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Scientific foundations training and entrepreneurship activities in the domain of ICT-enabled Governance

Government 3.0 Roadmap

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Document description:	This report documents the results of task 2.1, which aimed at defining a research and knowledge roadmap of Government 3.0. The roadmap describes current and future fields of interest and research in the domain of digital government, governance and citizenship in combination with the use of disruptive technologies. It suggests specific roadmap actions, which, when realised, allow to significantly improve the understanding of the changes brought on by Government 3.0. Additionally, Task 2.1 identified the gaps concerning the missing knowledge from the current training curricula on different levels (undergraduate, postgraduate, vocational training levels) and provides input to WP3.

Document History

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		Dimitrios Sarantis, Soumaya Ben Dhaou (UNU)	Project analysis: Blockchain, eSignature, eIdentity
		Frank Danielsen (UiA)	Project analysis: Cloud Computing
		Jon Matthew Switters, Francesco Mureddu (LC)	Project analysis: Service Co-creation, Once-Only Principle, Service Modules, CAPS
		Zoi Lachana, Charalampos Alexopoulos (UAEGEAN)	Project analysis: Natural Language Processing, Gamification, Gaming-based Simulation
		Gabriela Viale Pereira (DUK)	Project analysis: Open and Linked Data
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Executive Summary

This report details the roadmapping activities within Work Package 2, task 2.1 of the Gov 3.0 project. It describes the methodology used to develop the roadmap and the results of the application of the methodology. The overall goal of Work Package 2 is to set the research and knowledge roadmap in the area of Government 3.0. The main objectives of this WP are the following:

- To monitor research developments in the area of e-government.
- To perform analysis and categorisation of e-government scientific research areas.
- To update and set up Future Research Directions (roadmap) and identify gaps of existing curricula.

The methodology applied in this report is based on previous roadmapping projects, led by the partners, including the projects eGovRTD2020[1], CROSSROAD[2], eGovPoliNet[3] and SCOOP4C[4]. The methodology has been adjusted and adapted to the specific needs of the Gov 3.0 project. The Roadmap has been developed based on the identified research and training needs, elaborated with the help of the future scenario technique along a set of interactive workshops with researchers, practitioners and students. Furthermore, an analysis of existing R&D projects around relevant topics has been conducted and the results are fed into the gap analysis and roadmap.

The project analysis covers a synthesis of 281 projects that explore 15 technologies and concepts of disruptive technologies of Government 3.0. From the inputs of WP 1 and the insights from the project analysis, 13 possible future scenarios have been depicted which exemplify the use of disruptive technologies in different settings of public service provisioning.

From these inputs, the Government 3.0 Roadmap is developed, comprising of two parts: research and training roadmaps. The research Roadmap details 19 specific research actions that will advance the understanding of the way disruptive technologies can contribute to better digital government services, improving service quality, accountability, transparency and efficiency. Suggested actions in research include:

- analysis of existing implementations of disruptive technologies, identification of (new) application areas, and possible positive or negative impacts of disruptive technologies generally;
- research of real-time analysis of data, automated decision algorithms, the requirements for transparency of such algorithms and their legislative regulation;
- formulation of standards and regulations for IoT and blockchain;
- research in organisational change in government, data governance, citizen-oriented cloud solutions, the OOP application on personal and sensitive data, cross-border interoperability for eID and eSignature;
- creation of guidelines for service modules implementing disruptive technologies and the use of (personal) data collected with AR/VR systems;
- research on ethical implications of disruptive technologies and elaboration of an ethical framework to address emerging ethical concerns.

[1] https://cordis.europa.eu/project/id/027139, the project was coordinated by Maria Wimmer, University of Koblenz-Landau, and it aimed at identifying and characterizing the key research challenges, required constituency, and an implementation model for comprehensive European initiatives on holistic and dynamic government 2020.

[2] https://cordis.europa.eu/project/id/248484, the project was coordinated by Yannis Charalabidis, at that time at National Technical University of Athens, and it aimed at mapping the research of ICT-enabled policy modelling and at developing a research roadmap for ICT-enabled policy modelling and digital governance.

[3] https://cordis.europa.eu/project/id/288136, the project was coordinated by Maria Wimmer, University of Koblenz-Landau, and it aimed at building a global multidisciplinary digital governance and policy modelling research and practice community, which defined five grand challenges of digital government and governance.

[4] https://cordis.europa.eu/project/id/737492, the project was coordinated by Maria Wimmer, University of Koblenz-Landau, and it aimed at developing a roadmap of actions for implementing the once-only principle across Europe.

The training roadmap is structured along different education levels, including higher education i) at Bachelor level and ii) at Master levels), iii) vocational, professional training and finally iv) end-user training. For each of the training roadmap actions, several focal points have been identified, along with stakeholders responsible for the realisation of each step.

A final contribution in this report are recommendations concerning various stakeholders relevant to the implementation of the roadmap actions. The results from D 2.2 feed into WP3 for the development of training modules and curricula as well as in WP4 for the development of the MOOCs.

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LIST OF TERMS AND ABBREVIATIONS

Term/Abbreviation	Definition
AI	Artificial Intelligence
AR	Augmented Reality
BB	Building Block
BC	Blockchain
BOLD	Big Open Linked Data
CAPs	Community Awareness Platforms
DUK	Danube University Krems (Austria)
EC	The European Commission
eIDAS	electronic IDentification, Authentication and trust Services
FP7	7th Framework Programme
G2B	Government to business
G2C	Government to citizen
G2G	Government to government
GS	Gaming-based Simulation
IaaS	Infrastructure as a Service
ICT	Information and Communication Technologies
IoT	Internet of Things
ISA	Interoperability Program for European Public Administration
LC	Lisbon Council (Belgium)
LOD	Linked Open data
ML	Machine Learning
NEGZ	Das Nationale E-Government Kompetenzzentrum (Germany)
NLP	Natural Language Processing
OOP	Once Only Principle
P2P	Peer-to-peer
PaaS	Platform as a service
PKI	Public key infrastructure
PwC	PricewaterhouseCoopers (Greece)
RDF	Resource Description Framework
RDFS	Resource Description Framework Schema
RQ	Research Question
SA	Sentiment Analysis

SaaS	Software as a Service
SAML	Standards for exchanging authentication and authorization data
SC	Smart City
SiLo	Singular Logic (Cyprus)
SPARQL	SPARQL Protocol and RDF Query Language
TOOP	The Once-Only Principle Project
UAEGEAN	University of the AEGEAN (Greece)
UiA	University of Agder (Norway)
UNU	United Nations University (Portugal)
URI	Uniform Resource Identifier
VR	Virtual Reality
WoT	Web of Trust
WP	Work Package

1. Introduction

1.1 Purpose and Scope

This report is the outcome of Work Package 2 of the Gov 3.0 project. Work Package 2 intends to set the research and knowledge roadmap in the area of Government 3.0. The main objectives of this WP are the following:

- To monitor research developments in the area of e-government.
- To perform analysis and categorisation of e-government scientific research areas.
- To update and set up Future Research Directions (roadmap) and find the gaps of existing curricula.

The Roadmap is an essential deliverable of the Gov 3.0 project that guides the development of the Work Packages 3 and 4.

1.2 Approach for the Work Package and Relation to other Work Packages and Deliverables

Deliverables D 1.1 and D 1.2 of WP 1 (T1.1. Baseline Research and T.1.2. Electronic Governance training programmes worldwide) serve as inputs in WP 2 to develop a list of roadmap actions in order to address the research and training needs in the emerging domain of Government 3.0. Task 1.1 has outlined the Government 3.0 scope and set up a knowledge base for the disruptive technologies in Government 3.0. Task 1.2 has analysed existing training offers and identified a set of gaps concerning the missing knowledge in the diffusion of disruptive technologies in the data driven public service provisioning and policy making from the current training curricula. Task 2.1 built on these insights and further elaborated the research and training needs based on future scenarios and roadmap actions. The results of task 2.1 are used for the development of the training courses and joint-master programme in WP3. Furthermore, the results are fed into the MOOC development in WP 4.

Deliverable 1.1 (Report for Electronic Governance research and practice worldwide) of the project produced the following definition of Government 3.0:

> *Government 3.0 refers to the use of disruptive technologies (AI, ML, IoT, NLP, VR, AR and big data technologies) in combination with established information and communication technologies (distributed technologies for data storage and service delivery) and the wisdom of crowd (crowdsourcing and co-creation) towards data-driven and evidence-based decision and policy making and provision of relevant smart customised public services for decision support of citizens and enterprises.*

Government 3.0 qualitatively differs from the previous e-government generations in its main goal (societal problem-solving), method (data-driven decision making, smart governance) and the area of application (including international level). The proposed definition of Government 3.0 provides a clear link between the use of big data and the new disruptive technologies combined with citizen-input from crowdsourcing and co-creation of services. Along this understanding, Government 3.0 can significantly improve the quality of governmental decisions, providing evidence-based and data-driven decision making. This definition shifts the focus from collaboration with citizens (as in Government 2.0) to the societal problem-solving, using large volumes of data collected from various sources.

The purpose of the roadmap is to outline the research and training activities that appropriately address the emerging new generation of Government 3.0. This includes (1) the identification of the research and training needs in the domain, (2) outlining the specific steps needed to address the needs and challenges of Government 3.0, and (3) formulating recommendations for the stakeholders for adequately implementing the disruptive technologies in the public sector.

Furthermore, based on the roadmap the consortium identified topics for research projects that can be conducted with the participation of students. Close collaboration with businesses and public agencies shall ensure that research generates practical impact and thus contributes to entrepreneurship. This in turn provides input to WP5. Figure 1 outlines the relations between different work packages in Gov 3.0.

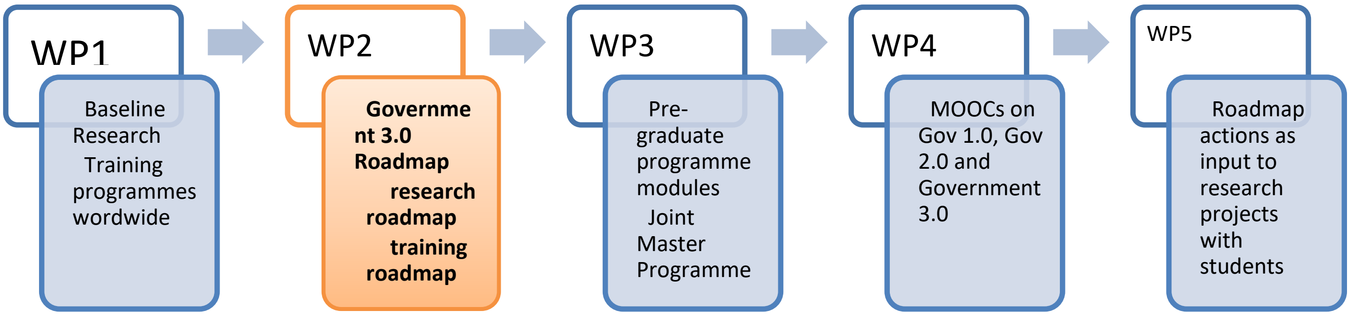

Figure 1. Relationship between work packages in the Gov 3.0 project

1.3 Structure of the Deliverable

The rest of this report is structured as follows: section 2 describes the methodology of the roadmapping effort. Section 3 presents the analysis of the projects in connection with the exploration of disruptive technologies as previously identified in WP1 (Task 1.1). For each technology at first a short introduction is provided (subsection 1), the relevant projects on the European level are described and systematized (subsection 2). The research and the training needs from the projects are extracted and described. In section 4, thirteen possible future scenarios depict potential usages of disruptive technologies in different areas of digital government. Section 4.2 details the research and training needs collected with the help of the scenario analysis. Section 5 contains research and training roadmaps, where specific actions are described in detail. Section 6 outlines recommendations for the implementations of the roadmap actions for different stakeholders. Finally, section 7 concludes the report by briefly summarising the findings and explaining how the findings of this work package can be used in the subsequent work packages of Gov 3.0 project.

2. Methodology

The overall methodological approach applied to elaborate the research and training roadmap of Government 3.0 is illustrated in Figure 2. The point of departure are the descriptions of the relevant disruptive technologies in Government 3.0, identified in WP 1 (cf. deliverable D 1.1) as well as an analysis of existing R&D projects in the domain (active or completed in the European Union), which explore relevant disruptive technologies (see elaborations in section 3). The methodical pathway for project analysis is outlined in section 2.1.1. Next, future scenarios are generated (see section 4) using the scenario technique with a set of interactive workshops as described in section 2.1.2. The scenarios are then analysed using gap analysis technique to extract research and training gaps and needs. In the context of the report, a "research need" is a gap identified by relevant stakeholders as important and if addressed will help to resolve a specific real-world problem (Chang et al., 2012). A "training need" is a gap in the existing training curricula (either formal or vocational), which when addressed allows the recipients of training to manage effectively a specific real-world problem. A "problem" in both of the definitions refers to the implementation of the disruptive technology in public service as illustrated in the scenarios (cf. description in section 2.1.2). The gap analysis is conducted in two ways, namely by expert analysis of the future scenarios conducted by the Gov 3.0 project's experts and in interactive group discussions along the future scenario workshops.

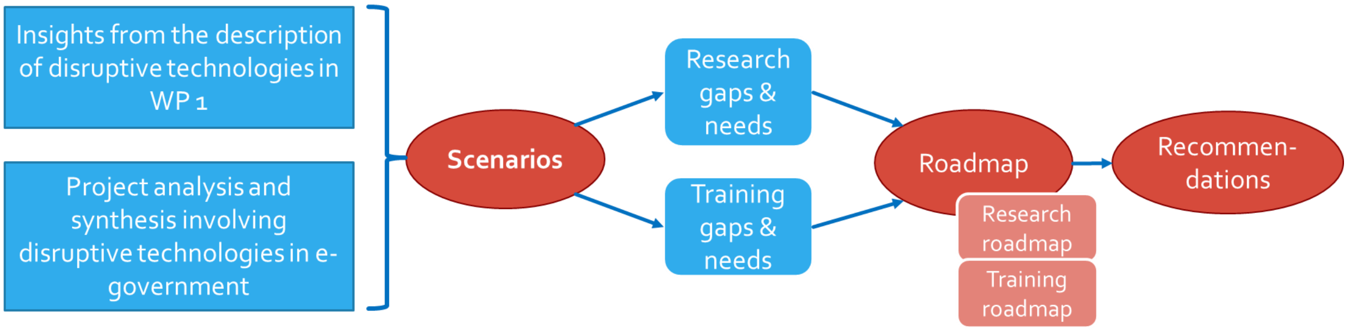

Figure 2. Methodological approach to roadmapping in Gov 3.0

2.1.1 Methodology for project analysis

First step in identifying research and training needs relevant to the technologies and concepts associated with Government 3.0 is the analysis and synthesis of active and completed European projects involving the application of disruptive technologies for the delivery of public services.

For the project analysis, the work of identifying and analysing projects was distributed along the core disruptive technology concepts partners elaborated in Work Package 1. Partners were asked to scan recent calls of the EC (and other funding bodies) to identify relevant projects. Recent calls meant that projects could have finished one to two years before the project analysis was conducted or are ongoing (i.e. H2020, FP7 and other relevant calls were scanned – see the overview of scanned project calls in Table 1). A total of 281 projects have been identified and analysed.

Table 1. Calls used for search of relevant projects

Project call	Funding body	# of projects
Horizon 2020	European Commission	205
FP7-ICT	European Commission	53
CIP-ICT-PSP	European Commission	6
ERC-2017-ADG	European Commission	4
CEF Programme	European Commission	2
Other	Various	11

Total		281

To collect relevant general information on the identified projects, a template spreadsheet as shown in Table 2 was developed.

Table 2.Template for collecting general information on the projects

Call identifier	Project Title (Acronym or long title)	Project Call	URL to the project website	General Description (abstract 200-300 words)	Technologies used	Soft Issues	Technology Readiness Level (TRL)	Pilot Application Areas

The projects were subsequently studied to determine their place on the Government 1.0/2.0/3.0 generation continuum and these were classified and analysed in order to extract the associated research and training needs. For this, the template in Table 3 was used to study the Gov 3.0 relevant aspects on research and training needs of the projects. The synthesis of this analysis is described in section 2 and the insights from the project analysis is subsequently used for the development of the future scenarios of the use of disruptive technologies in government.

Table 3.Template for analysing projects along the relevant Gov 3.0 research and training needs

Identified research needs	Research Needs addressed	Identified Training Needs	Addressed Training Needs	Further Comments

2.1.2 Methodology for future scenario development

Scenario building is a widely utilized method to represent possible future situations, including in public sector, academia and business contexts (Ratcliffe, 2000). The objective of creating future scenarios is to gain different viewpoints and perspectives of a topic area to understand better the future and possible directions of the field's evolution (Janssen et al., 2007).

Scenarios are the narratives created to explore multiple variants of the possible future developments in a specific area or domain (Johnson et al., 2012). They typically describe the future state of affairs (Ratcliffe, 2000), focussing on the activities of the stakeholders involved in the situations of interest (Carroll, 1999). The aim of the scenarios is to improve the understanding of the specific situation and serve as an instrument for better decision-making (Ratcliffe, 2000; Ringland, 2002) or to inform research and technology roadmapping (Codagnone & Wimmer, 2007). Scenarios can provide different viewpoints and perspectives of a topic area to understand better the future and possible directions of the field's evolution (Janssen et al., 2007). Scenarios are particularly useful for tackling complex problems with high levels of uncertainty, because, unlike forecasts that suggest the most probable way the situation develops (Berkhout et al., 2002), scenarios encourage to look into multiple possible developments with different degrees of probability (Bohensky et al., 2006; Peterson et al., 2003).

Future scenarios technique has been used in a number of studies in the context of digitalisation and ICT. The methodologies used in such studies served as a basis for the scenario development in Gov 3.0. In the project eGovRTD2020 (Xiaofeng & Wimmer, 2007), scenarios were developed in several regional workshops with the participation of experts from academia, governments and businesses. The aim was to generate future visions for how governments would interact with their constituency in 15 years into the future. These scenarios subsequently served as input for the roadmapping of e-government research in 2007, where 13 research themes have been identified and described in the research roadmap for e-government 2020 (Codagnone & Wimmer, 2007).

In a subsequent research and technology roadmapping, the CROSSROAD project (Bicking & Wimmer, 2011) used roadmapping and scenario technique to identify new technologies and new governance models for ICT-supported policy modelling. CROSSROAD developed a taxonomy (Lampathaki et al., 2010) to define research topics in ICT-enabled governance and policy modelling. The developed taxonomy informed the subsequent scenario building (Bicking & Wimmer, 2011). Along the project's timeline, CROSSROAD defined a scenario description framework to present a number of different scenarios in 2030. The framework presented the key impacts, influencing the future research in ICT. Scenarios were developed as a narrative description to present possible forecasts in selected key areas of ICT for governance and policy modelling. Scenario storyboards were presented to describe some possible real-life situations, which show how stakeholders (like citizens or policymakers) would act within the scenario (Bicking & Wimmer, 2011). The CROSSROAD scenario methodology provided a general framework to describe the European society in 2030 (Misuraca et al., 2010).

In the eGovPoliNet project, scenario technique was used to identify the grand challenges of ICT-enabled public policy making and governance. Six scenarios in policy modelling were developed by the project partners, depicting the interactions between governments and other stakeholders and potential use of ICT for policy modelling and governance in the mid-term future (in 6 years) (Majstorovic & Wimmer, 2014). The project identified five grand challenges (Wimmer & Majstorovic, 2015): (i) data and information characteristics and use, (ii) modelling and simulation, (iii) citizen and stakeholder engagement, (iv) government capabilities and legitimacy and (v) translating research results into policy action and support.

The most recent use of scenario technique in the development of a research roadmap was in the SCOOP4C project. In this project, future scenarios described how the once-only principle could be realised in cross-border public service provisioning. The scenarios were developed by the project team beforehand and then validated in interactive workshops with stakeholders. Subsequently, they were used to perform structured gap analysis to identify the needs for establishing necessary building blocks for the implementation of the OOP across borders[5].

The common aspect of the aforementioned initiatives was that all projects conducted a state of play analysis to outline the status quo of research and development. ii) Future visions regarding the evolution and use of new technologies in the public sector were elaborated. iii) To generate future visions or to validate future scenarios, interactive workshops were conducted to engage with relevant constituencies. iv) Gap analysis was carried out to generate a synthesis of the status quo vs. the future needs from the scenarios. v) Roadmaps or research needs (e.g. grand challenges of research) were extracted based on the scenarios and gap analysis. Again, interactive workshops may have been used to deliberate the roadmap definitions with relevant experts and constituencies. vi) The development activities in the different steps were usually a combination of elaborations by the project team and involvement of stakeholders.

The methodology applied in Gov 3.0 to identify research and training needs in Government 3.0 was informed by the above mentioned projects. The focus of future scenarios in Gov 3.0 is to outline potential uses of disruptive technologies in the Government 3.0 context. The scenarios were developed by the project team based on the information from the previous work in WP 1 and the project analysis. The scenarios took advantage of the insights acquired from the theory and case studies (WP 1) and from practice (project analysis), allowing the research team both to understand what is possible already and what can be realised in the future (by extrapolating from the pilot studies, theoretical elaborations and prototypes). Subsequently, the scenarios were exposed to experts from academia, businesses and governments for discussion and for identification of research and training needs. The research roadmap was mostly discussed among the project team and it was deliberated with experts and students attending the Samos Summit 2019, and with students attending relevant lectures at the University of Koblenz-Landau, Germany (research intern and one workshop in class).

