Horizon2020/EURO-6-2015

Coordination and Support Actions

SOcietal Needs aNalysis and Emerging Technologies in the public Sector

Deliverable D4.1

Analysis of the identified emerging technologies

Workpackage	WP4 – Roadmap for emerging research directions
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Abstract:	This deliverable contains an analysis of the identified emerging technologies comprising technology readiness, relevant research projects and relevant actors.

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Document Revision History

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		Modification Reason	**Modified by**
v0.1	24.01.2017	Introduction; Methodology	FhG
v0.2	15.02.2017	Tables with R&D activities, actors and TRL level filled	FhG
V0.3	21.03.2017	WBAT tables filled out	All partners
V0.4	28.03.2017	Review of WBAT tables done; new version included Review by Sotiris Koussouris (NTUA)	All partners
V0.5	03.04.2017	Inclusion of Executive Summary and Conclusion	ISMB, NTUA
V1.0	04.04.2017	Review	ATOS

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Definitions, Acronyms and Abbreviations

Acronym	Title
EC	European Commission
EU	European Union
IT	Information Technology
ICT	Information and Communication Technology
PS	Public Sector
R&D	Research and Development
SWOT	Strengths, Weaknesses, Opportunities and Threats
TRL	Technology Readiness Level
WBAT	Weighted-Bit Assessment Table
WP	Work Package

Table 1: Definitions, Acronyms and Abbreviations

Executive Summary

Work Package 4 has the overall aim to single out the gaps between the identified societal and public sector needs (Work Package 2) and the identified technological opportunities (Work Package 3). On the basis of these gaps, research needs and other non-research activities will be developed. The final output of this work package will be a roadmap that will put forward the different research and innovation directions that should be followed in order to reach the anticipated vision of reshaping and reforming the public sector into a technology leader and a key player in tackling societal challenges.

More specifically, the work presented in D4.1 is based on the work conducted in the context of Work Package 3 'Identification of Emerging Technologies and Innovation Identification Framework'. Within Work Package 3, ICT technologies and trends have been identified and analysed regarding their impact and suitability for the public sector. In this deliverable the identified emerging technologies of Work Package 3 with promising impacts in the public sector were analysed in more detail. Namely, the technology readiness level of each identified technology was determined and a desktop research was performed to survey research projects and programmes relevant for these technologies. For this survey, national, international as well as European activities were taken into account. Additionally, the relevant actors (universities, research organizations and companies) involved in the development of these technologies were identified.

From a methodological stand point, the analysis conducted for the production of the present deliverable leveraged on a Weighted Bit Assessment Table (WBAT) Method developed by Fraunhofer INT. This multi-criteria assessment tool has already been used in a variety of domains, ranging from chemistry to land transportation.

The filled out Weighted-Bit Assessment Table (WBAT) is the basis for the SONNETS research roadmap and contains the following information:

- The innovation potential and usefulness of each identified technology in the public sector,
- The potential of the respective technology to turn the public sector into an innovation driver,
- if research and development activities are needed to implement the technology under consideration in the public sector,
- if non-research activities (training, regulations, etc.) are needed before the respective technology could be used in the public sector and
- if the technology in question could have undesired ethical, legal or societal implications.

1 Introduction

1.1 Purpose and Scope

SONNETS pursues the aim to meet the need for a better, more efficient, effective and quality delivering public service. This does not only imply transforming the public sector itself and covering the needs of public sector employees and policy makers, but it will also have a positive impact on citizens and businesses, that will in turn accelerate the EU economy and improve quality of life.

In order to tackle the above-mentioned challenges, SONNETS delivers an innovative methodological framework for public sector organisations and related stakeholders to accelerate the transformation of the public sector through the identification, analysis and take-up of emerging technologies that hold the potential to transform and infuse real value to public services.

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 work presented in this deliverable is based on the previous work in the context of Work Package (WP) 3 'Identification of Emerging Technologies and Innovation Identification Framework'. Within WP 3, ICT technologies and trends have been identified and analysed regarding their impact and suitability for the public sector. In more detail, WP3 has analysed:

- 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 to the public sector.
- A link between these ICTs and the needs of the public sector and the society

The present deliverable is released within the context of WP 4 'Roadmap for emerging research directions' and is particularly associated with Task 4.1 'Analysis of the identified emerging technologies '. In this task, the identified emerging technologies of WP 3 with promising impacts in the public sector were analysed in more detail. Namely, the technology

readiness level of each identified technology was determined and a desktop research was performed to get an overview over research projects and programmes relevant for these technologies. For this survey, national, international as well as European activities were taken into account. Additionally, the relevant actors (universities, research organizations and companies) involved in the development of these technologies were identified.

The aim of this in-depth analysis of these technologies and trends is to identify research gaps and other non-research activities which are necessary for the final implementation of these technologies in the public sector.

1.2 Approach for the WP and Relation to Other WPs

This deliverable is related to WP 4, which has initially the overall aim to identify the gaps between the identified societal and public sector needs (WP 2) and the identified technological opportunities (WP 3). On the basis of these gaps, research needs and other non-research activities will be developed. The final output of this WP will be a roadmap that will put forward the different research and innovation directions that should be followed in order to reach the anticipated vision of reshaping and reforming the public sector into a technology leader and a key player in tackling societal challenges.

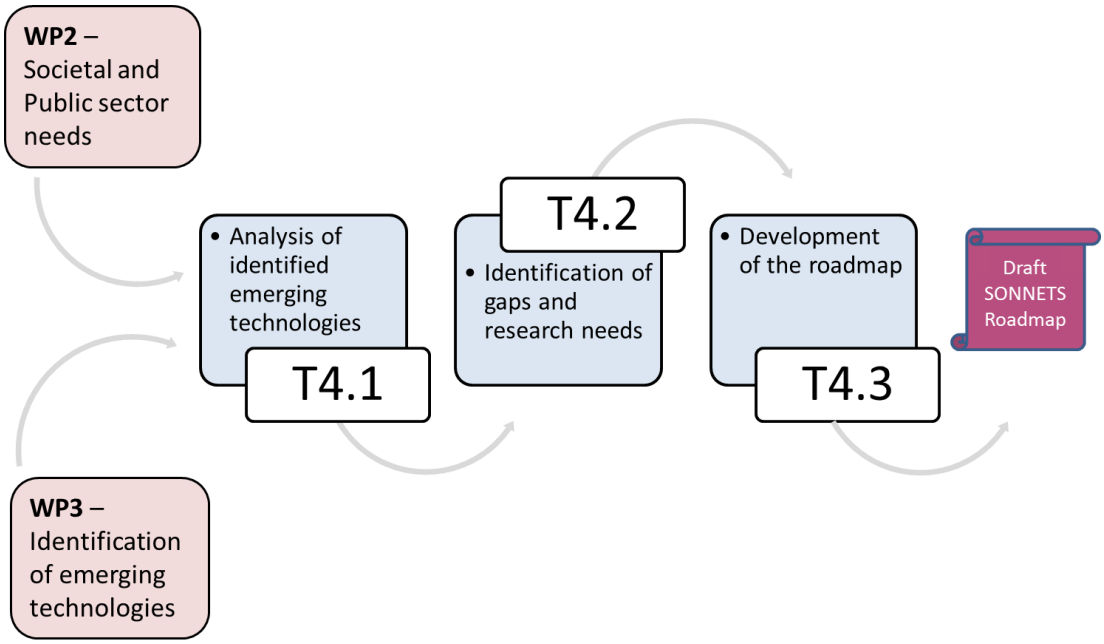

Figure 1: Tasks in WP4

1.3 Structure of the Document

The report at hand is structured as follows:

- Section 1 describes the purpose and scope of this document and places it into the context of the overall WP structure of SONNETS
- Section 2 describes and explains the methodology used to analyse the SONNETS technologies and trends
- Section 3 and 4 present the results of the technology and trend analysis
- Finally, Section 5 summarises the content of this deliverable and draws relevant conclusions.

2 Methodology

The basis of SONNETS Task 4.1 and the related in-depth analysis of technologies and trends are the results of Deliverable 3.2 'Emerging ICTs and Innovation Potential for the Public Sector' and Deliverable 3.3 'Emerging ICTs and Innovation Potential for the Public Sector'. Within Deliverable 3.2, technology and trend templates have been filled out with the aim to describe the impact of emerging ICTs in their domain of origin, the relevance of these ICTs to the public sector, as well as potential innovations which could be induced by these emerging ICTs. On the other hand, Deliverable 3.3 contains an impact and feasibility assessment of these technologies and trends to estimate their innovation potential in the public sector.

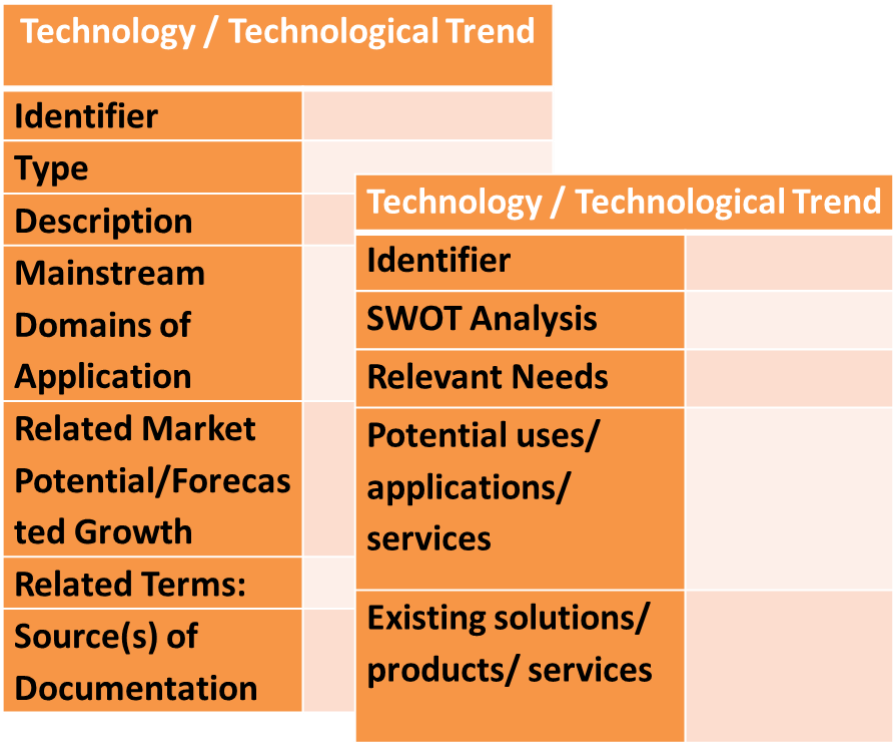

Figure 2: Technology and Trend Analysis Templates [1]

The list of technologies and trends analysed in more detail in this WP corresponds to the short list of technologies (see Table 2 below) generated through the SONNETS Innovation Identification Framework methodology.[1] 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 of the methodology. To refine 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 WP 2. Table 2 aggregates the

entries of this list, classified under the categories of 'trends' and 'technologies'.

