Methodology and Summary of WP3 Activities so far

The work presented in this deliverable complies with the guidelines set in D3.1, entitled "SONNETS Innovation Identification Framework for The Public Sector". The latter is an innovative methodological framework that targets to support and accelerate the transformation of the public sector into an innovation breeding carrier. In this respect, it emphasizes the role of Information and Communication Technology (ICT) as a key enabler for innovation and outlines the activities and steps required for coupling emerging ICTs and ICT trends with current societal and public sector needs. The Framework encompasses in particular six logical steps or phases as follows:

- viii)　　the identification of societal needs, societal and public sector trends/challenges *(Needs Identification)*
- ix) the identification of emerging technologies and trends that make a difference today in other sectors *(Technology Identification)*
- x) the selection of a subset of these technologies and trends, and the analysis of the latter in terms of their key characteristics and specificities (*Technology Pre-selection and Analysis)*
- xi) the assessment of these technologies in the domains originally met and their correlation to the public sector needs and societal challenges on the basis of existing services and applications, as well as new innovation

solutions that may benefit from these technologies *(Technology Assessment)*

xii) the evaluation of these services' and solutions' innovation potential in terms of both their impact and feasibility *(Innovation Potential Identification)*

xiii) the selection among the former, of those that make more sense to be ported to the public sector through the development of adequate scenarios *(Scenario Building)*

xiv) the evaluation and ratification of the overall findings *(Results Validation)*

Figure 2: SONNETS Innovation Identification Framework steps during D3.2

Given that the "Needs' Identification" (step (i)) outcomes have been covered in deliverable D2.1, the deliverable at hand summarizes the outcomes of steps (ii) to (iv) of the Framework, namely those of the "Technology Identification", "Technology Pre-selection and Analysis" and "Technology Assessment" activities.

From a methodological point of view, "Technology Identification" (step (ii)) took place by means of desk-based research. The latter followed in particular a crowdsourcing approach, involving both the SONNETS partners, as well as the members of the SONNETS Expert Committee, each of which placed effort on identifying and contributing a notable number of online resources and documents on emerging technologies and trends, towards the creation of a common knowledge base. In this context, preference was given to reports and testimonials, produced by reliable and credible sources (indicatively Gartner Hype Cycles, IDC, Forrester, Forbes, Deloitte, Accenture, etc. reports), whereas emphasis was also placed on the volume of materials, available on the web for each of the identified technologies / trends, in order to be able drive conclusions on the maturity and popularity of the related terms. A preliminary pool of technologies was generated as a result of this process, being referred to hereinafter as *SONNETS long list of technologies*. This list is presented in Appendix A of this document.

Technology Pre-selection and Analysis on the other hand involved the organisation of a focus group with the members of the SONNETS Experts Committee and the conduction of interviews with IT experts, which targeted the refinement of the initial long list of technologies, as well as another round of desk-based research which served the purpose of collecting more specific information on the identified technologies. More specifically, the members of the SONNETS Experts Committee came together in a technology-oriented session, which resulted in insights on technologies and trends that hold a high innovation potential for the public sector. Additionally, a total of 11 interviews with IT experts (see Appendix B) were performed following the interview guidelines set in D3.1, and allowing to complement and at the same time further refine the list of the identified technologies. The outcome of these activities, hereinafter being referred to as *SONNETS short list of technologies* (Table 2) is presented in Section 3 of the present document. It is worth noting that in view of the

refinement of the initial pool of technologies, the SONNETS consortium also took advantage of the local workshops, organized in the context of WP2 in order to maximise the input the consortium would be able to collect from the sample list of stakeholders.

The analysis of the produced short list of technologies and trends took then place, leveraging both the materials collected through desk-based research, as well as side stream information, collected in the margin of interviews and focus groups/workshops. The resulting materials are presented in Section 4 and can be considered and used as a _compendium of emerging technologies and trends_ for future reference.

Finally, the "Technology Assessment" process took place by additional rounds of desk-based research for each of the technologies and trends under investigation, extensive study of the materials collected, as well as brainstorming activities within the consortium. The latter aimed at supporting the conduction of an adapted SWOT analysis, which targeted on the one side to assess the impact of the identified technologies and trends in the domains originally met, and to point out, on the other, opportunities for their adoption, usage and promotion by the public sector as well as potentially involved challenges and threats. These activities further targeted to support the coupling of the identified technologies with specific needs and existing or new applications and services. In this respect, the SONNETS consortium also leveraged the judgements and the suggestions of the stakeholders involved during the interviews and the focus groups/local workshops already conducted. The outcomes of this step are accordingly presented in Section 5 of the document.

The pilot application of the Innovation Identification Framework for the Public Sector is going to be complemented by the activities of Innovation Potential Identification, Scenario Building and Results Validation, the outcomes of which are going to be covered in the context of deliverable D3.3 "Emerging ICTs and Innovation Potential for the Public Sector – Final Version".

3 List of Technologies and Trends

The list of technologies and trends presented in this section corresponds to the short list of technologies (Table 2 below), generated through step iii "Technology Pre-selection and Analysis" of the SONNETS Innovation Identification Framework methodology. It is a refined list of technologies that has been elicited from the initial pool of material, accumulated by means of desk-based research in the context of the Technology Identification step (step ii) of the methodology. It is worth noting that in view of the refinement of the initial pool of technologies, the consortium took advantage of the interviews with IT experts, as well as of focus groups with the members of the SONNETS Experts Committee and of local workshops, organized in the context of WP2. **Error! Reference source not found.** aggregates the entries of this list, classified under the categories of "trends" and "technologies". For the initial, long list of trends and technologies, the reader is prompted to Appendix A.

Trends	Technologies
API Economy	Artificial Intelligence
Crowdsourcing	Augmented Reality
Digitalization	Big Data
e-Participation	Biometrics
Gamification	Blockchain
Mobile Devices	Bots
Open Data	Cloud Computing
Open Government	Data Analytics
Personalization	e-Identities
Policy Making 2.0	e-Signatures
Sentiment Analysis	Geographical Information Systems
Smart Workplace	Internet of Things
Social Media	Machine Learning
	Natural Language Processing
	Wearables
	Virtual Reality

Table 2: Short List of Technologies and Trends

Each one of entries of Table 3 is analysed in the following sections as per the directions set in the context of steps iii) and iv) of the Innovation Identification Framework methodology.

4 Technologies and Trends Analysis

This section presents the results of the analysis performed in the context of step iii (Technology Pre-selection and Analysis) of the Innovation Identification Framework. The latter aims at recording basic information on the selected identified technologies and trends, in order to create a deeper understanding of their characteristics and specificities, and has taken advantage of the materials collected through both desk-based research, as well as of side stream information, collected in the margin of interviews and focus groups/workshops. The resulting materials can be considered and used as a compendium of emerging technologies and trends for future reference.

4.1 Aspects of Analysis

The analysis of each identified technology and trend, included in the SONNETS short list of emerging technologies includes several aspects, as follows:

- Identifier: a unique identifier that determines the particular technology (TE#x) or technological trend (TT#x) addressed.

- Type: an indication of whether a technology or trend is a self-standing one or has resulted from the technological convergence of other fields and which these fields are.

- Description: a brief description of the scope, aims and usage of the technology/ trend addressed.

- Mainstream Domains of Application: the application domains, in which a technology / trend is basically met.

- Related Market Potential / Forecasted Growth: quantitative (statistic) or qualitative information on the anticipated growth and spread of the technology / trend addressed or the potential and growth of the related market.

- Related Terms: a list of similar terms used to describe the particular technology / trend or to denote specific aspects of it, and that can be employed to collect further information.

- Source(s): a reference to the source(s) drawing attention to or pointing out the particular technology / trend as an important one for the years to come.

These aspects have been defined through brainstorming among the SONNETS consortium and discussions with the SONNETS Experts Committee.

4.2 Trends Analysis

4.2.1 API Economy

<table>
<tr><th colspan="2">API Economy</th></tr>
<tr><td>Identifier</td><td>TT#1</td></tr>
<tr><td>Type</td><td>Trend, based on engineering and software development advances.</td></tr>
<tr><td colspan="2">Description</td></tr>
<tr><td colspan="2">The API Economy refers to the trend of turning a business or organization into a platform by using Application Programming Interfaces (APIs) to integrate and connect people, places, systems, data, things and algorithms, create new user experiences, share data and information, authenticate people and things, enable transactions and algorithms, leverage third-party algorithms, and create new product/services and business models, thus positively affecting the organization's profitability[1]. An API is a set of subroutine definitions, protocols, and tools for building software and applications by abstracting the underlying implementation and only exposing objects or actions the developers need in order to reduce their cognitive load[2]. Essentially, an API is a customer interface for technology products that allows software components to communicate[3].</td></tr>
<tr><td>Mainstream Domains of Application</td><td>• Engineering / software development</td></tr>
<tr><td>Related Market Potential/Forecasted Growth</td><td>• The ProgrammableWeb directory of APIs reported that in 2015, 2,000 APIs were added to the site. This works out to around 40 APIs being added per week, and the total number of APIs represented on the directory currently stands at around 15,000. APIhound on the other hand estimates there are 50,000 public web APIs[4].
• The market for API management tools is still young. There is a need for more maturity in most of the offerings available in the market[5].</td></tr>
<tr><td>Related Terms</td><td>• Platform economy</td></tr>
</table>

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[1] Smarter with Gartner, Welcome to the API Economy,
http://www.gartner.com/smarterwithgartner/welcome-to-the-api-economy/

[2] Wikipedia - Application programming interface,
https://en.wikipedia.org/wiki/Application_programming_interface

[3] TechTarget, API economy (application programming interface economy),
http://searchsoa.techtarget.com/definition/API-economy-application-programming-interface-economy

[4] Nordic APIs, Tracking the Growth of the API Economy, http://nordicapis.com/tracking-the-growth-of-the-api-economy/

[5] ComputerWeekly.com – Clive Longbottom, The API economy – or the API Tower of Babel?,
http://www.computerweekly.com/feature/The-API-economy-or-the-API-Tower-of-Babel

API Economy
Source(s) of Documentation	API Economy appears among a series of eight current technology trends that will shape, according to Deloitte's report "Tech Trends 2015" the future of government[6].

4.2.2 Crowdsourcing

Crowdsourcing	
Identifier	TT#2
Type	Trend, based on the enabling technologies of the internet and social media.
Description	
Crowdsourcing, a combination of the words 'crowd' and 'outsourcing', is a specific sourcing model, which describes the processes for sourcing a task or challenge to a broad, distributed set of contributors using the Web and social collaboration techniques. It consists in obtaining needed services, ideas, or content by soliciting contributions from a large group of people, especially an online community, rather than from employees or suppliers. By definition, crowdsourcing combines the efforts of numerous self-selected volunteers or part-time workers; each person's contribution combines with those of others to achieve a cumulative result. Crowdsourcing applications typically include mechanisms to attract the desired participants, stimulate relevant contributions and select winning ideas or solutions[7],[8].	
Mainstream Domains of Application	- Competitions - Data gathering - Money raising - Business/Market research
Related Market Potential/Forecasted Growth	85% of the 2014 Best Global Brands have used crowdsourcing in the last ten years[9]. - The internet is the engine of the modern-day crowdsourcing platform. It provides both a broadcast mechanism for organisations to set or announce challenges and a network for connecting people and their diverse ideas, skill sets and knowledge. The number of internet users worldwide is growing

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[6] Deloitte (2015). Tech Trends 2015 - The fusion of business and IT: A public sector perspective, https://www2.deloitte.com/us/en/pages/public-sector/articles/tech-trends-2015-public-sector-perspective.html
[7] Wikipedia - Crowdsourcing, https://en.wikipedia.org/wiki/Crowdsourcing
[8] Gartner IT Glossary – Crowdsourcing, http://www.gartner.com/it-glossary/crowdsourcing/
[9] eYeka, The state of crowdsourcing in 2015, https://en.eyeka.com/resources/reports#CSreport2015

Crowdsourcing	
	exponentially, and has risen from just 414 million in 2000 to over 3.4 bn in 2016. At the current rate of growth, there will be approximately five bn internet users, and thus potential crowdsourcing workers by 2020[10].
Related Terms	- Citizensourcing - Crowdfunding - Crowdvoting - Crowdsolving - Crowdsearching - Mobile crowdsourcing - Macrowork - Microwork - Implicit crowdsourcing/ Passive crowdsourcing
Documentation Source(s) of	Gartner reports that by 2018, crowdsourcing will constitute 20% of all enterprise application development sourcing initiatives[11].

4.2.3 Digitalization

Digitalization	
Identifier	TT#3
Type	Trend, based on the advancements of digital technologies
Description	
	Digitalization is the use of digital technologies to change a business model and provide new revenue and value-producing opportunities; it is the process of moving to a digital business[12]. Digitalization is a sub-process of a much larger technological progress, involving digitization (the conversion), digitalization (the process) and digital transformation (the effect) that are collectively accelerating the global and societal transformation process. In this context, digitization represents the conversion of analog information into digital form that can be understood by computer systems or electronic devices, digitalization corresponds the process of the technologically-induced change, whereas digital transformation is described as the total and overall societal effect of digitalization[13]. In a narrower sense, digitalization as well as digital transformation may refer to the concept of "going paperless".

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[10] Deloitte, The three billion Enterprise crowdsourcing and the growing fragmentation of work, https://www2.deloitte.com/content/dam/Deloitte/us/Documents/strategy/us-cons-enterprise-crowdsourcing-and-growing-fragmentation-of-work.pdf

[11] Revolution IT, http://revolutionit.com.au/by-2018-crowdsourcing-will-constitute-20-of-all-enterprise-application-development-sourcing-initiatives-gartner/

[12] Gartner IT Glossary – Digitalization, http://www.gartner.com/it-glossary/digitalization/

Digitalization	
Mainstream Domains of Application	• Administrative processes • Research processes • Manufacturing processes
Related Market Potential/Forecasted Growth	• The 2016 CIO Agenda Survey data shows that digitalization is intensifying. In the next five years, CIOs expect digital revenues to grow from 16% to 37%. Similarly, public-sector CIOs predict a rise from 42% to 77% in digital processes[14].
Related Terms	• Digitization • Digital transformation • Paperless state
Source(s) of Documentation	• According to IDC, Digitalization is one of the 10 most needed CIO trends for 2015[15]. • *Interviews and focus groups*

4.2.4 e-Participation

e-Participation	
Identifier	TT#4
Type	Trend, based on the developments in CSCW (Computer Supported Cooperative Work) and groupware, e-democracy and e-government. It can be considered as part of e-democracy.
Description	

e-Participation refers to the ICT supported participation in processes involved in government and governance. Such processes may concern administration, service delivery, decision making and policy making. E-Participation is hence closely related to e-government and e-governance participation. According to a more detailed definition, e-

[13] Wikipedia – Digital transformation, https://en.wikipedia.org/wiki/Digital_transformation
[14] Gartner, (Gartner Executive Programs) Building the Digital Platform: Insights From the 2016 Gartner CIO Agenda Report, https://www.gartner.com/imagesrv/cio/pdf/cio_agenda_insights_2016.pdf
[15] ComputerWoche, Die wichtigsten IT-Trends 2015 von IDC, http://www.computerwoche.de/a/die-wichtigsten-it-trends-2015-von-idc,3090179

e-Participation
participation is the use of ICT to broaden and deepen political participation by enabling citizens to connect with one another and with their elected representatives[16]. E-Participation involves complex processes, as a result of the large number of different participation areas, involved stakeholders, levels of engagement, and stages in policy making, which characterize the research and applications[17].

Mainstream Domains of Application	Human ICT-mediated interaction, both work-related and social (supported by the use of CSCW and groupware)
Related Market Potential/Forecasted Growth	According to the UN e-Government Survey 2016[18]: • E-decision making, the most challenging aspect of public participation, rose substantially among the top 25 countries in EPI, from 36% in 2014 to 62% in 2016. • E-consultation has seen remarkable growth in 2016 topping 91% from 73% in 2014.
Related Terms	• e-Democracy • e-Consultations • e-Voting • e-Petitioning
Source(s) of Documentation	*Interviews and focus groups*

4.2.5 Gamification

Gamification	
Identifier	TT#5
Type	Trend, based on the use of game mechanics.
Description	

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[16] Macintosh, A. (2004), "Characterizing E-Participation in Policy-Making", In the Proceedings of the Thirty-Seventh Annual Hawaii International Conference on System Sciences (HICSS-37), January 5 – 8, 2004, Big Island, Hawaii.

[17] Wikipedia – e-Participation, https://en.wikipedia.org/wik i/E-participation#cite_note-1

[18] United Nations, UN E-Government Survey 2016, https://publicadministration.un.org/egovkb/en-us/Reports/UN-E-Government-Survey-2016

Gamification
Gamification is the use of game mechanics to drive engagement in non-game business scenarios and to change behaviours in a target audience to achieve business outcomes. Many types of games include game mechanics such as points, challenges, leaderboards, rules and incentives that make game-play enjoyable. Gamification applies these to motivate the audience to higher and more meaningful levels of engagement. Humans are "hard-wired" to enjoy games and have a natural tendency to interact more deeply in activities that are framed in a game construct[19].

Mainstream Domains of Application	• Marketing • Education
Related Market Potential/Forecasted Growth	• The global gamification market is expected to grow from 1.65 bn USD in 2015 to 11.10 bn USD by 2020, at a CAGR of 46.3%, because of increasing need of gamification solutions and applications in consumer and enterprise brands[20]. • In addition, gamification will be the primary mechanism that 40% of the Global 1000 organizations will employ to improve their business operations[21]. • According to MarketsandMarkets, the size of the global gamification market would be 5.5 bn USD by 2018[22].
Related Terms	• Serious Gaming • Edutainment • Gamelearn
Source(s) of Documentation	Gamification appears in Gartner's 2014 Hype Cycle for emerging technologies on Digital Marketing[23].

4.2.6 Mobile Devices

Mobile Devices	
Identifier	TT#6

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[19] Gartner IT Glossary – Gamification, http://www.gartner.com/it-glossary/gamification-2/

[20] Markets and markets (2016). Gamification Market - Global Forecast to 2020, http://www.marketsandmarkets.com/Market-Reports/gamification-market-991.html

[21] The Top Gamification Statistics And Facts For 2015 You Need To Know, https://elearningindustry.com/top-gamification-statistics-and-facts-for-2015

[22] pr web, Gamification Market is Estimated to Grow from USD 421.3 Million in 2013 to USD 5.502 Billion in 2018 – New Report by MarketsandMarkets, http://www.prweb.com/releases/gamification-market/07/prweb10893419.htm

[23] Gartner (2014). Gartner's 2014 Hype Cycle for Emerging Technologies Maps the Journey to Digital Business, http://www.gartner.com/newsroom/id/2819918

Mobile Devices	
Type	With more mobile-only internet users than desktop-only users, it is a sign that digital media is evolving towards "mobile first."
Description	
A *mobile device* (or handheld computer) is a small computing device, typically small enough to hold and operate in the hand and having an operating system, capable of running mobile apps. These may provide a diverse range of functions. Typically, the device will have a display screen with a small numeric or alphanumeric keyboard or a touchscreen providing a virtual keyboard and buttons (icons) on screen. Many mobile devices can connect to the internet and interconnect with other devices via Wi-Fi, Bluetooth or near field communication (NFC)[24].	
Mainstream Domains of Application	• Communications
Related Market Potential/Forecasted Growth	• According to Statista, the overall number of mobile phone users reached 4.43 bn in 2015. This number is expected to grow to 4.61 bn in 2016 and 4.77 bn in 2017. • According to StatCounter, 37% of website visits in 2015 were generated by mobile web browsers. • 87% of people always have their smartphone at their side[25].
Related Terms	• Handheld computer • Mobility
Source(s) of Documentation	*Interviews and focus groups*

4.2.7 Open Government

Open Government	
Identifier	TT#7
Type	Trend – the origins of open government arguments can be dated to the time of the European Enlightenment and debates about the proper construction of a then nascent democratic society.

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[24] Wikipedia – Mobile device, https://en.wikipedia.org/wiki/Mobile_device
[25] Device Atlas, 16 mobile market statistics you should know in 2016,
    https://deviceatlas.com/blog/16-mobile-market-statistics-you-should-know-2016

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Open Government	
Description	
Open Government stands for the governing doctrine which holds that citizens have the right to access the documents and proceedings of the government to allow for effective public scrutiny and oversight. In its recent development, it holds ties with the theory of open source governance, which advocates the application of the free software movement to democratic principles, enabling interested citizens to get more directly involved in the legislative process. Overall, Open Government is widely seen to be a key hallmark of contemporary democratic practice and is often linked to the passing of freedom of information legislation[26].	
Mainstream Domains of Application	• Freedom of the press • Freedom of information legislation
Related Market Potential/Forecasted Growth	• N/A
Related Terms	• Open source governance • Government 2.0 / Gov 2.0 • Participative Government
Source(s) of Documentation	• *Interviews and focus groups* • E-government policies across the world dictate the adoption of Gov 2.0 principles as key components of an open government. Notable examples include the *UK Digital Strategy* and the *EU Digital Agenda*. The *2009 US Open Government Directive* identifies "transparency, participation, and collaboration" as the key principles of an open government, and requires US agencies to, among other things, publish government information online, release high-value datasets in open formats on Data.gov, and create an Open Government website.

4.2.8 Open Data

Open Data	
Identifier	TT#8
Type	Trend, based on the advancements of networking technologies, enabling worldwide availability and distributed

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[26] Wikipedia – Open Government, https://en.wikipedia.org/wiki/Open_government

Open Data	
	process of scientific data in an open manner, making it available to everybody (but not always free to use)
Description	
The trend of *Open Data* pertains to the idea that data (especially that retrieved/generated through public funding and that which is important for the greater good) should be freely available to everyone to use and republish, without major restrictions from copyright, patents or other mechanisms of control[27]. The trend has gained popularity with the rise of the Internet and World Wide Web and, especially, with the launch of open-data government initiatives such as Data.gov and Data.gov.uk, and has many similarities with the Open Source software movement. The Open Data Charter, launched by the Open Government Partnership, in October 2015, prescribes six open data principles: 1. Open by Default, 2. Timely and Comprehensive, 3. Accessible and Usable, 4. Comparable and Interoperable, 5. For Improved Governance and Citizen Engagement, 6. For Inclusive Development and Innovation[28].	
Mainstream Domains of Application	Open access to scientific data. The concept of open access to scientific data was institutionally established with the formation of the World Data Center system, to minimize the risk of data loss and to maximize data accessibility[29].
Related Market Potential/Forecasted Growth	- For 2016, the direct market size of Open Data was expected to be 55.3 bn EUR for the EU 28+. Between 2016 and 2020, the market size will increase by 36.9%, to a value of 75.7 bn EUR in 2020, including inflation corrections. For the period 2016-2020, the cumulative direct market size is estimated at 325 bn EUR. - In 2016, there were 75,000 Open Data jobs within the EU 28+ private sector. By 2020, this number will increase to just under 100,000 Open Data jobs. - The accumulated cost savings for public administrations for the EU28+ in 2020 are forecasted to equal 1.7 bn EUR[30]. - Open data can help unlock $3 trillion to $5 trillion in economic value annually across seven sectors (Education, Transportation, Consumer products, Electricity, Oil and gas, Health care, Consumer finance)[31].

[27] Wikipedia – Open data, https://en.wikipedia.org/wiki/Open_data
[28] Open data Charter, http://opendatacharter.net/
[29] World Data Center System (18 September 2009). "About the World Data Center System". NOAA, National Geophysical Data Center.
[30] European Data Portal, Benefits of Open Data, https://www.europeandataportal.eu/en/using-data/benefits-of-open-data
[31] McKinsey Global Institute - James Manyika, Michael Chui, Diana Farrell, Steve Van Kuiken, Peter Groves, and Elizabeth Almasi Doshi, (October, 2013), Open data: Unlocking innovation and

Open Data	
Related Terms	• Open Government Data • Open Science Data • Open Knowledge • Linked Open Data
Source(s) of Documentation	• *Interviews* • Gartner recognizes Open Data Governance as key to building a smart city[32].

4.2.9 (Service) Personalization

Personalization	
Identifier	TT#9
Type	Trend, based on the continuous effort of software to adapt to the needs of its users and accommodate their most important needs, taking advantage of various personal data and preferences which are shared by individuals publicly in the Web2.0 or privately with the software system application.
Description	

Personalization, sometimes also referred to as advanced, user-centric customization, consists of tailoring a service or a product to accommodate specific individuals, sometimes tied to groups or segments of individuals, taking in most of the cases also the context in mind as well. A wide variety of organizations use personalization to improve customer satisfaction, digital sales conversion, marketing results, branding, and improved website metrics as well as for advertising. Personalization is a key element in social media and recommender systems[33].