The 13 developed scenarios are designed to sketch disruptive technologies and concepts associated with Government 3.0. They are meant to depict the essence of some usage of disruptive technologies in public service provisioning and decision-making. The scenarios covered in this report include disruptive technologies such as: Smart Cities, Cloud Computing, IoT, AR, VR, Blockchain, Big Data, eID, AI, Machine Learning, and Natural Language Processing. Some technologies and concepts are embodied in more than one scenario, the correspondence between scenarios and technologies is describe in section 3.1. It is important to stress that the scenarios only serve for giving a glimpse of the potential use of disruptive technologies in Government 3.0, while the list of scenarios is by no means exhaustive.

[5] Cf. Deliverables D 4.1 and D 4.2 of SCOOP4C, available under www.scoop4c.eu

The scenarios in Gov 3.0 consist of a narrative part and a diagram (presented in a form of a poster to facilitate the interactions with the stakeholders in the workshops). The textual description of each scenario is divided into three sections:

- The first part of the scenario describes the present state of the situation. This includes the environment of the situation and the current use of the technology in the area of the scenario. In addition, the problems with the status quo are listed.
- In the second part, the vision outlines how the future could look like with the use of the disruptive technology in the domain.
- The last part explains the benefits of the new technology for this scenario.

The scenario diagrams show the interaction between the main actors and technologies (enablers) involved at each step. The diagrams focus on the exchange of information between the parties and the use of disruptive technologies for generating/computing information or for conducting steps automatically and in an intelligent/smart manner. Visual representation of a complex story significantly improves the understanding of it by the audience (Gemino & Parker, 2009; Stiller et al., 2009). Accompanying the scenario with visual cues allows to explain the scenario quickly and this also ensures that the audience is able to see the whole scenario all the time, when suggesting and discussing specific research and training needs without the need to refer continuously to the scenario text. Practically, the diagrams are printed as a poster of a size appropriate to the audience and room size.

At the workshops, scenarios were presented to the groups of experts (both from academia and public sector), who in a workshop setting provided input on the viability of such applications of the technologies in the field, and on associated research and training needs. Figure 3 shows two examples (the evolution) of a poster generated throughout the activities in task 2.1. The left side image depicts a poster from the early stage of scenario development and the inputs generated in the group discussion in a workshop, while the right-side poster represents a more mature and enriched scenario version with the use of chatbots and a number of key enablers needed in the visionary scenario.

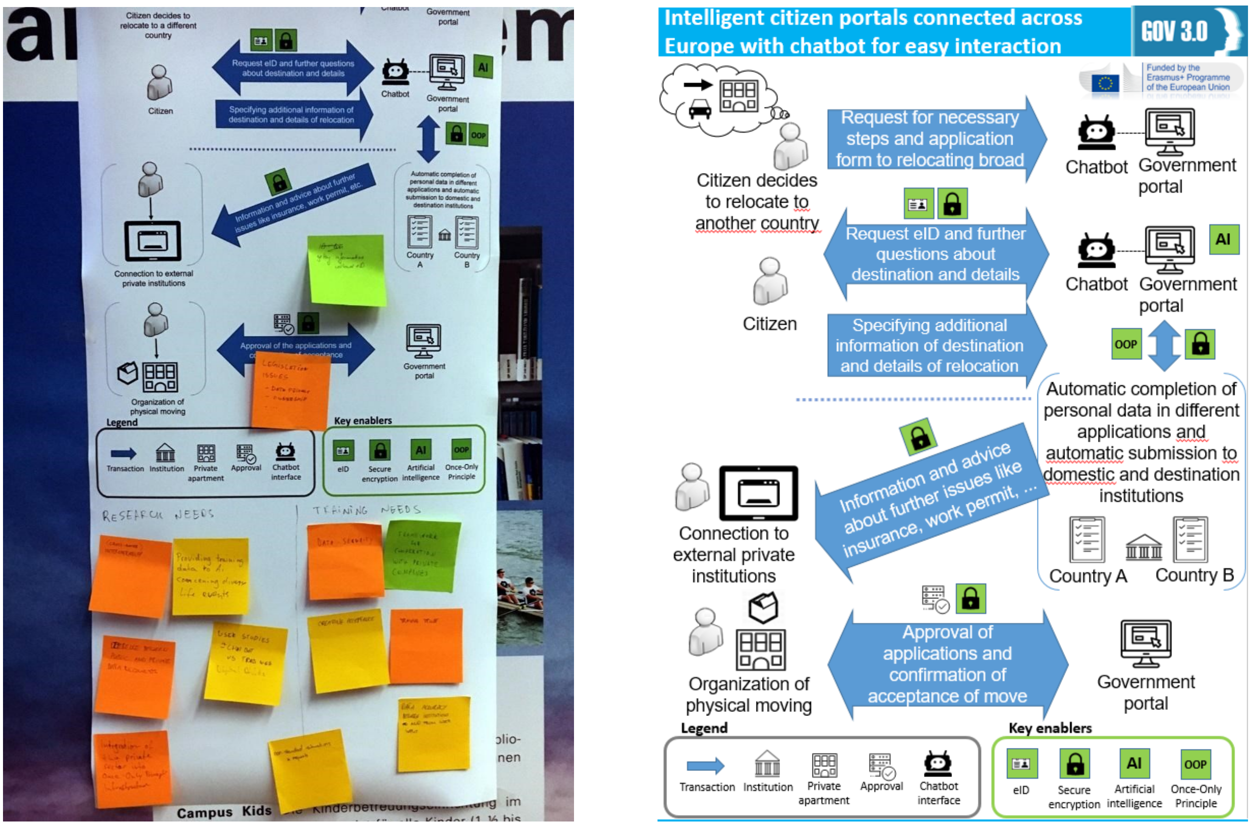

Figure 3. Examples of posters showing on the left side an early version of a scenario used to interact with the experts to identify research and training needs, while on the right side the poster demonstrates a more elaborate scenario

2.1.3 Methodology for roadmapping

Four workshops were conducted as a part of the roadmapping activity. First three workshops used a similar approach and structure and used future scenarios as a basis for the discussion of research and training needs. The future scenarios envisioned the use of specific disruptive technologies identified in the public service (cf. deliverable D 1.1). The fourth workshop included a presentation of the draft roadmap and was used for the validation of the findings. Table 4 provides an overview of the workshops and the number of participants. The structure and the content of each of the three workshops for eliciting research and training needs and the validation discussion of the draft roadmap are presented in the following subsections.

Table 4. Workshops for the Gov 3.0 Roadmapping

Workshop location	Time	Number of Participants
Samos Summit 2018 Workshop	July 4, 2018	21
EGOV-CeDEM-ePart 2018 Conference Workshop	September 3, 2018	28
NEGZ Autumn Conference Workshop	November 22, 2018	19
Samos Summit 2019 validation of the draft roadmap	July 2, 2019	42

2.1.3.1 Workshop 1: Samos Summit (July 4, 2018, Samos, Greece)

For the first workshop, three scenarios were developed by the WP2 leader (NEGZ) with the support of a team of 5 students from the University of Koblenz-Landau (Germany). The descriptions contained textual descriptions (narrations) and initial poster diagrams (similar to the example on the left side of Figure 3). The scenarios showed possible ways to implement different disruptive technologies in the public sector, among those identified during WP1 research.

In the workshop, three groups were formed. Moderators assured that the groups were composed of people from as diverse backgrounds as possible: i.e. participants from the same university/organisation were always assigned to different groups. The moderators introduced the respective scenario to the experts participating in the group. Subsequently, the scenarios were discussed and amended in the group, and research and training/curriculum needs were identified in relation to the specific scenario and Government 3.0 in general. At the end, the groups consisted of 5-7 members plus a moderator, who would first present the scenario and then steer the discussion and make notes of the discussion. One of the group members (but not the moderator) consequently presented the results of the discussion to the whole audience of the workshop and answered questions.

In the Samos 2018 workshop, the following three scenarios were discussed (dealing with specific disruptive technologies):

1. Smart city pollution monitoring (Smart Cities, Cloud Computing, IoT)
2. Using IoT to monitor soil erosion and degradation (IoT, Cloud Computing, AI)
3. Virtual reality and augmented reality for emergency management (VR, AR)

The workshop was planned with the following timeline:

1. Introduction (15')
2. Group Work (60')
    - 2.1. General discussion of the scenario. Possible improvements or changes.
    - 2.2. Discussion of the particular aspects of the scenario: stakeholders, technological enablers, data issues, barriers, legal issues to be addressed, timeline for possible implementation.

2.3. Identification of the research needs for the achievement of the scenario. Prioritisation of needs (green/yellow/orange).

2.4. Identification of the training/curriculum needs for the achievement of the scenario. Prioritisation of needs (green/yellow/orange).

2.5. Summarizing, wrapping-up by the moderator.

3. Presentation of the scenarios (30’) in plenum by one representative from each group and general discussion.
4. Summary of the discussion. Closing the workshop. (15’)

Steps 2.1 and 2.2 were used to familiarize the audience with the content of the scenario, while during 2.3 and 2.4 the input for the roadmapping activities was collected. Technically, the discussions were organised around posters depicting the processes in the scenarios. Workshop participants used post-it notes of different colours (corresponding to the priority of a need, green – relatively minor need, yellow – average, orange – important need) to note a specific research or training need. The priority of a specific need had to be agreed by the whole group before it was recorded.

The audience of the first workshop on roadmapping consisted of both the participants of the Samos 2018 Summit and the International Summer School on Government 3.0. Gov 3.0 project partners were the initiators of this workshop and participated as well. In general, the participants covered the whole quadruple helix (academia, business, public sector, NGOs) of the domain. However, the percentage of the academic participants reached 60%.

2.1.3.2 Workshop 2: EGOV-CeDEM-ePart 2018 Conference (September 3, 2018, Krems, Austria)

For the second workshop, three scenarios were developed by the WP2 leader (NEGZ). The workshop used a similar approach as in the Samos Summit 2018, the three scenarios were discussed by the experts in groups with the aim to identify research and training/curriculum needs in relations to the specific scenario and Government 3.0 in general. Scenarios were presented by the group moderators orally and visually as posters. The timeline of this workshop differed from the first workshop, because of shorter time allocation in the conference programme.

In the Krems workshop, the following three scenarios were discussed (dealing with specific disruptive technologies):

1. Blockchain for storing refugee information (blockchain)
2. Intelligent citizen portals connected across Europe using chatbot interface for easy interaction with citizens (AI, eID, Once Only Principle) (see the poster on the right side of Figure 3).
3. Gamification in social care (gamification, cloud computing)

The workshop was planned with a following timeline:

1. Introduction (15’)
2. Group Work (50’)

2.1. General discussion of the scenario. Possible improvements or changes.

2.2. Discussion of the particular aspects of the scenario: stakeholders, technological enablers, data issues, barriers, legal issues to be addressed, timeline for possible implementation.

2.3. Identification of the research needs for the achievement of the scenario. Prioritisation of needs (green/yellow/orange).

2.4. Identification of the training/curriculum needs for the achievement of the scenario. Prioritisation of needs (green/yellow/orange).

2.5. Summarizing, wrapping-up by the moderator.

3. Presentation of the scenarios (15’) by one representative from each group and general discussion.
4. Summary of the discussion. Closing the workshop. (10’)

Technically, the discussions were organised around posters depicting the processes in the scenarios. Workshop participants used post-it notes of different colours (corresponding to the priority of a need, green – relatively minor need, yellow –

average, orange – important need) to note a specific research or training need. The priority of a specific need had to be agreed by the whole group before it was recorded.

The audience of the EGOV-CeDEM-ePart workshop on roadmapping consisted of 28 participants from 17 different countries from Europe, Asia, North and South America. Most of the participants (21) represented the higher educational institutions, 4 came from other research institutions, 3 represented governments. Moderators of the workshop assured that the discussion in the groups were composed of people from as diverse backgrounds as possible. During the discussion, notes were made by the moderators, which together with the identified research and training needs were used for developing the subsequent roadmap. The results were added to this report.

2.1.3.3 Workshop 3: NEGZ Autumn Conference (November 22, 2018, Berlin, Germany)

For the third workshop, three scenarios were used. All of the scenarios used were developed by the WP2 leader (NEGZ). The regional annual event organised by NEGZ attracted experts from Germany and adjacent (German-speaking) countries. The workshop was organised in a similar way as the two workshops before. Three scenarios were discussed by the experts in groups with the aim to identify research and training/curriculum needs in relation to the specific scenario example and Government 3.0 in general. Scenarios were presented by the group moderators orally and visually as posters. The language of this workshop was German, and the scenario texts were translated into German by the scenario creators. Posters were printed in English.

Out of the three scenarios used in this workshop, two were re-used from the Krems workshop and the third one was developed specifically for this workshop:

1. Smart city pollution monitoring (Smart Cities, Cloud Computing, IoT)
2. Intelligent citizen portals connected across Europe using chatbot interface for easy interaction with citizens (AI, eID, Once Only Principle)
3. Using predictive policing to prevent property crimes (AI, Machine Learning, IoT)

The workshop used the same timeline as the Workshop 2 (see 2.1.3.2). Again, the workshop participants used post-it notes of different colours to indicate a specific research or training need. The priority of a specific need had to be agreed by the whole group. The audience of the workshop at the NEGZ autumn conference consisted of 19 participants representing three different countries (Germany, Austria and Turkey). Involved experts represented research institutions (7), public institutions (5) and private businesses (5). During the discussion, notes were made by the moderators, which together with the identified research and training needs were incorporated into this report.

2.1.3.4 Validation of the draft roadmap at Samos Summit 2019 (July 2, 2019, Samos, Greece)

During the workshop at the 9th Samos 2019 Summit on ICT-enabled Governance, the draft version of the roadmap was presented and discussed. The draft included a first list of research and training roadmap actions. The audience consisting of the Samos Summit participants (both experts from the academia and public sector, along with students attending the concurrent Summer School) provided valuable input for the further elaboration of the roadmap. The discussion was organised as follows: first the roadmap methodology and progress so far was presented, then the draft roadmap actions were described in detail (20 minutes in total). Afterwards, an open discussion was initiated (30 minutes), where the Samos Summit participants were able to ask questions about the roadmap and to suggest possible improvements. The main takeaway from the workshop was the need to formulate the roadmap actions more precisely, focusing more on the affected stakeholders and outlining the technologies in the focus of the actions. Most of the suggestions provided by the workshop participants have been considered and reflected in the final version of the Gov 3.0 roadmap.

After the four workshops, the collected information was transcribed and introduced into the deliverable at hand. The scenarios that were not discussed within these workshops were evaluated by the internal experts who outlined research and training needs along the proposed implementations. These inputs were used to draft the research roadmap and recommendations. The final roadmap is a synthesis of the steps concerning the individual disruptive technologies and trends in the Government setting.

3. Project analysis and identification of research and training needs

3.1 Technologies and concepts in Government 3.0

The main so-called disruptive technologies identified as relevant for Government 3.0 (see definition in section 1.2) were outlined and synthesized in Deliverable 1.1 (Report for Electronic Governance research and practice worldwide). These main concepts served as clustering and knowledge base for the project analysis and identification of research and training needs from the project analysis. The results from the project analysis are presented in the following subchapters, describing each concept along a brief summary of understanding (definition) from Deliverable 1.1 of the project, and followed by a textual and tabular synthesis of the project analysis. The results serve as a basis for the development of scenarios in Section 4, and the research and training needs extracted from the project analysis feed into the elaborations of the roadmaps in section 5.

3.2 Big Data and Data Analytics

3.2.1 Definition

Big data refers to datasets characterized by the three V's: big volume, velocity and variety (Laney, 2001). Big data can help governments improve their efficiency, effectiveness and transparency (Milakovich, 2012), which have long been among the main goals of public sector ICT use (Cordella & Bonina, 2012; Heeks, 1999; Weerakkody et al., 2011). For example, big data can enable better decision support information, more informed policymaking (Janssen & Kuk, 2016), faster and richer images of evolving reality, and improved services based on better insight into citizen demands and needs (Chen & Hsieh, 2014). Such benefits can be a potent tool for solving lingering social problems, such as transport congestion, healthcare provision and sustainable energy production, thus contributing to the practice of smart governance (Scholl & Scholl, 2014).

Data analytics (DA) is the process of examining datasets in order to draw conclusions about the information they contain, increasingly with the aid of specialized systems and software. DA technologies and techniques are widely used in commercial industries and public sector to enable organizations to make more-informed decisions and by scientists and researchers to verify or disprove scientific models, theories and hypotheses. DA are indispensable when dealing with Big Data, which is due to its complexity is impossible to be analysed using manual analysis. DA is already being used in different areas of government, such as healthcare, cybersecurity, and education, often with significant positive impact (Chen & Hsieh, 2014).

Why is it relevant to Government 3.0? Big data has significant potential in the policy cycle by contributing to policy decision making. DA can be used to (i) identify underperforming areas of public services and help with reallocation of resources for optimisation of public service provision, (ii) improve existing processes by providing solutions for the citizens faster and with less paperwork, and (iii) be used to predict (through predictive DA) the future needs of the citizens (Höchtl et al., 2016).

3.2.2 Project analysis

34 projects have been identified and analysed regarding research and/or training needs related to Big Data (Table 5). Certain overlap has been found with Cloud Computing projects as distributed systems are often the preferred method of big data storage and analysis.

Most of the projects identify research needs related to the analysis and making sense of big data. Specific issues include anomaly detection in the data [datACRON] and analysing the datasets with the data on the global scale, related to the global development [D4D, LeMO], natural disasters [I-REACT], disease spread [CIMPLEX] and climate and global warming [BigClouT, OCEANDATAMODELS, WAZIUP]. A separate challenge is the big data generated by social media, as it poses additional challenges related to the natural language processing and evaluation of the message content [PHEME, SUMMA].

There are also more technical research needs addressing the specific challenges of dealing with video data [Cloud-LSVA, VICTORIA], machine-to-machine communication [FERARI], sensitive data storage [GenoPri, IASIS], standardisation, interoperability [EU-STANDS4PM], and data annotation [KConnect]. Increasing challenges of data protection and regulation with the continuous increase in data volumes are another subtopic [PDP4E, SAGE].

Decision-support tools are a further topic, covered by the projects [ERA-PLANET, IASIS], including the necessity to deal with real-time big data [FERARI] and visualize the collected data [VALCRI].

The most common training need identified in the big data projects also concerns the data analytics and the different approaches to making sense of the big data [TOREADOR, VICTORIA, SoBigData]. These projects tend to focus on the private sector companies and professionals dealing with data. Other identified training needs include the training for the entrepreneurs to develop applications leveraging big data datasets [BigClouT], the use of data intensive technologies [EDISON], general good practices in big data use and analysis [WAZIUP]. More citizen-oriented training needs include the training in the data protection (PDP4E) and practices of open science [SoBigData].