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 [1]

In addition to the work performed in WP 3, the following analysis has been undertaken during the course of Task 4.1:

- **Current R&D activities:**
  - To get an overview of current R&D projects in Europe the CORDIS data base [2] was used. Additionally national projects and programmes have been identified, as far as they are accessible and readable by the members of the consortium (e.g. [3], [4])
  - The aim of this literature research was to estimate the technology readiness level and also the gaps between the current status of R&D and the final implementation in the public sector.

- **Technology readiness level:**
  - Technology readiness levels (TRL) help to estimate the maturity of a technology. The TRL scale was originally developed by NASA to enable the assessment of the maturity of a particular technology and the consistent comparison of maturity between different types of technologies. TRL are based on a scale from 1 to 9 with 9 being the most mature technology. The use of TRL enables consistent, uniform discussions of technical maturity across different types of technology. [5] The definition of the TRL within Horizon 2020 is shown in Table 3.
- **Relevant actors:**
  - In a further desktop research, the relevant actors (universities, research organizations and companies) involved in the development of these technologies were identified. This information gives some hints if the technology is nearly market-ready (many companies involved in R&D) or more on the level of basic research (e.g. only national research centres involved), if there are actors in most European countries or if only isolated research centres are working in this area.

TRL Scale	Description
TRL 1	Basic principles observed
TRL 2	Technology concept formulated
TRL 3	Experimental proof of concept
TRL 4	Technological validity in a lab
TRL 5	Technology validated in relevant environment
TRL 6	Technology demonstrated in relevant environment
TRL 7	System prototype demonstration in an operational environment.
TRL 8	System completed and qualified
TRL 9	Actual system proven in operational environment

Table 3: TRL scale used in Horizon 2020 [5]

The main objective of this task is to use all the collected information regarding these technologies and trends and determine the gap between

the current R&D status and the final implementation of this technology in the public sector.

In the technology and trend analysis cards of Deliverable 3.2, the technologies and trends have already been matched to the identified societal and public sector needs of WP 2. [1]

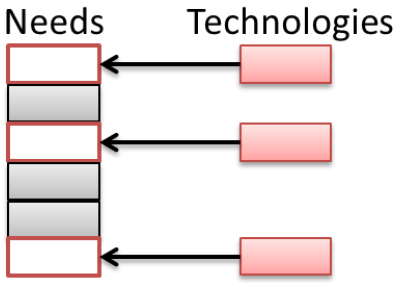

Figure 3: Matching of technologies and trends to societal and public sector needs. [1]

The aim of the current WP is to describe the activities needed to further develop the current ICT technologies until their final implementation in the public sector.

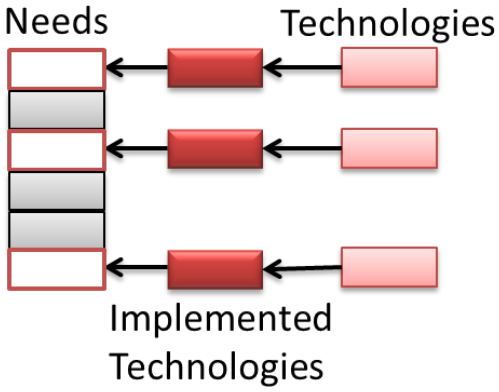

Figure 4: Objective of WP 4: Describe the activities needed from the current status of technologies to the technologies ready to be implemented in the public sector

Methodologically, this was done by using the Weighted Bit Assessment Table (WBAT) method developed by Fraunhofer INT. This multi-criteria assessment tool has already been used for a variety of tasks (e.g. the Weighted-Bit Assessment Table for Hazardous Chemicals, WBAT-C, the Weighted-Bit Assessment Table for Critical Dependencies, WBAT-CD, and the Weighted-Bit Assessment Table for Land Transport Problems and Solutions, WBAT-LTPS). [6–9] These tools are characterised by some special features:

- The items to be analysed (here: the technologies and trends) form the vertical axis of a two-dimensional matrix.
- The assessment parameters form the horizontal axis of the matrix.

- The assessment parameters are formulated as statements that are either 'true' or 'not true'.
- As a consequence, formulating the 'right' parameters is a demanding task, while choosing whether a parameter is 'true' or 'not true' should be simple for a domain expert.
- The assessment parameters are formulated in a way that 'yes/true' indicates an issue to be dealt with (either in a positive sense ('this technology has a high innovation potential') or also in a negative sense ('there are several ethical, legal or societal issues which have to be dealt with before using this technology')
- The matrix is usually implemented as a spreadsheet, e.g. in Excel.
- Further calculations (using weighted parameters) are possible, but not necessary.

The Weighted-Bit Assessment Table (WBAT) for ICT technologies and trends was developed and filled out with the aim to fulfil the following purpose:

- Determine the innovation potential and usefulness of these technologies in the public sector *(see Area 1: Innovation Potential (Modernization of PS))*
- Determine if the respective technology could help to turn the public sector into an innovation driver *(see Area 2: Innovation Potential)*
- Determine if (further) research and development activities are needed to implement the respective technology in the public sector *(see Area 3: Technology research and development activities needed (PS as innovation driver)*
- Determine if non-research activities (training, regulations, etc.) are needed before the respective technology could be used in the public sector *(see Area 4: Other activities needed)*
- Determining whether certain technologies could have undesired ethical, legal or societal implications. *(see Area 5: Ethical, legal and societal aspects (ELSA))*

The filled out Weighted-Bit Assessment Table (WBAT) is the basis for the SONNETS research roadmap, which will summarize all necessary activities to implement the ICT technologies successfully in the public sector.

In this way, the Weighted Bit Assessment Table uses the results of the hype curve and the magic quadrant of D3.2 [1] and increases the range of different types of assessment parameters. For the hype curve, the views of the different experts expressed in interviews and focus groups, as well as the knowledge about currents trends of ICT in general, has been used to estimate if the technologies and trends are mature, on the verge of maturity or still in its infantry. The magic quadrant of D3.2 is a two-dimensional presentation in which the technologies and trends are

represented on the basis of their maturity (x-axis) and their innovation direction (PS Modernization or PS as Innovation Driver; y-axis).

The assessment parameters used for the Weighted-Bit Assessment Table (WBAT) are listed in the table below.

Assessment Parameter	**Possible parameters and how they are derived**
Area 1: Innovation Potential (Modernization of PS)	
The implementation of this technology would meet a societal need.	**Parameters:** Yes – n/a – no **Source:** Technology/ Trends impact assessment 'Relevant needs' [1]
The implementation of this technology would meet a public sector need.	**Parameters:** Yes – n/a – no **Source:** Technology/ Trends impact assessment 'Relevant needs' [1]
The implementation of this technology would meet a business need.	**Parameters:** Yes – n/a – no **Source:** Technology/ Trends impact assessment 'Relevant needs' [1]
The implementation of this technology would help to modernize the public sector – even if at the moment this technology cannot be related to a formulated societal or public sector need.	**Parameters:** Yes – n/a – no **Source:** Impact Assessment [10]
Area 2: Innovation Potential (PS as innovation driver))	
The implementation of this technology would help to turn the public sector into an innovation driver	**Parameters:** Yes – n/a – no **Source:** Impact Assessment [10]
Area 3: Technology research and development activities needed	
The technology is very new and still at the level of basic research (TRL 1 or 2).	**Parameters:** Yes – n/a – no **Source:** Technology Readiness Level (TRL) analysis (chapter 3.3)
The technology is at a development stage and has neither been used in the public sector nor in any other	**Parameters:** Yes – n/a – no **Source:** Technology Readiness

domain (TRL 3 - 6).	Level (TRL) analysis (chapter 3.3)
The technology has been successfully tested as a prototype or is ready for the market in another domain (TRL 7 – 9); but a real use case for the public sector has yet to be defined.	**Parameters:** Yes – n/a – no **Source:** Technology Readiness Level (TRL) analysis (chapter 4.2); documentation of current R&D projects regarding this technology trend (see chapter 3.1); Interviews with IT experts [1, 11]
The technology has been successfully tested as a prototype or is ready for the market in another domain (TRL 7 – 9); but further modifications or adaptions to the specifics of the public sector are necessary.	**Parameters:** Yes – n/a – no **Source:** Technology Readiness Level (TRL) analysis (chapter 4.2); documentation of current R&D projects regarding this technology trend (see chapter 3.3)
The technology is in use in selected public sector organisations, but further modifications/ improvements / eliminations of errors are necessary.	**Parameters:** Yes – n/a – no **Source:** Technology / Trends impact analysis 'Existing solutions / products / services' and 'Weaknesses'[1]; documentation of current R&D projects regarding this technology trend (see chapter 3.1); Interviews with IT experts [1, 11]
There are competing technologies on the market or with a high TRL, which might hinder a further development of this technology/trend.	**Parameters:** Yes – n/a – no **Source:** documentation of current R&D projects regarding this technology trend (see chapter 4.1); further desktop research
The EU and/or national governments provide funds, so that the further development of this technology is rather likely.	**Parameters:** Yes – n/a – no **Source:** EU and national R&D programmes and policy papers (chapter 3.1)
There are several research institutions and/or companies interested in a further development of this technology.	**Parameters:** Yes – n/a – no **Source:** Relevant actors in this area (chapter 3.2)
Area 4: Other activities needed	