In the public sector, personalization goes hand in hand with the provision of public services to citizens and businesses at the ultimate level of automation (Level #5 - Personalized Transaction)[34], where eGovernment systems are in a position to pre-fill fields of the service applications, as well as to recommend and suggest services which are of need to the applicant, based on various criteria and possible life events.

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performance with liquid information, http://www.mckinsey.com/business-functions/digital-mckinsey/our-insights/open-data-unlocking-innovation-and-performance-with-liquid-information

[32] Open Data Governance Is Key to Building a Smart City (3, September 2015), https://www.gartner.com/doc/3124418/open-data-governance-key-building

[33] Wikipedia – Personalization, https://en.wikipedia.org/wiki/Personalization

[34] Koussouris, S.; Tsitsanis, A.; Gionis, G.; Psarras, J. (2010). Designing Generic Municipal Services Process Models towards eGovernment Interoperability Infrastructures

Personalization	
Mainstream Domains of Application	• Web personalization • Customer satisfaction • Advertising • Marketing • Branding • Sales
Related Market Potential/Forecasted Growth	• N/A for services personalization, however market surveys suggest that personalization is a key driver in retail.
Related Terms	• Customization • Mass personalization • Adaptive hypermedia
Source(s) of Documentation	*Interviews*

4.2.10   Policy Making 2.0

Policy Making 2.0	
Identifier	TT#10
Type	Trend, based on the advances of relatively new information and communication technologies in the fields of visualization, modelling, simulation, opinion mining, etc. for supporting decision making in public policies.

Policy Making 2.0
Description
Policy Making 2.0, refers to the set of methodologies and technological solutions, aimed at innovating policy making. Its scope goes well beyond the "policy adoption" notion typical of eParticipation, and encompasses all phases of the policy cycle. The common denominator of the wide set of methodologies and sets it encompasses (e.g. agent-based models, systems thinking, social network analysis, big data analyses, persuasive technologies, etc.) is that they use technology in order to design more effective public policies and share a common approach in taking account and dealing with the full complexity of human nature. Overall, Policy Making 2.0 is a new term to express in more understandable terms the somehow technical notion of "ICT for governance and policy-modeling" and allows all stakeholders to participate to the decision making process[35].

Mainstream Domains of Application	• Policy Making
Related Market Potential/Forecasted Growth	There is no definite market for Policy Making 2.0, however the main technological building blocks of the trend show a significant increase in terms of their market. Indicatively: • Data visualization applications market 4.12 bn USD and is expected to reach 6.99 bn USD by 2020[36]. • Social Network Analytics are expected to grow to 5.4 bn USD by 2020 from 1.6 bn USD in 2015[37].
Related Terms	• Government 2.0 / Gov 2.0 • Open Government • eGovernment
Source(s) of Documentation	*Interviews*

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[35] CROSSOVER project, Policy-Making 2.0 – Definition, http://debategraph.org/Details.aspx?nid=228979

[36] Mordor Intelligence (2016). Data Visualization Applications Market - Future of Decision Making - Trends, Forecasts and the Challengers (2016 - 2021)

[37] MarketsandMarkets (2016). Social Media Analytics Market by Type, Applications (Customer Segmentation & Targeting, Multichannel Campaign Management, Competitor Benchmarking, Customer Behavioral Analysis, & Marketing Measurement), Vertical, Region - Global Forecast to 2020

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4.2.11   Sentiment Analysis

Sentiment Analysis	
Identifier	TT#11
Type	Trend, based on NLP, statistics, text analysis and computational linguistics, fuelled by the rise of social networks and blogs.
Description	
Sentiment Analysis (also known as *Opinion Mining*) refers to the use of natural language processing, statistics, text analysis and computational linguistics, to identify and extract subjective information in source materials. Sentiment analysis aims to determine the attitude of a speaker or a writer with respect to some topic or the overall contextual polarity of a document. The attitude may be his or her judgment or evaluation, affective state (that is to say, the emotional state of the author when writing), or the intended emotional communication (that is to say, the emotional effect the author wishes to have on the reader). In simple words, sentiment analysis is the process of computationally identifying and categorizing opinions expressed in a piece of text, especially in order to determine whether the writer's attitude towards a particular topic, product, etc. is positive, negative, or neutral[38],[39].	
Mainstream Domains of Application	- Marketing - Customer service
Related Market Potential/Forecasted Growth	The global text analytics market has a potential to reach 6.5 bn USD by 2020, registering a CAGR of 25.2% during 2014-2020[40].
Related Terms	- Opinion mining - Text analytics - Natural Language Processing (NLP)
Source(s) of Documentation	*Interviews*

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[38] The Algorithmia Guide to Sentiment Analysis, http://developers.algorithmia.com/guides/sentiment-analysis/

[39] Wikipedia-Sentiment analysis, https://en.wikipedia.org/wiki/Sentiment_analysis

[40] PR Newswire, Text Analytics Market is Expected to Reach USD 6.5 Billion by 2020 - Allied Market Research, http://www.prnewswire.com/news-releases/text-analytics-market-is-expected-to-reach-65-billion-by-2020---allied-market-research-288040851.html

4.2.12   Smart Workplace

Smart Workplace	
Identifier	TT#12
Type	Trend, powered by IoT technologies, automation and collaboration solutions.
Description	
A *Smart or High Performance Workplace* is a physical or virtual environment designed to make workers as effective as possible in supporting business goals and providing value. Such a workplace results from continually balancing investment in people, process, physical environment and technology, to measurably enhance the ability of workers to learn, discover, innovate, team and lead, and to achieve efficiency and financial benefit[41],[42].	
Mainstream Domains of Application	• Business sector
Related Market Potential/Forecasted Growth	• The total market size of the smart and connected offices market is expected to reach $43.31 bn by 2020 at an estimated CAGR of 10.70% from 2014 to 2020[43]. • More than 50% of all IoT devices will be used in workplace by 2021[44].
Related Terms	• Smart Workspace • Smart Office • Smart Workforce • Smart Collaboration • Remote Working • Internet of Things
Source(s) of Documentation	*Focus groups*

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[41] Gartner IT Glossary, High Performance Workplace, http://www.gartner.com/it-glossary/high-performance-workplace

[42] TechRepublic, Gartner Hype Cycle: Exploring the leading-edge technologies for a digital business, http://www.techrepublic.com/article/gartner-hype-cycle-exploring-the-leading-edge-technologies-for-a-digital-business/

[43] Markets and markets, "Smart Office / Smart Workplace Market - Global Forecast to 2020", http://www.marketsandmarkets.com/PressReleases/smart-connected-offices.asp

[44] Orbis Research, Global Smart Workplace Market 2016-2021 Research Study, https://www.linkedin.com/pulse/global-smart-workplace-market-2016-2021-research-study-simone-kendle

4.2.13   Social Networking

<table>
<tr><td colspan="2" align="center">Social Networking</td></tr>
<tr><td>Identifier</td><td>TT#13</td></tr>
<tr><td>Type</td><td>Trend, based on Web 2.0 technologies.</td></tr>
<tr><td colspan="2">Description</td></tr>
<tr><td colspan="2"><i>Social Networking</i> refers to act of establishing online many-to-many human connections for the purposes of sharing information with the network or subsets thereof[45], and is based on computer-mediated technologies that make up an online environment allowing the creation, consumption, promotion, distribution, discovery, and sharing of content (e.g. information, ideas, career interests and other forms of expression) via virtual communities and networks[46]. The common features of social networking applications or social media are that they are interactive web 2.0 internet based applications, involving the creation of service-specific user profiles and leveraging user-generated content, and facilitating the development of online social networks. Essentially, social media are web-based services that allow individuals construct a public or semi-public profile within a bounded system, articulate a list of other users with whom they share a connection, and view and traverse their list of connections and those made by others within the system[47].</td></tr>
<tr><td>Mainstream Domains of Application</td><td>

Internet Communication
Advertising, Marketing
Gaming
E-commerce

</td></tr>
<tr><td>Related Market Potential/Forecasted Growth</td><td>

Out of 3 bn internet users globally (nearly 45% of the world's population), 2.1 bn people have social media accounts and 1.7 bn people are active social media users[48].

</td></tr>
<tr><td>Related Terms</td><td>

Social media
Web 2.0

</td></tr>
<tr><td>Source(s) of Documentation</td><td><i>Interviews</i></td></tr>
</table>

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[45] Gartner IT Glossary – Social networking, http://www.gartner.com/it-glossary/social-networking/
[46] Gartner IT Glossary – Social Media, http://www.gartner.com/it-glossary/social-media/
[47] Wikipedia – Social media, https://en.wikipedia.org/wiki/Social_media
[48] Search Engine Journal, The Growth of Social Media v 3.0 [Infographic],
    https://www.searchenginejournal.com/growth-social-media-v-3-0-infographic/155115/

4.3 Technologies Analysis

4.3.1 Artificial Intelligence

Artificial Intelligence	
Identifier	TE#1
Type	Technology field that draws upon computer science, mathematics, psychology, linguistics, philosophy, neuroscience and artificial psychology.
Description	
Artificial Intelligence (AI) is intelligence exhibited by machines. In computer science, an "intelligent" machine is ideally a flexible rational agent that perceives its environment and takes actions that maximize its chance of success at some goal. Colloquially, the term "artificial intelligence" is applied when a machine mimics cognitive functions such as "learning" and problem solving[49]. From another point of view, artificial intelligence is the science of doing by computer the things that people can do and in contrast to normal hardware and software, enables a machine to perceive and respond to its changing environment[50].	
Mainstream Domains of Application	• Computer science (calculating machines intending to perform operations on concepts rather than numbers, expert systems, data mining, search engines, image recognition, spam filtering) • Healthcare industry (medical diagnosis) • Automotive industry (self-driving vehicles) • Logistics
Related Market Potential/Forecasted Growth	• The overall artificial intelligence market is expected to be worth 16.06 bn USD by 2022, growing at a CAGR of 62.9% from 2016 to 2022[51]. • Global Intelligent virtual assistant Market was valued at 579.7 m USD in 2014 and is forecast to grow at a CAGR of 31.8% from 2015 to 2022[52]. • The Intelligent Virtual Assistant (IVA) market size was 750 m USDin 2015. The IVA market is expected to witness a substantial growth over the forecast period, owing to the rising adoption across several applications including BFSI, healthcare and automotive[53].

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[49] Wikipedia – Artificial intelligence, https://en.wikipedia.org/wiki/Artificial_intelligence
[50] World Economic Forum, Top 10 emerging technologies of 2015, https://www.weforum.org/agenda/2015/03/top-10-emerging-technologies-of-2015-2/#emergent-ai

Artificial Intelligence	
Related Terms	• Machine Intelligence • Smart Machines • Machine Learning • Autonomic Computing • Cognitive Computing • Autonomous Agents • Software Agents • Intelligent Personal Assistants (IPAs) • Virtual Personal Assistants (VPAs) • Bots • Chatbots / Chatterbots • Cognitive Expert Advisors
Source(s) of Documentation	Smart Machines appear in Gartner's "Top 10 Strategic Technology Trends for 2015"[54], whereas Emergent Artificial Intelligence is considered among the list of the top 10 emerging technologies of 2015, compiled by the World Economic Forum's Meta-Council on Emerging Technologies[55].

4.3.2 Augmented Reality

Augmented Reality	
Identifier	TE#2
Type	Technology, based on the advancements of computer vision and object recognition.
Description	
	Augmented Reality (AR) is the real-time use of information in the form of text, graphics, audio, video, GPS data and other virtual enhancements integrated with real-world objects, whose elements are thus augmented[56]. It is this "real world" element that differentiates AR from virtual reality, which in contrast replaces the real world with a simulated one. Augmentation is conventionally in real time and in semantic context with

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[51] Markets and markets, "Artificial Intelligence Market - Global Forecast to 2022", http://www.marketsandmarkets.com/PressReleases/artificial-intelligence.asp%20.asp

[52] Intelligent Virtual Assistant Market - Global Industry Analysis, Size, Share, Growth, Trends and Forecast 2015 – 2022, https://www.marketresearchengine.com/reportdetails/intelligent-virtual-assistant-market

[53] Grand View Research, Intelligent Virtual Assistant (IVA) Market Analysis - Forecasts To 2024, http://www.grandviewresearch.com/industry-analysis/intelligent-virtual-assistant-industry

[54] Gartner, Gartner Identifies the Top 10 Strategic Technology Trends for 2015 (Press Release), http://www.gartner.com/newsroom/id/2867917

[55] World Economic Forum, Top 10 emerging technologies of 2015, https://www.weforum.org/agenda/2015/03/top-10-emerging-technologies-of-2015-2/

[56] Gartner IT Glossary – Augmented reality (AR), http://www.gartner.com/it-glossary/augmented-reality-ar/

Augmented Reality	
environmental elements. With the help of advanced AR technology, the information about the surrounding real world of the user becomes interactive and digitally responsive. Information about the environment and its objects is overlaid on the real world. This information can be virtual or real. Overall, AR brings out the components of the digital world into a person's perceived real world and enhances one's perception of reality[57].	
Mainstream Domains of Application	- Military and Defence - Navigation - Architecture - Archaeology - Commerce (Marketing) - Video games - Industrial design - Spatial immersion - Workplace - Tourism & sightseeing
Related Market Potential/Forecasted Growth	- The global augmented reality market is expected to reach USD 117.40 bn by 2022, at a CAGR of 75.72% between 2016 and 2022[58]. - Augmented Reality (AR) Market size was over USD 2 bn in 2015, and is expected to grow at 75% CAGR from 2016 to 2024 to exceed USD 175 bn by 2024. Growing demand of in healthcare, architecture, e-commerce and retail sectors will drive revenue in the coming years[59].
Related Terms	- Mediated Reality - Mixed Reality
Source(s) of Documentation	Augmented Reality appears in Gartner's Hype Cycle for Emerging Technologies, 2015 (Sliding Into the Trough)[60], whereas it is considered, according to Deloitte's Tech Trends 2016 Report, as one of the eight trends that are likely to disrupt businesses in the months to come[61]. It further shows up in the list of the top 9 technology trends for 2016, compiled by the IEEE Computer Society[62].

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[57] Wikipedia – Augmented reality, https://en.wikipedia.org/wiki/Augmented_reality

[58] Markets and markets, "Augmented Reality and Virtual Reality Market - Global Forecast to 2022", http://www.marketsandmarkets.com/PressReleases/augmented-reality-virtual-reality.asp

[59] Global Market Insights - Augmented Reality (AR) Market Size, Industry Analysis Report, Regional Outlook, Application Development Potential, Price Trend, Competitive Market Share & Forecast, 2016 – 2024, https://www.gminsights.com/industry-analysis/augmented-reality-ar-market

[60] Gartner (2015). Hype Cycle for Emerging Technologies, 2015, https://www.gartner.com/doc/3100227

[61] Deloitte (2016). Tech Trends 2016, https://www2.deloitte.com/global/en/pages/technology/articles/tech-trends.html

[62] Computing Now (IEEE Computer Society), Top Technology Trends for 2016 https://www.computer.org/web/computingnow/trends/Top-Technology-Trends-2016

4.3.3 Big Data

<table>
<tr><td colspan="2" align="center">Big Data</td></tr>
<tr><td>Identifier</td><td>TE#3</td></tr>
<tr><td>Type</td><td>Technology, resulting from the advances in data storage and computation.</td></tr>
<tr><td colspan="2">Description</td></tr>
<tr><td colspan="2">

Big Data is a term for data sets with sizes and complexity beyond the ability of commonly used software tools to capture, curate, manage and process data within a tolerable elapsed time.

According to Gartner's definition, Big data is high volume, high velocity, and/or high variety information assets that demand cost-effective, innovative forms of information processing that enable enhanced insight, decision making, and process automation[63]. That definition, which includes the 3Vs (Volume, Velocity, Variety) has been recently complemented to include also Value of data as well as Veracity, coining in this manner a 5V Big Data definition.

The term often refers simply to the use of Big Data Analytics to collect, organize and analyze large sets of data to discover hidden patterns, unknown correlations and other useful information[64].

</td></tr>
<tr><td>Mainstream Domains of Application</td><td>

- Science
- Social media
- Manufacturing
- Health
- Education
- Government

</td></tr>
<tr><td>Related Market Potential/Forecasted Growth</td><td>

- The big data market is expected to grow from USD 28.65 bn in 2016 to USD 66.79 bn by 2021, at a high Compound Annual Growth Rate (CAGR) of 18.45%[65].
- Big Data investments are further expected to grow at a CAGR of 12% over the next four years, eventually accounting for over $72 bn by the end of 2020[66].
- The global big data market will grow from $18.3B in 2014 to $92.2B by 2026, representing a compound annual growth rate of 14.4 percent. Wikibon predicts

</td></tr>
</table>

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[63] Gartner IT Glossary – Big Data, http://www.gartner.com/it-glossary/big-data/
[64] Wikipedia – Big data, https://en.wikipedia.org/wiki/Big_data
[65] Markets and markets (2016). Big Data Market - Global Forecast to 2021, http://www.marketsandmarkets.com/Market-Reports/big-data-market-1068.html?gclid=Cj0KEQiA9ZXBBRC29cPdu7yuvrQBEiQAhyQZ9BzTre7Kfv-tiUd1bnaWxmjtMD6L0S-obB5kWqb0W78aAvYR8P8HAQ
[66] Reportlinker, The Big Data Market: 2016 - 2030 - Opportunities, Challenges, Strategies, Industry Verticals and Forecasts, http://www.reportlinker.com/p03895289-summary/The-Big-Data-Market-Opportunities-Challenges-Strategies-Industry-Verticals-and-Forecasts.html

Big Data	
	significant growth in all four sub-segments of big data software through 2026. Data management (14% CAGR), core technologies such as Hadoop, Spark and streaming analytics (24% CAGR), databases (18% CAGR) and big data applications, analytics and tools (23% CAGR) are the four fastest growing sub-segments according to Wikibon[67]. • International Data Corporation (IDC) predicts that worldwide revenues from the sales of big data and business analytics applications, tools, and services will grow from nearly $122 bn in 2015 to more than $187 bn in 2019, marking an increase of more than 50% over the five-year forecast period[68]. • The global business intelligence and analytics software market is expected to increase from $17.9B in 2014 to $26.78B in 2019, attaining a CAGR of 8.4%[69].
Related Terms	• Big Data Analytics • Big Data Computing • Big Data Infrastructure • Big Data Value Chains • Descriptive/Predictive/Prescriptive Analytics • Business Intelligence
Source(s) of Documentation	Big Data appears in Gartner's Hype Cycle for the Internet of Things, 2015 (Sliding Into the Trough)[70]. Big Data and Analytics further appear in IEEE CS 2022 Report as one of the 23 potential technologies that could change the landscape of computer science and industry by the year 2022[71].

4.3.4 Biometrics

Biometrics	
Identifier	TE#4
Type	Self-standing technology field.

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[67] Wikibon forecasts Big Data market to hit USD 92.2B by 2026, http://siliconangle.com/blog/2016/03/30/wikibon-forecasts-big-data-market-to-hit-92-2bn-by-2026/

[68] IDC, Worldwide Big Data and Business Analytics Revenues Forecast to Reach USD 187 Billion in 2019, According to IDC (Press Release), https://www.idc.com/getdoc.jsp?containerId=prUS41306516

[69] Blog post on Marketresearch.com, The Business Intelligence and Analytics Software Market, http://blog.marketresearch.com/the-business-intelligence-and-analytics-software-market

[70] Gartner (2015). Hype Cycle for the Internet of Things, 2015, https://www.gartner.com/doc/3098434

[71] IEEE, IEEE CS 2022 Report, https://www.computer.org/cms/Computer.org/ComputingNow/2022Report.pdf#page=5

Biometrics
Description

Biometrics as a characteristic is a measurable biological and behavioral characteristic that can be used for automated recognition and as a process it encompasses automated methods of recognizing an individual based on measurable biological and behavioral characteristics[72]. Biometric identifiers are often categorized as physiological and behavioral characteristics, where the former are related to the shape of the body (fingerprint, palm veins, face recognition, DNA, palm print, hand geometry, iris recognition, retina, odour/scent, etc.), while the latter are related to the pattern of behavior of a person (e.g. typing rhythm, gait, voice, etc.).

Biometrics authentication (or realistic authentication) is used in computer science as a form of identification and access control[73]. Biometric authentication methods use biometric characteristics or traits to verify users' claimed identities when users access endpoint devices, networks, networked applications or Web applications[74].

Mainstream Domains of Application	• Military and Defence • Forensics (Criminal Identification and Prison Security) • Safety and Security • Travel and Immigration • Banking and Finance
Related Market Potential/Forecasted Growth	• The next generation biometrics market is expected to reach $24,448.84 Million by 2020, growing at a CAGR of 17.9% between 2015 and 2020[75]. • The biometric system market size is expected to increase from USD 10.74 bnbn in 2015 to USD 32.73 bn by 2022, at a CAGR of 16.79% between 2016 and 2022[76]. • Biometrics Market size was USD 9.58 bn in 2015, and is forecast to surpass USD 31 bn by 2023, with 16.1% CAGR from 2016 to 2023[77]. • Tractica forecasts that the global biometrics market will increase from $2.0 bn in 2015 to $14.9 bn by 2024, with cumulative revenue for the 10-year period totaling $67.8 bn[78].

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[72] Mordor Intelligence, Global Next Generation Biometric Market - By Type, By Technology, End User Industry, Vendors and Geography Market Shares, Forecasts and Trends (2015-2020), https://www.mordorintelligence.com/industry-reports/next-generation-biometric-market-industry?gclid=CjwKEAiAgavBBRCA7ZbggrLSkUcSJACWDexAp3Ow-UWL-2Del_XtWHDGuI5wOyEYtVPH7AkzfVeKqBoCVcTw_wcB

[73] Wikipedia – Biometrics, https://en.wikipedia.org/wiki/Biometrics

[74] Gartner IT Glossary – Biometric Authentication, http://www.gartner.com/it-glossary/biometric-authentication/

[75] Markets and markets, Biometric System Market - Global Forecast to 2020, http://www.marketsandmarkets.com/PressReleases/biometric-technologies.asp

[76] Markets and markets, Biometric System Market - Global Forecast to 2022, http://www.marketsandmarkets.com/PressReleases/biometric-technologies.asp

[77] Global Market Insights, Biometrics Market Size, 2016 – 2023, https://www.gminsights.com/industry-analysis/biometrics-market

[78] Tractica, Biometrics Market Forecasts, https://www.tractica.com/research/biometrics-market-forecasts/

Biometrics	
	• Juniper Research Ltd. predicts that in 2019, apps with biometric authentication capability will rise to 770 million[79].
Related Terms	• Behaviometrics • Biometric Authentication • Realistic Authentication • Biometric Verification • Face Recognition • Fingerprint Recognition • Iris Recognition • Palm Recognition • Voice Recognition
Source(s) of Documentation	• As per Gartner, 30 Percent of Organizations Will Use Biometric Authentication for Mobile Devices by 2016[80]. • *Interviews*

4.3.5 Blockchain

Blockchain	
Identifier	TE#5
Type	Software technology for financial transactions, based on distributed database advances.
Description	

Blockchain is a peer to peer software technology that protects the integrity of a digital piece of information[81]. It is a type of distributed ledger or database in which value exchange transactions (in bitcoin or other token) are sequentially grouped into blocks. Each block contains a timestamp and is chained to the previous block and immutably recorded across a peer-to-peer network, using cryptographic trust and assurance mechanisms[82]. The data in a block cannot be altered retrospectively.

Though originally invented to create the alternative currency titled "Bitcoin", blockchainblockchain may be used for other cryptocurrencies as well, as the digital ledger underpinning them[83]. In fact, not only information, but anything of value - money,

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[79] 20 Reasons To Choose Biometrics Technology For Your Business | Advantages Of Biometricshttp://authenticid.co/blog/2015/01/31/20-advantages-of-biometrics-technology-for-your-business/

[80] Gartner Newsroom (February 4, 2014), http://www.gartner.com/newsroom/id/2661115

[81] MinuteVideos, Blockchain Introduction, http://minutevideos.com/project/blockchain-introduction-mgm0hv8m/pub?gclid=Cj0KEQjw3ZS-BRD1xu3qw8uS2s4BEiQA2bcfM3wG0lOXHXvCkQoPLy_xlLri5C9IrHMm1THERDyG34MaAizX8P8HAQ

[82] Gartner IT Glossary – Blockchain, http://www.gartner.com/it-glossary/blockchain

[83] CIO, 4 emerging technologies that will drive digital businesses, http://www.cio.com/article/3044067/leadership-management/4-emerging-technologies-that-will-drive-digital-businesses.html

Blockchain	
titles, signatures, deeds, music, art, scientific discoveries, intellectual property, and even votes – can be moved and stored securely and privately.	
Mainstream Domains of Application	• Digital transactions processing (underpinning digital currency) • Royalty collection and management of copyrights in music industry • Insurance industry (peer-to-peer insurance, parametric insurance and microinsurance) • Smart contracts (software programs that self-execute complex instructions)
Related Market Potential/Forecasted Growth	• The blockchain technology market is estimated to grow from USD 210.2 Million in 2016 to USD 2,312.5 Million by 2021, at a Compound Annual Growth Rate (CAGR) of 61.5%[84].
Related Terms	• Cryptocurrency
Source(s) of Documentation	Blockchain appears, according to Deloitte's Tech Trends 2016 Report, as one of the eight trends that are likely to disrupt businesses in the months to come[85].