Table 5. Identified projects involving Big Data

Project Call	Project Acronym	Project URL	Project start	Duration (in years)	Technologies used	Type	Identified research needs	Identified Training Needs
H2020-EU.2.1.1.	BigClouT	http://bigclout.eu/	2016	3	Big data, Cloud Computing, Smart city	RIA	Critical challenges such as global warming, economic crisis, security threats, inequality, natural disasters and ageing society, particularly in urban areas.	Community of external end-users to build their own applications/business on top of BigClouT tools and platform.
H2020-EU.3.4.7.1	BigData4ATM	http://www.bigdata4atm.eu/	2016	2	Big data	RIA	How the data from smart devices can be analysed and combined with more traditional demographic, economic and air transport databases to extract relevant information about passengers' behaviour and use this information to inform air transport authorities decision making processes.	
H2020-EU.2.1.1.4.	BigDataEurope	https://www.big-data-europe.eu/	2015	3	Big data	CSA	Collecting requirements for the ICT infrastructure needed by data-intensive science practitioners tackling a wide range of societal challenges; covering all aspects of publishing and consuming semantically interoperable, large-scale data and knowledge assets;	
H2020-EU.2.1.1.4.	BISON	http://bison-project.eu/	2015	3	Big data, NLP	IA	Addressing three areas of contact centres (CCs) in Europe: - Basic speech data mining technologies (systems quickly adaptable to new languages, domains and CC campaigns). - Business outcome mining from speech (translated into improvement of CCs' Key Performance Indicators). - CC support systems integrating both speech and business outcome mining in user-friendly way.	
H2020-EU.1.2.2.	CIMPLEX	http://cimplex-project.eu/	2015	3	Big data	RIA	Modelling and big data analysis of the disease spread and other contagion phenomena in complex social systems.	
H2020-EU.2.1.1.	Cloud-LSVA	http://cloud-lsva.eu/	2016	3	Big data, Cloud Computing	RIA	Analysis of petabyte scale video datasets.	
FP7-PEOPLE	D4D	https://cordis.europa.eu/project/rcn/187862/	2014	2.5	Big data	IEF	Big data in the field of international development.	
H2020-ICT-2015	datACRON	http://datacron-project.eu/	2016	2	Big data	RIA	Novel methods for threat and abnormal activity detection in very large fleets of moving entities spread across large geographical areas. Increasing the safety, efficiency and economy of operations concerning	

							moving entities in the Air-Traffic Management and Maritime domains.	
H2020-EU.2.1.1.3.	DICE	http://www.dice-h2020.eu/	2015	3	Big data, Cloud Computing	RIA	Quality-driven development methodology for developing data-intensive cloud applications.	
H2020-EU.1.4.2.2.	EDISON	https://cordis.europa.eu/project/rcn/198292/	2015	2	Big data	CSA		Data Intensive or Big Data technologies
H2020-EU.3.5.5.	ERA-PLANET	http://www.era-planet.eu/	2016	5	Big data	ERA-NET Cofund	Advanced decision support tools and technologies aimed to better monitor our global environment and share the information and knowledge in different domain of Earth Observation.	
H2020-EU.2.1.1.4.	EuDEco	http://data-reuse.eu/	2015	3	Big data, Open data	CSA	Understanding and exploiting the potentials of data reuse in the context of Big and Open Data big data.	
H2020-EU.3.1.6.	EU-STANDS4PM	https://cordis.europa.eu/project/rcn/220958/	2019	3	Big data	CSA	Assessment and evaluation of the national standardization strategies for interoperable health data integration.	
FP7-ICT	FERARI	http://www.ferari-project.eu/	2014	3	Big data	CP	Efficient, real-time Big Data technologies of the future, focused on machine-to-machine data exchange.	
H2020-EU.1.3.2.	GenoPri	http://www.cs.bilkent.edu.tr/	2016	2	Big data	EF	A new unifying framework for quantification of genomic privacy of individuals. Establishing a complete framework for privacy-preserving utilization, sharing, and verification of genomic data under real-life threat models.	
H2020-EU.2.1.1.	HOBBIT	https://project-hobbit.eu/	2015	3	Big data, Linked data	RIA	Providing a family of industry-relevant benchmarks for the Big Linked Data value chain through a generic evaluation platform.	
H2020-EU.3.1.5.	IASIS	http://project-iasis.eu/	2017	3	Big data	RIA	Big data in healthcare as a resource for deriving insights to improve decision and policy making. Integration and analysis of information from heterogeneous sources. Semantic integration of data.	
H2020-EU.3.7.	I-REACT	http://www.i-react.eu/	2016	3	Big data	IA	Increased resilience to natural disasters though better analysis and anticipation, effective and fast emergency response, increased awareness and citizen engagement	
H2020-EU.2.1.1.4.	KConnect	http://kconnect.eu/	2015	2	Big data, Cloud Computing	IA	Cloud-based tools for multilingual Semantic Annotation, Semantic Search	

							and Machine Translation of Electronic Health Records and medical publications.	
FP7-ICT	LeanBigData	http://leanbigdata.eu/	2014	3	Big data	CP	Scaling big data analytics for streaming and static data sources; integration of existing big data management technologies and improving response time; creating an integrated big data platform addressing major big data challenges;	
H2020-EU.3.4.	LeMO	https://lemo-h2020.eu/	2017	3	Big data	CSA	Implications of the utilisation of big data to enhance the economic sustainability and competitiveness of European transport sector. Study and analyse big data in the European transport domain in particular with respect to five transport dimensions: mode, sector, technology, policy and evaluation. Crucial issues linked to privacy, data security and legal aspects.	
FP7-PEOPLE	OCEANDAT AMODELS	https://cordis.europa.eu/project/rcn/186366/	2014	3	Big data	MC-IOF	Statistical modelling and estimation procedures that are appropriate for Big Data challenges with high-dimensional dependent data (specifically in global climate modelling).	
H2020-EU.3.6.	OpenBudgets.eu	http://openbudgets.eu/	2015	2.5	Big data	IA	Multi-stakeholder financial transparency framework, which is scalable, easy-to-use, flexible and attractive.	
H2020-EU.3.7.6.	PDP4E	https://cordis.europa.eu/project/rcn/214860/	2018	3	Big data	IA	Data protection, specifically compliance with GDPR for the software and engineering products.	Data protection, GDPR
FP7-ICT	PHEME	http://www.pheme.eu/	2014	3	Big data	CP	Content analytics of social media content. Modelling, identification, and verification of phemes (internet memes with added truthfulness or deception), as they spread across media, languages, and social networks.	
H2020-EU.3.6.2.2.	PoliVisu	http://www.polivisu.eu/	2017	3	Big data	RIA	Improvement of the traditional public policy making cycle using big data.	
H2020-EU.1.2.2.	SAGE	http://www.sagestorage.eu/	2015	3	Big data	RIA	Next-generation multi-tiered object-based data storage system. Improvement of the scientific output through advancements in systemic data access performance and drastically reduced data movements.	

							Exabyte scale systems and extreme scale HPC systems.	
H2020-EU.1.4.1.2.	SoBigData	http://www.sobigdata.eu/	2015	4	Big data	RIA	Social Mining & Big Data Ecosystem: a research infrastructure (RI) providing an integrated ecosystem for ethic-sensitive scientific discoveries and advanced applications of social data mining on the various dimensions of social life, as recorded by big data.	Promoting repeatable and open science.
H2020-EU.2.1.1	SUMMA	http://www.summa-project.eu/	2016	3	Big data	RIA	(1) External media monitoring - intelligent tools to address the dramatically increased scale of the global news monitoring problem; (2) Internal media monitoring - managing content creation in several languages efficiently by ensuring content created in one language is reusable by all other languages; (3) Data journalism.	
H2020-EU.2.1.1.	TOREADOR	http://www.toreador-project.eu/	2016	3	Big data	RIA	Automation and commoditisation of Big Data analytics.	Big data analytics for EU organizations (including SMEs) that do not have either in-house Big Data expertise or budget for expensive data consultancy.
FP7-SECURITY	VALCRI	https://cordis.europa.eu/project/rcn/188614/	2014	4	Big data	CP-IP	Visual analytics. Statistical and text analysis of criminal intelligence data.	
H2020-EU.3.7.6.	VICTORIA	https://www.victoria-project.eu/	2017	3	Big data	RIA	More efficient video analytics technologies in criminal and terrorist investigations.	The use of video analytics platform in criminal and terrorist investigations.
H2020-EU.2.1.1.	WAZIUP	http://www.waziup.eu/	2016	3	Big data, IoT	RIA	Applying IoT and Big Data to improve the working conditions in the rural ecosystem of Sub-Saharan Africa	Fostering new tools and good practices, entrepreneurship and start-ups, aiming at long term sustainability.
H2020-EU.3.6.2.2	Big Policy Canvas	https://www.bigpolicycanvas.eu/	2017	2	Big data	Roadmapping	Research challenges for big data in the public sector	Use of big data technologies in the public administration

3.3 Internet of Things

3.3.1 Definition

Internet of things (IoT) is the *"interconnection of sensing and actuating devices providing the ability to share information across platforms through a unified framework, developing a common operating picture for enabling innovative applications"* (Gubbi et al., 2013, p. 4). IoT is often used as a supporting technology, which aids in the realisation of smart city and smart healthcare paradigms.

Brous and Janssen (2015) identified the benefits of IoT in digital government on three levels: On strategic level, data collected with IoT can aid long-term planning, improve forecasting and trend analysis. Large amounts of IoT data can be also made open to the public improving government transparency and leading to better accountability and reduced government waste (Castro, 2008). On the tactical level, IoT can improve medium-term planning and maintenance of public services, thus leading to overall cost reduction (Brous & Janssen, 2015). On the operational level, data collected in real-time enables greater flexibility of service provision, thus leading to improved efficiency and effectiveness (Andrews, 2015).

Why is it relevant to Government 3.0? IoT is a valuable supporting technology that can enhance and improve public service delivery through the realisation of the Smart City concept. IoT can provide a detailed view of the different aspects of life in the city by collecting plethora of information using different sensors. The information then can be analysed using the big data analytics approaches with the support of cloud computing and be used for the provision of customised and personalised public services. Finally, the open data produced by IoT and shared with citizens can improve government transparency and accountability.

3.3.2 Project analysis

15 projects related to the Internet of Things are presented in Table 6. IoT is often mentioned in the context of Smart City projects, where IoT sensor devices are used for collecting data that is later used as a basis for decision-making by Smart City systems. A significant number of projects deals with the challenges of collecting data from the IoT devices (visual data [FoT], environmental data [HOMED, Quakebots], data in hostile environments [HarshEnergy]) and learning from the collected data [FoodMonitor, IoF2020]. The use of IoT in disaster management and prevention is also discussed [Quakebots, SURVEIRON]. More general research needs include the investigation of the novel economic development strategies leveraging the advantages of IoT technology [BE WISER].

Beyond devices used as sensors, main topic is the synchronisation and cooperation between large number of autonomous devices [IoTEE, PROACTIVE, symbIoTe]. Standardisation and API protocols enabling interfaces and interoperability between devices remains an important topic [bIoTope, HEASIT, IoTEE], as well as security of the IoT individual devices and networks [BE WISER].

Soft issues are relatively underrepresented, for example, the ethics research needs of the IoT use are mentioned in just one project [VIRT-EU].

Identified training needs refer to general use of IoT for the development of business propositions [BE WISER] and creation of software platforms for IoT ecosystems [bIoTope]. Ethics, especially with regard to privacy and personal data use, is another training need for developers building solutions with IoT [VIRT-EU].

Table 6: Identified projects involving Internet of Things

Project Call	Project Acronym	Project URL	Project start	Duration (in years)	Technologies used	Type	Identified research needs	Identified Training Needs
FP7-REGIONS	BE WISER	http://be-wiser.eu/	2013	3	IoT	CSA	Security of the IoT systems, RTD challenges, economic development strategies connected to IoT technology.	IoT technology, business and clustering themes. Seek new market opportunities for regional enterprises, especially SMEs.
H2020-EU.2.1.1.	bIoTope	http://biotope.cs.hut.fi/	2016	3	IoT, Smart City	RIA	Standardized Open APIs for enabling horizontal interoperability between IoT silos. Open innovation ecosystems.	Companies: creation of new software components for IoT ecosystems, as well as creation of new Platforms for Connected Smart Objects with minimal investment
H2020-EU.2.1.1.1.	EoT	http://www.eyesofthings.eu/	2015	3.5	IoT	IA	Embedded systems, computer vision	
H2020-EU.3.	FoodMonitor	http://www.insort.at/	2018	0.5	IoT, ML	SME	Machine learning algorithms and Internet of the Things in the food production.	
H2020-EU.2.3.2.2.	HarshEnergy	http://www.inanoe.com/	2017	1	IoT	CSA	Use of IoT sensors in harsh environments.	
H2020-EU.2.1.1.	HEASIT	http://greenwaves-technologies.com/en/green-ofdm-technology/	2016	2	IoT	SME	Improved data interface for IoT	
H2020-EU.3.2.1.1.	HOMED	https://cordis.europa.eu/project/rcn/215943/	2018	4	IoT	RIA	Science-based, innovative practical methods and tools to assess and control emerging or invasive pests and pathogens threatening EU forests. Use of the new tools, e.g., electronic sensors, hyper spectral cameras, the latest satellite constellation, high-throughput sequencing, unmanned aerial vehicles and artificial intelligence.	

H2020-EU.3.1.4.	IoF2020	http://www.iof2020.eu/	2017	3	IoT	IA	Application of IoT systems in farming. Innovative IoT solutions in different areas of farming.	
H2020-EU.2.1.6.	IoTEE	http://www.iot-everywhere.eu/	2017	2	IoT	SME	Space IoT, secure machine-to-machine (M2M) communication, particularly outside of smart cities. Cheaper, more autonomous operation of very large networks of small devices.	
H2020-EU.3.4.	MAVEN	http://www.maven-its.eu/	2016	3	IoT, Smart City	RIA	Management of automated vehicles in a smart city environment.	
FP7-SECURITY	PROACTIVE	https://cordis.europa.eu/project/rcn/103500/	2012	3	IoT, Smart City	CP-FP	Holistic citizen-friendly multi sensor fusion and intelligent reasoning framework enabling the prediction, detection, understanding and efficient response to terrorist interests, goals and courses of actions in an urban environment.	
H2020-EU.3.7.	Quakebots	https://www.quake.cloud/	2018	0.5	IoT, AI	SME	Use of AI and IOT for seismic monitoring, assessment of damage.	
H2020-EU.3.7.	SURVEIRON	http://www.surveiron.com/	2016	2	IoT, AI	SME	Prevention and management of potential disasters, intelligent robots, swarm robots, AI-based decision during disaster management	
H2020-EU.2.1.1.	symbIoTe	https://www.symbiote-h2020.eu/	2016	3	IoT	RIA	Abstraction layer for a unified control view on various IoT platforms and sensing/actuating resources. an IoT orchestration middleware capable of unified and secure access to physical and virtualized IoT resources.	
H2020-EU.2.1.1.	VIRT-EU	https://virteuproject.eu/	2017	3	IoT	RIA	How ethics are enacted in the IoT innovations. New framework for Privacy, Ethical and Social Impact Assessment (PESIA), which will proactively position ethical self-assessments in the development process of IoT technologies.	IoT ethics

3.4 Smart City Government

3.4.1 Definition

The concept of Smart City can be defined as *"using high technology and especially ICT to implement better living conditions in large metropolises, to involve citizens in city government, and to support sustainable economic development and city attractiveness. The final goal is to improve the quality of city life for all stakeholders"* (Dameri & Benevolo, 2016, p. 1). Smart City is also defined as innovative solutions that enhance urban living in terms of people, governance, economy, mobility, environment and living (Anthopoulos & Reddick, 2016).

According to Muthulakshmi et al. (2017), the progression of technologies such as big data and IoT has played an imperative role in operationalizing Smart City initiatives. The integration of the smart city and big data concepts allows the development of smart city applications that will help to reach sustainability, better resilience, effective governance, enhanced quality of life, and intelligent management of smart city resources (Al Nuaimi et al., 2015). Anthopoulos and Reddick (2016) performed a literature review on smart government and its relation to smart cities, concluding that *"smart government is proved not to be synonymous to smart city but a broader term that describes the next step for government transformation, while the smart city is considered to be an area within the overarching term smart government"* (p. 354).

Why is it relevant to Government 3.0? Smart City is an area of practice for smart government (including collaboration and service co-creation), and therefore for Government 3.0. The Smart City concept is intrinsically connected to other Government 3.0 concepts: 1) big data and data analytics, by providing deeper insights and better decision-making practices 2) IoT, by enhancing the decision-making of city management; 3) Cloud computing, to provide the computational and storage facilities to support smart city big data management and applications.

3.4.2 Project analysis

37 projects were identified that address Smart City (Table 7). Purely technical or engineering projects have been excluded from the list. While technical challenges are crucial in the future realisation of smart cities, they are not related to the domain of digital government and therefore are not relevant to the proposed roadmap.

Two main strands in the collected Smart City projects are the technical realisation of the concept (sensors, organisation of data collection, etc.) and the use of the collected data as a basis for decisions.

Technical issues include the best way to organise sensing devices in urban environment (overlapping with the IoT projects like [IoTEE]) and standardize the data obtained from the devices [bIoTope, ESPRESSO]. Technical limitations are another big topic, involving a large number of existing projects. This includes the development of better sensors, cheaper, more-cost effective sensors, standardisation and interoperability of various sensors. And finally making sense of the large amounts of data produced by often heterogeneous arrays of sensors in the urban environment with the help of better programming interfaces [bIoTope, HEASIT]. Many of the studied projects deal with questions of mobility, managing transportation [GHOST, DORA, SETA, MAVEN, CARES]. There is a number of solutions to the infrastructural problems of traffic congestion like shared vehicles [STARS], autonomous cars [MAVEN], smart public transportation [iSCAPE] and others. Traffic management is especially relevant in regard to the larger freight vehicles: optimised routing [U-TURN, NOVELOG, BuyZET] is seen as a significant tool to mitigate the congestion and pollution in cities.

Beyond that, decision-making is in the focus of many projects. The primary questions here are how the effective decisions based on the collected data [RAMSES, SmartH2O] are made and what decision-support systems can allow taking advantage of the Smart City data [BESOS, QUANTICOL]. Integrating data and data visualisation are other important subtopics [DARWIN, PoliVisu].

Training needs described in the Smart City projects often concern the engagement of individual citizens, especially in regard to co-creation tools [smarticipate, THUNDHUB, OrganiCity, ROCK]. To get input from the citizens through the co-creation tools, it is first necessary to guarantee the participation of as many citizens as possible, overcoming digital divide and ensuring equal access to the digital government tools for the people of various socioeconomic statuses and providing motivating citizens to contribute [IRIS]. Another training need concerned the necessity to coordinate the management of public infrastructure to ensure sustainability of Smart City solutions [BESOS] and generally improve the understanding of the sustainability of modern cities, often related to energy consumption [ENERGISE, iSCAPE, eTEACHER]

Table 7: Identified projects involving Smart City Government

Project Call	Project Acronym	Project URL	Project start	Duration (in years)	Technologies used	Type	Identified research needs	Identified Training Needs
FP7-ICT-2011-8	ATELIER	https://cordis.europa.eu/project/rcn/225258/	2019	5	Smart city	IA	Energy positive cities, Citizen engagement	
H2020-EU.3.3.1.3.	ESPRESSO	http://www.espresso-project.eu/	2016	2	Smart city	CSA	Standardisation, open innovation ecosystems, horizontal interoperability	
FP7-ICT	BESOS	https://cordis.europa.eu/project/rcn/110133/	2013	3	Smart city, co-creation	CP	Decision-support systems	coordinated management of public infrastructures in Smart Cities, sustainability, energy efficiency
H2020-EU.3.3.1.	IRIS	https://irissmartcities.eu/	2017	5	Smart city	IA	Citizen motivation, effective urban planning, more stable, secure and affordable energy and mobility services for citizens	
H2020-EU.3.6.	smarticipate	https://www.smarticipate.eu/	2016	3	Open Data, co-creation, smart city government,	IA	Co-production of services	Understanding the data
H2020-EU.2.1.6.	GHOST	http://www.ghost-project.eu/	2015	2	Smart city	IA	Managing transportation, monitoring urban infrastructure	
FP7-ICT	iURBAN	http://www.iurban-project.eu/	2013	3	Smart city	CP	Integration of various ICT energy management systems	
H2020-EU.2.1.1.	bIoTope	http://biotope.cs.hut.fi/	2016	3	Smart city, IoT	RIA	Standardized Open APIs for enabling horizontal interoperability between IoT silos. Open innovation ecosystems.	Companies: creation of new software components for IoT ecosystems, as well as creation of new Platforms for Connected Smart Objects with minimal investment
H2020-EU.3.3.1.3.	POCITYF	https://cordis.europa.eu/project/rcn/225261/factsheet/en	2019	5	Smart city	IA	City Information Platforms integrated solutions.	Providing holistic urban services.
H2020-EU.2.1.1.	BigClouT	http://bigclout.eu/	2016	3	Big data, Cloud Computing, Smart city	RIA	Critical challenges such as global warming, economic crisis, security threats, inequality, natural disasters and ageing society, particularly in urban areas.	Community of external end-users to build their own applications/business on top of BigClouT tools and platform.

H2020-EU.2.1.1.3.	OrganiCity	http://organicity.eu/	2015	3	Smart city, co-creation	RIA	Citizen involvement, co-creation, trans-disciplinary participatory urban interaction design.	Experimentation-as-a-Service, civil co-creation
H2020-EU.3.5.6.	ROCK	https://rockproject.eu/	2017	3	Smart city	IA	ICT sensors and tools, effective and shared policies.	Bottom-up participation via living labs
H2020-EU.3.5.1.	iSCAPE	https://www.iscapeproject.eu/	2016	3	Smart city	RIA	Mobility patterns for more resilient healthy and sustainable cities	Engaging citizens in the use of alternative solution processes to environmental problems. Use of low-cost sensors
H2020-EU.3.6.	THUNDHUB	https://learn.thundermaps.com/cities/thundermaps-winner-horizon-2020-innovation-program/	2015	2	Smart city	SME	Presenting a unified 'one face of government' to citizens; offering a personalized user experience; increasing citizen engagement; increasing transparency, reducing communication costs & environmental impact.	
H2020-EU.3.7.	City.Risks	http://www.cityrisks.eu/	2015	3	Smart city	RIA	Proactive protection of citizens from criminal activity	
H2020-EU.3.4.	CITYLAB	http://www.citylab-project.eu/	2015	3	Smart city	RIA	Cost effective strategies, measures and tools for emission free city logistics in urban centres	Cost-effective policies and implementations that lead to increased load factors and reduced vehicle movements of freight and service trips in urban areas.
H2020-EU.3.4.	DORA	https://dora-project.eu/	2015	3	Smart city	RIA	Optimisation of travel times from/to airports.	
H2020-EU.3.4.	NOVELOG	http://www.novelog.eu/	2015	3	Smart city	RIA	Effective and sustainable policies for freight distribution	
H2020-EU.3.4.	BuyZET	http://www.buyzet.eu/	2016	3	Smart city	CSA	Innovative procurement plans, minimising "transportation footprint" of goods.	
H2020-EU.2.1.1.	SETA	http://setamobility.eu/	2016	3	Smart city, Big Data	RIA	Understanding urban mobility and make it more efficient, sustainable and resilient.	
FP7-ENVIRONMENT	RAMSES	https://cordis.europa.eu/project/rcn/105326/factsheet/en	2012	5	Smart city	CP	Adaptation decision-making, climate change decision-making, adaptation costs and measures	User-friendly guide for stakeholders who need to prioritize adaptation and mitigation decisions
H2020-EU.3.7.	CITYCoP	http://citycop.eu/	2015	3	Smart city	RIA	Surveillance, sociology of community policing as well as cognitive science perspectives	

							of the citizen's interaction with community.	
H2020-EU.3.6.	Mobile-Age	http://www.mobile-age.eu/	2016	3	Smart city	IA	Co-creation of services for senior citizens, social inclusion, management of health information	
H2020-EU.3.4.	STARS	http://stars-h2020.eu/	2017	2.5	Smart city	RIA	Impact of car sharing on other travel modes	
FP7-ICT	QUANTICOL	http://blog.inf.ed.ac.uk/quanticol/	2013	4	Smart city	CP	The design of collective adaptive systems (CAS). Such systems of heterogeneous components with competing goals must manage resources in a fair and efficient way.	
H2020-EU.3.1.5.	PULSE	http://www.project-pulse.eu/	2016	4	Smart city	RIA	Leveraging diverse data sources and big data analytics to transform public health from a reactive to a predictive system	
H2020-EU.3.4.	MAVEN	http://www.maven-its.eu/	2016	3	IoT, Smart City	RIA	Management of automated vehicles in a smart city environment.	
H2020-EU.3.5.4.	UrBAN-WASTE	http://www.urban-waste.eu/	2016	3	Smart city	RIA	Tackling high levels of unsustainable resource consumption and waste production. UrBAN-WASTE will adopt and apply the urban metabolism approach to support the switch to a circular model where waste is considered as resource and reintegrated in the urban flow.	
H2020-EU.3.3.6.	ENERGISE	http://energise-project.eu/	2016	3	Smart city	RIA	Energy sustainability assessment, design and implementation of measures to effectively reduce household energy consumption.	ENERGISE offers an ambitious social science programme to enhance understanding of changes in energy consumption practices across 30 European countries
FP7-ICT	SmartH2O	http://www.smarth2o-fp7.eu/	2014	3	Smart city	CP	Social Computing for the efficient management of Water Consumption. Development and implementation of better water management practices and policies	The use of social awareness and dynamic pricing instruments to modify the behaviour of water use.