The usage of this technology demands a rather high level of general ICT knowledge (of the PS staff working with this technology every day, i.e. not the ICT staff implementing this technology).	**Parameters:** Yes – n/a – no **Source:** Feasibility Assessment[10]; Technology / Trends impact analysis 'Weaknesses'[1]; Interviews with IT experts [1, 11]
Before using this technology a specific training is needed (for the PS staff working with this technology every day).	**Parameters:** Yes – n/a – no **Source:** Feasibility Assessment[10]; Technology / Trends impact analysis 'Weaknesses'[1]; Interviews with IT experts [1, 11]
There are well-established and well performing processes and/or technologies in place in the public sector, so that the preparedness to try new technologies is rather low.	**Parameters:** Yes – n/a – no **Source:** Feasibility Assessment[10]; Interviews public sector representatives
The technology is highly visible in the media and popular among citizens or businesses, so that the pressure to implement this technology is rather high.	**Parameters:** Yes – n/a – no **Source:** Further desktop research
For the implementation of this technology a specific or advanced ICT infrastructure is needed in the public sector	**Parameters:** Yes – n/a – no **Source:** Feasibility Assessment[10]; Technology / Trends impact analysis 'Weaknesses'[1]¸ Interviews with IT experts [1, 11]
The usage of this technology might raise cyber security issues / issues of misuse of this technology/ other side-effects on the ICT infrastructure.	**Parameters:** Yes – n/a – no **Source:** Technology / Trends impact analysis 'Threats'[1]; Interviews with IT experts [1, 11]
The technology has to be explained and promoted among business stakeholders and/or citizens.	**Parameters:** Yes – n/a – no **Source:** Technology / Trends impact analysis 'Weaknesses', 'threats'[1]; Interviews with IT experts [1, 11]

The successful usage of this technology is only possible after the adaption of the processes of the public sector and ensuring the interoperability with existing systems.	**Parameters:** Yes – n/a – no **Source:** Technology / Trends impact analysis 'Weaknesses', 'threats'[1]; Interviews with IT experts [1, 11]
The successful usage of this technology is only possible if all or several EU/national authorities exchange relevant data/ agree on a certain standard /develop common processes or regulations.	**Parameters:** Yes – n/a – no **Source:** Technology / Trends impact analysis 'Weaknesses', 'threats'[1]; Interviews with IT experts [1, 11]
Before using this technology a new or modified legislative framework has to be developed in the EU or in the national governments.	**Parameters:** Yes – n/a – no **Source:** Feasibility Assessment[10]; Technology / Trends impact analysis 'Weaknesses', 'threats'[1]; Interviews with IT experts [1, 11]
The implementation or maintenance of this technology is rather costly.	**Parameters:** Yes – n/a – no **Source:** Technology / Trends impact analysis 'Weaknesses'[1]; Interviews with IT experts [1, 11]
Area 5: Ethical, legal and societal aspects (ELSA)	
The technology is likely to raise ethical issues (e.g. gender, age, minorities or other forms of discrimination).	**Parameters:** Yes – n/a – no **Source:** Technology / Trends impact analysis 'Weaknesses' and 'Threats'[1]; Interviews with IT experts [1, 11]
The technology is likely to raise legal issues (e.g. freedom infringements, constriction of fundamental rights, data protection issues).	**Parameters:** Yes – n/a – no **Source:** Technology / Trends impact analysis 'Weaknesses' and 'Threats'[1]; Interviews with IT experts [1, 11]
The technology is likely to raise societal issues (e.g. loss of jobs, side-effects of technologisation).	**Parameters:** Yes – n/a – no **Source:** Technology / Trends impact analysis 'Weaknesses' and 'Threats'[1]; Interviews with IT

	experts [1, 11]
The technology is likely to raise health issues (e.g. ergonomics, eyesight).	**Parameters:** Yes – n/a – no **Source:** Technology / Trends impact analysis 'Weaknesses' and 'Threats'[1]; Interviews with IT experts [1, 11]
The technology is likely to encounter problems regarding public acceptance.	**Parameters:** Yes – n/a – no **Source:** Technology / Trends impact analysis 'Weaknesses'[1]; Interviews with IT experts [1, 11]

Table 4: The assessment parameters of the Weighted-Bit Assessment Table

3 Results

3.1 Research and Development projects related to the identified technologies and trends

Desktop research was used to get an overview of current and recently completed R&D projects involving the identified ICT technologies and trends[1] of the SONNETS project. Our main sources have been the CORDIS data base [2] and other R&D data bases such as the EUREKA network [4], COST actions [12] or national data bases like the German Förderkatalog [3] and the Spanish CDTI data base [13].

	EU R&D projects and programmes [2]	**Other national or international R&D projects and programmes**	**Other resources (R&D programmes, policy papers, etc.)**
API Economy	NEAT and some **applications of APIs**: CANGOPAL, MusicBricks	DARIAH-DE (BMBF)[14], KobRA (BMBF)[15]	API strategies[16]
Crowdsourcing	IoT Lab, c-Space, FutureEnterprise, CrowdRec, NOMAD, we.learn.it, RESCUER, Citizen Cyberlab, CROWDLAND, CROWDFLOWS, Be-novative, CloudTeams, CroDS, CORAL	Study about crowdsourcing[17], Challenge Cloud and Crowd[18]	
Digitalization	In the last years, there have been few projects which are dedicated to the digitalization of administrative work in general (e.g. EIII, TEL-CONVERGENCE), but several very specialised projects e.g. cataloguing of ancient artworks, shoe development for diabetic feet.	Digital Work Design (BMBF) [19], Digitalisation and the future of work (BMBF) [20],[21]; **EUREKA** project (Dev. Of a next generation evaluation module for complete tender management software that enables full e-procurement)[22]; CDTI (Spain): Digital transformation of the public administration[23]	Digitalisation – an opportunity for the future[24], Digitalisation of the German economy [25], German digital agenda[26]

e-Participation	DEMO_NET, Policy Compass, Live+Gov, IMPACT, ePolicy, OCOPOMO, MHEPS, EUth, STEP, WeGovNow, U_CODE, OurSpace, Puzzled by Policy, MyUniversity, Immigration Policy 2.0, PARTERRE	**EUREKA** project (Achieving increased citizen participation and engagement via electronic voting)[27]	The Europe for Citizens Programme (2007-2013) promotes initiatives that facilitate the active participation in the civic and democratic life of the EU.[28] The CIP ICT Policy Support Programme for 2009 supported projects empowering and involving citizens in transparent decision-making in the EU.[28]

Gamification	RAGE, GALANOE, PLAYMANCER, PERGAMON and also several projects with very different applications of Gamification: **air traffic management:** PACAS; **Cars**: Safe and Sound Drive; **Education**: STIMULATE, SIREN, ILearnRW, ManuSkills, TARGET, GaLA, ADAPTIMES, ProsocialLearn, BEACONING, TheCityGame pilot, Q-Tales, FACE, **Environment**: Waternomics, WaterWatt, TRIBE, ENTROPY, EnerGAware, PEAKapp, GreenPlay, ECO – ENGAGE, **health**: DOREMI, BLINDPAD, VERVE, HEALTHNAR, IRIS, 3D-Tune-In, **police, first responder**: LEILA, INSPEC2T, TARGET, CITYCoP, AUGGMED, **policy, government**: SYMPHONY, xDELIA, JobCity	PlayFM – Serious Games for knowledge transfer in facility management[29], Serious Games in nursing training [30]; **EUREKA** project (Gamified school information system)[31], EUROSTARS projects (LBSaaS)[32] and (FRAIL)[33]	In 2016, the European Commission published a H2020 call regarding 'ICT-24-2016 Gaming and gamification'[34], and in 2014 the call 'ICT-21-2014 Advanced digital gaming/gamification technologies'[35]

Mobile Devices	There are a lot of projects dealing with mobile devices in general – in CORDIS 279 projects have been published. Specifically, in the area of mobile devices in the public sector the following projects are running: **Innovative mobile e-government applications:** THUNDHUB, NAV4I, PW, A-BAM, Mobile E-Admini, MPGS, TAIS, PRIFOG, Foodakai-1 , **ICT-enabled open government**: Mobile-Age	Call of the German Federal Ministry of Education and Research 'smart services of the cities'[36]; **EUREKA** project (Use of mobile devices such as tablets&smartphones for data collection, data processing & operational process management)[37]	DG 'Internal Market, Industry, Entrepreneurship and SMEs' has published a call regarding 'Innovative mobile e-government applications by SMEs' in 2013 [38] and on 'INSO-1-2015 - ICT-enabled open government'[39] in 2015. In 2013, the European Commission published an orientation paper in which research and innovation activities in the area of 'ICT-supported co-created, personalised and high impact public services, including the use of social media and smart mobile devices' were recommended[40].