4.3.6 Bots

Bots	
Identifier	TE#6
Type	Trend, based on the advancements of Artificial Intelligence and of the WWW.
Description	

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[84] Markets and markets, Blockchain Technology Market - Global Forecast to 2021, http://www.marketsandmarkets.com/Market-Reports/blockchain-technology-market-90100890.html
[85] Deloitte (2016). Tech Trends 2016, https://www2.deloitte.com/global/en/pages/technology/articles/tech-trends.html

Bots
A *Bot* (short for "robot" and often referred as "Internet bot" or "chat bot") is a program that operates as an agent for a user or another program or simulates a human activity[86]. It is a software application that is designed to automate tasks one would usually do on their own, like making a dinner reservation, adding an appointment to their calendar or fetching and displaying information. Typically, bots perform tasks that are both simple and structurally repetitive, at a much higher rate than would be possible for a human alone[87]. The increasingly common form of bots, chatbots, simulate conversation. They often live inside messaging apps — or are at least designed to look that way — and it should feel like one is chatting back and forth as one would with a human[88].

Mainstream Domains of Application	• Communication / messaging • Gaming • Commercial use
Related Market Potential/Forecasted Growth	• Botego CEO predicts 2017 will be the year of the bots with $2 bn market size[89].
Related Terms	• Software robots • Chatbots • Internet bots / Web bots / WWW bots
Source(s) of Documentation	• *Interviews* • Smart robots appear in Gartner's Hype Cycle for Emerging Technologies, 2015 (On the Rise)[90]. Bots are also considered, according to Harvard Business Review, as one of the eight Tech Trends to Watch in 2016[91].

4.3.7 Cloud Computing

Cloud Computing	
Identifier	TE#7

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[86] TechTarget - bot (robot), http://searchsoa.techtarget.com/definition/bot
[87] Wikipedia – Internet bot, https://en.wikipedia.org/wiki/Internet_bot
[88] recode - Bots, explained, http://www.recode.net/2016/4/11/11586022/what-are-bots
[89] PR Newswire - Botego CEO predicts 2017 will be the year of the bots with $USD 2 billion market size, http://www.prnewswire.com/news-releases/botego-ceo-predicts-2017-will-be-the-year-of-the-bots-with-2-billion-market-size-300243119.html
[90] Gartner (2015). Hype Cycle for Emerging Technologies, 2015, https://www.gartner.com/doc/3100227
[91] Amy Webb (Harvard Business Review), 8 Tech Trends to Watch in 2016, https://hbr.org/2015/12/8-tech-trends-to-watch-in-2016

Cloud Computing	
Type	Mainly based on the enabling technology of virtualization (datacentre scale virtualization of computing resources) and the Service-oriented Architecture (SOA) paradigm.
Description	

Cloud Computing is a style of computing in which scalable and elastic IT-enabled capabilities are delivered as a service using Internet technologies[92]. It refers to the practice of using a network of remote servers hosted on the Internet to store, manage, and process data, rather than a local server or a personal computer. It is a type of internet-based computing and a model for enabling ubiquitous, on-demand access to a shared pool of configurable computing resources (e.g., computer networks, servers, storage, applications and services) which can be rapidly provisioned and released with minimal management effort.

Cloud Computing and storage solutions provide users and enterprises with various capabilities to store and process their data in third-party data centers that may be located far from the user – ranging from across a city to across the world. Cloud computing relies on sharing of resources to achieve coherence and economy of scale, similar to a utility (like the electricity grid) over an electricity network. It provides users with access to an integrated set of IT solutions, including the Applications (SaaS), Platform (PaaS), and Infrastructure (IaaS) layers[93].

In a cloud computing environment, end users can choose their devices, applications and services, synchronize content and application state across multiple devices and address application portability across devices[94].

Mainstream Domains of Application	• Telecommunications - Telecommunications companies offering virtual private network (VPN) services with comparable quality of service as dedicated point-to-point data circuits but at a lower cost. • NASA's OpenNebula was the first open-source software for deploying private and hybrid clouds, and for the federation of clouds.
Related Market Potential/Forecasted Growth	• IDC predicts external cloud adoption will increase from 22% today to 32.1% in 24 months achieving 45.8% growth[95]. • The worldwide cloud computing market grew 28% to $110B in revenues in 2015[96]. • IDC predicts cloud IT infrastructure spending will grow at

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[92] Gartner IT Glossary – Cloud Computing, http://www.gartner.com/it-glossary/cloud-computing/
[93] Wikipedia – Cloud Computing, https://en.wikipedia.org/wiki/Cloud_computing
[94] Gartner, Gartner Identifies the Top 10 Strategic Technology Trends for 2015 (Press Release), http://www.gartner.com/newsroom/id/2867917
[95] IDC, IDC's Latest CloudView Multiclient Study Reveals Attitudes and Strategies of the 58% of Organizations Embracing Cloud, February 26, 2016 (Press Release), http://www.idc.com/getdoc.jsp?containerId=prUS41039416
[96] Synergy Research Group (January 7, 2016), 2015 Review Shows USD 110 billion Cloud Market Growing at 28% Annually, https://www.srgresearch.com/articles/2015-review-shows-110-billion-cloud-market-growing-28-annually

Cloud Computing
<table><tr><td></td><td>CAGR of 15.1% from 2014 to 2019, reaching $53.1B bn by 2019[97]. • Worldwide spending on public cloud services will grow at a 19.4% compound annual growth rate (CAGR) from nearly $70B in 2015 to more than $141B in 2019[98]. • TBR predicts worldwide public cloud revenue will increase from $80B in 2015 to $167B in 2020[99].</td></tr></table>

Related Terms	Related terms: • Private/Community/Public/Hybrid Cloud • Software as a Service (SaaS), Platform as a Service (PaaS), Infrastructure as a Service (IaaS Shares characteristics with: • Client Computing (Client-server model) • Distributed Computing • Edge Computing • Fog Computing • Grid Computing
Source(s) of Documentation	Cloud Computing appears in Gartner's "Top 10 Strategic Technology Trends for 2015"[100], as well as in IEEE CS 2022 Report as one of the 23 potential technologies that could change the landscape of computer science and industry by the year 2022[101].

4.3.8 e-Identities

e-Identities	
Identifier	TE#9
Type	Technology, based on smart cards, RFID and recently biometrics.
Description	

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[97] IDC, IDC Forecasts Worldwide Cloud IT Infrastructure Market to Grow 24% Year Over Year in 2015, Driven by Public Cloud Datacenter Expansion, http://www.idc.com/getdoc.jsp?containerId=prUS25946315

[98] IDC, Worldwide Public Cloud Services Spending Forecast to Double by 2019, According to IDC (Press Release), https://www.idc.com/getdoc.jsp?containerId=prUS40960516

[99] TBR, Soaring Toward USD 167B: TBR Projects Key Trends in Cloud

[100] Gartner, Gartner Identifies the Top 10 Strategic Technology Trends for 2015 (Press Release), http://www.gartner.com/newsroom/id/2867917

[101] IEEE, IEEE CS 2022 Report, https://www.computer.org/cms/Computer.org/ComputingNow/2022Report.pdf#page=5

e-Identities

An *e-Identity* or *Electronic Identity* is a means for people to prove electronically that they are who they say they are and thus gain access to benefits or services provided by government authorities, banks or other companies[102].

One form of Electronic Identification (eID) is an electronic identification card (eIC), which is a physical identity card that can be used for online and offline personal identification or authentication. The eIC is a smartcard in ID-1 format of a regular bank card, with identity information printed on the surface (such as personal details and a photograph) and in an embedded RFID microchip, similar to that in biometric passports. The chip stores the information printed on the card (such as the holder's name and date of birth) and the holder's biometric photo. It may also store the holder's fingerprints. The card may be used for online authentication, such as for age verification or for e-government applications. An electronic signature, provided by a private company, may also be stored on the chip. Apart from online authentication, an eIC may also provide users the option to sign electronic documents with a digital signature (e-signature)[103].

Mainstream Domains of Application	• Financial Sector (Banking and Financial Transactions) • Military and Defence (Access and Control) • Business Sector (Access and Control) • E-Government (Access and Control)
Related Market Potential/Forecasted Growth	According to "The Global National eID Industry Report: 2014 Edition" by Aquity[104]: • 127 countries will implement National eID programs by 2018 issuing more than 740 million eIDs annually while generating more than \$55 bn in revenue from 2013 to 2018. • By 2018, the number of National eID issuing countries will exceed those issuing traditional National IDs by a ratio of more than 5 to 1. This rapid acceleration in the deployment of National eIDs means that by the end of 2018, 84% of all National IDs issued will be eIDs and that there will be nearly 3.5 bn National eIDs in circulation. • Shipments of electronic government (e-government) credentials – including e-passports, e-identity cards, e-health cards and e-driving licenses and others are projected to reach 1 bn in 2020, nearly doubling 2015 volume[105]. • The global market for Personal ID credentials was valued

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[102] European Commission, Electronic Identities – a brief introduction, http://ec.europa.eu/information_society/activities/ict_psp/documents/eid_introduction.pdf

[103] https://en.wikipedia.org/wiki/Electronic_identification

[104] Acuity Market Intelligence, The Global National eID Industry Report: 2014 Edition, http://www.acuity-mi.com/GNeID_Report.php#sthash.BLADol5k.dpuf

[105] HIS Markit, Don Tait (SeptemberSeptember 27, 2016). Shipments of cards for eGovernment to reach 1 billion units in 2020, https://technology.ihs.com/583936/shipments-of-cards-for-egovernment-to-reach-1-billion-units-in-2020

e-Identities	
	at \$5.3 bn in 2009, and is forecast to reach \$9.1 bn by 2019. This increase equals a global compound annual growth rate (CAGR) over the 10 years of 5.6%, with a CAGR of 2.6% for the period 2014-19 as investments shift to digital identity [106].
Related Terms	• Electronic Identity • Electronic Identification (eID)
Source(s) of Documentation	• eID especially as a means of citizen's identification towards the Public Sector is identified as one of the key top-10 technology strategies.[107]. • *Interviews*

4.3.9 Data Analytics

Data Analytics	
Identifier	TE#8
Type	Software technology, relying on the most current methods in computer science, statistics, and mathematics.
Description	

Data Analytics refers to the discovery, interpretation, and communication of meaningful patterns in data, based on the simultaneous application of statistics, computer programming and operations research to quantify performance. It further often favoursfavours data visualization to communicate insight. The goal of Data Analytics (big and small) is to get actionable insights resulting in smarter decisions and better business outcomes[108]. Data Analytics can be descriptive (explaining in more detail a phenomenon which is represented with data), predictive (trying to forecast the future behaviour of a system for which past and present data is available) or prescriptive (targeting the prediction of the impact of the behaviour of a system in a future scenario)).

Data analytics are closely related with Big Data, as the advert of the latter propelled the rapid development of novel analytics methods, capable of handling bigger data loads and of providing more evidence-based results with less uncertainty due to the bigger data samples available.

Mainstream Domains of Application	• Marketing (marketing optimization, digital analytics) • Finance / Bank sector / Insurance industry (portfolio

[106] Smithers Pira, The Future of Personal ID to 2019, http://www.smitherspira.com/industry-market-reports/security/personal-id/personal-identification-information-2019
[107] Gartner, Gartner Highlights Top 10 Strategic Technologies for Government in 2016, http://www.gartner.com/newsroom/id/3360317
[108] Wikipedia – Analytics, https://en.wikipedia.org/wiki/Analytics

Data Analytics	
	analytics, risk analytics) • It security / software engineering (security analytics, software analytics)
Related Market Potential/Forecasted Growth	• Global revenue in the business intelligence (BI) and analytics market is forecast to reach 16.9 bn USD in 2016, an increase of 5.2 percent from 2015, according to the latest forecast from Gartner, Inc[109]. • The Total Data market is expected to nearly double in size, growing from $69.6B in revenue in 2015 to 132.3 bn USD in 2020[110]. • The market for prescriptive analytics software is estimated to grow from approximately $415M in 2014 to $1.1B in 2019, attaining a 22% CAGR[111]. • By 2020, predictive and prescriptive analytics will attract 40% of enterprises' net new investment in business intelligence and analytics[112].
Related Terms	• Descriptive Analytics • Predictive Analytics • Prescriptive Analytics • Big Data Analytics
Source(s) of Documentation	Advanced, Pervasive and Invisible Analytics appear in Gartner's "Top 10 Strategic Technology Trends for 2015"[113], whereas Advanced Analytics With Self-Service Delivery appear in Gartner's Hype Cycle for Emerging Technologies, 2015 (At the Peak)[114]. Real time Analytics and Predictive Analytics are also placed within the Gartner's Hype Cycle for the Internet of Things, 2015[115]. Analytics is further considered in IEEE CS 2022 Report as one of the 23 potential technologies that could change the landscape of computer science and industry by the year 2022[116].

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[109] Gartner (2016). "Gartner Says Worldwide Business Intelligence and Analytics Market to Reach USD 16.9 Billion in 2016", http://www.gartner.com/newsroom/id/3198917

[110] 451 Research, Total Data market expected to reach USD 132bn by 2020, https://451research.com/report-short?entityId=89339&referrer=marketing&utm_source=website_homepage&utm_medium=website&utm_term=data_platforms_analytics&utm_content=apply_for_trial&utm_campaign=2016_market_insight

[111] Gartner Forecast Snapshot: Prescriptive Analytics, Worldwide, 2016; 5 February 2016.

[112] Gartner, 100 Data and Analytics Predictions Through 2020 Published: 24 March 2016 ID: G00301430 Analyst(s): Douglas Laney | Ankush Jain.

[113] Gartner, Gartner Identifies the Top 10 Strategic Technology Trends for 2015 (Press Release), http://www.gartner.com/newsroom/id/2867917

[114] Gartner (2015). Hype Cycle for Emerging Technologies, 2015, https://www.gartner.com/doc/3100227

[115] Gartner (2015). Hype Cycle for the Internet of Things, 2015, https://www.gartner.com/doc/3098434

[116] IEEE, IEEE CS 2022 Report, https://www.computer.org/cms/Computer.org/ComputingNow/2022Report.pdf#page=5

4.3.10   e-Signatures

e-Signatures	
Identifier	TE#10
Type	Technology, based on encryption or biometrics technology.
Description	

An *e-Signature* or Electronic Signature refers to data in electronic form, which is logically associated with other data in electronic form and which is used by a signatory party to sign a data document[117]. Such data may be a traceable e-mail or a biometric data structure, which may be based on digitized handwriting (i.e. handwriting that is converted by cryptography into a digital signature) or some other biometric characteristic (e.g. a fingerprint that can be combined with a hash or digest of the message to show the signer's intent)[118]. This type of signature provides the same legal standing as a handwritten signature as long as it adheres to the requirements of the specific regulation it was created under (e.g., eIDAS in the European Union, NIST-DSS in the USA or ZertES in Switzerland)[119]. The electronic signature cannot be removed and applied to other documents to forge a signature.

Mainstream Domains of Application	• Military and Defence • E-Commerce • E-Government
Related Market Potential/Forecasted Growth	• The global e-signature market is expected to grow at a CAGR of 39.2% in terms of value during 2016-2020[120]. • The global digital signature market is expected to increase from $501.7 million in 2015, and reach $3,318.6 million by 2022, growing at a CAGR of 31.5%[121]. • The digital signature market size is estimated to grow from USD 512.5 Million in 2015 to USD 2.02 bn by 2020, at an estimated Compound Annual Growth Rate of (CAGR) of 31.6% from 2015 to 2020[122]. • Forrester Research estimates that the electronic

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[117] Dawn Turner, "What is a Digital Signature - What It Does, How It Works". Cryptomathic, https://www.cryptomathic.com/news-events/blog/what-is-a-digital-signature-what-it-does-how-it-works

[118] Gartner IT Glossary - Electronic Signature (e-Signature), http://www.gartner.com/it-glossary/electronic-signature

[119] Wikipedia – Electronic signature, https://en.wikipedia.org/wiki/Electronic_signature#cite_note-Cryptomathic_WHATISADIGITALSIGNATURE-1

[120] P&S Market Research, Global E-Signature Market Size, Share, Development, Growth and Demand Forecast to 2020, https://www.psmarketresearch.com/market-analysis/e-signature-market

[121] P&S Market Research, Global Digital Signature Market Size, Share, Development, Growth and Demand Forecast to 2022, https://www.psmarketresearch.com/market-analysis/digital-signature-market

[122] Markets and markets, Digital Signature Market - Global Forecast to 2020, http://www.marketsandmarkets.com/Market-Reports/digital-signature-market-177504698.html?gclid=CjwKEAiAmdXBBRD0hZCVkYHTl20SJACWsZj9mAkd0vBWf8Kr2j3cASKIwAyIyi2ZdYArPMQyePyRohoCz-Lw_wcB

e-Signatures	
	signature market is seeing an average annual growth rate of 53 percent, with transactions estimated to grow from 210 million in 2014 to 700 million in 2017[123].
Related Terms	• Electronic signature • Digital signature
Source(s) of Documentation	*Interviews*

4.3.11   Geographic Information Systems

Geographic Information Systems	
Identifier	TE#11
Type	Technology based on geographic information science (or geo-informatics.
Description	
A *Geographic Information System (GIS)* is a computer system for capturing, storing, manipulating, analyzing, checking, sharing and displaying every form of geographically referenced information, often called spatial data. GIS can show many different kinds of data on one map, using also layers as presentation formats, enabling to more easily see, analyze and understand patterns and relationships[124]. GIS applications allow in particular to create interactive queries, analyze spatial information, edit data in maps and present the results of all these operations[125].	
Mainstream Domains of Application	• Military and Defence • Engineering • Transport/logistics

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[123] Geek Wire, Tricia Duryee, E-signatures are going to hit more than 700M in 2017 as consolidation gobbles up the competition, http://www.geekwire.com/2015/e-signatures-to-hit-more-than-700m-in-2017-as-consolidation-gobbles-up-the-competition/

[124] Gartner IT Glossary – Geographic information system (GIS), http://www.gartner.com/it-glossary/geographic-information-systems-gis/

[125] Wikipedia – Geographic information system, https://en.wikipedia.org/wiki/Geographic_information_system

Geographic Information Systems	
Related Market Potential/Forecasted Growth	• The global geographic information system (GIS) market is expected to increase from $7,612.9 million in 2014 to reach $14,623.8 million by 2020, growing at a CAGR of 11.4%. Among the various industry verticals, the Government sector accounted for about 28.3% share of the global GIS market in 2014[126].
Related Terms	• Geographic information science • Geoinformatics • 3D based GIS
Source(s) of Documentation	*Interviews*

4.3.12   Internet of Things

Internet of Things	
Identifier	TE#12
Type	Technology, based on the convergence of multiple technologies, including ubiquitous wireless communication, real-time analytics, machine learning, commodity sensors, and embedded systems and the proliferation of smart devices.
Description	

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[126] PR Newswire, Global Geographic Information System (GIS) Market Expected to Grow at 11% CAGR During 2015 - 2020: P&S Market Research, http://www.prnewswire.com/news-releases/global-geographic-information-system-gis-market-expected-to-grow-at-11-cagr-during-2015---2020-ps-market-research-567650721.html

Internet of Things
The *Internet of Things (IoT)* stands for the internetworking of physical devices, vehicles (also referred to as "connected devices" or "smart devices"), buildings and other items – embedded with electronics, software, sensors, actuators, and network connectivity that enable these objects to collect and exchange data[127]. IoT allows objects to be sensed and/or controlled remotely across existing network infrastructure, creating opportunities for more direct integration of the physical world into computer-based systems, and resulting in improved efficiency, accuracy and economic benefit. When IoT is augmented with sensors and actuators, the technology becomes an instance of the more general class of cyber-physical systems, which also encompasses technologies such as smart grids, smart homes, intelligent transportation and smart cities[128].   The Internet of Things, Industrial Internet, and Internet of Everything will gradually morph into the *Internet of Anything (IoA)*. IoA envisions a common software "ecosystem" capable of accommodating any and all sensor inputs, system states, operating conditions, and data contexts — an overarching "Internet Operating System"[129].

Mainstream Domains of Application	- Home automation - Logistics - Military and Defence
Related Market Potential/Forecasted Growth	- Gartner, Inc. forecasts that 6.4 bn connected things will be in use worldwide in 2016, up 30 percent from 2015, and will reach 20.8 bn by 2020. In 2016, 5.5 million new things will get connected every day. - The Internet of Things market size is estimated to grow from USD 157.05 bn in 2016 to USD 661.74 bn by 2021, at a Compound Annual Growth Rate (CAGR) of 33.3% from 2016 to 2021[130].

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[127] Gartner IT Glossary – Internet of Things, http://www.gartner.com/it-glossary/internet-of-things/
[128] Wikipedia – Internet of things, https://en.wikipedia.org/wiki/Internet_of_things
[129] https://www.computer.org/web/computingnow/trends/top-technology-trends-2015
[130] Markets and markets, Internet of Things (IoT) Market - Global Forecast to 2021, http://www.marketsandmarkets.com/Market-Reports/internet-of-things-market-573.html?gclid=Cj0KEQiAhNnCBRCqkP6bvOjz_IwBEiQAMn_TMXu3AOASg9jmD5A8ztGP8uRSeGU50QbKbCrwY_C9seUaAsfy8P8HAQ

Internet of Things	
Related Terms	- Web of Things - Cyber-physical systems - Everything Connects - Internet of Everything - Internet of Anything - Internet of Dust
Source(s) of Documentation	The Internet of Things appears in Gartner's "Top 10 Strategic Technology Trends for 2015"[131], as well as in Gartner's "Top 10 Strategic Technology Trends for 2016"[132]. It is also found in Gartner's "Hype Cycle for Emerging Technologies, 2015"[133] (At the Peak), as well as in IEEE CS 2022 Report as one of the 23 potential technologies that could change the landscape of computer science and industry by the year 2022[134]. IoT is further considered as one of the eight trends that are likely to disrupt businesses in the months to come[135].

4.3.13   Machine Learning

Machine Learning	
Identifier	TE#13
Type	Technology that has evolved from the study of pattern recognition and computational learning theory in artificial intelligence. It is closely related to (and often overlaps with) computational statistics, while it has strong ties to mathematical optimization, which delivers methods, theory and application domains to the field.
Description	
Machine learning is the subfield of computer science that "gives computers the ability to learn without being explicitly programmed" (Arthur Samuel, 1959)[136]. It explores the study and construction of algorithms that can learn from and make predictions on data. Within the field of data analytics in particular, machine learning is a method used to devise complex and algorithms that lend themselves to prediction. Machine learning	

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[131] Gartner, Gartner Identifies the Top 10 Strategic Technology Trends for 2015 (Press Release), http://www.gartner.com/newsroom/id/2867917

[132] Gartner, Gartner Identifies the Top 10 Strategic Technology Trends for 2016 (Press Release), http://www.gartner.com/newsroom/id/3143521

[133] Gartner (2015). Hype Cycle for the Internet of Things, 2015, https://www.gartner.com/doc/3098434

[134] IEEE, IEEE CS 2022 Report, https://www.computer.org/cms/Computer.org/ComputingNow/2022Report.pdf#page=5

[135] Deloitte (2016). Tech Trends 2016, https://www2.deloitte.com/global/en/pages/technology/articles/tech-trends.html

[136] Phil Simon (March 18, 2013). Too Big to Ignore: The Business Case for Big Data. Wiley. p. 89.