H2020-EU.3.4.	CARES	https://cordis.europa.eu/project/rcn/221849/factsheet/en	2019	3	Smart city	RIA	Monitoring and enforcement of real-world vehicle emissions, leading to reduced emissions and improvements in air quality	Remote emission sensing systems.
H2020-EU.3.4.	U-TURN	http://www.u-turn-project.eu/	2015	3	Smart city	RIA	Freight distribution in urban areas. A simulation tool and economic assessment model. Consolidation of transportation flows from food manufacturers to the various point-of-sales located in urban areas	
H2020-EU.1.3.3.	GRAGE	http://www.grageproject.eu/	2014	4	Smart city	MSCA	Green buildings, food and urban agriculture, information and language technology in relation to the inclusive citizenship for elderly people living in urban contexts.	Understanding challenges for smart/inclusive/ageing societies at global level.
H2020-EU.3.6.2.2.	PoliVisu	http://www.polivisu.eu/	2017	3	Smart city, co-creation	RIA	Use of Advanced Geospatial Data Analytics and Visualisation to improve traditional public policy making cycle using big data.	Training in the use of Advanced Geospatial Data Analytics and Visualisation for policy creation.
H2020-EU.3.7.	DARWIN	http://www.h2020darwin.eu/	2015	3	Smart city	RIA	Management of both man-made events (e.g. cyber-attacks) and natural events (e.g. earthquakes).	A multidisciplinary approach is applied, involving experts in the field of resilience, crisis and risk management, social media and service providers in the Air Traffic Management and health care domains. To ensure transnational, cross-sector applicability, long-term relevance and uptake of project results, a Community of Crisis and Resilience Practitioners is established, including stakeholders and end-users from other domains and critical infrastructures and resilience experts.
H2020-EU.3.3.1.	eTEACHER	http://www.eteacher-project.eu/	2017	3	Smart city	IA		Set of empower tools to drive informed decisions in order to save energy and optimise indoor environment quality
FP7-SECURITY	SMARTPREVENT	http://www.smartprevent.eu/	2014	2	Smart city	CP-FP	Crime detection systems in urban areas.	

3.5 Artificial Intelligence and Machine Learning

3.5.1 Definition

Machine learning (ML) can be defined as "*the field of study that gives computers the ability to learn without being explicitly programmed*" (Chui et al., 2017). Various problems can be tackled using machine learning algorithms, some examples are: classification, regression, clustering, dimensionality reduction, structured prediction, face detection, decision making, speech recognition, signal de-noising, anomaly detection, deep learning and reinforcement learning (Chui et al., 2017).

Artificial Intelligence (AI) is a general term that refers to the demonstration of the cognitive functions typically associated with human intelligence by the machines, usually to solve certain non-trivial problems or make decisions (Russell & Norvig, 2009). Computers use machine and deep learning techniques to collect information and acquire knowledge to make autonomous decisions. Thus, Machine Learning is an enabling technology for AI. AI itself is an important component of many other technologies like social bots, natural language processing, computer vision, gaming-based simulations and others (Luger, 2005).

AI has significant applications in healthcare, automotive industry, military, finance and economics (Luger, 2005), especially in relation to automatic decision making, perception and planning (Russell & Norvig, 2009). AI and ML have a potential to be used for automated decision making in government. The benefits include: capability to make more flexible and faster decisions based on real-time or dynamic data, possibility to handle much greater number of decisions, ability to detect patterns and decisions otherwise hidden (Le Sueur, 2015). Another possible benefit is fairer and more impartial decisions, based on data alone.

Why is it relevant to Government 3.0? AI and ML can be used in government to aid in data-driven decision making, especially where decisions need to be made quickly and autonomously. The advantages of machine learning systems are the efficiency, accuracy, performance, and usability in comparison to human analysis. Furthermore, when dealing with the Big Data datasets, ML is a necessary tool for making sense of data at all.

3.5.2 Project analysis

A total of 26 projects have been identified as addressing the topic of AI and robotics in digital government context (Table 8). There are two main directions of the AI research within the projects: AI in autonomous systems and collaborative Human-AI systems. Autonomous systems are systems designed to behave independently from humans, making decisions and acting mostly on their own. This direction is connected to the IoT research, especially in the domains of swarm intelligence, fog and edge computing [ALOHA, Bonseyes], where computation is carried out by a network of IoT devices working in the environment fulfilling a specific purpose.

Collaborative systems include AI, sometimes embodied as robots, used to aid humans directly. An example of the technologies of this second directions is the assisted living devices [ACANTO, CARESSES, DECI, ENRICHME, GrowMeUp, IN LIFE, MARIO], robotics for the elderly and other assisting medical devices. Other examples of such implementations include systems facilitating collaboration in business environment [botconnect, StoreHero, SYMBIO-TIC] and unobtrusive assistant systems at home [RADIO, RAMCIP]

AI-aided decision-making systems are aimed to provide decision support in security setting [iBorderCtrl] and in managing crises [VASCO], as well as addressing real-time challenges of urban navigation [ALBORA, SCOUT]. ML systems can make use of medical data for purposes of diagnosing the various conditions [CARESSES], general medical assessment [UNCAP] or providing personalised medicine [DIGI-B-CUBE].

Apart from the aforementioned connection to IoT, AI also intersects with Natural Language Processing, where Machine Learning is used to make sense of natural language data for the creation of digital assistants that can interact with people using natural language (chatbots) [TRACS, OmniBot].

Training needs in AI and robotics concern providing best practices for security and crisis management in urban environment [VASCO], health care management [DIGI-B-CUBE], social care support [MARIO], diagnosing health conditions based on machine learning [City4Age, DIGI-B-CUBE] and the implementation of support systems based on chatbots [OmniBot].

Table 8: Identified projects involving Artificial Intelligence

Project Call	Project Acronym	Project URL	Project start	Duration (in years)	Technologies used	Type	Identified research needs	Identified Training Needs
H2020-EU.3.1.4.	ACANTO	http://www.ict-acanto.eu/	2015	3.5	AI, robotics	RIA	Assisted living devices, CyberPhysical Social Network.	
H2020-EU.3.4.	ALBORA	http://www.albora.io/	2018	0.5	AI	SME	AI-based navigation, autonomous vehicles	
H2020-EU.2.1.1.	ALOHA	https://cordis.europa.eu/project/rcn/213927/	2018	3	AI	RIA	Deep learning (DL) on edge systems, algorithm design and analysis, DL for embedded architectures, security of edge systems, surveillance, smart industry automation, medical application domains	
H2020-ICT-2016-1	Bonseyes	https://www.bonseyes.com/	2016	3	AI, IoT, Cloud Computing	RIA	Edge computing, embedded computing systems, IoT, cloud computing	
H2020-EU.3.	botconnect	https://botconnect.ai/	2018	0.5	AI	SME	Human-AI collaboration in enterprise environment	
H2020-EU.3.1.4.	CARESSES	http://caressesrobot.org/en/	2017	3	AI, robotics	RIA	Culturally competent care robots, culture and technology.	
H2020-EU.3.1.4.	City4Age	http://www.city4ageinsight.org/	2015	3	AI, ML	RIA	Behavioural, sociological and clinical research on “frailty” and MCI in the elderly population; State of art ICT technology (i) for “sensing” personal data and exposing them as linked open data, (ii) for designing the algorithms and the API’s to extract relevant behaviour changes and correlated risks, and (iii) for designing interventions to counter the risks; Stakeholder engagement.	Detecting risks related to other health type problems, design and operation of the ultimate Age-friendly City
H2020-EU.3.1.	DECI	http://www.deci-europe.eu/	2015	3	AI	IA	Business model to supply assistant services for the elderly.	
H2020-EU.2.3.2.2.	DIGI-B-CUBE	https://cordis.europa.eu/project/rcn/223285/	2019	3	AI	IA	Personalised medicine, Bioimaging-Biosensing-Biobanking, diagnostics using AI	Health Economy 4.0, health care management
H2020-EU.3.1.4.	ENRICHME	http://www.enrichme.eu/	2015	3	AI, robotics	RIA	Adaptive Human-Robot Interaction, social inclusion, geriatrics, gero-technology, ambient Assisted Living, use of robotics for care of the elderly	Social inclusion, cognitive stimulation
FP7-IDEAS-ERC	E-SWARM	https://cordis.europa.eu/project/rcn/94377/	2010	5	AI	ERC	Artificial swarm intelligence systems, optimization, robotics, networks, data mining.	Implementation of artificial swarm intelligence systems

H2020-EU.3.1.4.	GrowMeUp	http://www.growmeup.eu/	2015	3	AI, robotics	RIA	Use of robotics for care of the elderly, healthy ageing	
H2020-EU.3.7.	iBorderCtrl	https://www.iborderctrl.eu/	2016	3	AI	RIA	Border management, data analytics, an automated decision support system for the border control officers	
H2020-EU.3.1.6.	IN LIFE	http://www.inlife-project.eu/	2015	3	AI	IA	Assisted living devices, interoperable service for the elderly.	
FP7-ICT	MAESTRA	http://maestra-project.eu/	2014	3	AI, ML, Big Data	CP	Predictive modelling methods capable of addressing massive sets of network data incompletely labelled with structured outputs.	
H2020-EU.3.1.4.	MARIO	https://cordis.europa.eu/project/rcn/194106/	2015	3	AI, robotics	RIA	Assisted living devices, robotics in elderly care, service robots, semantic data analytics	Social care and community support programs to older persons
H2020-EU.3.	OmniBot	https://omnibot.ai/	2018	0.5	AI, chatbot, NLP	SME	AI-supported virtual digital assistants, Natural language recognition both spoken and written	Chatbots creation
H2020-EU.3.1.4.	RADIO	http://radio-project.eu/	2015	3	AI, robotics	RIA	Smart home/assistant robot systems with focus on with the objective of pursuing a novel approach to acceptance and unobtrusiveness. Sensing for health monitoring.	
H2020-EU.3.1.4.	RAMCIP	http://www.ramcip-project.eu/	2015	3.5	AI, robotics	RIA	Assisted living devices, robotics in elderly care.	
H2020-EU.3.4.	SCOUT	http://connectedautomateddriving.eu/	2016	2	AI	CSA	Connected automation in road transport, gaps and benefits identification	
H2020-EU.2.1.1.	StoreHero	https://get.storeheroapp.com/	2016	0.5	AI, ML	SME	AI-based virtual business coach	
H2020-EU.2.1.5.1.	SYMBIO-TIC	http://www.symbio-tic.eu/	2015	4	AI, robotics	IA	Safe, dynamic, intuitive and cost-effective working environment were immersive and symbiotic collaboration between human workers and robots can take place and bring significant benefits to robot-reluctant industries (where current tasks and processes are thought too complex to be automated).	
H2020-EU.1.4.1.2.	SYNTHESYS PLUS	https://cordis.europa.eu/project/rcn/220353/	2019	5	AI	RIA	Systematisation of scientific collections across Europe, applying cutting edge artificial intelligence to dramatically speed up the digital mobilisation of natural history collections.	
H2020-EU.2.1.1.	TRACS	https://trueai.io/	2017	0.5	AI, chatbot, NLP	SME	Automated AI-supported text-based customer support	

H2020-EU.3.1.6.	UNCAP	http://www.uncap.eu/	2015	3	AI	IA	Physical/cognitive assessment tools, new care & assistance paradigms with global interconnection and interworking, RoI analysis (both financial & social), an analysis of best practices of innovative organisational/business models as well as financing/procurement models for health & care service delivery at EU level.	
FP7-SECURITY	VASCO	https://cordis.europa.eu/project/rcn/185496/	2014	3	AI	CP-FP	Use of AI for security and crisis management in urban environment.	Best practices for security and crisis management in cities.

3.6 Augmented and Virtual Reality

3.6.1 Definition

Virtual reality is a simulation, in which computer graphics are used to create a dynamic realistic-looking world, which a user can interact with by using certain input methods (Burdea & Coiffet, 2003). Augmented Reality in contrast adds virtual elements to the user's view of the reality aiming to enrich it and provide additional information or features. That way, AR seamlessly bridges the gap between the real and the virtual (Lee, 2012).

AR and VR have potential to be used for the visualisation of data in healthcare, urban planning, transportation, policing, surveillance and more effective collaboration between public workers (Bermejo et al., 2017; Huang et al., 2014). In each of these areas, AR can help to make sense of large amounts of available data and make the public services more efficient. Apart from visualisation, AR has great potential for increasing the interactivity of citizen-oriented services. Along with the increase of AR-enabled consumer devices, increased the number of participatory solutions that take advantage of this technology. AR can be used to increase engagement of the young generation as a part of the gamification of e-participation initiatives (Argo et al., 2016).

Why is it relevant to Government 3.0? As Government 3.0 is characterised by the necessity to use the large amounts of big, open and linked data, in some of the domains AR can be extremely useful as an assisting technology, helping to visualise, make sense of and interact with big data. VR technology can be used for more dramatic visualisations, which can be used for example in training or education. VR is already used to create virtual meeting spaces and virtual public administration buildings where citizens interact with officials through digital avatars. Both VR and AR can be used as supportive technology in co-creation initiatives and help to improve citizen e-participation through gamification.

3.6.2 Project analysis

Table 9 provides a list of 11 projects, indicating research and training needs of AR/VR in digital government. Compared to technologies like AI, ML or IoT, the number of projects using AR/VR in digital government is limited.

Identified research needs include the use of Virtual and Augmented Reality for training, when training in the real world is either dangerous (medical [abcdeSIM-VR], emergency [EDUSAFE] and law-enforcement [LAW-TRAIN] training) or expensive (aerial navigation training [AEROGLASS], archaeology [LEAP]). Furthermore, AR/VR are especially well-suited for storytelling and narrative-driven experiences [Lyfta, REVEAL] as well as efforts in 3D preservation of art and cultural objects [Scan4Reco, eHERITAGE].

As both Virtual and Augmented Reality are relatively complicated technologies to use (and are still rarely used by a typical person in daily life), there is clear need to educate the intended users about how to properly set up, calibrate and maintain the system [abcdeSIM-VR, LAW-TRAIN, EVA]. A different target for training is the developers of AR/VR systems, who need to take into account the specific challenges of their use in different environments [EDUSAFE, LEAP].

Table 9. Identified projects involving Augmented and/or Virtual Reality

Project Call	Project Acronym	Project URL	Project start	Duration (in years)	Technologies used	Type	Identified research needs	Identified Training Needs
H2020-EU.2.1.1.	abcdeSIM-VR	http://www.virtualmedschool.com/	2017	0.3	VR	SME	Disruptive technologies for medical/health professionals, VR-based medical training.	VR training for health professionals.
H2020-EU.3.4.	AEROGLASS	https://glass.aero/	2015	2	AR	SME	Use of AR in aerial navigation.	
FP7-PEOPLE	EDUSAFE	https://cordis.europa.eu/project/rcn/105266/	2012	4	AR, VR	ITN	The use of Virtual Reality (VR) and Augmented Reality (AR) during planned and emergency maintenance in extreme environments (nuclear installations, space, deep sea etc.). Advanced VR and AR technologies for a personnel safety system platform, including features, methods and tools. The research challenges lie in the development of real-time (time-lags less than human interaction speed) data-transmission, instantaneous analysis of data coming from different inputs (vision, sound, touch, buttons), interaction with multiple on-site users, complex interfaces, portability and wearability, wear/tear.	Training in VR and AR application in extreme environments and design of VR/AR systems for such environments, addressing the current challenges.
H2020-EU.4.b.	eHERITAGE	http://www.eheritage.org/	2015	3	VR	CSA	Modern cultural heritage preservation techniques using VR	
H2020-EU.3.4.	EVA	http://www.eva.vision/	2017	0.4	AR	SME	AR solution for visually impaired people, mobility within urban environment.	
H2020-EU.2.1.6.	LARA	http://www.lara-project.eu/	2015	2	AR	IA	AR in infrastructure management, 3D GIS.	
H2020-EU.3.7.	LAW-TRAIN	http://site.law-train.eu/	2015	3	AR, VR	RIA	AR/VR-based training in law enforcement	Law enforcement interrogation training using VR and AR.
FP7-PEOPLE	LEAP	https://cordis.europa.eu/project/rcn/187945/	2014	2	VR	IEF	Virtual Archaeology (VA).	Virtual Archaeology training.
H2020-EU.3.6.	Lyfta	http://www.lyfta.com/	2017	0.5	AR, VR	SME	Educational storytelling using VR and AR.	
H2020-ICT-2016-1	REVEAL	http://revealvr.eu/	2017	2	VR	IA	Narrative-driven VR experiences for education. Improving the social and physical accessibility of cultural heritage and contribute to the digital preservation of historical sites.	
H2020-EU.3.6.3.	Scan4Reco	http://www.scan4reco.eu/	2015	3	VR	RIA	3D scanning, 3D printing, accessibility of the digitized cultural objects to the scientific community	

3.7 Open and Linked Data

3.7.1 Definition

Open data is *"data that can be freely used, re-used and redistributed by anyone - subject only, at most, to the requirement to attribute and sharealike"* (Dietrich et al., 2009). Open Data varies extensively in terms of format and content. Usually it comes in textual or numerical format; however, it may also include non-textual formats such as figures, graphs, maps, genomes, chemical compounds, formulae, medical information and data, scientific, etc. Governments are among the largest producers of Open Data datasets (Hardy & Maurushat, 2017). Proponents of the government Open Data argue that it allows more transparency and accountability, leading to a higher level of public scrutiny (Yu & Robinson, 2012). Open data can help to engage the citizens, that may use the datasets and add value to the data (Robinson et al., 2009).

Linked data is about applying the principles of the web to sharing data and doing so at a deeper level than just publishing a full document or a file. It is "a set of design principles for sharing machine-readable data on the Web for use by public administrations, business and citizens" (ISA, 2013, p.1). It is presented as the evolution from the "document-based web" to the "Web of interlinked data" (Heath & Bizer, 2011).

There is a clear link between Open Data, Big Data and Linked Data: researchers often use these three characteristics of data together talking about the Big Open Linked Data (BOLD). According to Janssen and Van Den Hoven (2015) BOLD is transforming the interactions between the government and the public, providing new opportunities such as the possibilities to analyse the behaviour of citizens, increase control, and address privacy issues (Janssen and Van den Ven, 2015). BOLD is also an important factor of an "open and transparent government". Use of BOLD contributes to improving transparency, accountability and openness (Futia et al.2017), it is strongly connected to the concept of open government (Mattheus and Janssen, 2015).

Why is it relevant to Government 3.0? Linked Open Data (LOD) has the potential to transform e-government and public sector in general, increasing the quality and quantity of provided services. LOD defines a vision of globally accessible and interconnected data based on the RDF standards of the semantic web. LOD has been proposed as the basis for open government and for solving many of the data integration issues. Compared to unstructured big data, linked data is much better readable by automated algorithms, so that it can be more efficiently used for automated data-based decision making in Government 3.0.

3.7.2 Project analysis

The project analysis revealed 20 projects, indicating research and training needs of Open and Linked Data in digital government (Table 10). In the collected projects, the most predominant research needs identified were related to the Open Data quality and linkability of Open Data, data exchange and trade, practical application of Open Data as well as education and capacity building. Data quality [LOD2, ROADIDEAinco] and linkability is an issue widely present in Open Data of all kinds, stemming from design and organizational capacity. The matter of data exchange and trade comes up in different forms – gaps between data exchange and interoperability between different fields or sectors, lack of uptake of Open Data, lack of exploitation of the potential value of Open Data in the economy. The question of practical application of Open Data is complex: it touches co-creation [smarticipate, Open4Citizens] – the potentials and possibilities of using Open Data to create services or as a basis for planning and decision making –, the lack of practical uses of Open Data in sectors where there would otherwise be potential for this. Education and capacity building projects touch on both the provider and the user side of Open Data and cover much of the above-mentioned aspects.

Training needs identified in these projects include skills and competencies that relate to the use of Open Data, in general, or in sector- or stakeholder-specific manner, as well as organizational capacity development that enhances the potential value of the outputted Open Data sets [AquaSmart, Open4Citizens, POSTDATA]. They include professional (specialty) training, informal education as well as academic curricula design [EDSA].