Open Data	**Open Access for Research:** OPENAIRE2020, OPENAIRE, OPENAIRE+, PASTEUR4OA, FOSTER, RECODE, **Infrastructure projects (with Open Access components):** e.g. GEO/GEOSS, ELIXIR[41], **Analytics for Open Data:** FutureTDM, LinDA, COMSODE, ALIADA, EUCases, and more than **150 EU projects** regarding open data for **specialised applications**, e.g. in the area of environment (GROW), property data (proDataMarket), active aging (City4Age), energy consumption (HotMaps) or poetry standardization (POSTDATA).	**Tools, standards, and best practices for publishing data:** Frictionless data[42] **Open Source, free software:** CKAN[43] **Open data for other applications:** Open Data for Development (OD4D)[44], Open Data Handbook[45], OpenSpending[46], Open Trials[47], The Public Domain Review[48], School of data[49], The Open definition[50] Notable examples of **Open Data portals** maintained by public administrations in Europe are:[51] • opendata.paris.fr • www.data.gouv.fr • www.dati.piemonte.it • www.dati.gov.it • www.data.overheid.nl • data.gov.uk	The EU itself has an European Union **Open Data Portal**[52] containing datasets in areas as for example employment, social questions, economics, finance, trade, industry, education and science. The European Commission has also published a **Communication** on 'Open data - An engine for innovation, growth and transparent governance'.[53]

Open Government	**ICT-enabled open government (2014):** ROUTE-To-PA, YDS, DIGIWHIST, WeLive, OpenBudgets.eu, YourDataStories, **ICT-enabled open government (2015):** smarticipate, RECAP, Mobile-Age, CLARITY, FLOOD-serv, **Projects of other calls:** OpenGovIntelligence, STEP, WeGovNow, OpenCube, ENGAGE, DIACHRON, VisiOn, E-GOS, VRE4EIC	Global Open Data Index[54], Local Open Data Census[55]	In 2014, the European Commission has published the call 'INSO-1-2014 - ICT-enabled open government'[56] and, in 2015, 'INSO-1-2015 - ICT-enabled open government'. The European Commission has published a report on the study 'Towards faster implementation and uptake of open government' (SMART 2015/0041).[57] DG Connect has drafted a vision paper 'A vision for public services', in which open government plays a major role.[58]

Personalization	**Personalization in the area of public service interaction:** SIMPATICO (personalized online services), EGOV (online one-stop government), RECAP (regarding common agricultural policy), Mobile Age (for elderly), Flood-serv (floods – emergency and awareness), ROUTE-To-PA (transparency of public administration), WeLive (Open Government), **By using the once-only principle:** TOOP, SCOOP4C, **In Health care:** ProAct, POLYCARE, PICASO, CONNECARE, ICT4Life, C3Cloud, **Smart and personalised inclusion:** RAPP, EIII, BLINDPAD, POSEIDON, Prosperity4All, BNCI Horizon 2020, ABBI, WAI-Dev		The EC has published the call 'ICT-2013.5.3 - ICT for smart and personalised inclusion'[59], 'INSO-1-2014/2015 ICT-enabled open government'[39, 56], 'CO-CREATION-05-2016 - Co-creation between public administrations: once-only principle'[60] and some Horizon 2020 calls ICT for Health. [61]

Policy Making 2.0	CROSSOVER, **e-government:** STORK, SPOCS, PEPPOL, epSOS, e-CODEX, eSENS, **also see e-participation above**		The European Commission has released the 'European eGovernment Action Plan 2016-2020'.[62] The European Parliament think tank published a report about 'eGovernment: Using technology to improve public services and democratic participation'.[63]
Sentiment Analysis	TransModal, SUMMA, COLEDISO, SSIX, SEWA, xLiMe, MULTISENSOR, MINDPICS, PHEME, EUROSENTIMENT, OpeNER, MediaGist, CrossLingMind, SUPER		
Smart Workplace	INTERACT, **Working environment for persons with special needs**: MATS, **Video Communication Workplace**: VIDEOCOM, **Smart factory environments**: SatisFactory, FACTS4WORKERS, SO SMART	Living Lab smart office space[64],GLOBAL WORKPLACE INNOVATION (GWi)[65]	Dell & Intel Future Workforce Study - Global Report[66],[67] Smart Workplace Market: Global Industry Analysis and Opportunity Assessment 2016-2026[68]

Social Media	There are more than 230 EU projects in and around the topic 'social media'. With relevance for the **public sector** the following projects are worth mentioning: STEP, COLEDISO, MULTISENSOR, ENGAGE, COCKPIT		
Artificial Intelligence	**e-learning**: Icarus, Infantium2.0, **theories:** WhoLoDancE, AI4REASON, **production**: Workshop4.0, ZinkOn Growth, PREVIEW, AUTOUNIMO, **linguistics**: LOVe, DASMT, **robotic:** DREAM, MULTI-ROBOT, **logistic**: TIMON, **decision making:** SURVEIRON, CoPS, **search algorithms:** SSX, GRAISearch, **analysis:** SCaEL, CYPRES	Hybr-iT (BMBF) [69], **EUREKA** project (Artificial intelligence platform development)[70], EUROSTARS project (MLB)[71], TRASPAIR[72], Pocket Pet[73], Intelligent transportation system[74], Research and development of intelligent oversight centre [75], Smartcare - expert system for better healthcare outcomes [76]; CDTI (Spain): platform for the automatic and intelligent learning of robots software[77]	'The National Artificial Intelligence Research and Development Strategic Plan'[78]

Augmented Reality	REALITY (eyewear), VOSTARS (medical domain), LARA (for Galileo and EGNOS), AEROGLASS (aviation), Augmented Commerce (e-commerce), iMARECULTURE (cultural heritage), TARGET (e.g counterterrorism), SPARK (prototyping), DBRLive (cameras), INSITER (energy-efficient buildings), MOBILE AUGMENTER (education), Wear3D (wearables), ARVisS (medical domain), MARWIN (for welding installations), MARCUS (urban settings)	Overview – virtual technologies (BMBF)[79], AVILUS, AVILUSplus[80], ViERforES[81], AR4DOC [82], ARVIDA [83], AUGUR [84], MIRACLE [85], SMART Vidente [86], MARIN2 [87], BMBF:[3] AR-UROLO, VIERforES II, Kognit, ENDOGUIDE, E! 5547, TOUAREG, ARinFLEX, ERANET, MANUNET, ARSGuide, itsowl, MMI, SPIRIT, THIN but Great Silicon 2 Design Objects, Professionelles Wireless Industrie LAN,EFA2014/2 BMWi:[3]CRUMBS, EXIST research transfer **EUREKA** projects: COMINDED[88], MOVAR[89], HIVIP[90], AR-LEAN[91], HDF DOR CSF[32, 92], Pocket Pet[73] **EUROSTARS** projects: [93], TouAREG[94], HISARTOUR[95], CAMILIS[96], ORBIPS[97], LBSAAS[32],	

Big Data	AutoMat, BACI, BD2Decide, BIG, BigDataEurope, BigStorage, BYTE, CIMPLEX, CoherentPaaS, DAIAD, DATA SIM, datACRON, DEDALE, EDSA, ENLIGHT-TEN, EO4wildlife, EoT, ERA-PLANET, EUDAT2020, EuDEco, EXCELL, FERARI, FREME, GROWTHCOM, iKaaS, INDIGO-DataCloud, INSIGHT, i-PROGNOSIS, L3MATRIX, LeanBigData, LinDA, MixedEmotions, MUSING, OCEANDATAMODELS, PANORAMIX, PETRA, PHEME, PROTEUS, RETHINK big, SAGE, SEE.4C, SENSATION, SoBigData, STREAMLINE, TOREADOR, TrendMiner, VaVeL, VELaSSCo, VICINITY	BigDieMo (BMBF, DLR, PTKA)[98] Big data projects (BMBF):[99] News-Stream 3.0, iPRODICT, BigPro, BDSec, FEE, GeoMultiSens, HUMIT, BigGIS, AGATA, ABIDA [100] BMWi projects:[3] iTESA, PRO-OPT, SmartEnergyHub, Fast Genomics, EnOB: BigData, NetzDatenStrom, LeichtFahr **EUROSTARS** projects: WINDELIN [101], PBD[102], ReProsis[103]; CDTI (Spain):SISAMED[104]	The British government has announced a joint project with IBM[105] Digital Agenda Germany[106] Big data competence centres (BMBF)[107] Big-Data research (BMBF)[107]
Biometrics	AMBER (mobile biometrics), PROTECT (automated border control), SpeechXRays (speech biometrics), BEAT(evaluation and testing), ACTIBIO (unobtrusive authentication), TABULA RASA (biometrics under spoofing attacks), BBFor2 (forensics), RISE (security ethics), BIO-DISTANCE (biometrics at distance), BIO-RESIDENCE (access), BIOHEALTH (eHealth)	BMBF:[3, 108] GES-3D, MARS, MisPel, FeGeb[109], CRISP, IP2 Projekt[110] BSI:[111] BioFace, BioFinger, BioP, BioKeyS, NFIQ2[112] **EUROSTARS** projects: MOBITOUCH-ID[113], BioSec[114], BioSpeak[115], BIRDS [116], ASSURE-ID[117]	

Blockchain	MH-MD, DECODE, D-CENT	EUROSTARS project T-CAB[118]	CollCo [119] Intellisys Capital[120]
Bots	IST-AFRICA, IST-Africa 2010 - 11, IST-Africa 2012-13, IST-, SEMAINE, COBOTNITY	Social Media Forensics (BMBF)	
Cloud Computing	SPOTLIGHT (radio access technologies), HOLA CLOUD (EU roadmap), SECCRIT (for critical infrastructures), MONICA (mobile cloud computing), TRESCCA (secure cloud computing), MOBILECLOUD (linking sino-European research institutions) WELCOME (medical domain), CLOUDCATALYST (for EU economy), HARNESS (software systems) EUBrazilOpenBio (biodiversity), CloudScale (scalability), Cloud-TM (programming module), ICE Wish (energy and wastage reduction), CleanSky (network), DependableCloud (dependability), SOLAS (scalability)	BMBF:[3] Cloud Computing BMWi: Sealed Cloud, Value4Cloud, Cloud4E, GGC-Lab ,eBusiness Lotse Schwaben, MimoSecco ; CDTI (Spain): cloud-application for taxi drivers[121]	The European Cloud initiative[18, 122]

Data Analytics	There are 89 EU research projects in the area of 'data analytics'. For the public sector, the following projects might be relevant: ASGARD (analysis of raw data), DataBio (bioeconomy), PULSE (participatory urban living), BIMEDA (medial domain), NICHE (healthcare), AEGLE (healthcare), AEGIS (public safety), BYTE (societal externalities), CityPulse (smart cities)	BMBF:[3] LINDA, CODA, SELFPASS, Smart Urban Services, STEPS, Wachstumskern Potenzial - iLaP – B, E! 10196 MoVieStA, EINS3D SMICE, FLORIDA, Visual Analytics for Security Applications BMWi:[3] SERVICE-FACTORY, EMuDig 4.0, MIA, PRO-OPT	
e-Identities	ABC4Trust, ELUTE, FutureID, GUIDE, HIGHTRUSTWALLET, HYDRA, ICONN, NeMeCo, NOVEL TRANSALDOLASES, PERCY, SENSE, SWIFT, TURBINE, VADER, VAMPIRE, VIRTUALVIALS		
e-Signatures	ANTICS, PQCRYPTO, SAFEcrypto		