Machine Learning	
algorithms are composed of many technologies (such as deep learning, neural networks and natural-language processing), used in unsupervised and supervised learning that operate guided by lessons from existing information[137]. Originally, targeting to achieve artificial intelligence, machine learning has shifted its focus towards tackling solvable problems of practical nature, whereas it has benefited from the increasing availability of digitized information, and the possibility to distribute that via the Internet[138].	
Mainstream Domains of Application	• Spam filtering • Optical character recognition (OCR) • Search engines • Computer vision
Related Market Potential/Forecasted Growth	• The artificial intelligence market is estimated to grow from USD 419.7 Million in 2014 to USD 5.05 bn by 2020, at a CAGR of 53.65% from 2015 to 2020[139].
Related Terms	• Predictive analytics • Artificial Intelligence/Machine Intelligence • Autonomic Computing • Smart Machines
Source(s) of Documentation	Smart Machines appear in Gartner's "Top 10 Strategic Technology Trends for 2015"[140], whereas Advanced Machine Learning appears in Gartner's "Top 10 Strategic Technology Trends for 2016"[141].

4.3.14   Natural Language Processing

Natural Language Processing	
Identifier	TE#14
Type	Subfield of artificial intelligence and based on the advances in machine learning.
Description	

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[137] Gartner IT Glossary – Machine Learning, http://www.gartner.com/it-glossary/machine-learning/

[138] Wikipedia-Machine learning, https://en.wikipedia.org/wiki/Machine_learning#cite_ref-arthur_samuel_machine_learning_def_1-0

[139] Artificial Intelligence (AI) Market by Technology (Machine Learning, Natural Language Processing (NLP), Image Processing, and Speech Recognition), Application & Geography - Global Forecast to 2020, http://www.marketsandmarkets.com/Market-Reports/artificial-intelligence-market-74851580.html

[140] Gartner, Gartner Identifies the Top 10 Strategic Technology Trends for 2015 (Press Release), http://www.gartner.com/newsroom/id/2867917

[141] Gartner, Gartner Identifies the Top 10 Strategic Technology Trends for 2016 (Press Release), http://www.gartner.com/newsroom/id/3143521

Natural Language Processing

Natural Language Processing (NLP) is a field of computer science, artificial intelligence, and computational linguistics concerned with the interactions between computers and human (natural) languages. As such, NLP is related to the area of human–computer interaction142. NLP technology involves the ability to turn text or audio speech into encoded, structured information, based on an appropriate ontology143.

NLP solutions enable communication between human and machine by analysinganalysing the content written and spoken in natural human language and converting it into the machine understandable language[144]. Individual challenges within NLP involve natural language understanding, enabling computers derive meaning from human or natural language input, natural language generation, etc.

Mainstream Domains of Application	• Automatic machine translation • Human - computer interaction
Related Market Potential/Forecasted Growth	• The NLP market size is estimated to grow from 7.63 bbn USD in 2016 to 16.07 bbn USD by 2021, at a Compound Annual Growth Rate (CAGR) of 16.1%[145].
Related Terms	• Natural Language Search • Natural Language Question Answering • Speech recognition / Voice and tone recognition • Speech-to-Speech Translation / Text-to-Speech Translation
Source(s) of Documentation	Natural Language Processing (particularly Natural Language Question Answering) appears in Gartner's Hype Cycle for Emerging Technologies, 2015 (Sliding Into the Trough)[146].

4.3.15   Wearables

Wearables	
Identifier	TE#15
Type	Wearable technology is an extension of ubiquitous computing. It is based on the advances of mobile, Bluetooth

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[142] Wikipedia-Natural Language Processing, https://en.wikipedia.org/wiki/Natural_language_processing

[143] Gartner IT Glossary – Natural Language Processing, http://www.gartner.com/it-glossary/natural-language-processing-nlp/

[144] Future Market Insights, Natural Language Processing NLP Market: Global Industry Analysis and Opportunity Assessment 2015-2025, http://www.futuremarketinsights.com/reports/natural-language-processing-nlp-market

[145] Markets and markets, Natural Language Processing Market - Global Forecast to 2021, http://www.marketsandmarkets.com/PressReleases/natural-language-processing-nlp.asp

[146] Gartner (2015). Hype Cycle for Emerging Technologies, 2015, https://www.gartner.com/doc/3100227

Wearables	
	and wireless interfacing and networking, and in particular WPAN and WBAN specifications.
Description	
	Wearables (wearable computers and interfaces) are miniature electronic devices that are designed to be worn on the body, such as a wrist-mounted screen or head mounted display, to enable mobility and hands-free/eyes-free activities[147]. Wearable computers are especially useful for applications that require more complex computational support, such as accelerometers or gyroscopes, than just hardware coded logic. One common feature of wearable computers is their persistence of activity. There is constant interaction between the wearable and user, so there is no need to turn the device on or off. Another feature is the ability to multi-task. When using a wearable computer, there is no need to stop what one is doing to use the device; its functionality blends seamlessly into all other user actions. These devices can be used by the wearer to act as a prosthetic. It may therefore be an extension of the user's mind or body[148].
Mainstream Domains of Application	• Sensory integration (help people see better or understand the world better) • Health care monitoring systems • Mobile devices • Military and Defence
Related Market Potential/Forecasted Growth	• CCS Insight predicts that wearable technology market increase its volume from 123 million units in 2016 to 411 million units in 2020. This corresponds to a rise of the market value from \$14 bn in 2016 to \$34 bn in 2020[149]. • Gartner, Inc. forecasts that 274.6 million wearable electronic devices will be sold worldwide in 2016, an increase of 18.4 percent from 232.0 million units in 2015. Sales of wearable electronic devices will generate revenue of \$28.7 bn in 2016. Of that, \$11.5 bn will be from smartwatches[150].
Related Terms	• Wearable technology • Wearable computers • Body-borne computers • Wearable interfaces • Wearable devices

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[147] Gartner IT Glossary – Wearable Computer, http://www.gartner.com/it-glossary/wearable-computer/

[148] Wikipedia - Wearable computer, https://en.wikipedia.org/wiki/Wearable_computer

[149] Forbes, Wearable Tech Market To Be Worth USD 34 Billion By 2020, http://www.forbes.com/sites/paullamkin/2016/02/17/wearable-tech-market-to-be-worth-34-billion-by-2020/#5b39b2f03fe3

[150] Gartner (2016). Gartner Says Worldwide Wearable Devices Sales to Grow 18.4 Percent in 2016 (Press Release) http://www.gartner.com/newsroom/id/3198018

Wearables	
	• Internet of Things
Source(s) of Documentation	Wearables appear at the peak of Gartner's "Hype Cycle for Emerging Technologies, 2015"[151],[152].

4.3.16   Virtual Reality

Virtual Reality	
Identifier	TE#16
Type	Technology evolving from advancements in Computer Graphics, Cognitive Intelligence and Human Computer Interaction
Description	
Virtual Reality (VR) provides a computer-generated 3D environment that surrounds a user and responds to that individual's actions in a natural way[153]. It refers to computer technologies that use software to generate realistic images, sounds and other sensations (e.g. smell, vibrations, etc.) that replicate a real environment (or create an imaginary setting), and simulate a user's physical presence in this environment, by enabling the user to interact with this space and any objects depicted therein using specialized devices (e.g. display screens, projectors, goggles, headsets or head-mounted displays, gloves, etc.) VR actually brings the user into the digital world by cutting off outside stimuli. In this way user is solely focusing on the digital content[154].	
Mainstream Domains of Application	• Entertainment/Video games • Education & training • Engineering • Archaeology • Architecture/ Urban design
Related Market Potential/Forecasted Growth	• The virtual reality market is expected to grow from USD 1.37 bn in 2015 to USD 33.90 bn by 2022, at a CAGR of 57.8% between 2016 and 2022[155]. • Total revenue for VR is projected to increase from $5.2 bn in 2016 to over $162 bn in 2020. Software will be a notable revenue source, growing more than 200% year-

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[151] Gartner (2015). Hype Cycle for Emerging Technologies, 2015, https://www.gartner.com/doc/3100227
[152] Gartner (2015). Hype Cycle for the Internet of Things, 2015, https://www.gartner.com/doc/3098434
[153] Gartner IT Glossary – Virtual Reality, http://www.gartner.com/it-glossary/vr-virtual-reality/
[154] Wikipedia – Virtual reality, https://en.wikipedia.org/wiki/Virtual_reality
[155] Markets and markets, "Virtual Reality Market - Global Forecast to 2022", http://www.marketsandmarkets.com/PressReleases/ar-market.asp

Virtual Reality	
	over-year in 2016. Hardware shipments of VR devices alone will increase from 2.2 million in 2015 to 20 million in 2018. Furthermore, there is an excessively high demand for VR headsets, gaming, and video entertainment platforms[156]. • The market for immersive virtual reality systems is expected to cross 2 bn market by 2021[157].
Related Terms	• Artificial reality • Immersive multimedia • Computer-simulated reality • Human Computer Interaction • Virtual Worlds
Source(s) of Documentation	Virtual Reality appears in Gartner's Hype Cycle for Emerging Technologies, 2015 (Sliding Into the Trough)[158], whereas it is considered, according to Deloitte's Tech Trends 2016 Report, as one of the eight trends that are likely to disrupt businesses in the months to come[159]. It further shows up in the list of the top 9 technology trends for 2016, compiled by the IEEE Computer Society[160].

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[156] Advanced MP Technology, The Growth of Virtual Reality, http://www.advancedmp.com/the-growth-of-virtual-reality/

[157] Mordor Intelligence, Immersive Virtual Reality Market - Market Potential Estimation and Possible Competitive Landscape – Forecasts, Trends and Analysis (2016 – 2021), https://www.mordorintelligence.com/industry-reports/immersive-virtual-reality-market?gclid=CjwKEAiAg5_CBRDo4o6e4o3NtG0SJAB-IatYJjYO2Lc_gykA8ZLi4mQofM0UwSEj1KTacGs6uBzptBoCIg3w_wcB

[158] Gartner (2015). Hype Cycle for Emerging Technologies, 2015, https://www.gartner.com/doc/3100227

[159] Deloitte (2016). Tech Trends 2016, https://www2.deloitte.com/global/en/pages/technology/articles/tech-trends.html

[160] Computing Now (IEEE Computer Society), Top Technology Trends for 2016 https://www.computer.org/web/computingnow/trends/Top-Technology-Trends-2016

5 Technologies and Trends Impact Assessment

This section presents accordingly the results of the impact assessment analysis performed in the context of step 4 (Technology Assessment) of the Innovation Identification Framework. The latter is basically grounded on a SWOT analysis that targets on the one side to assess the impact of the identified technologies and trends in the domains originally met, and to point out, on the other, opportunities for their adoption, usage and promotion by the public sector as well as potentially involved challenges and threats. It further aims to correlate identified technologies with specific needs, as well as couple them with the latter by means of existing or new services.

5.1 Aspects of Assessment

The impact assessment of each identified technology and trend, included in the SONNETS short list of emerging technologies includes a number of aspects, as follows:

- Identifier: a unique identifier that determines the particular technology or technological trend addressed (same as in the technology analysis phase).

- SWOT Analysis: An adapted SWOT analysis, that will use the "Strengths" and "Weaknesses" components of the SWOT matrix to identify the impact, namely the benefits and weak points, of each identified technology / trend in the domain originally met, and the "Opportunities" and "Threats" blocks to draw high level correlations among the considered technologies and trends and the opportunities of their adoption, usage and promotion by the public sector as well as the imposed challenges and threats.

- Relevance for Public Sector: preliminary assumptions on the relevance of each analysed technology or trend for the public sector as a result of the opportunities and threats identified through the SWOT analysis.

- Relevant Needs: a list of the societal needs that may be associated with the particular technology or trend.

- Potential Applications / Services: a list of existing or new services that may materialise the envisaged innovations.

- Existing solutions / products / services (tentative): a list of established solutions or best practices based on the specific technology or trend.

As in the case of the "Technology Analysis" step, these aspects have been defined through brainstorming among the SONNETS partners and discussions with the SONNETS Experts Committee.

5.2 Trends Impact Assessment

5.2.1 API Economy

API Economy	
Identifier	TT#1
SWOT Analysis	

Strengths	Weaknesses
• Integration of applications pertaining to different domains. • Reliability and user friendliness – through APIs developers can change applications without affecting the way they interact with each other. • Speed of new services development. • Extensibility and interoperability. • Reusability - content can be created once and be automatically published or made available to many channels. • Efficiency and automation of work – workflows within an organisation can be updated with fewer steps and greater productivity. • Enabling the development of mashup applications. • Facilitating the development of mobile applications.	• Programming knowledge required. • Poor or badly written APIs. • Associated costs (development costs, maintenance costs, API documentation, support provision to users of the API). • Maintenance required. • Potential of system crash when testing APIs. • Steep learning curve to knowing how to program APIs • No standardised documentation
Opportunities	**Threats**
• Design of innovative online services for citizens and businesses. • Cross-sector integration • More integrated user experience • Entrepreneurship and innovation acceleration • Exposure of Public Data and Services to third parties • Personalization	• Security exposure / security concerns - API vulnerabilities may be used by hackers. • Improper use of APIs by third parties • High utilisation of Public Sector infrastructures
Relevant Needs	**Individuals' needs:** • Connected and integrated Europe **Businesses' needs:** • Streamlined and reliable administrative procedures in the public sector • Easy access to public sector information (open data) • Access to a unified European market • Technology implementation **Governments' needs:** • Resource optimization • Digitization • Accessible public sector information

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API Economy	
Potential uses / applications/ services	• Central point of service portals • Access to open data from the municipalities
Existing solutions / products / services	• ECIM[161] Smart Mobility API • STORK project[162] • WatchUK, CitaDel, Public Contracts http://public-contracts.nexacenter.org/, Open Coesione[163] (to monitor how EU money is spent) http://www.opencoesione.gov.it/ , Visual OPML[164] (to make available employment data through innovative interfaces) • CitySDK APIs (Amsterdam)[165]

5.2.2 Crowdsourcing

Crowdsourcing	
Identifier	TT#2
SWOT Analysis	

Strengths	Weaknesses
• Access to new pools of external talent and expertise from a diversity of fields. • Reduced cost of conducting research and development. • Less cost compared to outsourcing. • Incorporation of end users/customers early in the development process. • Faster design and prototyping. • Potential for higher quality. • Increased agility and faster time to market.	• Recruiting and retaining users can be a challenge. • Types of users' contributions are mostly limited (e.g. review/rate/tag/etc.). • Difficulty in combining and evaluating user contributions - unstructured information gathered, cumbersome to filter. • Good quality of user contributions is not guaranteed. • Difficulty in keeping hold of confidential information and intellectual property.
Opportunities	**Threats**
• Pervasive use of smartphones. • Collective Intelligence. • Cocreation and collaboration for needs tackling. • Citizens' greater public awareness. • Sharing Economy business models.	• Ethical concerns. • Private Data Exposure. • IPR issues.

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[161] European Cloud Marketplace for Intelligent Mobility, http://ecim-cities.eu/
[162] https://www.eid-stork.eu/
[163] http://www.opencoesione.gov.it/
[164] http://visual.opmltorino.it/
[165] http://www.citysdk.eu/

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Crowdsourcing	
Relevant Needs	**Individuals' needs:** • Political participation • Education and training **Businesses' needs:** • Business Expansion (Access to funds) **Governments' needs:** • Civil servants as a community of change
Potential uses / applications/ services	• Collaborative Policy making • production of public services. • Urban and transit planning.
Existing solutions / products / services	• Spacehive[166] • Goteo.org[167] • Crowdcube crowdfunding platform[168] • Paribas Securities Services and Smart Angels crowdfunding platform[169] • FinStat Data Feeds[170]

5.2.3 Digitalization

Digitalization	
Identifier	TT#3
SWOT Analysis	

Strengths	Weaknesses
• Offering more communication and transaction channels. • Convenience – enabling access through a digital device. • Flexibility in manipulating information. • Innovation. • Scalability. • Speed of doing business.	• High initial investment and maintenance costs. • Availability of digital equipment (e.g. computer) needed. • Digital literacy and competence needed both in the backoffice and in the front desk.

Opportunities	Threats
• Digitalisation of public services. • Use of electronic files and electronic records. • Citizens' demand for digital processes. • 24/7 services availability.	• Changes required in both processes and IT systems of the public sector. • Digital illiteracy of public sector employees, citizens. • Resistance to change.

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[166] https://www.spacehive.com/
[167] https://www.goteo.org/
[168] https://www.crowdcube.com/
[169] https://group.bnpparibas/en/news/putting-blockchain-work-crowdfunding
[170] http://www.interactivedataclients.com/web/vista/finstat

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Digitalization	
• Increased system interoperability. • Information and service reuse • Economies of scale enabled.	• Security and Vulnerability threats.
Relevant Needs	**Individuals' needs:** • Transparent and participative access to public sector services • Connected and integrated Europe **Businesses' needs:** • Ease of doing business • Easy access to public sector information (open data) • Access to a unified European market **Governments' needs:** • Digitization • Accessible public sector information
Potential uses / applications/ services	• Online citizens accounts – common source database of relevant citizens' documents (applications, certificates, IDs, etc.). • Full scale eGovernment • Make available state archives in a linked open data format.
Existing solutions / products / services	• STORK project[171] • PAE (Portal Administracion electronica)[172] • Cita Previa de Atención Primaria (online medical appointment)[173] • Agencia Tributaria[174]

5.2.4 e-Participation

e-Participation	
Identifier	TT#4
SWOT Analysis	
Strengths	**Weaknesses**
• Active citizenship. • Engagement and empowerment of people with mobility problems.	• Internet access and familiarity with e-participation technologies as prerequisites.

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[171] https://www.eid-stork.eu/
[172] https://administracionelectronica.gob.es
[173] https://www.citaprevia.sanidadmadrid.org/Forms/Acceso.aspx
[174] https://www.agenciatributaria.gob.es/

e-Participation	
• Enhanced transparency and increased acceptance of political decisions (e.g. with regard to planning processes, cost savings, etc.). • Reducing democratic deficit.	• Lack of participants' identification. • Resolutions often not considered seriously by decision makers
Opportunities	**Threats**
• Alternative forms of engagement and (young) people's disengagement in 'traditional' politics. • Non discrimination of participants • Technological advancements in ICTs, which make traditional democratic institutions look sluggish, irresponsive and 'outdated'.	• Digital divide (both in terms of digital infrastructure and in terms of citizens' experience with e-participation). • Manipulation by organised groups (especially in small scale applications). • Online propaganda. • If not properly addressed, e-participation can be frustrating for the citizenship.
Relevant Needs	**Individuals' needs:** • Transparent and participative access to public sector services • Connected and integrated Europe **Businesses' needs:** • Agile and participative public sector • Stimulate an entrepreneurial culture **Governments' needs:** • Participative democracy • Civil servants as a community of change
Potential uses / applications/ services	• Cross Boarder/National/Regional/Local Community resolutions • Active dialogue • e-voting • Participatory Budgeting
Existing solutions / products / services	• Agora Voting[175] • OpenKratio[176] • VTaiwan[177] • Policy Compass[178] • Sirvo A Mi Pais[179]

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[175] https://agoravoting.com/
[176] http://openkratio.org/open-government/
[177] https://vtaiwan.tw
[178] https://policycompass.eu//app/#!/
[179] https://www.sirvoamipais.gov.co/

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5.2.5 Gamification

<table>
<tr>
<td colspan="2" align="center">Gamification</td>
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<tr>
<td>Identifier</td>
<td>TT#5</td>
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<tr>
<td colspan="2">SWOT Analysis</td>
</tr>
<tr>
<td>Strengths</td>
<td>Weaknesses</td>
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<tr>
<td>

Availability of a minimal shared language, which enables simplicity and speed in implementation by designers, facilitates widespread adoption by services and systems far away from the entertainment world and shortens the learning curve for users.
Availability of ready-to-use solutions.
Enhanced user engagement and motivation.

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Unclear effects on user attitudes and behaviours.
Simplification and limitation of the game elements employed.
One-size-fits-all approach that impedes customization of the game mechanics for specific user groups.
Legal restrictions applying to gamification with regard to the use of virtual currencies and virtual assets, data privacy laws and data protection, or labour laws.
High development costs
Target groups being mostly youngsters and those familiar with gaming.
Need for expertise in information systems, organization behaviour and human psychology.

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<tr>
<td>Opportunities</td>
<td>Threats</td>
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<tr>
<td>

Changing behaviour towards better practices.
Enhance engagement of youngsters, which are politically alienated.
New marketing strategies for the public sector
Increasing IT literacy skills of users

</td>
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Failure by poor design.
Behaviour manipulation and ethical issues – promotion of mechanical behaviours without any improvement of the user experience.
Unrealistic expectations.

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<tr>
<td>Relevant Needs</td>
<td>
Individuals' needs:

Experiential education and training

Businesses' needs:

Agile and participative public sector

Governments' needs:

Participative democracy
Appropriate remuneration and incentives
Employee empowerment and recognition
Civil servants as a community of change

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<tr>
<td>Potential uses / applications/ services</td>
<td>

Services supporting collaboration among teams – Provision of work incentives.
Awareness on and adoption of e-government systems.
Education and awareness raising

</td>
</tr>
</table>

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Gamification	
Existing solutions / products / services	- Economie.gouv.fr[180] - The UVA baygame[181] - PEPC, MISIVIAS[182] - Games of Social Change by Engagement Lab @ Emerson College[183] - MIT, Education arcade[184] - https://www.youtube.com/watch?v=Xw4DTcinBss - MMOWGLI Portal[185]

5.2.6 Mobile Devices

Mobile Devices	
Identifier	TT#6
SWOT Analysis	

Strengths	Weaknesses
- Ease of communication. - Flexibility and dynamicity. - Portability. - Efficiency. - Support for several applications – all-in-one device.	- Internet access required for certain functions. - Variable connectivity. - Hindering real human interaction. - Increasing the probability of accidents.
Opportunities	**Threats**
- Public Services reaching more people. - Increased personalisation opportunities. - Increased sensory data collection. - Enablement of novel technologies related to mobile devices (wearables, biometrics, eIDs, etc.).	- Cyberattacks and security breaches. - Privacy and Personal Data. - Vendor lock-in.

Relevant Needs	**Individuals' needs:** - Modern workplaces **Businesses' needs:** - Technology implementation **Governments' needs:** - Digitization
Potential uses / applications/ services	M-learning.

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[180] http://www.economie.gouv.fr/facileco/dr-cac-serie-pedagogique-sur-leconomie
[181] http://www.virginia.edu/baygame
[182] http://www.pepco.fr/misivias.aspx
[183] https://elab.emerson.edu/projects/games-for-social-change
[184] http://education.mit.edu/
[185] https://portal.mmowgli.nps.edu/game-wiki

Mobile Devices	
	• Mobile services. • Booking and payment of health services. • Reservation of doctor appointment in mobile. • Transport-related services (traffic updates, footprint monitoring)
Existing solutions / products / services	• https://play.google.com/store/apps/details?id=cat.gencat.mobi.conduint&hl=es • http://sem.gencat.cat/ca/061CatSalutRespon/app_mobil_061_catsalut_respon/ • PlatgesCat[186] • ECIM[187] Smart Mobility API • Gov2go app (personal government assistant)[188]. • Commercial Driver License (CDL) practice knowledge test mobile application[189]. • Mobile inspections app for agencies to easily conduct inspections in the field right from a tablet[190] allows users in Thailand to make police reports using their phones, instead of having to locate a police station.DubaiNow, Unified Government Services App, to enable citizens transact with government services through a single platform[191]. • Whim, Mobility-as-a-Service App, linking all transport networks in Finland and suggesting travel routes using all available means of transport[191]. • Qlue, City Improvement and Monitoring App (Jakarta)[191]. • Beeline, Adaptive Transport App (Singapore), allowing commuters to pre-book rides on express shuttle buses, track bus arrivals in real-time and pay for their rides though mobile[191]. • Home Guard, Police Services App (Thailand), allowing users to make police reports using their phones, instead of having to locate a police station[191].

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[186] http://aca-web.gencat.cat/aca/platgescat/index.html
[187] European Cloud Marketplace for Intelligent Mobility, http://ecim-cities.eu/
[188] https://www.getgov2go.comf
[189] http://wisconsindot.gov/Pages/dmv/com-drv-vehs/cdl-how-aply/practiceapplication.aspx
[190] http://www.alabama.gov/inspection_demo/
[191] http://www.enterpriseinnovation.net/article/6-innovative-mobile-apps-citizens-1659286554

5.2.7 Open Government

Open Government	
Identifier	TT#8
SWOT Analysis	

Strengths	**Weaknesses**
• Transparency and accountability of governance. • Citizens' engagement. • Reduced incidents of government corruption, bribery and malfeasance. • Wider access to information.	• Organisational and legal reforms needed. • High costs for maintenance • No well-defined business model for exploitation
Opportunities	**Threats**
• Offering the means for private companies, civil society, government organisations and crucially individuals to self-organise and create value. • Novel ways for access to public information. • Entrepreneurship support. • Transparency enhancement. • New business models for Public Sector.	• • Technical and financial challenges. • Concerns on citizens' privacy. • Data prone to misinterpretation and manipulation.