Table 10. Identified projects involving Open and Linked Data

Project Call	Project acronym	Project URL	Project start	Duration (in years)	Technologies used	Type	Identified research needs	Identified Training Needs
H2020-EU.2.1.1.4.	AquaSmart	https://www.aquasmartdata.eu/	2015	2	Open Data	IA	Global knowledge access and data exchanges between aquaculture companies and its related stakeholders	enhance innovation capacity to the aquaculture sector
FP7-ICT-2011-SME-DCL	CODE	http://code-research.eu/	2012	2	Open Data, Linked Data	CP	Mining facts and their integration into LOD repositories and light-weight ontologies.	N/A
H2020-EU.3.1.	COMPARE	https://www.compare-europe.eu/	2014	5	Linked Data	RIA	Analytical framework and data exchange platform that will allow real time analysis of data Risk assessment, risk based collection of data	N/A
H2020-EU.3.6.	dEUdil	https://www.duedil.com/	2016	2	Open Data, Linked Data	SME	Business information aggregation and contextualisation Transparency	N/A
H2020-EU.2.1.1.4.	EDSA	http://edsa-project.eu/	2015	3	Big data, linked data, open data	CSA	Need of innovative data management services, creating a demand for Data Scientists possessing skills and detailed knowledge in this area.	Data science
H2020-EU.1.4.1.3.	EGI-Engage	https://wiki.egi.eu/wiki/EGI-Engage:Main_Page	2015	2.5	Open Data, Big data, cloud computing	RIA	Open science ecosystem	Making sense of complexity Powering EU research
H2020-EU.2.1.1.4.	EuDEco	http://data-reuse.eu/	2015	3	Linked Data, Open Data, Big Data	CSA	Data reuse in context of big and open data	Creating competitive solutions using big and open data
FP7-ICT-2009-5	LOD2	http://lod2.eu/	2010	4	Open Data, Linked Data, Big Data	CP	Improve coherence and quality of data published on the web; close the performance gap between relational and RDF data management; establish trust on the Linked Data Web; lower generally the entrance barrier for data publishers and users.	N/A
H2020-EU.3.6.	Mobile-Age	https://www.mobile-age.eu/	2016	3	Open Data, Co-creation	IA	Senior citizens do not normally share the same level of connectivity to the Internet as younger generations, and while government agencies are increasingly providing their services through digital platforms, these risks excluding senior citizens from the design and use of such services.	N/A
H2020-EU.2.1.1.4.	ODINE	https://opendataincubator.eu/	2015	2.5	Open Data	IA	Supporting the formation process of innovative open data-driven services and business ideas	N/A

H2020-EU.2.1.1.	Open4Citizens	http://open4citizens.eu/	2016	2.5	Open Data	RIA	Empowering citizens to seize the opportunities offered by the availability of open data to address needs related to social sustainability.	Open Data skills, awareness
H2020-EU.1.4.1.3.	OpenAIRE2020	https://www.openaire.eu/	2015	3.5	Linked Data, Open Data, NLP	RIA	Open access policies in EU. Scholarly data, open science. Managing and monitoring the outcomes of research.	N/A
FP7-ICT-2009-5	PlanetData	http://www.planet-data.eu/	2010	4	Open Data, Big data, Linked data, Co-Creation	NoE	Large-scale ata management, open data principles	N/A
H2020-EU.1.1.	POSTDATA	http://postdata.linhd.uned.es/	2016	5	Open Data, Linked Data	ERC-STG	N/A	Digital gap among traditional cultural assets and the growing world of data.
H2020-EU.2.1.1.	SELECT for Cities	https://www.select4cities.eu/	2015	4	Open Data, co-creation, smart city government	COFUND-PCP	The extension of the Internet to the physical spaces and objects is a massive opportunity for new services and business for example in the areas of logistics, transport, environment, security and wellbeing.	N/A
FP7-ICT-2011-7	SEMANCO	https://cordis.europa.eu/project/rcn/100893_en.html	2011	3.2	Open Data	CP	Energy data models	N/A
H2020-EU.3.6.	smarticipate	https://www.smarticipate.eu/	2016	3	Open Data, co-creation, Smart City Government	IA	N/A	In the most cases it is only raw dump of data. It is hard for laymen to interpret the data sets, yet even impossible to determine if the content is useable as mostly no meta-information is given
H2020-EU.3.6.	WeLive	https://www.welive.eu/	2015	3	Co-Creation, Open Data	IA	Recognising that governments can no longer be the single providers of public services, ICT-enabled open and collaborative government is vital to deliver 'more from less'. To achieve this, it is necessary to empower stakeholders by giving them incentives to take a more active role in the delivery of public services.	N/A
H2020-EU.2.1.1.	XPRESSO	http://www.xpressomics.com/	2015	0.5	Open Data	SME	Open data in drug discovery	N/A
H2020-EU.3.6.	YDS	https://yourdatastories.eu/	2015	3	Linked Data, Big	IA	Government transparency through Open Government Data, citizen data management	N/A

					Data, Open Data			

3.8 Cloud Computing

3.8.1 Definition

Cloud computing is *"a model for enabling convenient, on-demand network access to a shared pool of configurable computing resources (e.g. networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction"* (Mell & Grance, 2011, p. 2). It can also be defined as *"a broad array of web-based services aimed at allowing users to obtain a wide range of functional capabilities on a pay-as-you-go' basis that previously required tremendous hardware/software investments and professional skills to acquire"* (Kepes, 2011). These definitions suggest that cloud computing is the realisation of traditional computing whilst removing the worries of deployment and the technical complexity using a pay-per-use/pay-as-you-go basis.

The implementation of cloud computing in government organisation can provide a variety of benefits. Firstly, economic savings can be made by reducing the operating and maintenance costs of their hardware and software infrastructures (Danielsen et al., 2019). Secondly, cloud solutions can provide an increased capacity to test and purchase IT capabilities otherwise unaffordable. Thirdly, cloud computing services give government organisations the flexibility to manage their IT resources, with them being able to scale-up or scale-down capacity on demand and only pay for the real usage. Finally, the use of cloud platforms promotes the use of an agile development environment. This, in turn, makes it easier for professionals to develop and adopt applications more quickly (Mohammed et al., 2017).

Why is it relevant to Government 3.0? Cloud Computing is crucial for computationally intensive areas of Government 3.0 like Big Data Analytics, Machine Learning and Internet of Things. Cloud computing solutions present governments with greater collaboration capabilities whilst reducing infrastructure needs and support costs for IT with the use of on-demand options.

3.8.2 Project analysis

A total of 26 projects were analyzed to indicate research and training needs for cloud computing in digital government (Table 11). Security and privacy were named as research needs in several of the projects. Public organizations hesitate to trust the safety of data stored in the cloud. Several of the projects deal with the issue of safety (e.g., [PRISMORACLE] aims to create tools to help public sector choose the best providers for cloud solutions or other security models). Cloud computing also enables or extends the capabilities of harmful hacking attempts. Other initiatives are focused on how cloud platforms can be utilized in research communities [CONTRAIL, Cydar PaaS, INDIGO-DataCloud, LEADS]. Several also focused on cross-border collaboration using cloud computing, enabling more benefits. Other themes connected to cloud computing were data analysis (e.g., big data analytics) [LEADS], improvement of digital government services [SEED, SUNFISH], green ecological systems [ICE-WISH], scientific clouds [EOSCpilot, Helix Nebula], cloud service brokers and policy design [FUPOL].

Among the identified training needs, security [OpenI, PASSIVE, PRISMACLOUD, ProBOS] and data privacy [CLIPS, GODINO, PaaSword] are mentioned most frequently. It is also important to train the intended users on the legal aspects of using cloud computing in the public sector [CLOUDWATCH2]. Related to this, cloud management was identified as a training need. Other themes mentioned are best practices [CloudWATCH], usage of cloud-based services as scientific tools, management and operating cloud systems.

Table 11. Identified projects involving Cloud Computing

Project Call	Project Acronym	Project URL	Project start	Duration (in years)	Technologies used	Type	Identified research needs	Identified Training Needs
H2020-EU.2.1.1.3.	AppHub	http://www.apphub.eu.com/	2015	2	Cloud Computing	CSA	Open source management and collaboration through cloud platforms	
FP7-ICT	Broker@Cloud	https://cordis.europa.eu/project/rcn/105609_en.html	2012	3	Cloud Computing	Research	Quality assurance and optimization in future enterprise cloud service brokers.	
FP7-ICT	C4E	https://cordis.europa.eu/project/rcn/109302_en.html	2013	4	Cloud Computing	Research	How to remove obstacles for cloud adoption. Harmonize the requirements from different public organizations beyond national borders.	
CIP	CLIPS	https://cordis.europa.eu/project/rcn/191776_en.html	2014	2	Cloud Computing	Research / development	Development of new cloud-based services. Migration of current public services into the cloud.	Privacy control
FP7-ICT	Cloudspaces	https://cordis.europa.eu/project/rcn/105603_en.html	2012	3	Cloud Computing	Research	Person-centric. Personal Clouds. Interoperability and privacy issues. Vendor lock-in risks. Users control of their information. Synchronization.	Managing cloud systems
FP7-ICT	CloudWATCH	https://cordis.europa.eu/project/rcn/110185_en.html	2013	2	Cloud Computing	Research / Use cases	Cloud computing in public and private sectors in Europe. Collaborative, international dialogue on interoperability and portability. Best practices. Benefits of Cloud systems.	Best practices
H2020-EU.2.1.1.3.	CLOUDWATCH2	http://www.cloudwatchhub.eu/	2015	2	Cloud Computing	Development	Different needs were supported by the tool: Transparent pricing, benefits consumers. Portfolio of standards for interoperability and security. A mapping of technologies, development status and practical support activities for projects to cluster and collaborate on common challenges, carry out interoperability testing, validate and endorse the level of interoperability. Digital innovation hub. Educating SME and public administrators on legal and risks. Provide practical guidelines.	Training on legal aspects addressing increasingly common consumer concerns. Security and privacy certifications and attestations. Guidance to cloud service customers, cloud service providers and policy makers in their evaluation of suitable security and privacy certification schemes for cloud services. Standards and certification in order to understand if and how certification can increase the level of trust in the cloud computing business model.
FP7-ICT	CONTRAIL	https://cordis.europa.eu/project/rcn/95934_en.html	2010	4	Cloud Computing	Research / Development	Virtualization. Infrastructure as a Service (IaaS), services for federating IaaS Clouds, and Platform as a Service (PaaS) on top of federated Clouds. Outputs of CONTRAIL are a collection of infrastructure services offering network, computation and storage as a service; services to federate IaaS Clouds; a set of high level services and runtime environments for typical Cloud applications, including efficient map/reduce, scalable service-oriented application hosting, and automatic workflow execution; and a set of applications and use cases from the domains of e-business, e-science and telecommunication.	Cloud management, Security
H2020-EU.2.1.1. H2020-EU.2.3.1.	Cydar PaaS	http://www.cydar.co.uk/	2015	1	Cloud Computing	SME	Platform as a Service for Enterprises, healthcare organisations and academic institutions.	Usage of Cloud-based services as scientific tools. (PaaS)

FP7-IDEAS-ERC	DEPENDABLECLOUD	https://cordis.europa.eu/project/rcn/105323_en.html	2012	5	Cloud Computing	Research	Identify and explore methods for sustaining and making cloud systems dependable and avoid crash and adversarial faults. Develop new better methods. Scalability and consistency.	Methods of operating Cloud systems
H2020-EU.1.4.1.1.	EOSCpilot	https://www.eoscpilot.eu/	2017	2	Cloud Computing	RIA	Governance framework and development of European open science policy and best practice. (Governance, policy, skills, interoperability, service architectures)	Usage of Cloud-based services as scientific tools.
FP7-ICT	FUPOL	https://cordis.europa.eu/project/rcn/100737_en.html	2011	4	Cloud Computing	Research	Policy design and implementation.	
FP7-PEOPLE	GODINO	https://cordis.europa.eu/project/rcn/108829_en.html	2014	2	Cloud Computing	Research	Public organizations and: Privacy & Security. Legal frameworks.	Security & Privacy
FP7-INFRASTRUCTURES	Helix Nebula	https://cordis.europa.eu/project/rcn/104130_en.html	2012	2	Cloud Computing	Research	Cloud-based services as scientific tools.	Usage of Cloud-based services as scientific tools.
H2020-EU.2.1.1.3.	HOLA CLOUD	http://www.holacloud.eu/	2015	2	Cloud Computing	Research / Development	Cloud computing roadmap. SME and Cloud computing expert's collaboration through an online platform. Cloud based eco-system.	
CIP	ICE-WISH	http://www.ice-wish.eu/uk/icewish.asp	2011	3.5	Cloud Computing	Research /Development	Smart home. Green systems. Cloud computing enables environmental benefits.	
H2020-EU.1.4.1.3.	INDIGO-DataCloud	https://www.indigo-datacloud.eu/	2015	3	Cloud Computing	Research / Development	Usage of cloud computing in scientific communities. Authentication/authorization, availability of cloud services, QoS policies, identify available services, Identify static un-scalable services, Public vs private cloud infrastructures, Lock-ins & Licensing problems.	PAAS and SAAS platforms
FP7-ICT	LEADS	https://cordis.europa.eu/project/rcn/105472_en.html	2012	3	Cloud Computing	Research	Data-as-a-Service (DaaS) - for analyzing the growing data on today's internet. Solutions for analyzing these data. Mixing public and private data.	Big Data DaaS
FP7-ICT	OpenI	https://cordis.europa.eu/project/rcn/105553_en.html	2012	3	Cloud Computing	Research / Development	Securing and protecting content and personal data on mobile devices that uses cloud-based services.	Security
H2020-EU.2.1.1.3.	PaaSword	https://cordis.europa.eu/project/rcn/194247_en.html	2015	3	Cloud Computing	Research	Implementation of secure and transparent Cloud-based applications and services. Distributed and totally encrypted data persistence layer. Data protection, integrity and confidentiality. Cloud security principles.	Data privacy and security.
FP7-ICT	PASSIVE	https://cordis.europa.eu/project/rcn/95251_en.html	2015	2	Cloud Computing	Research	Security architecture that lower the barriers to adoption of virtualised hosting by government users, so that they may achieve the considerable gains in energy efficiency, reduced capital expenditure and flexibility offered by virtualisation.	Security

H2020-EU.2.1.1.	PQCRYPTO	https://cordis.europa.eu/project/rcn/194347_en.html	2015	3	Cloud Computing	Research / Development	Security and post-quantum cryptography. Cloud systems enable hacking of today's security systems.	Post-quantum cryptography
H2020-EU.2.1.1.	PRISMACLOUD	https://prismacloud.eu/	2015	3	Cloud Computing	Research / Toolkit development	Confidentiality of data during their life cycle in the cloud. Verifiability features for data in the cloud. Privacy of users interacting with a cloud environment.	Security
H2020-EU.3.7. H2020-EU.2.3.1.	ProBOS	https://reaqta.com/	2016	2	Cloud Computing	Research /Development	Security. Innovative cyber security solutions. Artificial Intelligence. Cloud systems hacking.	Security
CIP	SEED	https://cordis.europa.eu/project/rcn/191907_en.html	2012	2	Cloud Computing	Research	Citizen-centric e-Gov Services. Saving costs of e-government and e-governance deployments.	Citizen-centric e-Gov Services in cross-border services of European, National, Regional and Local level public organizations.
H2020-EU.2.1.1.3.	SUNFISH	http://www.sunfishproject.eu/	2015	3	Cloud Computing	Research	Integrate public sector in computing clouds. Legislative barriers for integrating cloud solutions. Security.	Security and hinders for implementing cloud systems in public organizations

3.9 Service Co-Creation, Once-Only Principle, Service Modules, CAPS

3.9.1 Introductory definitions

3.9.1.1 Service co-creation

Co-creation refers to active involvement of end-users in various stages of production process (Prahalad & Ramaswamy, 2000; Vargo & Lusch, 2004). In the case of public service production, co-creation is active involvement of the citizens in different stages of public service production. This involvement can be voluntary or involuntary and may happen during public services' design, management, delivery and/or evaluation (Osborne et al., 2016). This definition clearly delimits co-creation from more general citizen participation, which may involve also passive participation (W. Voorberg et al., 2017).

Co-creation is seen as a cornerstone of today's public service provision (OECD, 2011; Osborne et al., 2016), which may help to address the problems of democratic deficit (Pestoff, 2006), insufficient citizen involvement and be a way to acquire additional resources for the delivery of public services (W. H. Voorberg et al., 2015). Co-creation is a necessary part of the open innovation in government. Open innovation in the government services can be realised by allowing citizens to contribute in the process of co-design and co-creation of the services. Such deeper involvement of the citizen stakeholders, especially on the early stages of the projects, can make use of the widely distributed useful knowledge that may improve the ultimate quality of the services or tools (Chesbrough, 2006).

Why is it relevant to Government 3.0? Co-creation is an important aspect of open innovation in public services. Through service co-creation, government can take advantage of the wider knowledge by engaging a range of citizen and private sector stakeholders into the development of the future solutions. Over the recent years, co-creation has evolved into a concept of actively engaging citizens in the design and improvement of public services. The use of AI and machine learning can enable the efficient use of larger amounts of data from the citizens, by that improving the decision-making processes within the government and providing better public services.

3.9.1.2 Service modules

Grönroos (2011) has presented a view of managing a company's service offering in which a service comprises a basic service package and the subsequent augmentation of this package. The augmentation, in turn, comprises four parts: the core solution, the enabling service, the enhancing services, and the user interface (UI). Such argument according to Tuunanen & Cassab (2011) can help achieve a better conceptualization of information systems and information technology-enabled services. It can be argued that core, enabling, and enhancing services should be considered as service modules (Johansson & Lahtinen, 2012) that include aspects such as infrastructure, deployment, and user interface

The service modules are provided by means of a modular architecture that is based on building blocks reuse (Corradini et al., 2018). The services are exposed via web services and through a modality of interaction with non-invasive back-office systems. Using service modules, each single authority separates the core competence services from the supporting ones that are instead shared among different organisations. This allows authorities to improve digital government assessment results, develop their strategic functions while optimising investments by sharing services and resources of common interest. In this approach, each authority externalises its core services by providing them to outside organisations in the form of separate functional modules.

Why is it relevant to Government 3.0? The use of service modules may improve interoperability and assist in horizontal integration of government services. It is an important means of improving both the efficacy of national services and implementing cross-border interaction.

3.9.1.3 Once-Only Principle

Once only principle (OOP) is defined by the European Commission in the EU eGovernment Action Plan 2016-2020 (European Commission, 2016) as *"public administrations should ensure that citizens and businesses supply the same information only once to a public administration. Public administration offices take action if permitted to internally re-use this data, in due respect of data protection rules, so that no additional burden falls on citizens and businesses"* (p. 4).

The "once only" principle means that citizens and businesses should supply information only once to a public administrations within the EU. Public administrations act to share needed data across organisational borders, so that no additional burden falls on citizens and businesses. The OOP supports the concept of user centricity. It focuses on the reduction of administrative burden of users by re-organising public sector internal processes rather than making users to adapt to the public sector's internal processes (Lethbridge, 2015; Veiga et al., 2016). The implementation of OOP is expected to bring numerous benefits: cost savings and time savings, reducing administrative burden and bureaucracy (Dečman, 2016), reducing costs for businesses and fulfilling legal obligations faster while improving the accuracy of the same data (Veiga et al., 2016). Applying the once-only principle on the EU level is estimated to generate total net savings of around €5 billion per year (Tallinn Digital Summit, 2017).

Why is it relevant to Government 3.0? The OOP can simplify public services by reducing administrative burden and improving cross-border cooperation. In future, the OOP will become one of the important principles for managing data across borders as the single digital gateway regulation[6] requires.

3.9.1.4 Community Awareness Platforms

Community awareness platforms (CAPs) can be defined as *"important crowdsourcing instruments that may promote cooperation, emergence of collective intelligence, participation and promotion of virtuous behaviours in the fields of social life, energy, sustainable environment, health, transportation, etc"* (Pacini & Bagnoli, 2016, p. 19).

CAPs contribute to creating awareness of emerging challenges and therefore foster changes by boosting collective action. To this end, community awareness platforms can enable government to connect with citizens so as to directly raise awareness on several domains relevant to digital government such as informing citizens for serious public health issues, natural disasters, environmental issues, etc. These platforms can be an example of citizen co-production/ co-creation and crowdsourcing in e-government.

3.9.2 Project analysis

Table 12 presents 29 projects that address aforementioned concepts. A brief description of the current state of research as well as research and training needs for each one follows:

- *Public service co-creation*: for a first set of projects, the research fields are generic and centred on new models of governance and public engagement, as well as on public value co-creation models and methodologies such as service design, living labs, and public sector innovation networks. For a second set of projects the research domains include big data, smart cities technologies (e.g. urban and transport planning, energy, social care), and disruptive technologies such as big data, blockchain, augmented reality, geolocated social network, liquid democracy tools and gamification. In the first case, the training needs are aimed to increase the skills to use disruptive technologies, as well as the skills to participate in co-creation activities such as service design and living labs. In the second case such training should be complemented with the one on disruptive technologies;
- *Once only principle*: here the research needs are clearly focused on the extension of the use of the once only principle in public administration, both through the development of new regulations, technologies and methodologies, which are also the future training object for the population;
- *Community awareness platforms*: here the research is mostly focused with the creation of platforms and communities to create solutions in domains such as air quality, social innovation, open source, open data, food waste, circular economy, social and health care, open democracy and digital rights, smart transports, CO_2 emissions and climate change, network analysis, light pollution. In this respect, citizens need to be trained to use such tools and methodologies.
- *Service modules*: here the research domains are mostly focussed on the development of platforms providing service modules that can be modified and re-used, especially in the domains of MObility Open Network of Services (MOONS), Big bio-data, cloud computing, data analytics, open science, data re-use, open innovation. In this respect, citizens need to be trained to use such tools and methodologies.