Geographical Information Systems	There are over 120 EU research projects in the area of 'geographical information systems'. For the public sector, the following projects might be relevant: SDI4Apps (Open Geographic Information), LIMES (security), EMETEOSRV (meteorological information), GEORAMA (geo-navigation), DIGITAL-SEE (south east Europe), AGORA 2000 (urban planning), SPIN! (statistical data), CLIMAS (climate data), MAGIS (real estate), ECOST (fishing), DITTY (lagoons), COMET (urban economies), ECHAINE (wood)		

Internet of Things	SecIoT (cybersecurity), AUTOPILOT (driving), MIIMETIQ (telemetry), BIG IoT (interoperability), REMINDER (low power consumption), HORSE (robotics), PRIVACY FLAG (privacy), ULPIoT (low power consumption), U4IoT (user engagement), IoTEE (satellite based), UMI-Sci-Ed (education), Be-IoT (business), REMOSIS (medial domain), INSTET (security), ECRYPT-NET (cryptography), XS bitworker (industry 4.0), HEASIT (access solutions), EPoCH (cryptography), QR-PATROL PRO (security companies), BASTION (security), Teraki (big data), ALMANAC (reliable, secure), TrustNode (router platform), IoT5 (interoperability), PROBE-IT (benchmarks),	**EUROSTARS** project: IoTBridge[123], EXCITING[124]; CDTI (Spain):PRINT [125]	

Machine Learning	**Medical domain**: SACCSCAN-IA-ML, DecoMP_ECoG, INVeST, MlPM2012 **Biologcial data:** SMAC, MLCS, MLPHENOM **Other:** MALCOD (computational dynamics), SCALABIM (large complex datasets), NEOSURANCE (insurance), MALORCA (speech recognition), HERL (simultaneous heterogeneous tasks), Jam (vehicles) PROTEUS (predictive analytics), biomachinelearning (chemical sensing), Epigene Informatics (epigenomic research), SublinearOptML (smart data analysis), JointStructuredPred (natural language processing), MorpheusS (music), SUBLRN (learning theory), QQML (working with large-scale low-quality datasets), INFERENCEHCI (human-computer interaction), MLTSRMSRFID (mixed signal/RF integrated devices)	DFG: DEVIL: Detection of Software Vulnerabilities using Machine Learning, Auto-Tune: Structural optimization of Machine Learning frameworks for large datasets, DYNAMO: Dynamic Malware Detection using Machine Learning[126] Siemens: MALTE: Machine Learning for Threat Intelligence[126] **EUROSTARS** projects: HF PREDICT[127], BENgine II[128], HealthSCOPE[129], ASSURE-ID[117]	

Natural Language Processing	Overall there are 151 projects related to 'natural language processing'. Projects which set the focus on 'natural language processing' itself are HeLeNLP (using heterogeneous data), JointStructuredPred (machine learning methods), GRAMPLUS (grammar based processing),		
Wearables	In total there are 184 projects related to 'wearables'. Pojects in which wearables play the main role are MONICA (networked IoT wearables); Wearable4 Work (workplace productivity), WEAR_n_Pay (payment), I-SEE (eyewear), BlendIn (business card wearable), NewMoon (baby monitoring), WEAKID (medical domain), NIGHTINGALE (medical domain), MONILET (medical domain)	**EUROSTARS** projects: ELVIRA[130], HF-PREDICT[131], SensMotion[132], PersRadSens[133], Respiratory Blood Gas[134], My Health 1.0[135], SenSuit Safety System[136]; CDTI (Spain): Wearables[137]	

Virtual Reality	In total, there are 160 projects related to virtual reality. Projects which set the focus on virtual reality itself are AbsZero (VR camera), eHERITAGE (cultural heritage), VRMIND (medical domain), FURNIT-SAVER (furniture), VR4Health (medical domain), VR STROKE REHAB (medical domain), SP3D (e-commerce), MicroNanoTeleHaptics (mechanics & neural mechanisms of touch), IMOSHION (work health), IMERSO (VR system), V-TIME (elderly)	BMBF:[3] UniTyLab, EmoAdapt, VIERforES, IMMMA, Evotech, Fluvis, VRV, TRACY.B:, IRoProg, ALLVR -, DeepC, PRO, USE-VR -, INCENTIVE, EmoAdapt, Mmi, **EUROSTARS** projects: ELVIRA[138], MobileViz[139], Neurostars[140]	

Table 5: EU, as well as national R&D projects and programmes and important policy papers regarding each technology or trend.

3.2 Relevant actors regarding R&D activities of identified technologies and trends

In a second step, relevant actors, like companies or research organizations which work in the area of the identified technologies and trends [1] of the SONNETS project, have been identified. They have been identified by using complementing approaches. Firstly, the CORDIS open data have been downloaded and filtered and, secondly, data of Web of Science [141] were used to associate the different technologies and trends to the institutions involved in the respective R&D activities.

The CORDIS data have been filtered by individual search terms and cross-checked by analysing the resulting list of published project descriptions. All institutions with at least two relevant CORDIS projects in the respective area were initially taken into account. A selection was formed by applying both quantitative and qualitative criteria:

The number of projects and contributing institutions is broadly varying across the technologies and trends in question. Therefore, a cut-off was made to identify the institutions most frequently involved in R&D activities (regarding to the technology/trend), i.e. the number of the participations of the institution in relation to the total number of identified projects for the technology/trend.

The Web of Science data (plus institutional self-descriptions) were used to assess the probability that the actors' contribution was actually related to the technology/trend (and not, e.g., to societal or ethical issues, to cross-cutting issues of the projects or dissemination, etc.). In some cases, this was easy to accomplish, while in other cases, it was a matter of plausibility due to the fact that the CORDIS data are mostly listing institutions on a high level of the respective organizational structure (rather naming universities than working groups, etc.). The effort of making the attributions for thousands of institutions in hundreds of projects more accurate would have been beyond the scope of the actual task.

Last but not least, the Web of Science data sometimes indicated additional institutions involved in research regarding the technology/trend.

Technology/ Trend	**Relevant actors**
API Economy	Fraunhofer-Gesellschaft zur Förderung der Angewandten Forschung e.V., European Crowdfunfind Network, Technische Universiteit Eindhoven, Ethniko Kentro Erevnas Kai Technologikis Anaptyxis, Europe

	Unlimited S.A., Fundacion Centro de Tecnologias De Interaccion Visual y Comunicaciones Vicomtech, Institut Jozef Stefan, Universidad Politecnica de Madrid, University of Southampton, IBM, Vordel (now part of Axway)
Crowdsourcing	Alma Mater Studiorum-Universita di Bologna, Centre National de la Recherche Scientifique, University of Oxford
Digitalization	Fraunhofer-Gesellschaft zur Förderung der Angewandten Forschung e.V., Universität Koblenz-Landau, Brunel University, Ethniko Kentro Erevnas Kai Technologikis Anaptyxis, Liquid Democracy Ev, University of Leeds, University of Newcastle Upon Tyne
e-Participation	Fraunhofer-Gesellschaft zur Förderung der Angewandten Forschung e.V., Ecole Polytechnique Federale de Lausanne, Ethniko Kentro Erevnas Kai Technologikis Anaptyxis, Consiglio Nazionale delle Ricerche, Stiftelsen Sintef, University of Patras
Gamification	Fraunhofer-Gesellschaft zur Förderung der Angewandten Forschung e.V., Telefonica Investigacion y Desarrollo SA, Institut National de Recherche En Informatique et en Automatique, Universidad Politecnica de Madrid
Mobile Devices	Fraunhofer-Gesellschaft zur Förderung der Angewandten Forschung e.V., Technische Universiteit Delft, Universidad Politecnica de Madrid
Open Data	Athena Research and Innovation Center in Information Communication & Knowledge Technologies, Centre National de la Recherche Scientifique
Open Government	Intrasoft International SA, Technische Universiteit Delft, National Center for Scientific Research 'Demokritos', Ayuntamiento de Zaragoza, Foundation for Research and Technology Hellas, Fraunhofer-Gesellschaft zur Förderung der Angewandten Forschung e.V., National University of Ireland, Galway, Universidad Politecnica de Madrid, Vereniging Eurocris
Personalization	Fraunhofer-Gesellschaft zur Förderung der Angewandten Forschung e.V., Institute of Communication and Computer Systems, Ecole Polytechnique Federale de Lausanne, Nederlandse

	Organisatie voor Toegepast Natuurwetenschappelijk Onderzoek TNO, Telefonica Investigacion y Desarrollo SA Unipersonal
Policy Making 2.0	National University Of Ireland, Galway, Technische Universiteit Delft, Universität Koblenz-Landau, Intrasoft International SA
Sentiment Analysis	University of Edinburgh, University Of Oxford, Fundacio Barcelona Media, Institut Jozef Stefan, Institute Of Communication and Computer Systems, Universita degli Studi di Torino, Universitat Politecnica de Catalunya
Smart Workplace	Commissariat a l'Energie Atomique et aux Energies Alternatives, Fraunhofer-Gesellschaft zur Förderung der Angewandten Forschung e.V., University of Surrey, Katholieke Universiteit Leuven, Aalborg Universitet, Atos Spain SA, Technische Universiteit Eindhoven, Telefonica Investigacion y Desarrollo SA, Thales Communications & Security SAS
Social Media	Fraunhofer-Gesellschaft zur Förderung der Angewandten Forschung e.V., Ethniko Kentro Erevnas Kai Technologikis Anaptyxis, Universidad Politecnica de Madrid, University of Sheffield, Centre National de la Recherche Scientifique
Artificial Intelligence	Institut National de Recherche en Informatique et en Automatique, Centre National de la Recherche Scientifique, University of Edinburgh, University of Oxford, Imperial College of Science, Technology and Medicine
Augmented Reality	Fraunhofer-Gesellschaft zur Förderung der Angewandten Forschung e.V., Centre National de la Recherche Scientifique, Ethniko Kentro Erevnas Kai Technologikis Anaptyxis, Teknologian Tutkimuskeskus VTT, Technische Universität Graz, Technische Universiteit Delft
Big Data	Fraunhofer-Gesellschaft zur Förderung der Angewandten Forschung e.V., Atos Spain SA, Universidad Politecnica de Madrid, Deutsches Forschungszentrum für Künstliche Intelligenz GmbH, University College London