Relevant Needs	**Businesses' needs:** • Easy access to Public Sector information (open data) **Governments' needs:** • Civil servants as a community of change
Potential uses / applications/ services	• Access to procurement and financial data • Cross country data analysis • Fiscal management • Transport and Traffic data • Cultural and Education Services • Smart City Applications
Existing solutions / products / services	• European Data Portal[192] • Portal de la transparencia (Gobierno de Espana)[193] • CKAN[194] • Policy Compass[195]

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[192] https://www.europeandataportal.eu/
[193] http://transparencia.gob.es/
[194] http://ckan.org
[195] http://www.policycompass.eu

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5.2.8 Open Data

Open Data	
Identifier	TT#7
SWOT Analysis	

Strengths	Weaknesses
• Enhanced government transparency, accountability and democratic control – Impact measurement of policies. • Enhanced public participation and engagement. • Self-empowerment/ capability to make better decisions in citizens' life. • Improved or new private products and services. • Improved efficiency and effectiveness of government services. • Technological innovation and economic growth by enabling third parties to develop new kinds of digital applications and services. • New knowledge from combined data sources and patterns in large data volume. • Acceleration of rate of scientific discovery by better access to data.	• Nowell defined standards • Lack of data validation mechanisms regarding their veracity and completeness • Collecting, 'cleaning', managing and disseminating data are typically labour- and/or cost-intensive processes. • Additional processing is often needed by targeted end-users (analysis, apps, etc.). • Little incentives to invest in the processing required to make data useful.
Opportunities	**Threats**
• Promote birth of open data driven business ventures. • Stimulate interagency benchmarking and learning. • Enable an evidence-based approach to policy making. • Allow open and citizen-driven innovation. • Generation of new business services around open data	• Further advantage already privileged groups (e.g. a small elite of technical specialists or those who can afford to employ open data) -Increase the digital divide and social inequality, unless approached right. • Concern that open data will be misinterpreted, if analysed without the input of the researchers who collected the data. • Potential of open data misuse.
Relevant Needs	**Individuals' needs:** • Transparent and participative access to public sector services • Environmental amicability **Businesses' needs:** • Stimulate entrepreneurial and start-up culture • Easy access to public sector information **Governments' needs:** • Lean bureaucracy • Digitization • Rework the trust deficit • Participative democracy

Open Data	
	• Accessible public sector information
Potential uses / applications/ services	• Open data portals • Open Health Records • Public Transport Data • Geospatial data and services • Financial Data Services
Existing solutions / products / services	• EU Open Data Portal, http://data.europa.eu/euodp/en/data • Public Data portal, http://publicdata.eu/ • Policy Compass Portal, http://www.policycompass.eu • WatchUK, CitaDel, Public Contracts http://public-contracts.nexacenter.org/, Open Coesione[196] (to monitor how EU money is spent) http://www.opencoesione.gov.it/ , Visual OPML[197] (to make available employment data through innovative interfaces) • RES (Research and Education Space) project to improve access to public archives for use in education[198]. • 3cixty initiative of the Innovation Action Line Digital Cities, a powerful platform of websites and apps that helps compare and combine information about events, places and transport in a one stop shopping window[199]. • Good Basic Data for Everyone" initiative in Denmark[200] • Publicspending.net[201]

5.2.9 (Service) Personalization

Personalization	
Identifier	TT#9
SWOT Analysis	

Strengths	Weaknesses
• Offering a better customer experience/Improving customer	• Higher cost. • Anonymity may be preferred.

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[196] http://www.opencoesione.gov.it/
[197] http://visual.opmltorino.it/
[198] https://bbcarchdev.github.io/res/
[199] http://www.eitdigital.eu/conference/exhibition/3cixty/
[200] http://www.eurogeographics.org/sites/default/files/BasicData_UK_web_2012%2010%2008.pdf
[201] http://publicspending.net/greece/home

Personalization	
- satisfaction. - Improving customer/user retention. - Enabling time and money savings for the user – preventing redundant work. - Providing more targeted (filtered) information.	- Lack of relevance. - Can create a "filter bubble" that prevents people from encountering a diversity of viewpoints beyond their own.
Opportunities	**Threats**
- Improving the effectiveness of public services. - Reducing errors. - Enabling time and money savings for citizens. - Linking life events and real-time needs with services - Potential of using data from a user's personal social graph. - Fighting digital divide.	- Increasing system complexity. - Increasing service provisioning costs. - High Privacy and Ethical concerns.
Relevant Needs	**Individuals' needs:** - Inclusive well-being and health **Businesses' needs** - Lessen complexity - Stimulate entrepreneurial & start-up culture - Technology implementation - Agile and participative public sector
Potential uses / applications/ services	- Personalized services for citizens. - More targeted services to citizens. - Personalized education (provide an education experience adapted to personal necessities, preferences or context information). - Recommendation mechanism to assist citizens in identifying the proper applications/services for addressing a specific need. - Geolocation and personalization settings to provide the desired public service according to location and previous user behaviour. - Recommending user related public services according to user profile, occupation, marital and financial status, involving news feeds, notifications and alerts, reminders in user calendars with regard to deadlines on their obligations and rights as individual citizens and business owners. - Single sign-on access to cross-organizational services in a personalized fashion. - Consolidation of citizen data, cadastral information, etc.

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Personalization	
Existing solutions / products / services	• Google Optimize 360[202] • Barilliance - Saas Personalisation for Ecommerce[203] • Rich Relevance[204] • Pureclarity - Ecommerce Personalisation[205] • Bunting Website Personalisation[206] • Personyze[207]

5.2.10 Policy Making 2.0

Policy Making 2.0	
Identifier	TT#10
SWOT Analysis	

Strengths	Weaknesses
• Enabling all stakeholders to participate in the decision/policy making process. • Citizen engagement and democratic participation. • Enabling citizens to offer a set of unique skills and competencies (as provided by participating citizens) that government cannot acquire or can do so at high cost. • Enabling governments to acquire feedback on planned or implemented policies. • Enabling the civil society to act a watchdog for government.	• Changes in legislation needed. • High cost of implementation. • Not guaranteed participation of stakeholders involved. • Existence of bias – results and outputs may represent just a sample of the society.
Opportunities	**Threats**
• More participative policy formulation. • Higher alignment between societal needs and policies implemented. • Enablement of learning processes. • Non-discriminatory participation in policy making • Transparency support	• Neglecting citizen's opinions • Manipulation of user groups and/or specific resolution by organised communities • One-Off approaches, not sustained • No clear Policy Making 2.0 strategy • High costs in data/information curation
Relevant Needs	**Individuals' needs:**

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[202] https://www.google.com/analytics/optimize/
[203] https://www.barilliance.com/website-personalization/
[204] http://www.richrelevance.com/
[205] http://www.pureclarity.com/
[206] https://getbunting.com/
[207] http://www.personyze.com/

Policy Making 2.0	
	• Transparent and participative access to Public Sector services • Environmental Amicability **Governments' needs:** • Rework the trust deficit
Potential uses / applications/ services	• Online platforms to gather feedback on citizens' experience as users of public services. • "Citizens for the citizens" platforms. • Governmental blogs, wikis, etc. • Open Simulation platforms
Existing solutions / products / services	• 2050 Pathways Analysis[208] • UrbanSIM[209] • GLEAM[210] • C-ROADS[211] • Arbeitsmarktmonitor[212]

5.2.11 Sentiment Analysis

Sentiment Analysis	
Identifier	TT#11
SWOT Analysis	

Strengths	Weaknesses
• Identify big picture trends with regard to a particular topic. • Filter through mass quantities of content and identify the specific content that needs attention. • Enable public relations monitoring and reputation management. • Analyse competition – set benchmarks or probe for competitor weaknesses. • Allow to determine marketing strategy, improve chances of campaign success, enhance customer service. • Predict future trends and behaviour (if accurate).	• Large and relevant data sample needs to be mined (so that outliers are diluted in the aggregate) – Cannot be relied upon for small data samples. • Inaccurate results due to ignorance of context, sarcasm or irony - it is still up to humans to parse the fine nuances of human language. • Not able to analyse historical tendencies of the individual commenter. • Different features or aspects of the same issue may generate different sentiment responses. • Multiple languages support is needed in order to obtain accurate results for large sections of the world.

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[208] https://www.gov.uk/guidance/2050-pathways-analysis
[209] http://www.urbansim.com
[210] http://www.gleamviz.org
[211] https://www.climateinteractive.org/tools/c-roads/
[212] https://arbeitsmarktmonitor.arbeitsagentur.de

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Sentiment Analysis	
Opportunities	**Threats**
• Identify the citizens' sentiment on public policies and/or public services. • Improve the quality and efficiency of public policies and/or public services. • Anticipate and (proactively) manage citizens' complaints or forthcoming protests. • Identify behaviour patterns (e.g. corruption).	• Manipulation of citizens perceptions. • "Big brother" control over society as a result of tracking citizens' opinions. • Privacy and Ethical Issues • Online Data is not always representative of society due to digital divide
Relevant Needs	**Governments' needs:** • Rework the trust deficit • Participative democracy • Civil servants as a community of change
Potential uses / applications/ services	• Election results prediction (identifying political sentiment in blogging, microblogging and social media posts). • Establish a taxonomy of critical keywords and combine it with organisations' structures data, so as to allow departments to better formulate outgoing messages, target specific audiences for those messages and agilely respond to citizens' complaints. • Combine social media posts and geo-tagged information to reveal patterns of malpractice or corruption.
Existing solutions / products / services	• Anlzer Analytics Engine[213] • Alchemy API (Sentiment Analysis API)[214] • TheySay Sentiment Analysis API[215] • Applause Mobile Sentiment Analysis[216]

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[213] http://www.anlzer.com
[214] http://www.alchemyapi.com/products/alchemylanguage/sentiment-analysis
[215] http://www.theysay.io/sentiment-analysis-api/?gclid=CjwKEAiA17LDBRDElqOGq8vR7m8SJAA1AC0_gLhQWT142TOe3trjeg21nScCv9qk9V6Jte9_VspsbBoCNMjw_wcB
[216] https://www.applause.com/mobile-analytics/

5.2.12 Smart Workplace

<table>
<tr>
<td colspan="2" align="center">Smart Workplace</td>
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<tr>
<td>Identifier</td>
<td>TT#12</td>
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<tr>
<td colspan="2">SWOT Analysis</td>
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<tr>
<td>Strengths</td>
<td>Weaknesses</td>
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<td>

Efficiency and productivity.
Greater employee commitment.
Competitive advantage.
Higher degree of collaboration.
Multiple channels of communication.

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High setup costs.
Skilled personnel/employees required.

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<tr>
<td>Opportunities</td>
<td>Threats</td>
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Better work-life balance.
Higher environmental sustainability.
Public services closer to citizens needs
Spin-Out/Off opportunities for Public Sector

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Resistance to change.
Bureaucracy
Privatisation of Public Assets

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<tr>
<td>Relevant Needs</td>
<td>
Individuals' needs:

Modern workplaces
Equal employment opportunities

Businesses' needs

Talent acquisitions and retention

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<tr>
<td>Potential uses / applications/ services</td>
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Silo-busters (tools transcending organizational boundaries to enable teams to solve problems and generate ideas across work silos).
Police-messenger similar to WhatsApp to enhance communication, data protection and privacy among police officers.

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<tr>
<td>Existing solutions / products / services</td>
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Slack, intra-office messaging service[217]
iVivaCloud solution[218]

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[217] https://www.technologyreview.com/s/600771/10-breakthrough-technologies-2016-slack/
[218] http://www.ivivacloud.com/

5.2.13 Social Networking

Social Networking	
Identifier	TT#13
SWOT Analysis	
Strengths	**Weaknesses**
- Improving individuals' sense of connectedness with real and/or online communities. - Effective communication (or marketing) tool for corporations, entrepreneurs, non-profit organizations, including advocacy groups and political parties and governments. - Building reputation and bringing in career opportunities and monetary income. - Popularity, outreach. - Virality. - Ease of use. - Immediacy. - Integration on mobile devices.	- Negatively impacting social skills due to the absence of face-to-face contact and interaction. - Affecting mental and physical health - links found between heavy social media use and depression, sleep deprivation, addictive behaviours, etc. - Becoming a factor of distraction and a way to waste time for many users. - Enabling behaviours, like cyberbullying, online harassment and "trolling". - Scepticism around the reliability of user-generated content. - Huge debate on the ownership of the content on social media platforms. - Privacy concerns – data captured without the user's knowledge or consent through electronic tracking and third party applications. - Potential of data and information collected for third party use.
Opportunities	**Threats**
- Higher participation opportunities. - Promotion of a distributed environmental sensitivity. - Personalised Services. - Novel communication channels. - Online information/data sourcing opportunities. - Crowdsourcing enabler.	- Exclusion of people with no social media profiles or no access to web services or even technology illiterates. - Citizen data being collected for law enforcement and governmental purposes. - Privacy and Ethics concerns.
Relevant Needs	**Individuals' needs:** - Transparent and participative access to Public Sector services - Environmental Amicability **Governments' needs:** - Rework the trust deficit
Potential uses / applications/ services	Usage of social media to represent the public sector – Social media as vehicles for increased transparency of an agencies actions, e.g. use of the micro-blogging service Twitter to inform journalists and professional groups and direct them to longer updates on a government's website

Social Networking	
	• Social media enhanced idea exchange platforms for local issues. • Social-media enhanced platforms enabling governments to consult citizens on policy issues. • Consultation platforms for government employees/Private networks for government employees enabling the exchange of ideas and experiences.
Existing solutions / products / services	• Facebook page for civil servants in the U.S.A • Digital Pioneers (Netherlands)[219] • NASA Virtual CoLab[220]

5.3 Technologies Impact Assessment

5.3.1 Artificial Intelligence

Artificial Intelligence	
Identifier	TE#1
SWOT Analysis	

Strengths	Weaknesses
• Greater precision and accuracy – almost nil chances of error. • Overcoming the limitations of human nature (not limited by fatigue, boredom or emotions intercepting rational thinking). • Undertaking laborious tasks – reducing human effort. • Convenience – making daily life a lot easier with its several applications (auto-correct apps, personal assistants, gps, etc.) • Saving the need of organisations for human resources. • Carrying out repetitive and time-consuming tasks efficiently. • Capable of carrying out dangerous or risky tasks.	• Ethical and moral issues, found in embedding intelligence in a machine. • Significant maintenance and repair costs to suit changing requirements. • Lacking common sense, creativity, intuitiveness and the human touch. • Difficulty in ensuring that AI will be used ethically. • Not as efficient as humans in adapting responses, depending on changing situations.
Opportunities	Threats
• Personal Public Services Assistance. • Intelligent Agents for Policy Decisions • Automation in mainstream tasks	• Hesitancy in fully delegating important tasks to AI applications. • Fear of replacing humans in their job

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[219] https://www.kl.nl/en/projects/digital-pioneers/
[220] https://appel.nasa.gov/2008/06/01/nasa-colab-creating-a-space-for-participatory-exploration/

Artificial Intelligence	
	positions /unemployment. • Fear of lateral thinking and multitasking abilities of humans gradually declining due to the reduced need to use their intelligence - humans becoming overly dependent on machines. • Fear of destructive consequences if control of AI goes to the wrong hands. • Fear of smart machines superseding and enslaving humans.
Relevant Needs	**Individuals' needs:** • Transparent and participative access to Public Sector services **Businesses' needs** • Easy access to Public Sector information (open data) **Governments' needs:** • Resource Optimization • Accessible Public Sector information
Potential uses / applications/ services	• Bots to answer simple citizen questions / automated online assistants instead of call centers with humans to provide a first point of contact. • Smart personal advisors to control and support proper dietary habits. • Citizen personal agents taking action on the behalf of citizens (alerting citizens with regard to their obligations toward the Public Administration, retrieving information for them, filling out forms for them, etc. • Buyer agents/shopping bots, retrieving information about goods and services. • data mining agents finding trends and patterns in the interaction of citizens with public organisations. • Ambient Assisted Living.
Existing solutions / products / services	• Inteliwise eGov Virtual Assistant[221] • Chatbots Directory[222]

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[221] https://www.inteliwise.com/products/egov-virtual-assistant/
[222] https://www.chatbots.org/country/gr

5.3.2 Augmented Reality

Augmented Reality	
Identifier	TE#2
SWOT Analysis	

Strengths	Weaknesses
• Creating a more interactive and personal experience. • Allowing to experience the word at one's ease and convenience. • Revolutionising mobile user experience. • Improving mobile usability by acting as the interface itself, requiring little interaction. • Enabling more cost-effective and risk-free training – allowing to simulate practices without to actually expose people to risky situations or hazardous environments. • Advancing and facilitating education (visualize "difficult" to explain concepts, facilitate learners' interaction, apply trial and error methods, etc.). • Providing real-time feedback. • Broad field of applications. • Supporting research.	• Hampering the interaction with the real world – replacing human interaction. • Still facing technical challenges and limitations. The accurate tracking of the position and the line of sight of the user are still challenging aspects. However, this is important for the accuracy of the alignment of the virtual objects on the real world).
Opportunities	**Threats**
• Public employees training. • Safer and informative navigation. • Aiding disabled people by providing vital information, otherwise cumbersome to obtain and enhancing their environment. • AR can be utilized to support decision-making processes of personnel in the areas of safety and security, or medicine. • They can also be used for maintenance tasks, as virtual labels or for training purposes.	• (Individual) privacy concerns – probability of access to information that one should not readily possess about a given person. • High development costs • Need for investments in wearables

Relevant Needs	**Individuals' needs:** • Inclusive well-being and health **Governments' needs:** • Recruitment, training
Potential uses / applications/ services	• AR-enhanced learning applications • Virtual tours on Museums • Transportation checking points with people consenting to be scanned digitally. • Customs and border protection.

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Augmented Reality	
	• Augmented emergency management (enhancing search and rescue through geospatial AR application). • Contact lens displays or systems for augmenting tactile information (still in development). • Future developments will include the improvement of the collection of gestic data from the user e. g. with time-of-flight cameras, ultrasonic- and acceleration sensors, magnetometers or GPS navigation devices[223].
Existing solutions / products / services	• The technology for visual augmentation is already in use, especially by private persons for gaming purposes. By now, the growing sophistication of the systems could enable e.g. security personnel to use the technology on a regular basis e.g. for crime detection and prevention. • There are already commercial systems available, which add visual information (e.g. AR apps for mobile phones or Google glass)**Error! Bookmark not defined.**.

5.3.3 Big Data

Big Data	
Identifier	TE#3
SWOT Analysis	

Strengths	Weaknesses
• Faster, better decision making. • Informed and often real time insights on issues of interest. • Development of new products and services. • Ever-narrower segmentation of customers and therefore much more precisely tailored products or services.	• Using real-time insights requires a different way of working within organisations. • Data quality concerns. • Imperfect methodology issues – questionable quality of predictions.

Opportunities	Threats
• Better simulation services for the Public Sector • Development of Smart Cities. • Traffic management systems.	• Privacy concerns. • Limited data availability relevant to Public Sector operations

[223]Fraunhofer for the SOURCE project, Technology Trend Card „Augmented Reality Systems", http://societalsecurity.net/sites/default/files/document-database/files/2016-01/pdf/2669935-augmented-reality-systems.pdf

Big Data	
• Development of improved public services. •	
Relevant Needs	**Individuals' needs:** • Inclusive well-being and health • Connected and integrated Europe **Businesses' needs:** • Easy access to public sector information (open data) **Governments' needs:** • Accessible public sector information
Potential uses / applications/ services	• Public opinion mining during elections (sentiment analysis) • Statistics generation to help understand local, regional and global patterns and trends • Predictive Analytics (pattern analysis to predict future developments or behaviour (e.g. of consumer)) • Complex event processing • Social Network Analysis (using data from social networks) • Network Attack Monitoring**Error! Bookmark not defined.** • Tailored healthcare services. • Early detection of pandemics. • Crime control. • Counterterrorism[224].
Existing solutions / products / services (tentative)	• Customer 360 degree view (Online Retailer analyse consumer behaviour) by IBM[225] or Pentaho[226]. • Optimization of business processes (Retailers are able to optimize their stock based on predictions generated e.g. from social media data, web search trends and weather forecasts) • Big data analytics before president elections in US or before Brexit votum

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[224] Thomas Euting (2014), „Big data", Europäische Sicherheit und Technik, März 2014.
[225] https://www-01.ibm.com/software/data/bigdata/use-cases/enhanced360.html
[226] http://www.pentaho.com/customer-360-degree-view

5.3.4 Biometrics

<table>
<tr><td colspan="2" align="center">Biometrics</td></tr>
<tr><td>Identifier</td><td>TE#4</td></tr>
<tr><td colspan="2">SWOT Analysis</td></tr>
<tr><td>Strengths</td><td>Weaknesses</td></tr>
<tr><td>

Unique and accurate identification.
Accountability (clear, definable audit trail of transactions or activities – connection of activities to a particular person).
Time saving (a person can be identified or rejected in a matter of seconds), increasing productivity.
Easy and safe to use (no need for excessive training).
Convenience and user friendliness (no need to remember passwords – also cannot forget or lose it).
Higher degree of security than traditional authentication methods (no issues of sharing, duplication or fraud).
Versatility (several types of biometric scanners available, several applications).
Scalability.
Reduced password administration cost and increased ROI in areas such as Loss Prevention or Time & Attendance.

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High cost
Cannot be cancelled or replaced by a new version as passwords or tokens.
Offending human dignity (turning the human subject into a collection of biometric parameters, dehumanizing the person, infringing bodily integrity).
Low social acceptability/User resistance.

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<tr><td>Opportunities</td><td>Threats</td></tr>
<tr><td>

Novel identification and authentication schemes
Improved public sector services security.
Assistance for impaired people.
International sharing of biometric data.

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Privacy concerns – fear that that data obtained during biometric enrolment may be used in ways for which the enrolled individual has not consented.
Discrimination concerns (Soft biometrics traits complementing the identity information provided by the primary biometric identifiers are strongly cultural based.)
Danger to owners of secured items (chance of assaulting the owner him/herself).
The accuracy of biometric recognition technologies depends on the user and on environmental conditions (e.g. lighting during print capture). Additionally, there are concerns about the safety of stored data, as biometric data cannot be changed if compromised.

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<tr><td>Relevant Needs</td><td>
Individuals' needs:

Transparent and participative access to public sector services

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Biometrics	
Potential applications / services	• Physical access control • Computer log-in • Welfare disbursement • International border crossing / Border management / Speed mobility in borders • National ID cards • Passports • Airport kiosks for checking passports • Driver's license • Facial recognition to speed up processes and manage queues • Instructions to get to the specific room to impaired people entering a hospital through their smartphone or trough panels • Identify criminals on the fly • Avoid fraud on competitive examinations • Life identification against watch lists (terrorism) • The safety of biometric data will be crucial for user acceptance and wide spread implementation of biometric recognition technologies. If it is possible to succeed in the assurance of the safety of biometric data and high accuracy the technology can be implemented from personal computers to nuclear power plants[227]
Existing solutions / products / services	• The technology is already in use, however increasing advancements (eg. in mobile biometrics) and further developments (e.g. biometrics for banking) due to enhanced tools such as big data analysis can be expected. • Airport security (automated passport control) • Fingerprint access to buildings • Voice recognition in cars • Fingerprint scanner for mobiles, laptops, etc. • ATM iris recognition

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[227] Fraunhofer for the SOURCE project, Technology Trend Card, „Biometric recognition technologies", http://societalsecurity.net/sites/default/files/document-database/files/2016-12/pdf/2647490-biometric-recognition-technologies.pdf

5.3.5 Blockchain

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<td colspan="2">Blockchain</td>
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<tr>
<td>Identifier</td>
<td>TE#5</td>
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<tr>
<td colspan="2">SWOT Analysis</td>
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<tr>
<td>Strengths</td>
<td>Weaknesses</td>
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Trustful exchanges (reducing or even eliminating counterparty risk) without the oversight or intermediation of a third party.
User empowerment – users are in control of all their information and transactions (easy to audit).
High quality data - blockchain data is complete, consistent, timely, accurate, and widely available.
Durability, reliability, and longevity (decentralization allows to better withstand malicious attacks).
Process integrity – transactions executed exactly as the protocol commands.
Transparency and immutability – transactions are publicly viewable by all parties cannot be altered or deleted.
Ecosystem simplification - single public ledger, instead of multiple ones.
Faster transactions – transactions are processed 24/7 enabling faster transaction settlement.
Lower transaction costs - third party intermediaries and overhead costs are eliminated.