[6] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv:OJ.L_.2018.295.01.0001.01.ENG

Table 12. Identified projects involving Service Co-creation, Once-Only Principle, Service Modules, CAPS

Project Call	Project Acronym	Project URL	Project start	Duration (in years)	Technologies used	Type	Identified research needs	Identified Training Needs
H2020-ICT-2015	ChainReact	http://chainreact.org/	2016	3	Community Awareness Platforms	Pilots	ChainReact is an effort to make supplier networks transparent, understandable, and responsive, so that companies and their stakeholders can see, react to, and ultimately transform corporate network impacts.	Use of the open platform to provide information.
H2020-ICT-2015	CROWD4 ROADS	http://c4rs.eu/	2016	3	Community Awareness Platforms	Pilots	Smart transports, CO2 emissions and climate change, network analysis.	Skills to use the platform for road maintenance and transport sustainability.
H2020-ICT-2015	DSI4EU	http://www.digitalsocial.eu/	2016	1.5	Community Awareness Platforms	Pilots	The DSI4EU project will support, grow and scale the current Digital Social Innovation network of projects and organisations, bringing together social entrepreneurs, hackers, communities and academics working on key DSI fields such as the makers movement, the collaborative economy, open democracy and digital rights.	Skills to get involved in the platforms to create new digital social innovation solutions.
H2020-ICT-2015	hackAIR	http://www.hackair.eu/	2016	3	Community Awareness Platforms	Pilots	Data air quality, data fusion algorithms and reasoning services.	Use of the open platform for measuring and publishing outdoor air pollution levels.
H2020-ICT-2015	Making Sense	http://making-sense.eu/	2015	2 .17	Community Awareness Platforms	Pilots	Making Sense shows how open source software, open source hardware, digital maker practices and open design can be effectively used by local communities to appropriate their own technological sensing tools, make sense of their environments and address pressing environmental problems in air, water, soil and sound pollution.	Skills to use the Smart Citizen platform for bottom up citizen science.
H2020-ICT-2015	Open4Citizens	http://open4citizens.eu/	2016	2.5	Community Awareness Platforms	Pilots	Open data, social innovation.	Hackathons, co-creation of new solutions for existing or future services based on the use of data,
H2020-ICT-2015	OPENCARE	http://www.opencare.cc/	2016	2	Community Awareness Platforms	Pilots	OpenCare prototypes a community-driven model of addressing social and health care and explore its implications at scale. It draws on three elements: advances in collective intelligence research; advances in digital fabrication and cheap-and-open hardware technology; and the rise of a global hacker community.	Skills to use the platform to co-create e-health digital solutions.
H2020-ICT-2015	OpenMaker	http://openmaker.eu/	2016	2.5	Community Awareness Platforms	Pilots	OpenMaker brings together mainstream manufacturers and makers (i.e. tech-savvy craftsmen driven by social innovation and open source principles) in a purposely designed ecosystem built to enable	Skills to use the digital platform on social innovation.

							cross-boundary partnerships for innovation.	
H2020-ICT-2015	SavingFood	https://savingfood.eu/	2016	2.33	Community Awareness Platforms	Pilots	The project builds on the collaborative power of ICT networks and creates an online community of citizens, food waste stakeholders and policy makers that through knowledge creation and sharing they are empowered to take direct action and become part of the suggested food waste solution.	Use of advanced open source tools connected to a social networking environment.
H2020-ICT-2015	STARS4ALL	http://www.stars4all.eu/	2016	3	Community Awareness Platforms	Pilots	STARS4ALL creates an Light Pollution Initiative (LPI) incubation platform that will allow generating (and maintaining) customizable on-demand domain-focused LPIs	Use of the platform.
H2020-SC6-CULT-COOP-2016	CITADEL	http://www.citadel-h2020.eu/	2016	3	Co-creation	Pilots	Public sector innovation and transformation, citizen centric services.	Skills for co-creation of citizen centric services.
H2020-SC6-CULT-COOP-2017	CLARITY	http://clarity-h2020.eu/	2017	3	Co-creation	Pilots	Urban and transport planning, climate management and intelligence models.	User-centred design, co-creation of a Climate Services Information System (CSIS) to integrate resilience into urban infrastructure.
H2020-SC6-TRANSFORMATIONS-2018	CO3	https://cordis.europa.eu/project/rcn/218757/	2019	3	Co-creation	Pilots	Blockchain, augmented reality, geolocated social network, liquid democracy tools and gamification, in the co-creation, co-production and co-management of public services with citizens as PAs partners	Skills for co-creation of services using blockchain, augmented reality, geolocated social network, liquid democracy tools and gamification
H2020-EU.3.6.3	COGOV	http://www.cogov.eu/	2018	3	Co-creation	Case studies	Public Value Creation models, used in combination with Co Creation and Co Governance ideas, in turn combined with Digital Era Governance inspirations with their possible implications for more participatory approaches to e-government.	Skills to use disruptive technologies, skills to participate in co-creation activities such as service design, living labs, public sector innovation networks
H2020-SC6-CO-CREATION-2017	Co-Inform	http://coinform.eu/	2018	4	Co-creation	Pilots	Socio-technical solutions to increase resilience to misinformation, and to generate more informed behaviors and policies.	Skills for co-creating such solutions, especially for what concerns the use of ICT.
H2020-EU.3.6.3	Co-VAL	http://www.co-val.eu/	2017	3	Co-creation	Case studies	New models of governance and public engagement, service design, living labs, public sector innovation networks.	Skills to use disruptive technologies, skills to participate in co-creation activities such as service design, living labs, public sector innovation networks.
H2020-SC6-CO-CREATION-2017	CUTLER	https://www.cutler-h2020.eu/	2018	3	Co-creation	Pilots	Sensing infrastructures installed in the cities offering demographic data, statistical information, sensor readings and user contributed content forming	Skills to get involved in the co-creation of coastal urban development policies based on big data.

							the big data layer. Methods for big data analytics.	
H2020-SC6-CO-CREATION-2016-3	DESIGNSCAPES	http://www.designscapes.eu/	2017	4	Co-creation	Case studies	Design enabled Innovation, design thjnking.	Training Modules for local facilitators and innovators will be developed within the scope of the project.
H2020-SC6-CULT-COOP-2016	ENLARGE	http://www.enlarge-project.eu/	2016	2	Co-creation	Case studies	Participatory governance for sustainable energy.	Skills to be involved in participatory practices such as co-design, co-production and co-assessment.
H2020-EU.3.6.3	TROPICO	http://www.tropico-project.eu/	2017	3	Co-creation	Case studies	Use of ICT for collaboration between citizens and public sector in the view to co-create services.	Skills to use disruptive technologies, skills to participate in co-creation activities such as service design, living labs, public sector innovation networks
H2020-SC6-CO-CREATION-2017	PoliVisu	http://www.polivisu.eu/	2017	3	Co-creation, Smart city	Pilots	Use of Advanced Geospatial Data Analytics and Visualisation to improve traditional public policy making cycle using big data.	Training in the use of Advanced Geospatial Data Analytics and Visualisation for policy creation.
H2020-SC6-TRANSFORMATIONS-2018	QualiChain	https://cordis.europa.eu/project/rcn/218758/	2019	3	Co-creation	Pilots	Blockchain technology, algorithmic techniques and computational intelligence for disrupting the domain of public education	Use of blockchain technologies, algorithmic techniques and computational intelligence.
H2020-SC6-CO-CREATION-2017	SoCaTel	http://www.socatel.eu/	2017	3	Co-creation	Pilots	Social care and services for the ageing population.	Skills to use a multi-module/multi-stakeholder platform to create policies for social care.
H2020-ICT-2014-1	AEGLE	http://www.aegle-uhealth.eu/	2015	3.5	Service modules	Pilots	Big bio-data, cloud computing, data analytics, visualization techniques.	Skills to use big bio-data platforms.
H2020-EINFRA-2017	EOSC-hub	https://cordis.europa.eu/project/rcn/216096/	2018	3	Service modules	Pilots	Open science, cloud computing, big data analytics, data re-use, open innovation.	Skills to use the platform for co-creating big data solutions.
H2020-MG-2014	MASAI	http://www.masai.teleticketing.eu/	2015	3	Service modules	Pilots	MASAI designs, prototypes and pilots in the field a MObility Open Network of Services (MOONS) as an interconnected distributed environment, on which any service module can be easily plugged to interact with others (using principles such as DNS-SD)	Skills to use mobility module services and platforms.
H2020-SC1-2016-CNECT	MIDAS	http://www.midasproject.eu/	2016	3.33	Service modules	Pilots	Data mapping solution, social media, open data, big data, privacy by design, ethics, data governance, e-health.	Skills to co-creation the e-health solutions by mean of a platform.
H2020-SC6-CO-CREATION-2016-2	SCOOP4C	http://www.scoop4c.eu/	2016	2.5	Once Only	Roadmapping	Once only principle for public services provision	Skills related to the once only principle in co-creation and public service provisioning contexts involving citizens

H2020-SC6-CO-CREATION-2016-2	TOOP	http://www.toop.eu/	2017	4	Once Only	Pilots	Once only principle for public services provision	Skills related to the once only principle in co-creation and public service provisioning contexts involving citizens

3.10 Gamification and Gaming-based Simulation

3.10.1 Introductory definitions

3.10.1.1 Gamification

Gamification refers to *"a process of enhancing a service with affordances for gameful experiences in order to support users' overall value creation"* (Huotari & Hamari, 2017, p. 25). Gamification represents a conceptual tool or deliberate intervention applied to leverage the motivational potential of games and game-play in order to promote participation, engagement, persistence and achievement (Hassan, 2017; Richter et al., 2015).

Though a relatively recent concept, gamification is already a growing practice in business, education, government, the non-profit sector, and healthcare (Kim & Werbach, 2016). Simultaneous to the developments in technology and pervasive/ubiquitous computing that have prompted the widespread adoption of digital government systems by a variety of public sector organizations eager to engage their citizens in the process of smart governance, there has also been an increased interest in how gamification can be harnessed to modify citizen behaviour to tackle Smart City concerns (Kazhamiakin et al., 2016; Schouten et al., 2017). It is argued that first-hand experience with public data creates a data-literate citizenry that actively engages with governance processes and contributes to the co-design and innovation of public services (Wolff et al., 2017).

Why is it relevant to Government 3.0? Gamification is an important mechanism or intervention for facilitating and sustaining changes in citizens' behaviour within the conceptual fields of electronic government or digital government; modifying their actions towards the achievement of desired policy outcomes. Gamification as a tool has become highly relevant in Smart City contexts, where it is used to encourage active citizen engagement with the data-driven city, to promote civic participation (via crowdsourcing or in co-creation) in governance process, and to foster the co-creation of public services.

3.10.1.2 Gaming-based simulation

Gaming-based simulation (GS) is the use of game elements to allow actors to participate in the simulation of a specific model. GS includes an operating model of central features of real or proposed systems or processes. Scenarios are developed, roles are defined in interacting systems, and players are given goals, resources, and rules. Then, they work out the simulations, trying out alternative roles and strategies within the system constraints defined (Tanwattana & Toyoda, 2018). In practice, GSs require individuals to assume roles, interact with multiple actors and experience the results of their choices, and can therefore provide an excellent environment for entertainment, training, motivation, assessment, education and learning, research and decision support (Mayer & Veeneman, 2002; Oblinger, 2004).

GS has been widely used by the governments worldwide, particularly for purposes of policy development. Some GS have been used effectively as intervention method with local stakeholders at a community level, for instance with local farmers or fishermen in rural areas of developing countries (Barreteau et al., 2007; Hertzog et al., 2014; Le Bars et al., 2014; Magombeyi et al., 2008), or as a method for communicating issues in planning transport infrastructure due to being good tools for assessing the social and informal spaces of urban transport systems (Raghothama & Meijer, 2015).

Why is it relevant to Government 3.0? Gaming-based simulation constitutes a powerful tool for explaining alternative concepts and situations of real or even imaginary systems. Although its usage is relatively new especially in the field of public services, GS is particularly useful for dealing with urban information. GS provides a better way for understanding and exploring situations, experimenting alternative futures and even in some cases predicting solutions and behaviours. Thus, GS can be a useful component of decision-making, Smart City governance and policy modelling.

3.10.2 Project analysis

14 projects were analysed in Table 13 and the identified training needs of the gamification projects are very similar to the gaming-based simulation projects. The main scope in both cases is to support and improve citizens' daily life. The identified research needs concern data acquisition [SUPREMA], analysis [REDALERT, RAGE, REPOPA], visualization [INSIGHT], and protection techniques and tools. Furthermore, most of the projects in both cases include the identification and the analysis of cases studies and best practices based on each project's scope. Service Innovation, Data Analysis [RAGE], personalized public

services [GABLE, GamECAR], proactive services [ProsocialLearn] and context-specific services [3D Tune-In, GATES] are the main identified training needs. In cases of the development of a tool, software engineering is a required training need while in all cases the Community Awareness (techniques and platforms) is also necessary.

Table 13. Identified projects involving Gamification and Gaming-based Simulation

Project Call	Acronym	Project URL	Project start	Duration (in years)	Technologies used	Type	Identified research needs	Identified Training Needs
H2020-EU.2.1.1.4.	3D Tune-In	http://3d-tune-in.eu/	2015	3	gamification	IA	Hearing aid algorithms and techniques, gamification for improving hearing aspects (e.g. different acoustic environments), gamification techniques, audio technologies	Context-specific services, Digital Government and Service Innovation, Sustainable Development and Governance Responsibility, Personalised Public Services, Simulation in Governance
H2020-EU.2.1.1.	GABLE	https://projectgable.eu/	2016	3	gamification, machine learning, mobile services	IA	Image Processing, Personalised public services, machine learning techniques in combination with gamification	Digital Governance and Service Innovation, Cyber Security (target group with health issues in combination with an online game), personalized public services
H2020-EU.2.1.1.	GamECAR	http://www.gamecar.eu/	2017	1	gamification	IA	Personalised Services, Visualization Techniques, smart cities and eco-driving best practices, Visualization techniques for Real – time data processing and providing (eg augmented reality)	Service Innovation, Cyber Security, Simulation in Governance.
H2020-EU.2.1.1.	Gaming Horizons	http://www.gaminghorizons.eu/	2016	2	gamification, policy modelling	RIA	All the aspects of Gamification (e.g ethics and impact) in order to increase the awareness and lead the public sector to the policy modelling through the use of gamification, identification and analysis of technologies which can be used to visualizing data	Knowledge sharing, Digital Government and Service Innovation, Proactive Services, Government 3.0
H2020-ICT-2016-1	GAPARS	http://gapars.mmos.ch/	finished	2	gamification, gaming-based simulation, Cloud computing, Big Data, AR	IA	Simulation in government, foundations of cyber security, visualization techniques, serious games, real time communication techniques	Big Data, community awareness platform, context specific services, statistics and data analytics
H2020-EU.2.1.1.	GATES	http://www.gates-game.eu/	2017	2	gaming-based simulation	IA	Smart farming (best practices and case studies), Simulation in Governance, gaming technologies (e.g. 3D)	Context-specific services, Personalised Public Services, smart cities, software engineering
H2020-EU.2.1.1.	INLIFE	http://inlife-h2020.eu/	2017	2	Gamification, IoT	IA	Digital Government and service innovation, how the Virtual Reality strengthens the infusion of gamification into non-leisure contexts, serious games,	Software engineering, data analysis, data analysis (for observing players' behaviour to ensure the sustainability of the outcomes)
FP7-SEC-2013-1	LEILA	http://www.leila-project.eu/	2014	2	Gaming-based simulation, big data, decision making, AR	CP-FP	Intelligence analysis, Semantic e-government, Data Sharing, Serious games	Proactive Services, Big Data, Data Analytics, Service Innovation
H2020-EU.2.1.1.4.	No One Left Behind	http://no1leftbehind.eu/	2015	2.5	Gaming-based simulation	IA	Digital games development, business model, economics and business	Computer Science, Statistics and Data Analytics, Software Engineering, Context-specific services, Business process management

H2020-EU.2.1.1.4.	ProsocialLearn	http://prosociallearn.eu/	2015	3	Gamification	IA	Prosocial Learning, Gamification of Prosocial Learning, gamification and education (case studies, impact), data acquisition and protection	Service Innovation, Personalized public services, Proactive services, awareness platforms, data analysis, cyber security
H2020-EU.2.1.1.4.	RAGE	http://www.rageproject.eu/	2015	4	Gamification, Gaming-based simulation	RIA	Interoperability, case studies and best practices, community awareness platform, serious games, data analytics	Impact and measurement of government services, enterprise architecture, business process management, digital government and service innovation
H2020-EU.3.3.1.	TRIBE	http://tribe-h2020.eu/	2015	3	Gaming-based simulation, big data	RIA	Energy savings, energy efficiency in public buildings, awareness using social networks, serious games impact, data acquisition techniques	Digital Government and Service Innovation, Sustainable Development and Governance Responsibility, Security and Authentication in Public Administration, Smart City, Proactive Services, Community Awareness Platforms, Impact and Measurement of e-governance, Context-specific services, Data sharing
FP7-2011-NMP-ICT-FoF	VISTRA	https://cordis.europa.eu/project/rcn/99491/	2011	3	Gaming-based simulation	CP	Interoperability, enterprise data, simulation techniques, business model aspects	Interoperability, Digital Government and Service Innovation, Sustainable Development and Governance Responsibility, collaborative and decentralized application and development tools, Data analytics
H2020-EU.3.3.7.	WaterWatt	https://cordis.europa.eu/project/rcn/100759/	2011	3	Gamification	CP	Awareness: How to be achieved, (community awareness platform), identify the best practices and case studies (public and private sector)	How to achieve policy making through gamification, data analysis techniques, software engineering

3.11 Policy Modelling

3.11.1 Definition

Policy Modelling is *"an academic or empirical research work that is supported by the use of different theories as well as quantitative or qualitative models and techniques, to analytically evaluate the past (causes) and future (effects) of any policy on society, anywhere and anytime"* (Ruiz Estrada, 2011, p. 524). Academic research on policy modelling and the development of the necessary technology provides insights in how technology could assist policy makers.

Ruiz Estrada (2011) reviewed 1501 papers published in the *Journal of Policy Making* to provide a classification of the policy modelling research conducted so far with respect to the field in which it contributes. In particular, Estrada identifies 12 different categories of policy making research including (i) domestic and international trade policy modelling; (ii) energy, communications, infrastructure and transportation policy modelling; (iii) environmental and natural resources management policy modelling; (iv) fiscal and government spending policy modelling; (v) institutional, regulation and negotiation policy modelling; (vi) labour, employment and population policy modelling; (vii) monetary, banking and investment policy modelling; (viii) production and consumption policy modelling; (ix) technological and R&D policy modelling; (x) welfare and social policy modelling; (xi) economic growth and development policy modelling; (xii) miscellaneous policy modelling (Ruiz Estrada, 2011).

Why is it relevant to Government 3.0? Policy modelling can support and improve policy decision-making processes in government. Policy modelling can be conducted based on the open linked big data sources and employing various other techniques like Gaming-Based Simulation, supported by visualisation. Policy modelling also has implications for Smart City governance and innovation in government generally.

3.11.2 Project analysis

Table 14 lists 13 projects. Major research needs in relation to policy modelling are concerned with handling of data (data acquisition, analysis, and visualization techniques), the techniques of modelling policies and risk analysis. The end goal is often the effective Data Analysis [CRISMA, FRESHER], which very much connects this topic to Data Analytics (both analytics and big data analytics), discussed in section 3.2. Apart from the practical issues related to handling of data, the research needs for Policy Modelling also include the theoretical foundations (e.g., in Complexity Theory as seen in some projects [INSIGHT], the need to look into the legislation behind policy modelling [EURECA], public perception [PARTHENOS], societal impact of the changes brought along [SIMPOL] and management of the outcomes [RISK].

The training needs include the foundations of cybersecurity [PARTHENOS, REDALERT], interoperability [SUPREMA], proactive services [FRESHER], and sustainable development and governance responsibility [INSIGHT, RISK, SIMPOL]. For the projects that take advantage of gaming-based simulation as a tool for policy modelling [REPOPA], the training needs are similar to the training needs identified in section 3.10 and require training specifically in the domain of computer simulations.