Biometrics	Fraunhofer-Gesellschaft zur Förderung der Angewandten Forschung e.V., Morpho, Katholieke Universiteit Leuven, Centre National de la Recherche Scientifique
Blockchain	Centre National de la Recherche Scientifique, Forum Virium Helsinki Oy, Fundacio Barcelona Media, Fundacio per a la Universitat Oberta de Catalunya, Geie Ercim, Immi Alpjodleg Stofnun Um Upplysinga-Og Tjaningarfrelsi*Immi International Modern Media Institute, Neo Innovation Europe Ltd, Nesta Lbg, Open Knowledge Foundation Lbg, Stichting Dyne. Org
Bots	Iimc International Information Management Corporation Limited, Tanzania Commission for Science and Technology, Agence Nationale des Technologies de l'Information et de la Communication, Department of Science and Technology, Unidade Tecnica de Implementacao da Politica de Informatica, Universiteit Twente
Cloud Computing	Atos Spain SA, Fraunhofer-Gesellschaft zur Förderung der Angewandten Forschung e.V., Institut National de Recherche en Informatique et en Automatique, Centre National de la Recherche Scientifique, Commissariat a l'Energie Atomique et aux Energies Alternatives, Engineering - Ingegneria Informatica Spa
Data Analytics	Centre National de la Recherche Scientifique, Fraunhofer-Gesellschaft zur Förderung der Angewandten Forschung e.V., University College London, University Of Oxford, University Of Manchester
e-Identities	IBM Research Gmbh, University of Birmingham, Universität Stuttgart, Aalborg Universitet, Danmarks Tekniske Universitet, Katholieke Universiteit Leuven, Norsk Regnesentral Stiftelse, Technische Universitaet Darmstadt, Technische Universiteit Eindhoven, University Of Cambridge
e-Signatures	Institut National de Recherche en Informatique et en Automatique, Ruhr-Universität Bochum
Geographical Information Systems	University Of Cambridge, Wageningen University, Centre National de la Recherche Scientifique, JRC - Joint Research Centre- European Commission

Internet of Things	Fraunhofer-Gesellschaft zur Förderung der Angewandten Forschung e.V., Commissariat a l'Energie Atomique et aux Energies Alternatives, Institut National de Recherche en Informatique et en Automatique, University of Surrey, Atos Spain SA
Machine Learning	Imperial College of Science, Technology and Medicine, Universitat Politecnica de Catalunya, University of Edinburgh, University of Oxford, Institut National de Recherche en Informatique et en Automatique
Natural Language Processing	University Of Edinburgh, Centre National de la Recherche Scientifique, University of Oxford, University of Cambridge, Athena Research and Innovation Center in Information Communication & Knowledge Technologies, Stichting Katholieke Universiteit, The University of Sheffield
Wearables	Fraunhofer-Gesellschaft zur Förderung der Angewandten Forschung e.V., Commissariat a l'Energie Atomique et aux Energies Alternatives, University Of Surrey, Atos Spain Sa, Institut National de Recherche en Informatique et en Automatique
Virtual Reality	Centre National de la Recherche Scientifique, Universitat de Barcelona, University College London, Fraunhofer-Gesellschaft zur Förderung der Angewandten Forschung e.V., Technische Universität München

Table 6: Relevant actors of the technologies and trends.

3.3 Derived Technology Readiness Level of identified technologies and trends

On the basis of the results of the desktop research above (chapter 3.1 to 3.2) the technology readiness level of the SONNETS technologies and trends (as far as possible) have been identified. The Technology Readiness Level (TRL) has been derived by using the following sources: The reports of recent relevant R&D projects have been analysed to decide on the current status of research, development or demonstration / testing. The list of relevant actors shows if the technology is still on a level of basic research (e.g. only national research institutes involved) or nearly ready for market (e.g. several IT companies work in this area). A desktop research using Web of Science[142] gave further hints on how to assess the TRL of the different technologies.

Technology/ Trend	Technology Readiness Level (TRL)	Sources or justification
API Economy	Already in use in other domains	APIhound estimates there are 50,000 public web APIs.[143]
Crowdsourcing	Already in use in other domains	85% of the 2014 Best Global Brands have already used crowdsourcing in the last ten years[144] Open Innovation and Crowd Sourcing [3, 145]; Crowdworking[146]; Crowdsourcing[147]
Digitalization	Already in use in several institutions of the public sector	Interviews with public sector representatives[148]
e-Participation	Already in use in some institutions of the public sector	Examples given in SONNETS D3.2[1]; interviews and focus groups[148]
Gamification	Already in use in other domains and also in some institutions of the public sector	There has been a high growth of gamification solutions among small and medium enterprises in various industry verticals due to increasing need for gamification solutions and applications in enterprise and consumer brands.[149] Gamification is also in use in some public sector organisations, e.g. the UK Department for Work and Pensions has begun to exploit the principles of gaming technology to improve internal performance. [150]
Mobile Devices	Already in use in other domains and also in several institutions of	Examples given in SONNETS D3.2[1]; Interviews and focus groups[151]

	the public sector	
Open Data	Already in use in other domains and also in several institutions of the public sector	Data base of the European Union on open data portals containing public sector information[52]
Open Government	Already in use in several institutions of the public sector	Currently the database of open government applications contains 395 cases.[152]
Personalization	Already in use in other domains and also in some institutions of the public sector	There are already products for the public sector available, which include the idea of personalized services.[153, 154]
Policy Making 2.0	Already in use in several institutions of the public sector	In a UN study, Europe was the highest-ranking region overall for eGovernment. France, the Netherlands, the United Kingdom (UK) and Finland were the highest ranking EU Member States. In specific areas such as eParticipation, France, the Netherlands and the UK were also world leaders.[63, 155]
Sentiment Analysis	Already in use in other domains and also in some institutions of the public sector	Policy paper 'Using sentiment analysis to support the action of policy-makers across the policy cycle' [156] 'Sentiment analysis algorithms and applications: A survey'[157]
Smart Workplace	Already in use in other domains	'Top 12 Emerging Digital Workplace Technologies', Gartner[158] Smart office, Dell[159]
Social Media	Already in use in several institutions of	'The National Artificial Intelligence Research and Development Strategic Plan'[78]

	the public sector	
Artificial Intelligence	Already in use in other domains and also in some institutions of the public sector	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.[160]
Augmented Reality	Already in use in other domains	In Social Media - Tagwhat[161]
Big Data	Already in use in other domains	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%.[162]
Biometrics	Already in use in other domains and also in some institutions of the public sector	As per Gartner, 30 Percent of Organizations Will Use Biometric Authentication for Mobile Devices by 2016; Interviews
Blockchain	Already in use in other domains	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.[163]
Bots	Already in use in other domains	Interviews, Smart robots appear in Gartner's Hype Cycle for Emerging Technologies, 2015 (On the Rise).[164] Bots are also considered, according to Harvard Business Review, as one of the eight Tech Trends to Watch in 2016.[165]
Cloud Computing	Already in use in other domains	Cloud Computing appears in Gartner's 'Top 10 Strategic Technology Trends for 2015',[166] 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.[167]

Data Analytics	Already in use in other domains	Advanced, Pervasive and Invisible Analytics appear in Gartner's 'Top 10 Strategic Technology Trends for 2015'[166], whereas Advanced Analytics With Self-Service Delivery appear in Gartner's Hype Cycle for Emerging Technologies, 2015 (At the Peak)[164]. Real time Analytics and Predictive Analytics are also placed within the Gartner's Hype Cycle for the Internet of Things, 2015.[164] 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.[167]
e-Identities	Already in use in several institutions of the public sector	eID especially as a means of citizen's identification towards the public sector is identified as one of the key top-10 technology strategies.[168], interviews
e-Signatures	Already in use in several institutions of the public sector	Interviews
Geographical Information Systems	Already in use in some institutions of the public sector	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[158, 169].
Internet of Things	Already in use in some institutions of the public sector	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[170]. IoT is further considered as one of the eight trends that are likely to disrupt businesses in the months to come.
Machine Learning	Already in use in some institutions of the public sector (spam filtering)	The overall artificial intelligence market is expected to be worth USD 16.06 Billion by 2022, growing at a CAGR of 62.9% from 2016 to 2022.[171]
Natural Language Processing	Already in use in other domains	The NLP market size is estimated to grow from 7.63 bn USD in 2016 to 16.07 bn USD by 2021, at a Compound Annual Growth Rate (CAGR) of 16.1%[172].
Wearables	Already in use in other domains	CCS Insight predicts that wearable technology market will 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[173]. 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[174, 175], Wearables appear at the peak of Gartner's 'Hype Cycle for Emerging Technologies, 2015'[164],[175, 176]
Virtual Reality	Already in use in other domains	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[177]. 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-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[178]. The market for immersive virtual reality systems is expected to cross 2 bn market by 2021[179]. Virtual Reality appears in Gartner's Hype Cycle for Emerging Technologies, 2015 (Sliding Into the Trough)[164], 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[163]. It further shows up in the list of the top 9 technology trends for 2016, compiled by the IEEE Computer Society[180].

Table 7: Technology Readiness Level (TRL) of the technologies and trends.