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Irreversible transactions.
Nascent technology - challenges exist with regard to transaction volume and speed, the verification process, and data limits (data storage).
Uncertain regulatory status, impeding widespread adoption.
Large energy consumption – the bitcoin blockchain network's miners are attempting 450 thousand trillion solutions per second in efforts to validate transactions, using substantial amounts of computer power.
High initial capital costs.
Concerns on control, security, and privacy.
Integration concerns - significant changes to, or complete replacement of, existing systems are needed.
Complex to implement and maintain (especially private blockchains).

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<tr>
<td>Opportunities</td>
<td>Threats</td>
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<td>

Verify integrity of transactions.
Reduce fraud and corruption.
Openness and Transparency
Distributed Control of Operations

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Widespread adoption is challenging.
Blockchain's linkage with illegal activities.
Large scale deployments are necessary to ensure integrity.

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<td>Relevant Needs</td>
<td>Individuals' needs:

Transparent and participative access to public sector services

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</tr>
<tr>
<td>Potential uses / applications/ services</td>
<td>

Vehicle registries
Storing citizens' identities - personal details/data
Voting records (Electronic voting)
Benefits disbursements
Electronic medical records - Use of blockchain technologies to secure data integrity of patients' health records.
Property/Land record registry.

</td>
</tr>
</table>

Blockchain	
	• Use by Resident Registration Offices. • Decentralised crowdfunding. • Use of blockchain technologies to access public service providers based on performance rather area of residence. • Decentralized management of information and data related to citizens and enterprises which involve or are monitored by public sector entities. • Management of property titles and monitoring/regulating transactions among citizens and enterprises. • Smart contracts (self-executing contractual states, stored on the blockchain, which nobody controls and therefore everyone can trust) • Music industry (start-up Ujo; blockchain-based distribution of songs) • Connecting smart consumer electronics, cars or bicycles with a mini-computer to a blockchain system to use them as part of the sharing economy • 75 of the biggest banks in the R3 consortium are working on CORDA - a distributed ledger platform. CORDA is heavily inspired by blockchain systems[228] • elections[229]
Existing solutions / products / services	• Bitcoin (digital currency) • Bitnation[230] • Blockchain-based Guardtime service (Estonia) to develop and accelerate blockchain-based security, transparency and governance of patients' healthcare records[231],[232]. • Bitnation & Estonian eResidency initiative to allow Estonian e-residents, "regardless of where they live or do business to be able to notarize their marriages, birth certificates, business contracts, and much more on the blockchain[233].

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[228] Sebastian Stommel, „Blockchain Ökosysteme", Datenschutz und Datensicherheit, 1/2017.
[229] Stefan Mey, Die Verkettung der Welt, Spektrum, 7/2016, http://www.spektrum.de/news/die-blockchain-koennte-die-weltwirtschaft-revolutionieren/1416132
[230] https://bitnation.co/
[231] https://guardtime.com/blog/estonian-ehealth-partners-guardtime-blockchain-based-transparency
[232] https://news.bitcoin.com/estonian-health-records-secured-by-blockchain/
[233] https://cointelegraph.com/news/estonian-e-residency-and-bitnation-launch-new-public-notary-in-blockchain-jurisdiction

5.3.6 Bots

Bots	
Identifier	TE#6
SWOT Analysis	

Strengths	Weaknesses
• Chatbots are more "human". • They speak the real language. • Improved interaction with users. • Easy to use – simple interface. • Can be developed fast. • Not expensive to build. • Saving manpower – Cutting resources down. • Providing answers faster. • Able to multi-task. • Performing constantly-not restricted by time limits. • Unbiased and straight to the point.	• Can also be used as malware, allowing attackers to take control over an affected computer. • Can be used to generate spam, and spread viruses, spyware. • Can be used to steal personal and private information (like credit card numbers, bank credentials, other sensitive information) and communicate it back to the malicious user. • Launching denial of service (DoS) attacks against a specified target.
Opportunities	Threats
• Save manpower – Channel manpower to other tasks. • Facilitate interaction with the public sector for citizens. • Providing service to citizens 24/7. • Enable easier identification of/access to services and quicker transaction processing. • More natural interaction with services.	• Privacy Considerations • Limited Interaction Patterns

Relevant Needs	**Individuals' needs:** • Transparent and participative access to Public Sector services **Governments' needs:** • Resource optimization • Accessible Public Sector information
Potential uses / applications/ services	• Bots to answer simple citizen questions / automated online assistants instead of call centers with humans to provide a first point of contact. • Buyer agents/shopping bots, retrieving information about goods and services. • Votebots • Smart Agents in citizens' offices, e.g. in Resident Registration offices or call centers. If someone would like to register himself in a new city, then the software robot could answer the call and direct the citizen to the different systems (e.g. registration at school, kindergarten)

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Bots	
Existing solutions / products / services	• Inteliwise eGov Virtual Assistant[234] • Chatbots Directory[235]

5.3.7 Cloud Computing

Cloud Computing	
Identifier	TE#7
SWOT Analysis	

Strengths	Weaknesses
• High computing power and performance • Agility and flexibility • Scalability and elasticity • Productivity (capability of users simultaneous work on the same data) • Device and location independence • Portability across devices • Speed and improved manageability in getting applications up and running • Cost reductions (operational expenditure instead of capital expenditure, lower needs for in-house IT skills, lower maintenance costs) • Improved security (at central level)	• Absence of legislative framework anout cloud services • Loss of control over sensitive data • Non strict SLAs
Opportunities	**Threats**
• Low infrastructure Costs • Ability to open up services and data • Data Resilience and Sharing • Big data analytics enablement • Low Cost for testing and development environments • Vendor independence	• Insecure Interfaces and API's • Data Loss & Leakage • Risk of vendor lock-in in certain cases • Vagueness around legal ownership of the data • DevOps roles necessary • Unexpectedly high charges (e.g. ingress of data might be free, but extracting it can be costly)
Relevant Needs	**Individuals' needs:** • Transparent and participative access to public sector services **Businesses' needs:** • Easy access to public sector information (open data). **Governments' needs:** • Resource optimization

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[234] https://www.inteliwise.com/products/egov-virtual-assistant/
[235] https://www.chatbots.org/country/gr

Cloud Computing	
	• Accessible public sector information
Potential applications / services	• Share ICT resources among multiple agencies • Collaboration applications (e-mail, web conferencing) • Cloud bursting for increased availability at peak seasons (gsis, final exams' results, etc.)
Existing solutions / products / services (tentative)	• Public clouds (Google docs, Microsoft Office 365, SAP Business by Design) • Private Cloud of companies • Hybrid Clouds (has elements of private and public cloud) [236] • Infrastructure as a service (IaaS) (e.g. Amazon Web Services, Google Compute Engine, Windows Azure)[237] • Platform as a service (PaaS) (e.g. Google App Engine, Amazon Elastic Beanstalk)[238] • Software-as-a-Service (SaaS) (e.g. from Microsoft, Google, Salesforce.com, Cisco, Intuit)[239]

5.3.8 Data Analytics

Data Analytics	
Identifier	TE#8
SWOT Analysis	

Strengths	Weaknesses
• Analysis of unstructured data types. • Greater and faster insights. • Faster and better decision making. • Competitive advantage. • Better customer service. • Enabling anticipation of business opportunities. • High ROI if implemented successfully.	• Potential of high initial investment. • Special computer power required (particularly for big data). • New way of working within an organisation required to leverage real-time insights. • Biases, imperfect data (incomplete, inaccurate, of variable quality and format).

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[236] Maamar Ferkoun, „Cloud computing news", 2014, https://www.ibm.com/blogs/cloud-computing/2014/02/top-7-most-common-uses-of-cloud-computing/
[237] Heinrich Seeger, „IaaS - vergleichen lohnt sich", Computerwoche, 8.12.2014, http://www.computerwoche.de/a/iaas-vergleichen-lohnt-sich,3060832
[238] Klaus Manhar, „PaaS-Anbieter im Vergleich", Computerwoche, 15.12.2014, http://www.computerwoche.de/a/paas-anbieter-im-vergleich,3066351
„[239] Top100 - Cloud Computing", http://www.computerwoche.de/g/top100-cloud-computing,103280,3

Data Analytics	
Opportunities	**Threats**
• Better citizen service. • Rapid understanding of citizens, applicants and providers across multiple programs, cases and locations. • Benefit eligibility determination and fraud determent. • Improved risk management and resource optimization.	• Data management and access to talent can be problematic. • Structure around coordination and alignment of the use of data analytics is needed, as typically analytics is managed by a variety of executive roles and can benefit a wide range of functions.
Relevant Needs	**Individuals' needs:** • Inclusive well-being and health **Businesses' needs:** • Easy access to public sector information (open data). **Governments' needs:** • Accessible Public Sector information
Potential uses / applications/ services	• Public services' usage analytics. • Report generation. • Citizen information repository with shared access by multiple government organisations (while adhering to privacy restrictions). • Predictive analytical framework to identify crime "hot spots", based on historical and real-time crime data, to efficiently allocate resources and reduce crime. • What if scenarios analysis. • Policy making, but also public sector management based on data analytics. • Predictive Analytics (pattern analysis to predict future developments or behaviour (e.g. of consumer)).
Existing solutions / products / services	• data analytics for financial markets (banking) • Betting firms use big data analytics • Big data analytics for insurance companies • Data analytics for selling fast moving consumer goods • Data Analytics for Social Networks (e.g. Topic Detection) • Data Analytics for Smart Cities • Watson Analytics, guided and automated analytics from the cloud[240] • ForecastThis: automated predictive modelling solutions[241] • Natero Customer Success platform that

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[240] https://www.ibm.com/analytics/watson-analytics/us-en/
[241] http://www.forecastthis.com/

Data Analytics
- predicts churn and up-sell opportunities[242]   - Wise machine Learning for Customer Success[243]

5.3.9 e-Identities

e-Identities	
Identifier	TE#9
SWOT Analysis	

Strengths	Weaknesses
- Supporting e-services and customized service-delivery. - Improving security in terms of accountability (establishing a direct trusted link between a person and an action within an application or website). - Increasing administrative efficiency and reducing cost (deployment of fully transactional systems, diminishing manual/repetitive work and interactions. - Reducing burden for citizens when engaging with the public administration. - Limiting possibilities for fraud, identity theft and phishing. - Supporting mutual recognition of documents and certificates in cross-border situations. - Facilitating mobility.	High costs of the eID infrastructure itself and organisational costs (card issuance and cardholder enrolment).
Opportunities	**Threats**
- Faster Access to Services - Global Identification Services for all organisations - Potentially improving national security. - Building a more inclusive European society (a seamless use of eID should offer EU wide service provision). - Stimulating the introduction of new e-services and generating economies of scale, as eID is part of an 'infrastructural approach'.	- Privacy concerns for end users. - Interoperability challenges (multiple identity schemes applied on a per-sector/per-country basis – multitude of standards used and lack of a commonly accepted one. - Legal difficulties (different legal frameworks on a per-country basis) in case of a cross-country infrastructure. - High costs for securing identity registries
Relevant Needs	**Individual's needs:** Transparent and participative access to public sector services

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[242] https://www.natero.com/
[243] http://www.wise.io/

e-Identities	
	Businesses' needs: • Streamlined and reliable administrative procedures in the Public Sector • Lessen complexity • Technology implementation • Easy access to public sector information (open data). **Governments' needs:** • Participative democracy • Accessible public sector information
Potential uses / applications/ services	• e-Identities for citizens (also for refugees and migrants). • Pan-European electronic-identity authentication system. • Use digital IDs in European processes.
Existing solutions / products / services	• Electronic identity cards in many European Countries (e.g. in Estonia for logging into bank accounts, as pre-paid public transport ticket, for digital signatures, for i-voting, for assessing government databases to check medical records, taxes, for picking up e-prescriptions)[244]

5.3.10   e-Signatures

e-Signatures	
Identifier	TE#10
SWOT Analysis	

Strengths	Weaknesses
• Digital authenticity (documents signed with a digital signature can stand up in court)/integrity of electronic documents. • Non-repudiation (signing an electronic document digitally identifies one as the signatory and that cannot be later denied). • Enhanced security and imposter prevention (e-signatures cannot be forged). • Ease of use. • Ease of tracking digitally signed	• High costs (verification software and signing certificates from certification authorities to encrypt a file with one's digital signature are needed). • Incompatibility among different digital signature standards.

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[244] „ Electronic ID Card", https://e-estonia.com/component/electronic-id-card/

e-Signatures	
documents. • Improved accuracy-reduced manual data errors. • Time-stamp inclusion. • Expansion of e-commerce. • Enhanced efficiency and speed of doing business. • Cost savings (in terms of time, printouts, stationery, postage, storage space). • Enhanced customer service.	
Opportunities	**Threats**
• Faster completion of administrative procedures.	• Trading with the help of digitally signed documents can be risky in states and countries where relevant laws are weak or non-existent. • Risk of financial loss and damage to corporate image and shareholder value in case of mishandling electronic files and signatures. • Related products may have a short shelf life.
Relevant Needs	**Businesses' needs:** • Streamlined and reliable administrative procedures in the Public Sector • Lessen complexity. • Technology implementation
Potential uses / applications/ services	• Citizen to Citizen Transactions • Business to Citizens transactions • eGovernment Services
Existing solutions / products / services	• DigiSigner, free e-signature service[245] • DocuSign[246] • eSignGenie[247] • Adobe Document Cloud / Adobe Sign

5.3.11   Geographic Information Systems

Geographic Information Systems	
Identifier	TE#11
SWOT Analysis	

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[245] https://www.digisigner.com/
[246]https://www.docusign.com/
[247] https://www.esigngenie.com/

Geographic Information Systems	
Strengths	**Weaknesses**
• Multi-layer visualization opportunities - 3D representation of territories. • Mature and reliable technologies. • Significant number of players on the market. • Improving communication. • Facilitating and improving decision making and management with regard to specific geographic locations.	• Updating and maintenance costs. • GIS accuracy depends upon source data, and how it is encoded to be data referenced. • GIS systems are not "off the shelf" solutions - they must be assembled and constructed to a user design. This could be a long, complex and costly process. • GIS require a complex command language.
Opportunities	**Threats**
• Location-enabled services for citizens, businesses and public organisations • Smart urban planning. • Possibilities to integrate crowd sensing and IoT data streams.	• High rate of obsolescence as GIS technology expands rapidly •
Relevant Needs	**Individuals' needs:** • Environmental Amicability **Businesses' needs:** • Technology implementation • Reduce taxation levels and lessen complexity
Potential uses / applications/ services	• Traffic updates • Local services suggestion • Indoor localization services • Integration with cadastrial and energy consumption data for tax collection and energy saving purposes.
Existing solutions / products / services	• Google earth[248] • Integrated Land and Water Information System (ILWIS) GIS and remote sensing software for both vector and raster processing by ITC Enschede (International Institute for Geo-Information Science and Earth Observation) in the Netherlands for use by its researchers and students[249]. • System for Automated Geoscientific Analyses (SAGA GIS) a free and open-source GIS computer program, used to edit spatial data by the Department of Physical Geography, University of Göttingen, Germany[250].

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[248] https://www.google.com/earth/
[249] Wikipedia - ILWIS, https://en.wikipedia.org/wiki/ILWIS
[250] https://en.wikipedia.org/wiki/SAGA_GIS

5.3.12   Internet of Things

Internet of Things	
Identifier	TE#12
SWOT Analysis	

Strengths	Weaknesses
• Advanced connectivity of devices, systems and services beyond machine-to-machine communications. • Advanced levels of automation, control and monitoring (avoiding human intervention). • Availability of more information and better decision making. • Higher Efficiency, Safety and Comfort. • Covering a variety of protocols, domains, and applications. • Enabling advanced applications (smart grid, smart cities, etc.). • Constant and diffused territory control. • Shorter reaction times. • Context awareness.	• Compatibility/interoperability issues – platform fragmentation and lack of a common standard. • Complexity – more opportunities of failure/failures may have serious consequences. • Single point of vulnerability of multiple systems. • Batteries dependency. • Fewer requirements in human resources – rise of unemployment. • Creating dependence of daily life upon technology.
Opportunities	Threats
• Better Human-Machine integration for public services • Empowering Big Data • Creation of smart cities/smart buildings. • Production of context-aware products/services. • Generation of dynamic and distributed information.	• Physical safety in case of private and confidential information being accessed by unauthorized intruders. • Privacy and security issues. • Issues around the ownership of data and how the latter is used.

Relevant Needs	**Individuals' needs:** • Inclusive well-being and health • Housing and secure shelters **Businesses' needs:** • Agile and participative Public Sector **Governments' needs:** • Digitization

Potential uses / applications/ services	• Use of IoT solutions for fall prevention or quick responses.
	• Logistics and Supply Chain Management in the public sector.
	• Health care applications:
	  o remote health monitoring
	  o emergency notification systems/contacting the hospital in case of emergencies
	  o telemedicine
	  o early detection of and warning

Internet of Things	

	about patients at risk
	• Transportation-related applications:
	  o road condition monitoring
	  o public transport vehicle monitoring system
	  o inter and intra vehicular communication
	  o smart traffic control, smart parking
	  o connected cars (data of mobile phones to compute the density of traffic)
	  o electronic toll collection systems
	  o logistic and fleet management
	  o vehicle control
	  o safety and road assistance
	• Environmental and Disaster Management applications:
	  o Energy management
	    o Smart lighting (depending on the twilight value)
	    o smart irrigation of green areas
	  o Waste management - management of garbage bins (with individual sensors)
	  o Forest fire detection
	  o earthquake or tsunami early-warning systems
	  o Monitoring and controlling operations of urban and rural infrastructures (e.g. bridges, railway tracks, on- and offshore- wind-farms, etc.)

Existing solutions / products / services	• Greencity solutions[251] • IBM Watson IoT Platform[252] • Marvell's EZ-Connect platform™[253])

5.3.13 Machine Learning

Machine Learning	
Identifier	TE#13
SWOT Analysis	

Strengths	Weaknesses
• Produce reliable, repeatable decisions and results. • Uncover "hidden insights" through	• Poor results if not investing in training • Technology not advancing in the paces expected

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[251] http://greencitysolutions.de/
[252] http://www.ibm.com/internet-of-things/
[253] http://www.marvell.com/solutions/internet-of-things/

Machine Learning	
• learning from historical relationships and trends in the data. • Faster processing than the human brain.	
Opportunities	**Threats**
• Value extraction from large volumes of data currently underexploited. • Identification of weak signals and patterns. • Intelligent Service Providers	• Machine ethics - Systems which are trained on datasets collected with biases may exhibit these biases upon use, thus digitizing cultural prejudices such as institutional racism and classism. Responsible collection of data thus is a critical part of machine learning.
Relevant Needs	**Governments' needs:** • Digitization • Recruitment, training
Potential uses / applications/ services	• Adaptive web sites • Text-based sentiment analysis (opinion mining) • Natural Language Processing and Speech recognition applications for enhanced customer service • Handwriting recognition • E-mail spam filtering • Recommendation systems • Fraud detection • Network intrusion detection • Machine learning systems for identification over the phone (e.g. via the pulse frequency of the caller). • Machine learning systems used in the waiting room of a general practitioner to ask the patient about his/her symptoms and suggest the doctor a first diagnose on which the doctor can agree or disagree.
Existing solutions / products / services	• AmazonML (Amazon Machine Learning)[254] • AzureML (Azure Machine Learning)[255] • BigML[256] • Google Prediction API, a Machine Learning black box for devs[257] • Wise, Machine Learning for Customer Success[258]

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[254] http://cloudacademy.com/blog/aws-machine-learning/
[255] http://cloudacademy.com/blog/azure-machine-learning/
[256] http://cloudacademy.com/blog/bigml-machine-learning/
[257] http://cloudacademy.com/blog/google-prediction-api/
[258] http://www.wise.io/

5.3.14   Natural Language Processing

Natural Language Processing	
Identifier	TE#14
SWOT Analysis	
Strengths	**Weaknesses**
• Enhanced customer experience. • Improved documentation efficiency and accuracy. • Identification of the most pertinent information from large databases. • Contextual understanding.	• Domain specific ontologies required. • Language specific dictionaries required. • Difficulty to identify irony.
Opportunities	**Threats**
• Perspectives and perceptions identification. • Extraction of value from large volumes of data currently underexploited. • Fighting Digital Divide	• Government rules and regulations hindering natural language processing solutions to be widely adapted. • Need for smart devices, web & cloud-based applications. • Privacy Considerations
Relevant Needs	**Governments' needs:** • Digitization • Rework the trust deficit
Potential uses / applications/ services	• Conversational interfaces / Voice interfaces • Automated online assistants (question answering) • Sentiment analysis • Native language identification
Existing solutions / products / services	• Clarabridge NLP[259] • RASA NLU[260]

5.3.15   Wearables

Wearables	
Identifier	TE#15
SWOT Analysis	
Strengths	**Weaknesses**

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[259] http://www.clarabridge.com/nlp-natural-language-processing/
[260] https://techcrunch.com/2016/12/16/nlpforeveryone/

Wearables	
• Convenience of use (hands-free). • Personal safety improvement. • Health and fitness tracking - Real-time monitoring and information provision to health providers. • Ensuring better engagement with the environment. • Endless possibilities for connectivity with other devices.	• Expensive. • Not as widely accepted- • Heat and precipitation can damage wearable devices. • Power management (constrained power reserves-short battery life) and heat dissipation issues affecting the quality and trust of the devices. • Not widely accepted – awkward for some.
Opportunities	**Threats**
• Improved service personalisation • Retrieval of sensory information about individuals • Compensating disabilities or supporting elderly people in public services/buildings. • Providing info in sites of interest through VR or augmented reality.	• Invading privacy of other people. • Potential misuse of private (biometric/physiological/health) data. • Risk of hacking and thus misusing wearable devices.
Relevant Needs	**Individuals' needs:** • Inclusive well-being and health • Modern workplaces **Governments' needs:** • Civil servants as a community of change
Potential uses / applications/ services	• Wrist computers • Smart watches • Digital glasses
Existing solutions / products / services	• VitalConnect Band Aid (wearables to check health vitals)[261] • Medical Wearable Solutions Eyeforcer[262] • Rooti Labs Limited W/Me2[263] • Cardio family of products[264] • Biovotion AG monitoring platform[265]

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[261] http://www.vitalconnect.com/news/vital-connect-uses-band-aid-like-wearable-strip-to-monitor-your-vital-signs

[262] http://medicalwearablesolutions.com/devices/

[263] https://www.rootilabs.com/index.html?en#/wme2/begin?en

[264] https://www.getgardio.com/about-us/

[265] http://www.biovotion.com/

5.3.16   Virtual Reality

Virtual Reality	
Identifier	TE#16
SWOT Analysis	

Strengths	Weaknesses
• Simulating the real world – realistic scenarios • Stimulus Control and Consistency. • Immersive experience. • Convenience-remote engagement, also saving time and money. • Safe Testing and Training Environment - modelling complex task-performance behaviours, many of which carry life-or-death risks in real-world learning. • Cuing Stimuli to Support "Error-Free Learning". • Self-Guided Exploration and Independent Practice. • Real-Time Performance Feedback. • Gaming Factors to Enhance Motivation. • Patient rehabilitation. • Innovative and enjoyable.	• High price. • Technical challenges (e.g. platform compatibility). • Interface-related challenges (cables impeding movement, poorly designed instruments causing fatigue and an unsettling feeling of enclosure). • Prolonged use side-effects (sickness, headache, vertigo, nausea, disorientation etc.). • Individuals having a hard time deciphering what is real and what is virtual. • Faulty training results in case of poor models of the real world.
Opportunities	Threats
• Virtual Public Sector Environments. • Public organizations employees training. • Citizen's Training.	• Risk of not wide use and acceptance. • High investments costs. • Health threats.