Table 14. Identified projects involving Policy Modelling

Project Call	Acronym	Project URL	Project start	Duration (in years)	Technologies used	Type	Identified research needs	Identified Training Needs
FP7-ICT-2013-10	Consensus	https://cordis.europa.eu/project/rcn/110507	2013	3	policy modelling	CP	Real-world planning process, Statistics and Data analytics, simulation tools, public opinion	Big Data, Digital Government and Service Innovation
FP7-SEC-2011-1	CRISMA	http://www.crismaproject.eu/	2012	3	policy modelling, gaming-based simulation	CP	(Crisis) management modelling, Simulation in Governance	Big Data, Data Analytics, Service Innovation, Proactive Services, Sustainable Development and Governance Responsibility
FP7-ICT-2013-10	EU Community	https://cordis.europa.eu/project/rcn/110877/	2013	3	policy modelling, text mining, social media	CP	Entrepreneurship & Innovation, statistics and data analytics	Text mining techniques, impact and measurement of e-governance, semantic e-government
H2020-EU.3.3.7.	EURECA	https://www.dceureca.eu/	2015	3	policy modelling	CSA	ICT Managers, Public Sector Innovation, Policies & Legislation, Business Case developments, KPIS, Standards, Risk analysis, Frameworks and best practices	Digital Government and Service Innovation, Data- oriented services, Public Administration Information Systems
H2020-EU.3.1.6.	FRESHER	http://www.foresight-fresher.eu/	2015	2	policy modelling, big data	RIA	Modelling policies and regulation techniques, identification and mapping of risk factors	Big Data, Foundations of Cyber Security, Proactive Services, Simulation in Governance, Software Engineering, Business Process Management, Statistics and Data Analytics, Digital Government and Service Innovation, Cyber Security,
FP7-ICT-2013-10	INSIGHT	https://cordis.europa.eu/project/rcn/109700/	2013	3	Policy Modelling, open data, big data, smart cities	CP	Data visualization methods and tools, Complexity Theory, Open Data, Big Data	Data Science, Simulation in Governance, Data mining, Data Analysis, Sustainable Development and Governance Responsibility
H2020-EU.1.4.1.1.	PARTHENOS	http://www.parthenos-project.eu/	2015	4.5	policy modelling, open data, interoperability	RIA	Open and Linked Data, Data- oriented services (best practices and case studies), Social Engineering, Risk analysis	Cyber Security. Data sharing, Data Analysis, Public Administration Information Systems, Interoperability
H2020-EU.3.3.7.	PUBLENEF	http://www.publenef-project.eu/	2016	3	policy modelling	CSA	Public Administration Information Systems, Decision Science: Theory and Practice, Impact and Measurement of e-governance	Digital Government and Service Innovation, Statistics and Data Analytics, Topics in Applied Policy Analysis, Sustainable Development and Governance Responsibility
H2020-EU.3.7.6., H2020-EU.3.7.1	REDALERT	http://redalertproject.eu/	2017	3	NLP, Data Mining, AI, Data Analytics, Open Data, Big Data, Policy Modelling	RIA	Further analysis to the predictive analytics tools, Data Analytics tools and techniques, Regulation, Social Network Analysis	Service Innovation, Text Mining (unstructured to structured data), Cyber Security, Data analysis,
FP7-HEALTH-2011	REPOPA	http://www.repopa.eu/	2011	5	Policy modelling, Gaming-based simulation	CP-FP	Evidence-informed policy making, Service Innovation, Statistics and Data Analytics, game simulation intervention/ policy game	Simulation in Governance, big data

FP7-PEOPLE-2013-CIG	RISK	https://cordis.europa.eu/project/rcn/109746/	2013	4	policy modelling, big data	MC-CIG	Risk analysis, management	Big data, statistics, Sustainable Development and Governance Responsibility
FP7-ICT-2013-10	SIMPOL	https://cordis.europa.eu/project/rcn/110645/	2013	4	policy modelling	CP	Banking financial networks, systems and risks (risks in global economy), climate and energy policies (based on the 2030 Framework for climate and energy policy), Crowdsourcing impact since the main scope of the project is the opinion of the crowd to be involved in a policy making process	Policy making, policy modelling, Data Analysis, Open Data, Big Data, Linked Data, Sustainable Development and Governance Responsibility
H2020-SFS-2017-1	SUPREMA	http://www.suprema-project.eu/	2018	2	Policy modelling, Big Data, Linked Data	CSA	policy impact analysis, basic skills in analysing results, data acquisition techniques	Interoperability, Data Sharing, Big Data, Linked Data, personalized service, Sustainable Development and Governance Responsibility

3.12 Natural Language Processing

3.12.1 Definition

Natural Language Processing (NLP) is an area of research and application that explores how computers can be used to understand and manipulate natural language text or speech in order to accomplish specific tasks (Noble, 1988). Natural language processing includes many different techniques for interpreting human language, ranging from statistical and machine learning methods, Bayesian and semantic networks to rules-based and algorithmic approaches (Cambria & White, 2014).

One of the great benefits of working with unstructured data (in this case, speech or text input) is that it is created directly by the people with the knowledge that is interesting to decision makers. Unstructured data directly reflects the interests, feelings, opinions and knowledge of citizens (Jade, 2018). Thus, government could use NLP to gain a better understanding of what citizens are discussing any given issue or in general. It allows for a clearer understanding of items that may need to be addressed, from healthcare to consumer safety. Data collection for NLP can be done with the help of data mining, passive crowdsourcing or e-participation tools, both on social media and outside. NLP could help government do a better job of not just listening to the people but answering them as well (Ojo & Millard, 2017).

Why is it relevant to Government 3.0? Digital Government includes a wide range of areas, which can be tackled by NLP, such as e-voting, e-procurement, data collection, management and analysis, inter-agency collaboration, intra- and inter-agency communication, e-learning, and human resource management. Unstructured natural language data collected in social media can be used as a basis for evidence-based decision-making.

3.12.2 Project analysis

Relatively few NLP projects (7) were identified (Table 15). Their identified research needs differ based on the scope of each project but all of them are aiming at eliminating the issues of natural language processing. Towards this purpose, the identified research needs concern the data acquisition [LETS-CROWD], analysis of the data (techniques, NLP using machine learning, tools, etc.) [HELENLP], multi-modal communication [KRISTINA], linguistics [GRAMPLUS], visualisation [CALCULUS] and the human-computer interaction [CALCULUS, NLPRO].

The main identified training needs are the digital government and service innovation [CALCULUS, GRAMPLUS, LETS-CROWD], semantic government [SEMANTAX, GRAMPLUS], software engineering [NLPRO, SEMANTAX], user-oriented systems and data analytics [SEMANTAX, KRISTINA].

Table 15. Identified projects involving Natural Language Processing

Project Call	Acronym	Project URL	Project status	Duration (in years)	Technologies used	Type	Identified research needs	Identified Training Needs
H2020-EU.1.1.	CALCULUS	https://cordis.europa.eu/project/rcn/216225/	ongoing	5	AI, NLP, Machine Learning	pilot	Further investigation on human-computer interaction, common-sense knowledge, visualization techniques, data analysis	Digital Government and service innovation (machine learning techniques, NLP)
ERC-2009-AdG	GRAMPLUS	https://cordis.europa.eu/project/rcn/94111/	finished	5	NLP, Machine Learning	pilot	Psycholinguistics, natural language processing, linguistics, learning/ supervised learning methods and techniques, common-sense knowledge	Semantic e-government, Digital Government and service innovation (machine learning techniques, NLP)
FP7-PEOPLE-2009-RG	HELENLP	https://cordis.europa.eu/project/rcn/95728/	finished	4	NLP, Machine Learning, AI	Large-scale implementation	Natural language problems in various languages and heterogeneous data sources of variable size, quality, amount of supervision and type. NLP algorithms analysis, data acquisition	Big Data, Digital Government and service innovation, data analytics, Sustainable Development and Governance Responsibility, Software engineering
H2020-EU.2.1.1.4.	KRISTINA	http://kristina-project.eu/en/	finished	3	NLP	Research	Dialogue management, multimodal (vocal, facial and gestural) communication analysis and multimodal communication, use cases (for validating the usability and usefulness of the platform)	Digital Government and service innovation, Foundations of Cyber Security, data analysis, software engineering, awareness
H2020-SEC-2016-2017-1	LETS-CROWD	https://letscrowd.eu/	ongoing	2	policy making/modelling, AI	pilot	How a dynamic risk assessment methodology lead to the policy making, identification and analysis of the existing data analytic tools (for security), human-centred tools analysis, social media and data acquisition	Community awareness platforms, Digital Government and service innovation
H2020-EU.1.1.	NLPRO	https://cordis.europa.eu/project/rcn/204693/	ongoing	5	NLP, Text mining	pilot	Robotics, cognitive computing, dynamic interpretation processes (for human - like machines), NLP (in combination with) and SE capabilities,	Software engineering, simulation in government, user-oriented system, Service innovation
H2020-EU.1.1.	SEMANTAX	https://cordis.europa.eu/project/rcn/210257/	ongoing	5	NLP, Machine Learning	N/A	Big data, machine learning techniques, common-sense knowledge	Digital Government and service innovation, Data Analytics, semantic e-government, Software engineering

3.13 Blockchain

3.13.1 Definition

BlockChain (BC) is "*a distributed ledger that maintains a continually growing list of publicly accessible records cryptographically secured from tampering and revision*" (Hou, 2017, p. 1). BC technology can be used to improve the quality of government services (Hou, 2017) by ensuring greater transparency and accessibility of government information (Atzori, 2017), development of information-sharing across different organizations, and assistance in building an individual credit system. BC-based platforms can be used to give citizens or even businesses (Engelenburg et al., 2019) access to reliable government information, which can in turn strengthen the government's credibility. Moreover, within the BC system, every transaction is recorded, which makes it easy to trace the parties authorizing transactions and understand the scope of the transaction. It also means that data can be more easily and safely transferred between different organizations and promoting the integration of information amongst different organizations. Ølnes (2016) reveals that storing certificates on the blockchain is a cost-effective way of storing and securing vital information. Thus, social benefits such as a more collaborative society could be a result of BC technology usage in government (Swan, 2015).

Why is it relevant to Government 3.0? Blockchain can be used as a recordkeeping solution. As long as BC technology uses public keys in association with cryptographic signatures, it provides secure transactions and reliable records. It is particularly useful for the realisation of secure eID service.

3.13.2 Project analysis

A total of 30 blockchain-related projects have been identified (Table 16). The current state of research around blockchain considers the following main topics:

- The creation of decentralized and distributed solutions and ecosystems, in favor of democratic engagement, transparency, citizen empowerment, security, data protection, and privacy.
- Concerns around the efficiency of the public services, the awareness about blockchain and its usefulness for societal problems.
- Implications, benefits, challenges and risks in the use of blockchain solutions for the creation of a digital society, for smart cities, cyber-physical systems, and infrastructure, including digital rights, risks propensity, use of appropriate governance models, consensus mechanisms and applications design.
- The challenges around legal aspects, ethics, and regulation of cryptocurrencies, financial services, and blockchain solutions.
- Benefits, challenges, and risks in the use of the technology for land registry, circular economy, collaborative economy, waste management, and e-voting.

The research needs to consider different aspects, such as scalability, security, data privacy, governance models, and legal issues, more precisely:

- Identify the main challenges and needs to enable Governments to create a scalable distributed network with blockchain technology.
- Identify how regulation should address the benefits of blockchain for society and how to reduce the risks for citizens.
- Characterization of a successful digital society from the perspective of the universal declaration of human rights and digital rights and evaluation of the contribution of blockchain.
- Potential use of blockchain for managing online identity and personal data in a citizen-friendly and privacy-aware way, considering data protection by design and privacy by default, giving citizens the control of their data and the possibility to authorization and disallowance of access to data in different situations.
- The role of the stakeholders in the ethics and governance model of blockchain solutions and its involvement in smart contracts and solution design process.
- Identification of success factors and main challenges in the use of blockchain for the circular economy, waste management, critical energy infrastructure protection, and security, electronic voting, biometric, and health data.
- Influence of blockchain for security issues in the context of smart cities projects.
- Advancements in the legal aspects regarding cryptocurrencies.

- The influence of big tech companies in the financial system of the future, possible scenarios, and how to deal with them. Regulation aspects for big tech companies dealing with cryptocurrencies globally.
- Implications and challenges of computational law
- Information asymmetry around big tech companies, collective risks for society, and the contribution of distributed and decentralized systems using blockchain.
- Compliance of blockchain technology with General Data Protection Regulation and how to deal with the right to be forgotten.
- Regulation of facial recognition and surveillance technology.
- Benefits, challenges, and capabilities development in public and private partnership of blockchain projects.
- Leapfrog in the use of blockchain by the government in developing countries.

The primary training needs are not only about blockchain but also regarding the new opportunities, challenges, and problems addressed by the technology, like the following:

- Definition of main concepts: blockchain technologies, smart contracts, governance models, consensus mechanisms, privacy by design solutions.
- Applications of BC in different areas: Smart Cities, cyber-physical systems and infrastructure, education, financial services, land registry, and e-voting, presenting the potential, risks, and challenges.
- Opportunities addressed by BC: citizen empowerment, appropriate governance models, ecosystem management, data protection, and privacy literacy, transparency in blockchain solutions, characterization of citizen digital rights and digital society, legal frameworks, involvement of stakeholders in governance models and smart contract design, public and private partnerships and the development of competencies.
- Challenges and problems addressed by BC: the centralization of the internet, scalability of blockchain solutions, information asymmetry in the context of big tech companies, regulations, compliance with general data protection regulation, myths, and realities around cryptocurrencies, how to deal with smart contracts and computational law.

Table 16. Identified projects involving Blockchain technology

Project Call	Acronym	Project URL	Project status	Duration (in years)	Technologies used	Type	Identified research needs	Identified Training Needs
H2020-EU.3.7.6., H2020-EU.3.7.1.	ANITA	https://cordis.europa.eu/project/rcn/214862/	ongoing	3	Big data analytics, neural networks	Research	- Systematic literature review about initiatives to deal with the use of cryptocurrencies for illegal activities. - Advancements in the mitigation of the use of cryptocurrencies for online illegal trafficking.	-Advancements in the mitigation of the use of cryptocurrencies for online illegal trafficking.
H2020-MSCA-IF-2017	Anticipatory Ledgers	https://cordis.europa.eu/project/rcn/215119/	ongoing	2	Blockchain	Research	- Characterization of the "governance crisis" in the emerging DLTs and the main challenges to address it. -The role of the stakeholders in the ethics and governance model of blockchain solutions. - The involvement of stakeholders in the smart contract design process. - Ethical aspects, risks and challenges of managing health data in blockchain solutions.	- Definition of governance models of blockchain solutions and ecosystems, success factors and the role of stakeholders in its creation. - Definition of smart contracts, benefits, risks, challenges and the role of stakeholders in its design process. - Neglected issues, ethical and governance guidelines for the use of health data in blockchain solutions.
H2020-ICT-2018-2	ARTICONF	https://cordis.europa.eu/project/rcn/219091/	ongoing	3	Blockchain	Research	- Identification of the main problems with centralized social media, including issues related to privacy, predictability of behaviour, information asymmetry and the lack of transparency of business model. - Opportunities and barriers for the use of blockchain for decentralized social media services.	- Presentation of the main problems with centralized social media, including issues related to privacy, predictability of behaviour, information asymmetry and the lack of transparency of business model. - Presentation of the benefits of decentralized social media and how blockchain can support it.
-	BC in Estonia	https://e-estonia.com/solutions/healthcare/e-health-record/	finished	N/A	Blockchain	Case	- How to deal with the right to be forgotten in European blockchain projects. - The implications of having health data in a blockchain that is supposedly immutable. - Authorization and disallowance of access to data in blockchain projects.	- Right to be forgotten in European blockchain projects.
-	BC in Malaysia	https://www.nst.com.my/news/nation/2018/11/429615/university-consortium-set-authenticate-degrees-using-blockchain	ongoing	N/A	Blockchain	Case	- Potential use of blockchain in education.	- Potential use of blockchain in education.
ERC-2017-STG	Blockchain Society	https://cordis.europa.eu/project/rcn/212798	ongoing	5	Blockchain	Research	- Identify how regulation should address the benefits of blockchain for society and how to avoid or reduce the risks for citizens.	- Regulatory advancements regarding blockchain technology and main legal challenges.
H2020-ICT-2016-2	BLOOMEN	http://bloomen.io/	ongoing	3	Blockchain	Research	- Requirements and challenges to the use of blockchain for content creation, sharing, personalized consumption, monetization and copyrighting.	- The transformation of media content production and distribution in the global entertainment and media industry over the last decades and the potential to use blockchain.
H2020-EU.3.6.2.2.	CO3	https://cordis.europa.eu/project/rcn/218757	ongoing	3	Blockchain, augmented reality, geolocated social network,	Research	- Identification of success factors and benefits for citizens in the use of blockchain technology for co-creation, co-production and co-management of public services. Suggestion to use multiple case studies research.	- The benefits, risks and challenges in the use of blockchain for the co-creation, co-production and co-management of public services.

					liquid democracy tools and gamification			
ERC-2017-ADG	CoHuBiCoL	https://cordis.europa.eu/project/rcn/216234	ongoing	5	Artificial intelligence	Research	- Implications and challenges of computational law. - History and advancements of computational law. - Assumptions in the relation of smart contracts and computational law.	- Computational law: history, advancements, challenges, risks and benefits. - Smart contracts and computational law.
FP7-ICT-2013-10	D-CENT	https://dcentproject.eu/	finished	2.5	Blockchain (Freecoin)	Research	- Analyse the impact of the centralization of the Internet in democracy and society. - Identify the influence of decentralized and distributed platforms and free and open source solutions in democratic engagement. -Verify how blockchain technology can be used as a distributed platform to citizen empowerment and transparency. - Identify the privacy requirements to give citizens the control of their data in blockchain projects.	- The journey of the centralization of the internet and its effects for society and democracy. - Present the initiatives and trends related to the decentralization of platforms. - The role, benefits and risks of blockchain in the context of distributed systems used by citizens. - Requirements and pitfalls of data privacy in governmental blockchain solutions.
H2020-EUK-2018	DECENTER	https://www.decenter-project.eu/	ongoing	3	Artificial intelligence, cloud computing	Research	- The use of smart contracts to customized service level agreements, its potential, challenges and risks.	- Smart contracts, definitions, potential and barriers to its use.
H2020-ICT-2016-1	Decode	https://decodeproject.eu/	ongoing	3	Blockchain	Research	- Systematic literature review about the effect of the centralization of the Internet and big tech companies in innovation. - The potential use of blockchain for managing online identity and personal data in a citizen-friendly and privacy-aware way. - The potential of blockchain for decentralised ecosystems, sustainable and commons-based economy. - The collective benefits of data protection and the collective risks of the lack of data protection. - Information asymmetry around big tech companies and collective risks for society. - Compliance of blockchain technology with General data protection regulation. - Data protection by design and by default: Suggestion of multiple case study research.	- Citizen digital rights. - Open source and free software: differences, history, principles, computer user freedom, community and standards. - Digital democracy. - The effect of the centralization of the Internet in innovation. - Information asymmetry around big tech companies and collective risks for society. - The potential use of blockchain for managing online identity and personal data in a citizen-friendly and privacy-aware. - General data protection regulation and blockchain: compliance and assumptions. - Data protection by design and by default.
H2020-EU.3.7.4., H2020-EU.3.7.2.	Defender	https://defender-project.eu/	ongoing	3	Cyber-Physical Systems, drones	Research	- Contributions of blockchain for critical energy infrastructure protection and security.	- Benefits of blockchain for critical energy infrastructure protection and security.
-	Financial Services	https://moni.com/	finished	N/A	Blockchain	Case	- The use of blockchain to support financial services of communities: technical challenges,	- Use of blockchain to support financial services of communities.

	in Finland						privacy concerns, consensus mechanisms and scalability.	
-	Land records in India	https://medium.com/auxesis/rajasthan-to-roll-out-blockchain-technology-for-land-records-80d181da4daa	ongoing	N/A	Blockchain	Case	- Blockchain's capabilities development in the government of developing countries.	- Blockchain governance and technical capabilities.
-	Land registry in Ghana	http://www.bitland.world/about/	ongoing	N/A	Blockchain	Case	- The contribution of public blockchains to transparency, its vantages and disadvantages.	- Public, private, permission and permissionless blockchains: advantages and disadvantages in different situations.
-	Land registry in UK	https://www.gov.uk/government/news/hm-land-registry-to-explore-the-benefits-of-blockchain	ongoing	N/A	Blockchain	Case	- Efforts in government to develop expertise about blockchain: initiatives, results and lessons learned.	- Advancements in the use of blockchain for land registry in different countries: challenges and results achieved.
H2020-EU.2.1.3., H2020-EU.2.1.5.1.	MARKET4.0	https://cordis.europa.eu/project/rcn/218272/	ongoing	3.5	VR/AR, simulations	Research	- Systematic literature review about the security issues of cryptocurrencies.	- Definition of cryptocurrencies, its developments, problems and potential. - Myths and reality around cryptocurrencies. - Regulation of cryptocurrencies.
H2020-ICT-2016-1	MH-MD	http://www.myhealthmydata.eu/	ongoing	3	Blockchain, eHealth	Research	- Problems and recent advances in data privacy and security in healthcare sector. - Principles and applications of blockchain for data privacy and security in the healthcare sector. - Data anonymization in blockchain solutions.	- Privacy and security in healthcare data, main problems and advances. - Potential use and limitations of blockchain for healthcare data. - Data protection and privacy literacy. - Data anonymization algorithms.
H2020-EUJ-2018	M-Sec	https://cordis.europa.eu/project/rcn/217772	ongoing	3	Big data, cloud computing and IoT	Research	- Systematic literature review about the influence of blockchain for security in the context of smart cities projects.	- Definition, challenges and risks of smart cities. - The use of blockchain for smart cities.
ERC-2017-STG	P2PMODELS	https://cordis.europa.eu/project/rcn/212785/	ongoing	5	Blockchain	Research	- Identification of self-enforcing rules for automatic governance and economic rewarding, in the use of blockchain for collaborative economy. - Identification of factors influencing users empowerment in blockchain applications for collaborative economy.	- Definition of agent-mediated organizations for collaborative communities. - Opportunities, challenges and risks with the use of blockchain for collaborative economy.
H2020-EU.3.7.6.	PoSeID-on	https://cordis.europa.eu/project/rcn/214840/	ongoing	2.5	Blockchain	Research	- Benefits of blockchain to end users for enabling data protection by design and by default.	- Data protection by design and by default: history, technical and governance requirements, advancements.
H2020-EU.2.1.1.	PTwist	https://ptwist.eu/	ongoing	2	Blockchain, Gamification, analytics, open source and	Research	- Identification of success factors and main challenges in the use of blockchain for circular economy and/or waste management. Suggestion to do a multiple case studies research.	- Presentation of cases of open source and blockchain solutions for circular economy and/or waste management. Presentation of the main benefits and challenges with the use of the technology for this purpose.

					open data solutions		- Identify the factors influencing the implementation of open source solutions using blockchain for circular economy and/or waste management.	
H2020-EU.3.6.2.2.	QualiChain	https://cordis.europa.eu/project/rcn/218758/	ongoing	3	Blockchain	Research	- Potential use of blockchain for education and employment qualifications management - Identification of needs and requirements from the different stakeholders for the governance model and for the design of the solution.	- Potential use of blockchain for the creation of ecosystems, with different stakeholders and requirements. - Process for the involvement and requirements gathering from the stakeholders in the definition of a governance model for a blockchain solution.
H2020-EU.3., H2020-EU.2.3., H2020-EU.2.1.	Roksnet	https://www.roksnet.com/	finished	0.25	Blockchain	Research	- Identify the main challenges to enable Governments to create a scalable distributed network with blockchain technology. - Characterization of a successful digital society from the perspective of the universal declaration of human rights and digital rights.	- Main challenges for the scalability of blockchain solutions for public services and how to address them. - Characterization and conditions for a successful digital society for the citizens.
H2020-EURO-6-2015	SONNETS	https://www.sonnets-project.eu/	finished	1.5	Blockchain	Research	- How to increase the efficiency of public services in the identification, monitoring and early detection of societal needs. - Propose a methodology to support the timely awareness of emerging technologies and their usefulness for societal problems.	- Lessons learnt from developed countries with the use of blockchain for public services that can be useful for the leapfrog of developing countries.
H2020-EU.3.7.4., H2020-EU.3.7.2.	STOP-IT	https://stop-it-project.eu/	ongoing	4	Computer vision	Research	- Implications of cyber physical threats and vulnerabilities for smart cities and smart homes. - The use of blockchain solutions to tackle cyber physical threats.	- Cyber physical threats and vulnerabilities. Its implications for smart cities and smart homes. - The use of blockchain for cyber physical systems and its potential to deal with attacks.
-	Sweden's Land registry	https://www.coindesk.com/sweden-demos-live-land-registry-transaction-on-a-blockchain	ongoing	N/A	Blockchain	Case	- Benefits and challenges in public and private partnership of blockchain projects. - Capabilities development in public and private partnership of blockchain projects. - Governance model and legal aspects in public and private partnerships of blockchain projects.	- The use of public and private partnerships in blockchain initiatives: challenges and governance model.
H2020-EU.3.7.6., H2020-EU.3.7.1.	TITANIUM	https://www.titanium-project.eu/	ongoing	3	Machine-learning, deep neural networks	Research	- Advancements in the legal aspects regarding cryptocurrencies. - The influence of big tech companies in the financial system of the future, possible scenarios and how to deal with them. - Regulation aspects for big tech companies dealing with cryptocurrencies globally. - Legal and ethical framework for investigations of crime and terrorism on the internet: controversies and concerns.	- The challenge to deal with the use of cryptocurrencies for money laundering and other illegal activities. - Legal frameworks and compliance of cryptocurrencies.
-	Zug IDs	https://www.ethnews.com/zug-and-uport-see-first-citizens-	finished	N/A	Blockchain	Case	- Systematic literature review about the use of blockchain for electronic voting: benefits, technical	- The requirements for e-voting and the contribution, risks and challenges with the use of blockchain.

		identity-registered-on-the-ethereum-blockchain					and data protection challenges, risks, potential and implications.	