4 Filled out Weighted-Bit Assessment Table of the identified technologies and trends

The above described input (current or recent R&D projects, relevant actors and the TRL level) as well as SONNETS deliverable D3.2 and D3.3 have been used as a basis to fill out the Weighted-Bit Assessment Table of the SONNETS technologies and trends. Each technology/trend has been assessed by two partners of the SONNETS consortium (one partner as the main responsible partner for the respective technology/trend and the second one as a critical reviewer). Additionally this table will be sent to the SONNETS Experts Committee for further review. The reviewed version will additionally be discussed during the next consortium meeting in May 2017.

	API Economy	Crowdsourcing	Digitalization	e-Participation	Gamification	Mobile Devices	Open Data
Assessment Parameter							
Area 1: Innovation Potential (Modernization of PS)							
The implementation of this technology would meet a societal need.	yes	yes	yes	yes	yes	yes	yes
The implementation of this technology would meet a public sector need.	yes	yes	yes	yes	yes	yes	yes
The implementation of this technology would meet a business need.	yes	yes	yes	yes	yes	yes	yes
The implementation of this technology would help to modernize the public sector – even if at the moment this technology cannot be related to a formulated societal or public sector need.	yes	yes	yes	yes	yes	yes	yes
Area 2: Innovation Potential (PS as Innovation Driver)							
The implementation of this technology would help to turn the public sector into an innovation driver	yes	yes	yes	yes	yes	yes	yes
Area 3: Technology research and development activities needed							
The technology is very new and still at the level of basic research (TRL 1 or 2).	no	no	no	no	no	no	no
The technology is at a development stage and has neither been used in the public sector nor in any other domain (TRL 3 - 6).	no	no	no	no	no	no	no
The technology has been successfully tested as a prototype or is ready for the market in another domain (TRL 7 – 9); but a real use case for the public sector has yet to be defined.	no	no	no	no	yes	no	no
The technology has been successfully tested as a prototype or is ready for the market in another domain (TRL 7 – 9); but further modifications or adaptions to the specifics of the public sector are necessary.	no	no	no	no	yes	no	no
The technology is in use in selected public sector organisations, but further modifications/ improvements / eliminations of errors are necessary.	no	no	yes	no	yes	no	no

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There are competing technologies on the market or with a high TRL, which might hinder a further development of this technology/trend.	no	no	no	no	no	no	no
The EU and/or national governments provide funds, so that the further development of this technology is rather likely.	yes	yes	yes	yes	yes	yes	yes
There are several research institutions and/or companies interested in a further development of this technology.	yes	yes	yes	yes	yes	yes	yes
Area 4: Other activities needed							
The usage of this technology demands a rather high level of general ICT knowledge.	yes	no	yes	no	yes	no	yes
Before using this technology a specific training is needed.	yes	no	yes	no	yes	no	yes
There are well-established and well performing processes and/or technologies in place in the public sector, so that the preparedness to try new technologies is rather low.	no	no	no	no	no	no	no
The technology is highly visible in the media and popular among citizens or businesses, so that the pressure to implement this technology is rather high.	yes	yes	yes	yes	no	yes	yes
For the implementation of this technology a specific or advanced ICT infrastructure is needed in the public sector	yes	no	yes	no	no	no	yes
The usage of this technology might raise cyber security issues / issues of misuse of this technology/ other side-effects on the ICT infrastructure.	yes	yes	yes	yes	yes	yes	yes
The technology has to be explained and promoted among business stakeholders and/or citizens.	yes	yes	no	yes	yes	no	yes
The successful usage of this technology is only possible after the adaption of the processes of the public sector and ensuring the interoperability with existing systems.	yes	yes	yes	yes	yes	yes	yes
The successful usage of this technology is only possible if all or several EU/national authorities exchange relevant data/ agree on a certain standard /develop common processes or regulations.	yes	yes	yes	yes	yes	yes	yes
Before using this technology a new or modified legislative framework has to be developed in the EU or in the national governments.	no	yes	no	yes	yes	no	yes
The implementation or maintenance of this technology is rather costly.	yes	yes	yes	yes	yes	no	no
Area 4: Ethical, legal and societal aspects (ELSA)							

The technology is likely to raise ethical issues (e.g. gender, age, minorities or other forms of discrimination).	no	yes	yes	yes	yes	no	no
The technology is likely to raise legal issues (e.g. freedom infringements, constriction of fundamental rights, data protection issues).	yes	yes	yes	yes	yes	yes	yes
The technology is likely to raise societal issues (e.g. loss of jobs, side-effects of technologisation).	yes	yes	yes	no	no	no	no
The technology is likely to raise health issues (e.g. ergonomics, eyesight).	no	no	no	no	no	no	no
The technology is likely to encounter problems regarding public acceptance.	no	no	no	yes	yes	no	no

Table 8: Filled out Weighted-Bit Assessment Table (Trends 1-7)

	Open Government	Personalization	Policy Making 2.0	Sentiment Analysis	Smart Workplace	Social Media	Artificial Intelligence
Assessment Parameter							
Area 1: Innovation Potential (modernization of PS)							
The implementation of this technology would meet a societal need.	no	yes	yes	no	yes	yes	yes
The implementation of this technology would meet a public sector need.	yes	no	yes	yes	no	yes	yes
The implementation of this technology would meet a business need.	yes	yes	no	no	yes	no	yes
The implementation of this technology would help to modernize the public sector – even if at the moment this technology cannot be related to a formulated societal or public sector need.	yes	yes	yes	yes	yes	yes	yes
Area 2: Innovation Potential (PS as innovation driver)							
The implementation of this technology would help to turn the public sector into an innovation driver	yes	n.a.	n.a.	no	yes	no	yes
Area 3: Technology research and development activities needed							
The technology is very new and still at the level of basic research (TRL 1 or 2).	no	no	no	no	no	no	no
The technology is at a development stage and has neither been used in the public sector nor in any other domain (TRL 3 - 6).	no	no	no	no	no	no	no
The technology has been successfully tested as a prototype or is ready for the market in another domain (TRL 7 – 9); but a real use case for the public sector has yet to be defined.	no	no	no	no	no	no	yes
The technology has been successfully tested as a prototype or is ready for the market in another domain (TRL 7 – 9); but further modifications or adaptions to the specifics of the public sector are necessary.	no	no	yes	no	yes	no	no
The technology is in use in selected public sector organisations, but further modifications/ improvements / eliminations of errors are necessary.	no	no	no	no	no	no	no

There are competing technologies on the market or with a high TRL, which might hinder a further development of this technology/trend.	yes	no	no	yes	no	yes	no
The EU and/or national governments provide funds, so that the further development of this technology is rather likely.	yes	no	no	no	no	no	no
There are several research institutions and/or companies interested in a further development of this technology.	yes	no	no	no	no	no	no
Area 4: Other activities needed							
The usage of this technology demands a rather high level of general ICT knowledge.	no	yes	no	yes	no	no	yes
Before using this technology a specific training is needed.	yes	yes	yes	yes	yes	yes	yes
There are well-established and well performing processes and/or technologies in place in the public sector, so that the preparedness to try new technologies is rather low.	yes	no	no	no	yes	no	no
The technology is highly visible in the media and popular among citizens or businesses, so that the pressure to implement this technology is rather high.	no	no	yes	no	no	yes	no
For the implementation of this technology a specific or advanced ICT infrastructure is needed in the public sector	no	no	no	no	yes	no	yes
The usage of this technology might raise cyber security issues / issues of misuse of this technology/ other side-effects on the ICT infrastructure.	yes	no	no	no	no	no	yes
The technology has to be explained and promoted among business stakeholders and/or citizens.	yes	yes	yes	no	no	yes	yes
The successful usage of this technology is only possible after the adaption of the processes of the public sector and ensuring the interoperability with existing systems.	yes	yes	no	no	no	no	yes
The successful usage of this technology is only possible if all or several EU/national authorities exchange relevant data/ agree on a certain standard /develop common processes or regulations.	yes	no	no	no	no	no	no
Before using this technology a new or modified legislative framework has to be developed in the EU or in the national governments.	yes	no	no	no	yes	no	no
The implementation or maintenance of this technology is rather costly.	yes	no	no	no	no	no	no
Area 5: Ethical, legal and societal aspects (ELSA)							

The technology is likely to raise ethical issues (e.g. gender, age, minorities or other forms of discrimination).	no	no	no	no	no	no	yes
The technology is likely to raise legal issues (e.g. freedom infringements, constriction of fundamental rights, data protection issues).	yes	no	no	no	yes	no	yes
The technology is likely to raise societal issues (e.g. loss of jobs, side-effects of technologisation).	no	no	no	no	no	no	yes
The technology is likely to raise health issues (e.g. ergonomics, eyesight).	no	no	no	no	no	no	no
The technology is likely to encounter problems regarding public acceptance.	yes	no	no	no	no	no	yes

Table 9: Filled out Weighted Bit Assessment Table (Trends 8-13, Technology 1)

	Augmented Reality	Big Data	Biometrics	Blockchain	Bots	Cloud Computing	Data Analytics
Assessment Parameter							
Area 1: Innovation Potential (modernization of PS)							
The implementation of this technology would meet a societal need.	yes	yes	yes	yes	yes	yes	yes
The implementation of this technology would meet a public sector need.	yes	yes	no	no	yes	yes	yes
The implementation of this technology would meet a business need.	no	yes	no	no	no	yes	yes
The implementation of this technology would help to modernize the public sector – even if at the moment this technology cannot be related to a formulated societal or public sector need.	yes	yes	yes	yes	yes	yes	yes
Area 2: Innovation Potential (PS as innovation driver)							
The implementation of this technology would help to turn the public sector into an innovation driver	yes	yes	yes	yes	yes	yes	yes
Area 3: Technology research and development activities needed							
The technology is very new and still at the level of basic research (TRL 1 or 2).	no	no	no	no	no	no	no
The technology is at a development stage and has neither been used in the public sector nor in any other domain (TRL 3 - 6).	no	no	no	no	no	no	no
The technology has been successfully tested as a prototype or is ready for the market in another domain (TRL 7 – 9); but a real use case for the public sector has yet to be defined.	no	no	no	no	no	no	no
The technology has been successfully tested as a prototype or is ready for the market in another domain (TRL 7 – 9); but further modifications or adaptions to the specifics of the public sector are necessary.	yes	yes	yes	yes	yes	yes	yes
The technology is in use in selected public sector organisations, but further modifications/ improvements / eliminations of errors are necessary.	no	yes	yes	no	yes	yes	yes
There are competing technologies on the market or with a high TRL, which might hinder a further development of this technology/trend.	no	no	no	no	no	no	no