Relevant Needs	**Individuals' needs:** • Experiential education and training • Environmental Amicability • Modern Workplaces **Businesses' needs:** • Talent acquisitions and retention **Governments' needs:** • Recruitment, training (and IT Literacy) • Resource optimization
Potential uses / applications/ services	• Virtual tours on Museums • rescue teams training • Citizens training for crisis situations
Existing solutions / products / services	• Oculus Rift[266]

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[266] https://www.oculus.com/

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6 Bridging Societal Needs with Technologies

6.1 Mapping Technologies to Societal Needs

Societal Needs	Technologies and Trends to address these needs
Individuals' Needs	
Inclusive well-being and health	• (Service) Personalisation • Augmented Reality • Big Data • Data Analytics • Internet of Things • Wearables
Transparent and participative access to Public Sector services	• Digitalization • e-Participation • Open Data • Policy Making 2.0 • Social Networking • Artificial Intelligence • Biometrics • Blockchain • Bots • Cloud Computing • e-Identities
Equal employment opportunities	• Smart Workplace
Experiential education and training	• Crowdsourcing • Gamification • Virtual Reality
Housing and secure shelters	• Internet of Things
Modern workplaces	• Mobile Devices • Smart Workplace • Wearables • Virtual Reality
Connected and integrated Europe	• API Economy • Digitalization • e-Participation • Big Data

Societal Needs	Technologies and Trends to address these needs
Environmental Amicability	- Open Data - Policy Making 2.0 - Social Networking - Geographical Information Systems - Virtual Reality
Businesses' Needs	
Ease of doing business	Digitalization
Streamlined and reliable administrative procedures in the Public Sector	- API Economy - e-Identities - e-Signatures
Agile and participative Public Sector	- e-Participation - Gamification - Internet of Things
Stimulate an entrepreneurial and start-up culture	- e-Participation - Open Data (Service) Personalisation
Easy access to Public Sector information (open data)	- API Economy - Digitalization - Open Data - Open Government - Artificial Intelligence - Big Data - Cloud Computing - Data Analytics - e-Identities
Talent acquisitions and retention	- Smart Workplace - Virtual Reality
Business expansion	Crowdsourcing
Access to a unified European market	- API Economy - Digitalization

Societal Needs	Technologies and Trends to address these needs
Technology implementation	- API Economy - Mobile Devices (Service Personalization) - e-Identities - e-Signatures - Geographical Information Systems
Reduce taxation levels and lessen complexity	(Service Personalization) - e-Identities - e-Signatures - Geographical Information Systems
Governments' Needs	
Resource optimization	- API Economy - Artificial Intelligence - Bots - Cloud Computing - Virtual Reality
Lean bureaucracy	Open Data
Digitization	- API Economy - Digitalization - Mobile Devices - Open Data - Internet of Things - Machine Learning - Natural Language Processing
Recruitment, training (and IT Literacy)	- Augmented Reality - Machine Learning - Virtual Reality
Rework the trust deficit	- Open Data - Policy Making 2.0 - Sentiment Analysis - Social Networking - Natural Language Processing
Participative democracy	- e-Participation - Gamification - Open Data - Sentiment Analysis - e-Identities

Societal Needs	Technologies and Trends to address these needs
Appropriate remuneration and incentives	• Gamification
Employee empowerment and recognition	• Gamification
Accessible Public Sector information	• API Economy • Digitalization • Open Data • Artificial Intelligence • Big Data • Bots • Cloud Computing • Data Analytics • e-Identities
Civil servants as a community of change	• Crowdsourcing • e-Participation • Gamification • Open Government • Sentiment Analysis • Wearables

Table 3: Mapping of identified societal needs to technologies

6.2 SONNETS Hype Curve of Emerging Technologies and Trends for the Public Sector

As a consequence of the analysis of the material presented previously and as indirect implication of the previous roadmap recommendations and technology maturity levels, it is clear that technology adoption and utilisation, especially in the case of the Public Sector, is highly related with a time horizon that demonstrates the maturity and applicability of technologies over different domains, without however taking for granted that technologies that are considered "new" are not applicable or are not in a position to boost innovation. In fact, innovation is highly linked with the uptake and exploitation of technologies close to their birth date. However when talking about the public sector it is imperative to understand that such innovations could only be realised and sustained if there exists a common and well defined technology uptake strategy that would make sure that mature technologies are already present in an organisation's body.

The next figure presents a conceptual hype curve (or hype cycle)[267] regarding the technologies and trends identified in the previous sections with regard to their maturity and applicability as seen from the Public Sector's perspective. This hype curve is based on information that derives from:

- the current trends of the ICT (in general) and of the ICT domain
- the views that have been recorded during the brainstorming activities, the focus groups and the interviews that took place during WP3.

One should consider that the placement of each element on the curve has been performed having in mind both the mature and the immature sub-areas it contains and how these are considered from the view of the public sector, where already established and widely used technologies are more preferable. As a result, an indicative timeframe for take-up/adoption and results expectancy can be drawn, grouping technologies and trends into those that are considered:

- more mature and could deliver concrete results in a short term horizon of no more than 1 years,
- on the verge of maturity and could produce results within 2 to 3 years of research and
- still in infantry and require more intense and long-lasting research efforts, putting their major concrete contribution to the domain of Public Sector Innovation in a timeframe that lies 3 to 5 years ahead from today.

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[267] http://en.wikipedia.org/wiki/Hype_cycle

Figure 3: Hype Curve of Identified technologies for supporting Public Sector Innovation

The next hype curve also presents the trends identified in the previous sections with relation to their take-up potential and their maturity (and therefore stability) by the public sector.

Figure 4: Hype Curve of Identified trends for supporting Public Sector Innovation

6.3 SONNETS Magic Quadrant of Emerging Technologies and Trends for the Public Sector

As indicated in the SONNETS Innovation Identification Framework, although the main objective of a public sector might be to import innovation and renovate itself, the vision of becoming itself an Innovation Driver cannot be neglected and recently gained a similar importance to self-digitalisation and internal improvement.

Therefore, when looking at the technologies and trends analysed in the previous section, one has to also distinguish which of those refer to renovating the public sector itself, and which could help the latter to become an innovation driver itself, once it comes to the position to successfully adopt them and use them internally at the first place.

The "magic quadrant"[268] in the next figure does not contain tools, as most magic quadrants do, but the technologies and trends as identified by SONNETS. Its purpose is to act as a "sample" of the current landscape of technologies and trends related to the public sector, and therefore the placement of those represents the "median" value of the actual placement on this 2D area of the elements/tools/technologies/methodologies they include.

As the "magic quadrant" in the next figure suggests, the current landscape could be divided in four spaces:

- "PS Labs" where applications are still highly experimental and they are only addressed (or can be used) by public sector personnel, and holding a great but uncertain innovation potential

- "PS Farms" where again the public sector makes extensive use of applications and tools that are in a highly mature and operational state, and holding a great but uncertain innovation potential

- "Open Labs" where direct engagement of citizens/businesses is quite high but applications are again experimental, and holding a more predicted innovation potential, being open for experimentation to third parties, and finally

- "Open Apps" where there exist at the same time high engagement of citizens/businesses and maturity of applications to be used for everyday purposes, and holding a more predicted innovation potential as they are open utilisation from third parties.

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[268] http://en.wikipedia.org/wiki/Magic_Quadrant

Figure 5: Magic Quadrant of Identified trends for supporting Public Sector Innovation

7 Conclusions

©openclipart.org	**What is the purpose of this report?**
	This report pursues the objective to present a compendium of emerging ICT technologies and trends including a description, the application domain of origin, related market potential, a SWOT analysis, the relevance for the public sector, associated societal and public sector needs as well as potential applications and services.
©openclipart.org	**Which objective of SONNETS does this report pursue?**
	The related task to this report attempts to identify:
	• The impacts of the identified emerging ICTs in their original domain
	• The relevance and potential innovations of these ICTs in the public sector
	• The societal and public sector needs which could be met by the application of these ICTs
©openclipart.org	**Which methods form the basis for this report?**
	This compendium has been compiled by using desk-based research as well as information taken from expert interviews, focus groups and workshops.
©openclipart.org	**Which stakeholders have been involved in the process?**
	This report uses information from 11 interviews with IT experts, 34 interviews with representatives of the society, the business sector and the public sector, 4 members of the SONNETS experts advisory board as well as 42 participants of local workshops.
©openclipart.org	**How will this report be used within the project?**
	The present version of this report will be validated during the WP3 validation workshop in Athens in February 2017.
	The final version of this report will be used in WP4 as a

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	compendium of emerging ICT technologies and trends.
©openclipart.org	**What are the next steps?**
	In WP4 these identified emerging technologies and trends will be further analysed (e.g. regarding current research activities), whereas their matching to the identified societal and public sector needs will be further considered with the aim to develop research needs and finally the SONNETS research roadmap.

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I. APPENDIX A: Preliminary Pool of Emerging Technologies and Trends

Generic IT Trends	Enterprise/Industry Trends
Ambient User Experience	Industry 4.0
API Economy	Enterprise Collaboration
Data-driven Culture	*Government Trends*
Digitalization / Use of Electronic files	(Citizen) Data Science
Information of Everything	Collaborative Government
Internet of Things /	Direct Democracy
Internet of Anything /	**e-Participation**
Internet of Everything	**Open Data**
People-Literate Technology	**Open Government**
Risk-Based Security and Self-Protection	**Personalization**
Software-defined everything/anything (SDx)	**Policy Modelling / Making 2.0**
(Software-defined Networking,	*Other*
Software-defined Applications and Infrastructures,	Agile Development / DevOps Philosophy
Software-defined Security)	**Crowdsourcing** (Crowdsourcing Platforms)
Two-Speed IT / Right Speed IT	Digital Dexterity
Whitelisting	**Gamification**
Cross-Platform-Development	**Mobile Devices** / Mobility
Workspace Trends	**Sentiment Analysis**
Automation of knowledge work / Intelligent Automation	Serious Gaming
Mobile Workspace and Apps / Mobile Productivity	Smart Cities
Smart Workplace	**Social Networking**

Technology	Sub-fields
3D Technologies	3D Displays (Volumetric and Holographic 3D Displays)
	3D Holograms
	3D Imagery and Content
	3D scanners
Affective Computing	Enhanced use of presence
	Emotion-aware mobile services
Ambient Computing / Ambient Intelligence	
Architectural / Design	Advanced System Architecture / Neuromorphic Architecture
	Client Computing
	Containers / Containarization
	Mesh App and Service Architecture
	Microservices architecture
	Network Function Virtualization (NFV)
	Responsive and adaptive web design
	Web-scale IT
	Virtualization
Artificial Intelligence and Autonomic Computing	Amplified Intelligence / Intelligence Amplification
	Artificial Intelligence
	Autonomic Computing
	Autonomous Agents and Things
	Autonomous and near-autonomous Vehicles / Autonomous Driving
	Autonomic Platforms
	Cyber Physical Systems
	Bots

Technology	Sub-fields
	Chatbots
	Machine Intelligence / Smart Machines
	Machine Learning
	Machine to Machine and Human-machine Interface
	Virtual Personal Assistants / Smart Advisors
Augmented and Virtual Reality	**Augmented Reality**
	DSCVR Headset
	Extrasensory Dimensions
	Haptics (Electrovibration, Weight shifting handsets)
	Immersive Communications
	Smart Glasses
	Virtual Reality
	Virtual worlds collaboration
Biometrics	**Biometrics**
	Bioacoustic Sensing
	Quantified Self
	Skinput
Computing	**Cloud Computing** (Hybrid / Federated / Mobile)
	Cloud Service Integration
	Distributed Computing
	Fog Computing / Device Mesh / Digital Mesh
	High-Performance Computing / Exascale Computing
	Intelligent routing to devices
	Quantum Computing
	Ubiquitous Computing / Computing Everywhere
Contextual Computing	Contextual Awareness
	Contextual Computing / Context-aware Computing

Technology	Sub-fields
Currency-related	**Blockchain**
	Cryptocurrency / Cryptocurrency Exchange
	Virtual Currency
	Mobile Money
Data Technologies	**Big Data** (Big Data Computing, Big Data Analytics)
	Business Intelligence
	Computer Vision
	Data Analytics (Descriptive / Predictive / Prescriptive / Self-Service / Pervasive and Invisible)
	Data Lakes
	Data Visualisation (Picture this)
	Geographical Information Systems (GIS)
	Linked Data
Data Storage	Micro Data Centers
	Nanostructured glass used for high-density 5D data storage
	Nonvolatile Memory
	Smart Data Storage
	Universal Memory
Digital Security / ICT Security	Adaptive Security Systems / Adaptive Security Architecture
	Authentication Mechanisms
	Big Data Security Analytics
	Capability-based Security
	Cyber Security
	Digital Certificates
	e-Identity / Electronic Identity
	e-signature / Electronic signature
	Homomorphic Encryption

Technology	Sub-fields
	Neuromorphic Security Systems
	Security by Software Design
Interfaces	Gaming interfaces and controls to run business applications
	Natural User Interfaces
Internet of Things (IoT) / Web of Things / Everything Connects	Beacons
	NFC Handsets, Payment Cards (Contactless Payments)
Natural Language Processing	Natural Language Processing
	Natural Language Search / Natural-Language Question Answering (NLQA)
	Speech-to-Speech Translation
	Conversational Interfaces / Voice Interfaces
	Speech recognition / Voice and tone recognition
Networking	4G / 5G / LTE (Long Term Evolution, also met as 4G)
	Centralised-RAN or Cloud-RAN
	Mesh Networks
	Network Optimization
	Photonics
?Processing	Multicore
Robotics	Advanced robotics
	Drones (Sense and avoid drones)
	Robots That Teach Each Other
	Smart Robots
	Software Robots
Sensors	Brain-Computer Interface / Brain wave sensing
	Eye tracking and response monitoring
	Gesture Control
	Microelectromechanical Systems (MEMS)

Technology	*Sub-fields*
	Sensors
	Smart Dust
?Utilities	Biochips / Organs on chips
	Printed Electronics
	3D Integrated Circuits
Mobile and Wearable Devices	**Mobile Devices**
	Ultra-Portable Computing
	Wearables / Wearable Devices
Wireless	Indoor Positioning (Wi-Fi and Bluetooth based positioning systems, light-based and magnetic field system)
	M2M communication services
	Near Field Communication (NFC)
	Power from the Air (wi-fi powered internet devices)
	RFID
	Wi-Fi Aware and Wi-Fi Sense

II. APPENDIX B: Summaries of Interviews with IT Experts

Informant Question	Adolfo Menéndez Fernández (ATOS Expert #1)	Carmen L. Padrón Nápoles, Atos (ATOS Expert #2)	Jesús Troya, 3M (ATOS Expert #3)
1. Can you briefly describe your profile, i.e. your occupation, the field(s) of expertise, your interest in ICT, etc.?	• IT Strategy Manager in a multinational energy company • Member of the Board of Directors of the Business Agility Corporation (BAC), which aims at promoting enterprise agility and allowing companies to take advantage of the digital transformation and the emerging technologies with confidence. • Areas of interest/expertise: IT Strategy and Innovation, Processes and ERP, digital transformation, mobility solutions, SAP.	• Computer Science Engineer, Dr • Broad experience in Education and technologies applied to this sector. • Interested in how the technology can help educational processes be more effective and how to improve education in general.	• Computer Science Engineer • Technical Director in national (Spain) and international governmental projects (Nederlands, Italy, Andorra) related to biometrics (Automated Fingerprint Identification Systems - AFIS, and other fingerprint biometric solutions). Technical expert in facial recognition systems. • Other interests: Artificial Intelligence, Robotics
2. In your opinion, which are the most important technologies / technological trends that could impact the public sector in the following (five) years?	Digitalization and all technologies involved around this concept will change how the public sector manages the relationship with the citizens and companies. *Cloud* adoption, *Mobility* and *Big Data* must help public organizations to simplify and speed the current processes. In terms of adoption, *Mobility* could be the easiest technology to implement while *Cloud* still shows some challenges, especially around cybersecurity. *Big Data*, requires probably a stronger investment and will probably require some time to provide the expected benefit.	Technologies contribute to trends Trends: • Device mesh (IoT, connected intelligent devices) (Infrastructure) • Machine learning (Intelligence of the Components) • Big data (Analytics, find behaviors and patterns in processes) Technology: • Mobile Devices • Augmented Reality • Gamification • Personalization (get context info) Impact is dependent on the maturity of the technologies and is greater if innovation is applied to horizontal processes in the PS rather than to vertical ones.	• Biometrics • Robotics • Big Data / Open Data

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Informant Question	Adolfo Menéndez Fernández (ATOS Expert #1)	Carmen L. Padrón Nápoles, Atos (ATOS Expert #2)	Jesús Troya, 3M (ATOS Expert #3)
a. Which are the most important technologies / technological trends that could improve the operation of the public sector in the following years?	(i) PS modernization • Cloud Computing • Big Data • Mobility (digitalization of processes)	(i) PS modernization • Personalization	(i) PS modernization • Big Data • Biometrics • Robotics
b. Which are the ones that could transform the public sector into an innovation driver?	(ii) PS as an innovation driver • Open Data	(ii) PS as an innovation driver Universities apply their research to the different sectors. If innovation can scale to other levels, these innovation actions make PS an innovation driver. The point is not in the innovation itself but on the scalability of the innovation.	(ii) PS as an innovation driver • Open Data • Biometrics • Robotics
c. Which are your predictions on the growth or market potential of these technologies?	-	-	-
3. Which are the societal needs / needs of the public sector that could be addressed through the use of these technologies?	Again, getting a quick and efficient answer from public organizations must be a focus around the digitalization of the public sector. No more long queues or waiting times for an official paper and so on. Public sector should provide "almost" an On Line answer to any citizen request wherever he/she is. At this point, mobilization of public services is a "must" for modern public sector. On the other hand, simplification and data centralization should be supported by technologies such as Big data.	Personalization • Inclusion (impaired people should have access to services, such as education, transport, etc.) Augmented Reality • Learning experience enrichment - learning becomes more attractive (more skilled people) Gamification • Achievement of higher levels of collaboration between teams	Robotics • Health care Big Data • Avoid fraud • Automatization of processes Biometrics • Citizen Security • Assistance for impaired people • Improve overall experience
4. Could you please expand on the way in	I guess that all actors will get an important benefit from digitalization and in general from	Tools that allow public servants to work more motivated (incentives through gamification).	• Facial recognition can help speed

Informant Question	Adolfo Menéndez Fernández (ATOS Expert #1)	Carmen L. Padrón Nápoles, Atos (ATOS Expert #2)	Jesús Troya, 3M (ATOS Expert #3)
which each of these technologies / trends could benefit the public sector / businesses / citizens?	modernization of public sector. We can expect direct impacts from mobile applications and cloud solutions around the simplification and streamlining of "heavy" processes. We should recall that cloud could prove some internal saving on public sector costs and maybe most relevant, a new speed releasing new services to the citizens. Open data and efficient public organization should be pushed by Big Data. Governments, at different level, store tons and tons of very useful data that could be converted into valuable information. At this point, again it is important to get balance between value coming from this information and open information, especially related to cultural regional aspects.	If companies use these technologies to create services, their business will grow. Personalization can help PS to deliver more targeted services to citizens.	processes and manage queues • Improve user experience, PS gaining recognition among citizens • Give instructions to get to the specific room to impaired people entering a hospital through their smartphone or trough panels • Identify criminals on the fly • Avoid fraud on competitive examinations • Speed mobility in borders In general, combination of individual recognition and big data can optimize PS services for each individual

a. Which are the specific (policy) domains (e.g. economic, social, environmental, etc.), these technologies will have an impact on?

Adolfo Menéndez Fernández column: -

Carmen L. Padrón Nápoles column:

Personalization	Extent of Application	Influence
Institutional/ Capacity Development	-	-
Political	All levels	Direct
Economic	-	-
Social	All levels	Direct
Environmental	All levels	Indirect

Jesús Troya column:

Biometrics	Extent of Application	Influence
Institutional/ Capacity Development	-	-
Political	-	-
Economic	All levels	Direct
Social	All levels	Indirect
Environmental	-	-

b. Which will be the extent of that impact (e.g. individual cases, local, regional, national,

Carmen L. Padrón Nápoles column: Bottom up transformation: if people use certain technologies (escalate from small pilots to larger areas), they can push policy makers to regulate.

Jesús Troya column:

Robotics	Extent of Application	Influence
Institutional/ Capacity Development	All levels	Direct
Political	-	-

Informant Question	Adolfo Menéndez Fernández (ATOS Expert #1)	Carmen L. Padrón Nápoles, Atos (ATOS Expert #2)	Jesús Troya, 3M (ATOS Expert #3)
international level)? c. Is this impact direct or indirect?			<table><tr><td>Economic</td><td>*All levels*</td><td>*Direct*</td></tr><tr><td>Social</td><td>*All levels*</td><td>*Indirect*</td></tr><tr><td>Environmental</td><td>*All levels*</td><td>*Direct*</td></tr></table>
5. How feasible do you consider the adoption of these technologies / trends by the public sector?	The adoption will be mainly driven by maturity of those new techs, part of the budgeting restriction. Anyway, we should expect an interesting "business" case coming from those technologies. As stated in the previous point, cybersecurity and the new roles around those technologies could be another factor driving the innovation and adoption speed. As some public organizations are already doing, new organization and cultural change is required to modernize the administration, getting the maximum value of digitalization and new techs.	-	-
a. Are these technologies mature enough and ready for adoption?	-	The supporting technologies are there (they are ready enough to permit other developments) but their application still needs more experience. There is a need to find the way to use these technologies in an innovative way.	Biometrics is mature enough (depending on the technology considered), although it is always evolving and error rates are constantly dropping.
b. Does the public sector already possess the necessary infrastructure and know-how for their adoption?	Education of employees or citizens and how they should change the mindset regarding the relationship with public orgs. Depending on age, adoption could be complex but probably getting the break point easily.	Infrastructure exists but there is a need for developing much more applications to leverage the interactions of people with mobile devices.	The technology is managed by private companies and external integrators but, when applied to PS services, the benefit and the innovation are perceived by citizens as delivered by PS.
c. Is the necessary legislative framework	-	No, only recommendations (personalized access to information). It is not seen as a priority from the authorities' point of view.	Legally speaking, users will have to give consent to surveillance (I am talking about facial recognition) but the benefit they get

Informant Question	Adolfo Menéndez Fernández (ATOS Expert #1)	Carmen L. Padrón Nápoles, Atos (ATOS Expert #2)	Jesús Troya, 3M (ATOS Expert #3)
already in place?			is huge.
d. How would you evaluate the readiness of the stakeholders involved, in terms of their educational level, skills, income, etc.?	-	Civil servants' change resistance. Either is the technology attractive or it is a must for them. Need for PoC and demonstration that the technology works; then, escalate Business models based on collaboration	Citizens are not ready due to privacy issues; a "machine" knows where you are at all times. PS should invest money so that private companies can innovate.
6. Do you see any relevant costs / risks / threats generated by their adoption?	It is easy to observe that CyberSecurity is turning into one of the mayor risk when adopting new technologies. A strong collaboration between all public organizations and why not, private companies, should be an important mitigation factor. On the other hand, education of employees or citizens and how they should change the mindset regarding the relationship with public orgs. Depending on age, adoption could be complex but probably getting the break point easily. Cost is always a factor to be considered but I would like to underline the new roles required for the public organizations that will "compete" with private companies in same "battle field". Government should take advantage of its position and start to adapt education models to these new techs so required balance between required and demanded capacities happens.	The application of these technologies is something that benefits everyone. But if there is not a legal framework that supports them, there will be change resistance. PS should make more visible the innovation that applies.	• Reduction of the number of jobs (or change from one type of work to another) • Threat of hackers modifying parameters or accessing to data • Dependency on technology, what happens if it no longer exists (due to financial crisis or catastrophes)? • IA can turn against us.
7. Could you propose relevant services and	From my point of view, Digital organization, in terms of new roles such as an Agile Officer or	-	See point 4

Informant Question	Adolfo Menéndez Fernández (ATOS Expert #1)	Carmen L. Padrón Nápoles, Atos (ATOS Expert #2)	Jesús Troya, 3M (ATOS Expert #3)
applications to put these technologies / trends in practice, i.e. to exploit the former for addressing specific needs?	Digital Officer is a must for this transformation. This only can happen with a strong sponsorship and budgeting effort supported by a stable strategy. It means and agreement between all parties, social forces and etc. Probably, those challenges require looking for new profiles in public sector. Moving to technology, mobility supported by an integrated citizen identity management could be the easy and faster way to kick off this transformation. Relay on Cloud technologies for sure will help a lot to speed up the changes, citizen feedback adoption, etc.		
a. What is the type of innovation these solutions stand for (e.g. service innovation, service delivery innovation, organizational innovation, etc.)?	-	Service delivery innovation	Service delivery innovation
b. Can you provide real life examples or cases where such services / applications have been implemented or are being implemented?	Some life examples: • Doctor appointment in mobile • Web payment of taxes • Consolidation of citizen data, cadastral information, etc.	• In public transport be able to know if the next bus is adapted to disabled people. • In education, provide an education experience adapted to personal necessities, preferences or context information	• Airport kiosks for checking passports • Life identification against watch lists (terrorism)

Informant Question	FhG Expert #1	FhG Expert #2	FhG Expert #3
1. Can you briefly describe your profile, i.e. your occupation, the field(s) of expertise, your interest in ICT, etc.?	• Director of Sales • Public Sector & Health of a large German IT company	Junior Professor at a German University in the area of information management	Telecommunication company; Business development for the area of the public sector
2. In your opinion, which are the most important technologies / technological trends that could impact the public sector in the following (five) years?	• Robotics (software robots) • Machine learning • Block chain technology • Also: electronic files, e-signature	She thinks that the public sector is not going to implement really new or emerging technologies in the next 5 years. She believes that the PS will integrate technologies which are already in use in the private sector – and that the PS is somewhat lagging behind. It will take some time until technologies like big data will enter the public sector. She said that the different areas of the public sector are badly interconnected and that a common standard is missing to exchange data. However, she thinks that the following (not so new) technologies will enter the PS in the next years: • Social Media • Mobile devices • Electronic files • Cloud solutions • Online citizens accounts	Internet of Things (sensors are getting cheaper every year, thus it will be only a matter of time until sensors will be used everywhere, e.g. coffee machine, fridge, etc.) (…and others not so new ones: Digitalization; Smart City; Clouds; Electronic files)
a. Which are the most important	(i) PS modernization • Robotics/software robots	(i) PS modernization	(i) PS modernization • Internet of Things

Informant Question	FhG Expert #1	FhG Expert #2	FhG Expert #3
technologies / technological trends that could improve the operation of the public sector in the following years?	• Machine Learning • Block chain technology	• Social Media • Mobile devices • Electronic files • Cloud solutions • Online citizens accounts	
b. Which are the ones that could transform the public sector into an innovation driver?	(ii) PS as an innovation driver • Robotics/software robots • Block chain technology	(ii) PS as an innovation driver -	(ii) PS as an innovation driver • Building Information Modeling (BIM) **BIM (Building Information Modeling)** has been introduced by the government for smarter building projects (including virtual models, electronic plans and electronic files); from 2020 onwards all big German building projects should be planned and managed with BIM. Other new technologies like **De-Mail** or the **e-identity card** have not been accepted by the citizens. Many times the public sector is lagging behind the industry, due to older regulations and directives.
c. Which are your predictions on the growth or market potential of these technologies?	-	-	-
3. Which are the societal needs / needs of the public sector that could be addressed through	Robotics / software robots: • staff shortage Machine learning: • easier, faster access to the PS	Electronic files/ Online citizen accounts: • more efficient, faster and easier access to the PS Use of Social Media:	Internet of Things: • traffic management ; car-park management; connected cars • waste management

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Informant Question	FhG Expert #1	FhG Expert #2	FhG Expert #3
the use of these technologies?	Block chain technology: • easy, fast and secure access to PS services	• modern presentation of the PS, to get rid of the negative "outdated" image Mobile devices: • modern work places • possibility of teleworking jobs Digitalization in general: • to help the PS to be a more interesting workplace for IT experts; to use e.g. digital IDs in European processes	• smart lightning (depending on the twilight value) • energy management (e.g. heating in public buildings) • Ambient Assisted Living (AAL) ->artificial intelligence
4. Could you please expand on the way in which each of these technologies / trends could benefit the public sector / businesses / citizens?	Robotics /software robots: They could be used in citizen's offices, e.g. in Resident Registration offices or call centers. If someone would like to register himself in a new city, then the software robot could answer the call and direct the citizen to the different systems (e.g. registration at school, kindergarten) Machine learning: Machine learning systems could be used for the identification over the phone (e.g. via the pulse frequency of the caller) or they can be used in the waiting room of a general practitioner – in this case the system could ask the patient about his/her symptoms and could suggest the doctor a first diagnose on which the doctor can agree or disagree. Block chain technology: Open source software which documents transactions, which are unchangeable and thus very secure. They can be used for financial transactions (bit coin) or also at the Resident Registration Offices or for changes in the land register. These transactions	-	See point 3 above

Informant Question	FhG Expert #1	FhG Expert #2	FhG Expert #3
	then would be secure, easy and fast.		
a. Which are the specific (policy) domains (e.g. economic, social, environmental, etc.), these technologies will have an impact on?	-	-	-
b. Which will be the extent of that impact (e.g. individual cases, local, regional, national, international level)?	-	-	-
c. Is this impact direct or indirect?	-	-	-
5. How feasible do you consider the adoption of these technologies / trends by the public sector?	Robotics /software robots & machine learning: ready for the market - there are pilot projects in UK. It is not a huge market, but there are few providers. In Germany the situation is different. The German public sector is not used to outsource e.g. IT services. They are used to do everything on their own. Therefore in Germany the public sector is nationwide the largest software developer. That's why there are 50 different applications for dog licenses or getting a severely handicapped pass. In other countries the public sector is more open to outsource IT services. Block chain technology: The technology itself is ready for the market (e.g. bit coin). But the applications for the public sector (e.g. for commercial registers) are still under	In Germany there is a lot to do before new IT technologies could be used in the PS: • the legal situation has to be adapted • they need new standards to be able to exchange data between the different areas of the PS • on a technical level it is still difficult to define a unified exchange of data • the personnel needs to be trained to use new IT technologies • in general in the public sector IT is not rated highly • the leadership in the PS in many cases do not promote an "IT culture" • in many cases the mindset in the PS has to change to be able to use IT technologies successfully	It is not a question *if* the internet of things will grow and will be implemented in the public sector – the only question is *how soon* this will happen.

Informant Question	FhG Expert #1	FhG Expert #2	FhG Expert #3
	development. There are very few experts, who could work in this area – but the banking sector is spending millions to further develop block chain technology.	• the education of the personnel in the PS has to change – to improve the IT know-how	
a. Are these technologies mature enough and ready for adoption?	-	Yes, see point No. 2	-
b. Does the public sector already possess the necessary infrastructure and know-how for their adoption?	-	-	-
c. Is the necessary legislative framework already in place?	-	No, it has to be adapted	-
d. How would you evaluate the readiness of the stakeholders involved, in terms of their educational level, skills, income, etc.?	-	See point No. 5	-
6. Do you see any relevant costs / risks / threats generated by their adoption?	There are always costs and risks when you develop a new technology. The problem is that the acceptance of new technologies in the public sector is generally quite low.	The risks are the usual cyber-security risks. Additionally she thinks that it will be hard for some of the staff members, which perhaps are elderly and are not able to adapt themselves to modern IT technologies.	Data protection: It depends, if the sensors only transmit a system status or if they also use personal data. It could also be problematic, if different types of data will be connected. E.g. it could be quite handy, if the data of mobile phones were used to compute the density of traffic, but there is always a risk, if

Informant Question	FhG Expert #1	FhG Expert #2	FhG Expert #3
			this is done anonymously)
7.Could you propose relevant services and applications to put these technologies / trends in practice, i.e. to exploit the former for addressing specific needs?	See point No. 4	-	
a.What is the type of innovation these solutions stand for (e.g. service innovation, service delivery innovation, organizational innovation, etc.)?	-	-	
b.Can you provide real life examples or cases where such services / applications have been implemented or are being implemented?	-	• City of Moers: Usage of social media to represent the public sector • Police in a city in Northern Germany: The police officers were using WhatsApp to communicate with each other. In order to enhance data protection and privacy they implemented a police-messenger similar to WhatsApp. • The electronic file is already in use in several cities.	Smart City: • "T-City" Friedrichshafen in 2007 (it was too early; today many applications could have been installed easier on a smartphone) • In Spain: smart lightning, car-park management, smart irrigation of green areas) Internet of things: • A Supply- and disposal company: management of garbage bins (with individual sensors)

Informant Question	FhG Expert #4	NTUA Expert #1	NTUA Expert #2
1. Can you briefly describe your profile, i.e. your occupation, the field(s) of expertise, your interest in ICT, etc.?	Telecommunication company, Sales Manager for the area of the public sector	Electrical and Computer Engineer, Research Analyst	Software Engineer specialized in Software Testing. Experienced in VoIP technologies and supporting software as well as in systems for the banking sector.
2. In your opinion, which are the most important technologies / technological trends that could impact the public sector in the following (five) years?	• Collaboration tools for the public sector (Bundesland <-> municipality; within one municipality) - Electronic files - Content management system • e-Participation • Digitalization • Clouds	**(i) Public sector modernization** / **(ii) ps as an innovation driver** Open Data Platforms (medium growth) — Yes Electronic Identities for Citizens (medium growth) — Yes Internet of Things (high growth) — Yes Augmented and virtual reality(high growth) — Yes Industrialized analytics (high growth) — *Yes* • Open Data Platforms • Electronic Identities for Citizens • Internet of Things • Augmented and virtual reality • Industrialized analytics	**(i) Public sector modernization** / **(ii) ps as an innovation driver** Blockchain — Linked/Open Data Data Analytics — e-ID/e-signatures
a. Which are the most important technologies / technological trends that could improve the operation of the public sector in the following years?	(i) PS modernization • Collaboration Tools • Digitalization • Clouds	(i) PS modernization • Open Data Platforms • Electronic Identities for Citizens • Internet of Things • Augmented and virtual reality • Industrialized analytics	(i) PS modernization • Blockchain • Data Analytics
b. Which are the ones that could transform	(ii) PS as an innovation driver • e-Participation	(ii) PS as an innovation driver • Open Data Platforms	(ii) PS as an innovation driver • Linked/Open Data

Informant Question	FhG Expert #4	NTUA Expert #1	NTUA Expert #2
the public sector into an innovation driver?	• Geographical Information Systems	• Electronic Identities for Citizens • Internet of Things • Augmented and virtual reality • Industrialized analytics	• e-ID/-e-signatures
c. Which are your predictions on the growth or market potential of these technologies?	-	• Open Data Platforms (medium growth) • Electronic Identities for Citizens (medium growth) • Internet of Things (high growth) • Augmented and virtual reality (high growth) • Industrialized analytics (high growth)	• Blockchain (high growth rate) • Data Analytics (high growth rate) • Linked/Open Data (medium growth rate) • e-ID/-e-signatures (medium growth rate)
3. Which are the societal needs / needs of the public sector that could be addressed through the use of these technologies?	Collaboration tools for the public sector & Digitalization • Faster processes (e.g. foundation of an enterprise) • Data concentration (The public sector knows more details about the citizens. This has advantages and disadvantages, e.g. a social welfare authority would know if a citizen registered an expensive car at the road traffic licensing department, but on the other hand data concentration also includes the risk of a loss of privacy.) e-Participation • more ways for the citizens to express their wishes and complains	Open Data Platforms • Transparency • New Business models based on public data • Safety • Social equality Electronic Identities for Citizens • Minimize bureaucracy • Obtain public certificate or consume public services in less time, effort and cost • Safety / Security Internet of Things • Minimize costs • Optimize Public Services	Blockchain • Limit frauds and public servants' errors • Reduce paper intensive processes Data Analytics • Data based policy making • Better justify governmental decisions Linked/Open Data • Improve public data management and utilization • Improve collaboration of governmental organisations

Informant Question	FhG Expert #4	NTUA Expert #1	NTUA Expert #2
		• New business models based on public IoT services Augmented and virtual reality • New business models for enterprises working with the public sector • Better / Innovative Public Services Industrialized analytics • Policy making Insights • Evidence based decision making • Increase public sector profitability • Improve performance	e-ID/e-Signatures • Fully automate e-Government services • Reduce citizens - public bodies physical interaction
4. Could you please expand on the way in which each of these technologies / trends could benefit the public sector / businesses / citizens?	See point 3 above	(see table below)	
a. Which are the specific (policy) domains (e.g. economic, social, environmental, etc.), these technologies will have an impact on?	-	(see table below)	(see table below)

NTUA Expert #1:

Open Data Platforms	Extent of Application	Influence
Institutional/ Capacity Development	Global	Direct
Political	Global	Direct
Economic	Global	Direct
Social	Global	Direct
Environmental	Global	Direct

Electronic Identities for Citizens	Extent of Application	Influence
Institutional/ Capacity Development	Local	Direct
Political	Local	Direct

NTUA Expert #2:

Blockchain	Extent of Application	Influence
Institutional/ Capacity Development	National/ Local	Direct
Political	National/ Local	Direct

SONNETS

Informant Question	FhG Expert #4	NTUA Expert #1			NTUA Expert #2		
b. Which will be the extent of that impact (e.g. individual cases, local, regional, national, international level)?	-	Economic	Local	Direct	Economic	National /Local	Indirect
		Social	Local	Direct	Social	National /Local	Indirect
		Environmental	Local	Direct	Environmental	National /Local	Indirect
		Internet of Things	Extent of Application	Influence	**Data Analytics**	Extent of Application	Influence
		Institutional/ Capacity Development	Local	Direct	Institutional/ Capacity Development	National/ Local	Direct
		Political	Global	Direct	Political	National/ Local	Direct
		Economic	Global	Direct	Economic	National /Local	Direct
		Social	Local	Direct	Social	National /Local	Indirect
		Environmental	Local	Direct	Environmental	National /Local	Indirect
c. Is this impact direct or indirect?	-	**Augmented and virtual reality**	Extent of Application	Influence	**Linked/Open data**	Extent of Application	Influence
		Institutional/ Capacity Development	Local	Direct	Institutional/ Capacity Development	National/ Local	Direct
		Political	Global	Indirect	Political	National/ Local	Direct
		Economic	Global	Direct	Economic	National /Local	Direct
		Social	Local	Indirect	Social	National /Local	Indirect
		Environmental	Local	Indirect	Environmental	National /Local	Indirect
		Electronic Identities for Citizens	Extent of Application	Influence	**e-ID/e-Signatures**	Extent of Application	Influence
		Institutional/ Capacity Development	Local	Direct	Institutional/ Capacity Development	National/ Local	Direct
		Political	Local	Direct	Political	National/ Local	Indirect
		Economic	Local	Direct	Economic	National /Local	Direct
		Social	Local	Direct	Social	National /Local	Direct
		Environmental	Local	Direct	Environmental	National /Local	Indirect
5. How feasible do you consider the adoption of these technologies / trends by the public sector?	These technologies are already mature and **ready for the market**. The problem is more that the structures and **mind-sets** of the clients are not adapted to these new technologies. On an emotional level the users need to trust these new technologies.						

Informant Question	FhG Expert #4	NTUA Expert #1	NTUA Expert #2
	The **data protection laws** in Germany are quite detailed and more elaborated than e.g. in the USA. But in some cases they are not practice-oriented. It would be good to have more feasible processes regarding data protection issues. In Germany it would also be good if the mentality of the citizens changed a bit and **opened up to new technologies.**		
a. Are these technologies mature enough and ready for adoption?	-	• Open Data Platforms: *mature* • Electronic Identities for Citizens: *emerging* • Internet of Things: *emerging* • Augmented and virtual reality: *under trial* • Industrialized analytics: *mature*	All those technologies are mature and ready for adoption from a technical point of view. Further research on how to use them in the public sector for replacing existing solutions could be needed.
b. Does the public sector already possess the necessary infrastructure and know-how for their adoption?	-	• Open Data Platforms: *sufficient* • Electronic Identities for Citizens: *incomplete* • Internet of Things: *incomplete* • Augmented and virtual reality: *incomplete* • Industrialized analytics: *sufficient*	Blockchain and data analytics have not been used extensively in the public sector, so there is no strong know how. For e-ID and Linked/Open data, many (but not all) public sector organizations do have knowledge and required infrastructure.
c. Is the necessary legislative framework already in place?	-	• Open Data Platforms: *inadequate* • Electronic Identities for Citizens: *inadequate* • Internet of Things: *inadequate* • Augmented and virtual reality: *inadequate* • Industrialized analytics: *sufficient*	Modernisation of the legislative framework is required, especially in order to adopt blockchain in the public sector and to fully adopt e-ID/e-Signature for all the transactions of citizens and enterprises with the public sector.
d. How would you evaluate the	-	• Open Data Platforms: *moderate* • Electronic Identities for Citizens: *low*	At least in Greece readiness is low for all the

Informant Question	FhG Expert #4	NTUA Expert #1	NTUA Expert #2
readiness of the stakeholders involved, in terms of their educational level, skills, income, etc.?		• Internet of Things: *low* • Augmented and virtual reality: *low* • Industrialized analytics: *moderate*	proposed solutions, as most public servants do not have the skills or the knowledge to take advantage of such innovative technologies.
6. Do you see any relevant costs / risks / threats generated by their adoption?	**Data concentration** has always two sides: we would get a more complete picture of the citizens, but on the other hand this has disadvantages regarding privacy and data protection. But data concentration is necessary, because otherwise with less and less personnel in the public sector the different services of the PS are not possible.	• Open Data Platforms: *privacy issues* • Electronic Identities for Citizens: *privacy/security issues* • Internet of Things: *privacy/security issues* • Augmented and virtual reality: *risk of non-adoption* • Industrialized analytics: *privacy/security issues*	• Blockchain: Costs are limited, however the fact that blockchain is not being used in the public sector extensively, could lead to technical and possibly organizational or legal issues which is a risk. • Data analytics: Costs for collecting data and for software able to provide different kind of analytics/ no serious risks or threats. • Open/linked data: Costs for digitizing information and data currently not in electronic format could be implied. • e-ID/e-Signatures: Costs for handling e-IDs do exist. Risks regarding the proper use of e-IDs and e-Signatures by the citizens do exist
7. Could you propose relevant services and applications to put these technologies / trends in practice, i.e. to exploit the former for addressing specific needs?	-	• Open Data Platforms: *EU Open Data Portal* • Electronic Identities for Citizens: *STORK project* • Internet of Things: *Smart Buildings* • Augmented and virtual reality: *Virtual tours on Museums* • Industrialized analytics: *Public services usage*	• Blockchain: Decentralized management of information and data related to citizens and enterprises which involve or are monitored by public sector entities. • E-ID/e-signature: Eliminate paper in all transactions with the public sector • Open/linked data: Direct cross-governmental access to public sector information at all

Informant Question	FhG Expert #4	NTUA Expert #1	NTUA Expert #2
		analytics	levels (local/regional/national), interconnecting services which are provided to citizens/enterprises. • Data analytics: Policy making, but also public sector management based on data analytics
a. What is the type of innovation these solutions stand for (e.g. service innovation, service delivery innovation, organizational innovation, etc.)?	-	Service innovation (for all)	• Blockchain: organizational innovation • E-ID/e-Signature: service delivery innovation • Open/linked data: organizational innovation, service innovation • Data analytics: organizational innovation, policy innovation
b. Can you provide real life examples or cases where such services / applications have been implemented or are being implemented?	-	• Open Data Platforms: *Data.gov.gr* • Electronic Identities for Citizens: *Implemented in government of Belgium, Bulgaria, Germany, Israel, Italy, Luxembourg, the Netherlands, Nigeria, Mexico, Morocco, Pakistan, Portugal, Romania, Estonia, Latvia, Lithuania, Spain, Slovakia, Malta, Mauritius and Germany* • Internet of Things: *Cookham Wood institution* • Augmented and virtual reality: *http://bfonics.com/bfonicscms/business/discover-history-with-ibeacon-technology/* • Industrialized analytics: *Engagedata.eu*	• Blockchain: Management of property titles and monitoring/regulating transactions among citizens and enterprises • E-ID/e-Signature: Make all points of services for citizens and enterprises operate without requiring physical presence, eg issuing construction permits • Open/linked data: offer guidance to visitors of any place, combining local/area data with security-related data, events data, health-related data etc. • Data analytics: analytics-based decision making in the public sector, eg improving public transport management and decisions based on passenger and traffic data analytics

Informant Question	ISMB IT Expert #1	ISMB IT Expert #2
1. Can you briefly describe your profile, i.e. your occupation, the field(s) of expertise, your interest in ICT, etc.?	R&D Manager within an IT consortium for the promotion of Public Sector Innovation	- Innovation Manager, - Director of Civic Tech School
2. In your opinion, which are the most important technologies / technological trends that could impact the public sector in the following (five) years?	- Mobile technologies - Social Networks/Media - Conversational Interfaces (eg: whatsapps) - Cloud and virtualization of data and application fruition - Sensors and data management - ICT Security (critical infrastructures) - GIS 3D - Paper Elimination Technologies (DOQUI) We are adapting technology to fit to existing processes, rather than redesigning existing processes.	Medium Term: - Data Technologies - Business Intelligence, prevision. - Direct democracy and public engagement (discussion, decisions, cooperation platforms, like: https://pol.is/home https://blog.pol.is/the-evolution-of-the-pol-is-user-interface-9b7dccf54b2f#.u202pg8h9 http://civichall.org/civicist/vtaiwan-democracy-frontier/) - Paper elimination technologies. - Distributed computing (cloud + thin clients /iPad Style) - IoT Sensors for energy efficiency (within the Smart City paradigm) More long term: - Artificial Intelligence - Block Chain Those technologies that will change the management of power (AI & blockchain) will lead to a more radical innovation. All the rest is operations.
a. Which are the most important technologies / technological trends that could improve the operation of the public sector in the following years?	(i) PS modernization - Cloud Computing - ICT Security (critical infrastructures) - GIS - Paper Elimination Technologies	-

Informant Question	ISMB IT Expert #1	ISMB IT Expert #2
b. Which are the ones that could transform the public sector into an innovation driver?	(ii) PS as an innovation driver • Conversational Interfaces (eg: whatsapps) • Mobile Apps	-
c. Which are your predictions on the growth or market potential of these technologies?	• Mobile technologies are ramping up • App economy vs websites are also growing	-
3. Which are the societal needs / needs of the public sector that could be addressed through the use of these technologies?	• Energy efficiency, reduction of carbon footprint • Healthcare optimization (reduction of costs without elimination of services) • Security/safety • Tax collection (once only principle to avoid data requests duplication) • eID as a simplification tool	• They change the way in which you interpret the role of Public Administration. Public Agencies become an enabler that valorizes the energies and opinions of stakeholders. • Increase of trust towards PA. This may change in different domains.
4. Could you please expand on the way in which each of these technologies / trends could benefit the public sector / businesses / citizens?	Citizens: • Simplification in the relationship with PA • Clearer information and less time wasted • Single point of access, homogeneity of interfaces • Seamless interaction through tools existing already on the citizen devices. PA: • More relaxed interactions with the citizenry • Higher productivity	• Efficiency and effectiveness of PAs. • A public procurement more qualified. • More citizen orientation. Use of market more frequent and light (less bureaucracy, more standards less centralization)
a. Which are the specific (policy) domains (e.g. economic, social, environmental, etc.), these technologies will have an impact on?	• Healthcare • Energy • Security/Safety • Innovation	• Labour Policies • Open Innovation • Procurement
b. Which will be the extent of that impact (e.g. individual cases, local, regional, national, international level)?	National Scale	National and regional

Informant Question	ISMB IT Expert #1	ISMB IT Expert #2
c. Is this impact direct or indirect?	Indirect	Indirect
5. How feasible do you consider the adoption of these technologies / trends by the public sector?	50% of probability. Considering that we have been discussing about eGov for the last 20 years. Without appropriate training and a generational handover.	Probable, but gradual
a. Are these technologies mature enough and ready for adoption?	Most of them yes (maybe Conversational Interfaces still require some time to reach a TRL9)	Technologies are there, convincing commercial offers not always present, demand is still building up.
b. Does the public sector already possess the necessary infrastructure and know-how for their adoption?	• Little technological innovation (it depends on the region, in Piedmont where it is present an IT consortium coordinating and managing IT assets) • No skill infrastructure.	In general I would say no, in certain places they may be more equipped.
c. Is the necessary legislative framework already in place?	We need a deep process of legal reform, that should be conceived as an ongoing process of revision (like perpetual beta), or at least to be flexible enough to avoid the creation of adoption obstacles of new technologies as they become available.	You may adopt changing regulations, and strategic planning. Not necessary to change norms. High organizational impact.
d. How would you evaluate the readiness of the stakeholders involved, in terms of their educational level, skills, income, etc.?	• Training initiatives • Broadband penetration within society • Technology friendliness of laws • Degree of mobile devices penetration among society	Technology literacy, leadership, age, communication and community management.
6. Do you see any relevant costs / risks / threats generated by their adoption?	• Technology addiction, loss of interpersonal relationships management.	Anarchy, inability of taking brave decisions.
7. Could you propose relevant services and applications to put these technologies / trends in practice, i.e. to exploit the former for addressing specific needs?	• Transport-related services (traffic, reduction of foot-print) • Booking & payment of health services, health service management, management of clinical records, indoor localization services.	• Independent information services • Data exchanges with stakeholders.

Informant Question	ISMB IT Expert #1	ISMB IT Expert #2
a. What is the type of innovation these solutions stand for (e.g. service innovation, service delivery innovation, organizational innovation, etc.)?	-	All types of innovations are required.
b. Can you provide real life examples or cases where such services / applications have been implemented or are being implemented?	-	• Italia Log-IN • Torino Facile more in general one-stop shopping portals