The EU and/or national governments provide funds, so that the further development of this technology is rather likely.	yes	yes	yes	yes	yes	yes	yes
There are several research institutions and/or companies interested in a further development of this technology.	yes	yes	yes	yes	yes	yes	yes
Area 4: Other activities needed							
The usage of this technology demands a rather high level of general ICT knowledge.	no	yes	no	yes	no	no	yes
Before using this technology a specific training is needed.	no	yes	no	yes	no	no	yes
There are well-established and well performing processes and/or technologies in place in the public sector, so that the preparedness to try new technologies is rather low.	n.a.	yes	n.a.	yes	yes	no	n.a.
The technology is highly visible in the media and popular among citizens or businesses, so that the pressure to implement this technology is rather high.	yes	yes	yes	yes	no	yes	no
For the implementation of this technology a specific or advanced ICT infrastructure is needed in the public sector	yes	yes	yes	yes	yes	no	yes
The usage of this technology might raise cyber security issues / issues of misuse of this technology/ other side-effects on the ICT infrastructure.	no	yes	yes	yes	yes	yes	no
The technology has to be explained and promoted among business stakeholders and/or citizens.	no	yes	yes	yes	yes	no	yes
The successful usage of this technology is only possible after the adaption of the processes of the public sector and ensuring the interoperability with existing systems.	no	yes	yes	yes	no	no	yes
The successful usage of this technology is only possible if all or several EU/national authorities exchange relevant data/ agree on a certain standard /develop common processes or regulations.	no	no	no	no	no	no	no
Before using this technology a new or modified legislative framework has to be developed in the EU or in the national governments.	no	yes	yes	yes	n.a.	yes	n.a.
The implementation or maintenance of this technology is rather costly.	yes	yes	yes	yes	no	no	no
Area 5: Ethical, legal and societal aspects (ELSA)							
The technology is likely to raise ethical issues (e.g. gender, age, minorities or other forms of discrimination).	yes	yes	yes	no	no	no	yes

The technology is likely to raise legal issues (e.g. freedom infringements, constriction of fundamental rights, data protection issues).	yes	yes	yes	yes	no	yes	yes
The technology is likely to raise societal issues (e.g. loss of jobs, side-effects of technologisation).	no	no	no	no	yes	no	no
The technology is likely to raise health issues (e.g. ergonomics, eyesight).	yes	no	no	no	no	no	no
The technology is likely to encounter problems regarding public acceptance.	yes	n.a.	yes	yes	yes	no	n.a.

Table 10: Filled out Weighted Bit Assessment Table (Technology 2-8)

	e-Identities	e-Signatures	Geographical Information Systems	Internet of Things	Machine Learning	Natural Language Processing	Wearables	Virtual Reality
Assessment Parameter								
Area 1: Innovation Potential (Modernization of PS)								
The implementation of this technology would meet a societal need.	yes	no	yes	yes	no	no	yes	yes
The implementation of this technology would meet a public sector need.	yes	no	no	yes	yes	yes	yes	yes
The implementation of this technology would meet a business need.	yes	yes	yes	yes	no	no	no	yes
The implementation of this technology would help to modernize the public sector – even if at the moment this technology cannot be related to a formulated societal or public sector need.	yes	yes	yes	yes	yes	yes	yes	no
Area 2: Innovation Potential (PS as innovation driver)								
The implementation of this technology would help to turn the public sector into an innovation driver	yes	yes	yes	yes	yes	yes	yes	yes
Area 3: Technology research and development activities needed								
The technology is very new and still at the level of basic research (TRL 1 or 2).	no	no	no	no	no	no	no	no
The technology is at a development stage and has neither been used in the public sector nor in any other domain (TRL 3 - 6).	no	no	no	no	no	no	no	no
The technology has been successfully tested as a prototype or is ready for the market in another domain (TRL 7 – 9); but a real use case for the public sector has yet to be defined.	no	no	no	no	no	no	no	no
The technology has been successfully tested as a prototype or is ready for the market in another domain (TRL 7 – 9); but further modifications or adaptions to the specifics of the public sector are necessary.	no	no	no	no	no	yes	yes	yes

The technology is in use in selected public sector organisations, but further modifications/ improvements / eliminations of errors are necessary.	yes	yes	yes	yes	yes	no	no	no
There are competing technologies on the market or with a high TRL, which might hinder a further development of this technology/trend.	no	no	no	no	no	no	no	no
The EU and/or national governments provide funds, so that the further development of this technology is rather likely.	yes	yes	yes	yes	yes	yes	yes	yes
There are several research institutions and/or companies interested in a further development of this technology.	yes	yes	yes	yes	yes	yes	yes	yes
Area 4: Other activities needed								
The usage of this technology demands a rather high level of general ICT knowledge.	no	no	yes	n.a.	yes	yes	no	no
Before using this technology a specific training is needed.	no	no	yes	no	yes	yes	no	no
There are well-established and well performing processes and/or technologies in place in the public sector, so that the preparedness to try new technologies is rather low.	no	yes	yes	no	no	no	no	no
The technology is highly visible in the media and popular among citizens or businesses, so that the pressure to implement this technology is rather high.	yes	yes	yes	yes	no	no	yes	yes
For the implementation of this technology a specific or advanced ICT infrastructure is needed in the public sector	yes	yes	yes	yes	yes	yes	no	yes
The usage of this technology might raise cyber security issues / issues of misuse of this technology/ other side-effects on the ICT infrastructure.	yes	yes	no	yes	yes	no	yes	no
The technology has to be explained and promoted among business stakeholders and/or citizens.	no	no	no	yes	yes	yes	yes	no
The successful usage of this technology is only possible after the adaption of the processes of the public sector and ensuring the interoperability with existing systems.	yes	yes	yes	yes	no	n.a.	n.a.	n.a.
The successful usage of this technology is only possible if all or several EU/national authorities exchange relevant data/ agree on a certain standard /develop common processes or regulations.	yes	yes	no	no	no	no	no	no
Before using this technology a new or modified legislative framework has to be developed in the EU or in the national governments.	yes	yes	no	yes	no	no	yes	no

The implementation or maintenance of this technology is rather costly.	yes	yes	yes	yes	yes	no	no	yes
Area 5: Ethical, legal and societal aspects (ELSA)								
The technology is likely to raise ethical issues (e.g. gender, age, minorities or other forms of discrimination).	yes	no	no	no	yes	no	yes	no
The technology is likely to raise legal issues (e.g. freedom infringements, constriction of fundamental rights, data protection issues).	yes	yes	no	yes	yes	yes	yes	no
The technology is likely to raise societal issues (e.g. loss of jobs, side-effects of technologisation).	no	no	no	yes	yes	yes	no	no
The technology is likely to raise health issues (e.g. ergonomics, eyesight).	no	no	no	no	no	no	no	yes
The technology is likely to encounter problems regarding public acceptance.	yes	no	no	no	yes	no	yes	yes

Table 11: Filled out Weighted Bit Assessment Table (Technologies 9-16)

5 Conclusions

The present deliverable, entitled 'Analysis of the identified emerging technologies', is released within the context of Work Package 4 'Roadmap for emerging research directions' and is more specifically associated with Task 4.1. The former builds upon the outcomes of WP3 with the view to further analyze the identified emerging technologies with promising impacts in the public sector. The aim of this in-depth analysis is to identify research gaps and other non-research activities which are necessary for the final implementation of these technologies in the public sector, and thus perform the first step in the sequence of activities required towards the development of a roadmap, putting forward the different research and innovation directions that should be followed in order to reach the anticipated vision of reshaping and reforming the public sector into a technology leader and a key player in tackling societal challenges.

Pursuant to the goals of WP4 and Task 4.1 in particular, the deliverable at hand has exposed the methodology employed for the conducted analysis and reported on the findings of its application. The methodology has revolved around the Weighted Bit Assessment Table (WBAT) method, a multi-criteria assessment tool, developed by Fraunhofer INT, whereas it has leveraged the results of Deliverable D3.2 and thereby the identified technologies and trends impact assessment tables, as well as additional information that has been deemed crucial for determining the gap between the current R&D status and the final implementation of this technology in the public sector. Such information has been collected by means of desktop research and includes the following parameters:

- the Technology Readiness Level of each identified technology, as a token of its maturity;
- the R&D activities currently running in each technology domain at both European and national level, as a proxy for the current R&D status in the specified domain, and
- the main actors, i.e. universities, research organizations and companies, involved in the development of the technologies identified, as a means to drive assumptions on whether each technology is market-ready or at the level of basic research.

The Weighted-Bit Assessment Table has been afterwards formulated with the view to serve the following purposes:

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- Determine the innovation potential and usefulness of each identified technology in the public sector *(Area 1: Innovation Potential (Modernization of PS))*
- Determine whether the respective technology could help to turn the public sector into an innovation driver *(Area 2: Innovation Potential (PS as innovation driver))*
- Determine if (further) research and development activities are needed to implement the technology under consideration in the public sector *(Area 3: Technology research and development activities needed)*
- Determine if non-research activities (training, regulations, etc.) are needed before the respective technology could be used in the public sector *(Area 4: Other activities needed)*
- Determine whether the technology in question could have undesired ethical, legal or societal implications. *(Area 5: Ethical, legal and societal aspects (ELSA))*

The task of filling out the Weighted-Bit Assessment Table for each technology or trend has been undertaken by two partners, one acting as the input provider and the other assuming the role of the reviewer.

The filled out Weighted-Bit Assessment Table (WBAT) is to be further reviewed and validated by the SONNETS Experts Advisory Board and will make up the basis for the SONNETS research roadmap, which will summarize all necessary activities to implement the ICT technologies successfully in the public sector.

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