3.14 eID and eSignature

3.14.1 Definition

The EU Regulation No 910/2014 of the European Parliament and of the Council of July 23, 2014 on electronic identification and trust services for electronic transactions in the internal market defines electronic identification or eID as: *"the process of using person identification data in electronic form uniquely representing either a natural or legal person, or a natural person representing a legal person"*[7]. In other words, eID is a way for citizens, businesses or administrations to prove electronically that *"they are who they say they are and thus gain access to services"* (European Commission, 2007). The same Regulation defines electronic signature or eSignature as *"data in electronic form which is attached to or logically associated with other data in electronic form and which is used by the signatory to sign"*[8]. An eSignature can represent a person's intent to agree to the content of a document or a set of data to which the signature relates, and a qualified electronic signature should have the same legal effect as handwritten signatures.

The adoption of systems such as eID and eSignature in the realm of public administrations allows a proper organisation autonomy, supporting access to the services offered by the institution. These services will also help increase the progressive adoption of cloud computing by public administrations (De Angelis et al., 2016). eID solutions can also provide citizens with the possibility to set up a business or to change a residence. This, together with an increasing mobility of citizens, provides the possibility of using eIDs issued in other states and thus enabling easy, simple and efficient handling of certain matters including tax payments for citizens of other countries (Průša, 2015).

Why are they relevant to Government 3.0? eID and eSignature solutions are fundamental pillars of the digital government systems, allowing for a more effective identification and authentication of citizens, facilitating access to government services and contributing to an easier, more simple and efficient handling of certain matters.

3.14.2 Project analysis

A total of 19 projects have been identified as related to the e-Identity/e-Signature technologies (Table 17). The main identified research needs can be classified in the following clusters:

- **Authentication and identification solutions.** This cluster includes research topics such as integration of authentication and identity services, authenticity and integrity of the hardware components, identification solutions for anyone who does not have a SIM card, common secure login on the Internet, federation and "interchangeability" of technologies that support trustworthy yet privacy-preserving, attribute-based credentials, authentication assurance, cross- border authentication (via eIDAS), cross- border authentication between cloud platforms, cross-border authentication, authentication mechanisms and distributed Ledger (e.g., OpenChain).
- **Trust infrastructure** cluster includes the following research topics: trust infrastructure for authentication, identity ecosystem, ID-card system, standardized, trustworthy and ubiquitously usable eID client.
- **Privacy issues.** Here are included research topics such as privacy enhancing authentication protocols for the real world and improved privacy in cloud identity management services.
- **Non-technical requirements.** This cluster includes research topics such as support of digital identity projects, driving multi-stakeholder collaboration to set the future course of digital ID, defining functional requirements to influence its technical development, funding projects deploying promising solutions in a range of environment, accelerating access to digital ID to underserved vulnerable populations, advocating for the widespread adoption of ethically-grounded digital ID solutions, and assisting in their implementation, advancing sustainable development; good practices on design and implementation; and standards and emerging technologies, raising awareness, harmonizing interests, and strengthening coordination among a range of actors, and facilitates peer-to-peer knowledge sharing, provides technical assistance to countries and regional organizations through a range of instruments in three stages: assessment and roadmap; design and dialogue; and implementation, Helps countries realize the transformational potential of inclusive, robust, and responsible digital identification systems, ensuring integration of digital identification systems.
- **Security aspects.** This cluster collects research topics such as reputation-based web of trust (WoT), aspects of security, security of proxy re-encryption schemes, new technologies, processes and security features for physical and virtual identity management.

[7] https://www.eid.as/Regulation

[8] ibid.

- **e-Signature aspects.** Research topics such as long-term preservation of signatures, remote signatures, attribute management and exchange, cloud signature, signing of online contracts and global trust validation of electronic signatures.
- **Mobile identity:** mobile signing, mobile eID, mobile phone wallet systems and mobile-ID.
- **Interoperability** includes the topics of cross-border interoperability of electronic representation and electronic mandates and cross-border interoperability.
- **Biometric** aspects cluster includes research needs such as biometric identity, strengthening the link between physical documents linked to the biometric and the digital (online and also mobile) identity and Identity management and biometrics.
- **Societal, ethical and legal aspects** include needs related to the societal, ethical and legal aspects of identity theft, privacy-by-design principles, and ethical, legal and sociological requirements in the development of ePassport solutions and liability provisions in the eID and trust services regulation.

Identified training needs that result from the collected projects include: interoperability aspects, different types of standards (identification protocols, authentication assurance, data protection, wireless public key infrastructure (PKI), open standards, standards for exchanging authentication and authorization data (SAML), authentication), privacy (personal data), trust, security, distributed ledger techniques, ethics, mobile signature techniques, cloud computing, authentication methods/techniques/schemes, security in integrated circuits (detection of functional clones or of counterfeited circuits), societal aspects of identity, legal aspects of identity, usability, biometric technologies, encryption techniques, system friendliness, project management.

Table 17. Identified projects involving eID and eSignature

Project Call	Project Acronym	Project URL	Project status	Duration (in years)	Technologies used	Type	Identified research needs	Identified Training Needs
FP7-ICT-2009-5	ABC4Trust	https://abc4trust.eu/index.php/home/fact-sheet	finished	4	e-Identity / e-Signature	proof of concept	Federation and "interchangeability" of technologies that support trustworthy yet privacy-preserving Attribute-based Credentials (ABC)	• Privacy technologies • Standards (authentication) • Authentication methods
H2020-FCT-2015	ARIES	https://aries-project.eu/	ongoing	2.5	e-Identity / e-Signature	proof of concept	• Identity ecosystem • New technologies, processes and security features for physical and virtual identity management • Biometric identity Strengthening the link between physical documents linked to the biometric and the digital (online and also mobile) identity	• Security • Privacy • Ethics • Standards (data protection)
H2020-DS-2014-1	CREDENTIAL	https://credential.eu/	finished	3	e-Identity / e-Signature	proof of concept	• Improved privacy in cloud identity management services • Security of proxy re-encryption schemes Authentication mechanisms	• Identification protocols (SAML, OpenID) • Encryption techniques • Authentication techniques • Privacy
2016-EU-IA-0064	eID@Cloud	https://www.arcos.inf.uc3m.es/eidcloud/	ongoing	N/A	e-Identity / e-Signature	large scale implementation	Cross- border authentication between cloud platforms	• Cloud Computing Interoperability
CEF-TC-2018-1	eID4Spain	https://lmtgroup.eu/eid4spain/	ongoing	N/A	e-Identity / e-Signature	large scale implementation	Cross- border authentication (via eIDAS)	• Standards (authentication) Interoperability
-	e-Identity	https://e-estonia.com/solutions/e-identity/smart-id/	finished	N/A	e-Identity / e-Signature	large scale implementation	• ID-card system • Mobile-ID Identification solution for anyone that does not have a SIM card	• Authentication techniques
FP7-SEC-2013-1	EKSISTENZ	https://cordis.europa.eu/project/rcn/188570/reporting/en	finished	3	e-Identity / e-Signature	proof-of-concept	• Societal, ethical and legal aspects of identity theft; Identity management and biometrics	• Societal aspects of identity • Ethical aspects of identity Legal aspects of identity
FP7-SEC-2011-1	FIDELITY	http://www.fidelity-project.eu/	finished	4	e-Identity / e-Signature	proof of concept	Privacy-by-design principles, and ethical, legal and sociological requirements in the development of ePassport solutions.	• Privacy (personal data) • Public trust and social acceptability of eIdentity • Ethical considerations in relation to privacy, social injustice and discrimination • Biometric technologies
FP7-ICT-2011-8	FUTUREID	http://www.futureid.eu/	finished	3	e-Identity / e-Signature	pilot	• Easy and cost-effective integration of authentication and identity services	• Standards (authentication) • Interoperability • Privacy • Trust

							• Coherent European trust infrastructure for authentication • Standardized, trustworthy and ubiquitously usable eID client • Privacy enhancing authentication protocols for the real world Addressing non-technical requirements	
H2020-DS-2015-1	FutureTrust	https://www.futuretrust.eu/	ongoing	3	e-Identity / e-Signature, Customised/ Personalised Public Services	pilot	• Distributed Ledger (e.g. OpenChain) • Reputation Based Web of Trust (WoT) aspects of security • Global trust validation of electronic signatures • Long term preservation of signatures • Remote signatures Mobile signing	• Interoperability • Privacy • Trust • Security • Distributed ledger techniques
FP7-SME-2013	HIGHTRUST WALLET	http://htw-public.nr.no/	finished	2	e-Identity / e-Signature	framework	Mobile phone wallet systems ePayment system	• Security Authentication methods
FP7-ICT-2011-8	HINT	http://hint-project.technikon.com/	finished	3	e-Identity / e-Signature	proof-of-concept	Authenticity and integrity of the hardware components	• Security in integrated circuits (detection of functional clones or of counterfeited circuits) • Authentication schemes (PUF technology)
-	ID2020	https://id2020.org/	ongoing	N/A	e-Identity / e-Signature	Support action	• Supports digital identity projects • Driving multi-stakeholder collaboration to set the future course of digital ID • Defining functional requirements to influence its technical development • Funding projects deploying promising solutions in a range of environment • Accelerating access to digital ID to underserved, vulnerable populations Advocating for the widespread adoption of ethically-grounded digital ID solutions and assisting in their implementation.	• System usability • System friendliness • Ethics • Standards • Project management
-	ID4D	http://id4d.worldbank.org/	ongoing	N/A	e-Identity / e-Signature	N/A	• Advancing sustainable development; good practices on design and implementation; and standards and emerging technologies.	• Project management • Ethics • Standards

							• Raising awareness, harmonizing interests, and strengthening coordination among a range of actors, and facilitates peer-to-peer knowledge sharing. • Provides technical assistance to countries and regional organizations through a range of instruments in three stages: assessment and roadmap; design and dialogue; and implementation. • Helps countries realize the transformational potential of inclusive, robust, and responsible digital identification systems. Ensuring integration of digital identification systems	
SMEInst-13-2016-2017	IDENTITY	https://cordis.europa.eu/project/rcn/204584/	finished	0.5	e-Identity / e-Signature	proof of concept	• Cloud signature Signing of online contracts	• Cloud computing • Standards(identity) • Security
-	NemID	https://www.nemid.nu/dk-en/about_nemid/index.html	finished	N/A	e-Identity / e-Signature	large scale implementation	Common secure login on the Internet	• Authentication techniques
CIP-ICT-PSP-2009-3	SEMIRAMIS	http://semiramis-cip.atosresearch.eu/	finished	2.8	e-Identity / e-Signature	pilot	• Cross-border interoperability Cross-border authentication	• Interoperability • Usability • Security • Trust • Privacy • Standards for exchanging authentication and authorization data (SAML)
CIP-ICT-PSP-2010-4	SSEDIC	https://cordis.europa.eu/project/rcn/191782/	finished	3	e-Identity / e-Signature	proof of concept	• Liability provisions in the eID and Trust Services Regulation • Mobile eID • Attribute Management and Exchange Authentication assurance	• Authentication assurance frameworks and standards • Semantic interoperability • Mobile signature techniques • Wireless PKI standards
CIP-ICT-PSP-2011-5	STORK 2.0	https://cordis.europa.eu/project/rcn/191751/	finished	3.5	e-Identity / e-Signature	pilot	Cross-border interoperability of electronic representation and electronic mandates	• Interoperability Open standards (SAML)

4. Scenarios for the use of disruptive technologies in Government 3.0

4.1 Government 3.0 Future Scenarios

To investigate the training and research needs arising in the implementation of Government 3.0 services, thirteen scenarios have been developed involving the technologies and concepts presented in section 3. The aim of each scenario is to provide a realistic, but not quite yet realised way to implement the disruptive technologies for the provision of government services. This way, it is possible to look into the future, identifying the needs, which are "around the corner" and will become more pronounced as the disruptive technologies become widely adopted in government. The 13 scenarios presented in the next subsections are the following:

1. Smart City AI-aided emergency monitoring system
2. Intelligent citizen portals connected across Europe using chatbot interface for easy interaction with citizens
3. Virtual and Augmented Reality for emergency training
4. Open Data lifecycle: maximizing OGD benefits
5. Digital government through Cloud Computing
6. Using IoT to monitor soil erosion and degradation
7. Gamification in energy consumption
8. Gaming-based simulation and policy modelling
9. Natural Language Processing in tourism
10. Blockchain for vehicle lifecycle management
11. Using e-ID and e-Signature for verified health data sharing
12. Co-creation of APIs using OGD
13. Community Awareness Platforms for behavioural change

The technologies presented are all interconnected and support each other, some technologies serving as enabling to the others. For that reason, all of the scenarios involve more than one technology. The correspondence between the thirteen scenarios and individual technologies is presented in Table 18.

Table 18. Correspondence between the scenarios and concepts

	Sc.1	Sc.2	Sc.3	Sc.4	Sc.5	Sc.6	Sc.7	Sc.8	Sc.9	Sc.10	Sc.11	Sc.12	Sc.13
Big Data	■					■			■				■
OL Data				■								■	■
IoT	■					■							■
Smart City	■						■						
AI/ML/Robotics	■	■				■							
AR/VR			■										
Cloud Computing	■				■	■					■	■	■
Co-creation				■				■				■	
OOP		■											
Service Modules		■											
CAPS													■
Gamification			■				■						
GBS								■					
Policy Modelling													
NLP	■	■							■				
Blockchain				■						■			
eID/eSignature		■									■		

Multiple scenarios per technology allowed to investigate the use of technology from different angles and in different areas of application. This allowed identifying more diverse and comprehensive array of research and training needs.

Following subchapters present the suggested scenarios in detail. Each scenario is illustrated by a scenario diagram and accompanied by the textual description. Identified researched and training needs (with the help of expert opinion, based on the methodology presented in 2.1.2) are listed along each scenario and later summarized in Section 4.2.

4.1.1 Scenario 1: Smart City AI-aided emergency monitoring system

Municipal operation centres play an important role in the response to emergencies and natural disasters through communication and coordination (Kula & Guler, 2016). City management centres support a variety of functions, for example: monitoring of vehicles and public transportation, control of traffic flow and adjustment of traffic lights to avoid traffic jams, monitoring and tracking of accidents in real time, enabling correct resource allocation to address a situation, collecting data on environmental conditions, allowing the measurement of air pollution, water levels and seismic activity, as well as aspects such as public participation and accountability through the monitoring of employees (Kitchin, 2014a). Their operations are based on real-time analysis, which are, however, mainly manipulated by isolated systems and controlled by a single agency (Kitchin, 2014b).

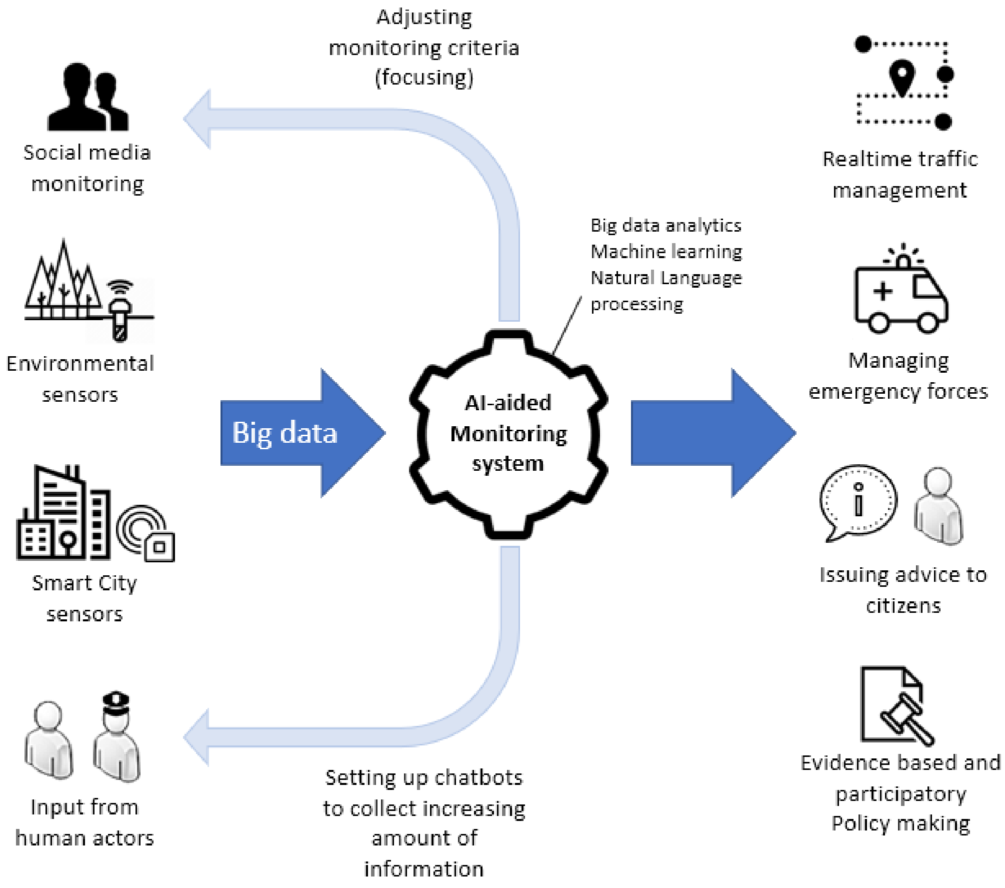

Figure 4. Future scenario "Smart City AI-aided emergency monitoring system"

As an evolution of those isolated systems, the operation centres represent an attempt to unify the management of several city aspects through the monitoring and analysis of public data from different agencies in a single location (Kula & Guler, 2016). The future scenario presented in Figure 4 outlines an improvement of emergency monitoring and response with the help of disruptive technologies by using AI-aided monitoring. Even though somewhat similar monitoring systems already exist (e.g. in Brazil (Matheus et al., 2018; Viale Pereira et al., 2017), where the information from various sources is aggregated and analysed in a smart operations centre), the incoming information is usually processed by people manually (Viale Pereira et al., 2017). In high-intensity emergency, this may not be optimal as it creates a significant bottleneck in the system, and employees of the monitoring centre are not able to process huge amounts of data coming in over a relatively short period of time.

In the Belo Horizonte emergency centre, for example, it was estimated that including a social media messages monitoring component would increase the reaction time by 5 minutes in a fallen overpass case (Viale Pereira, 2016). Real time social media analysis is not a task well suited for manual analysis though, it is much better accomplished using a machine learning trained system (Batrinca & Treleaven, 2014). There have been successful examples of the use of social media analysis for crisis mapping (Middleton et al., 2014) and emergency awareness (Yin et al., 2015).

In the 'Smart City Emergency AI-aided monitoring' scenario, AI is not only used for message analysis. Instead, AI, Machine Learning, Big Data and natural language processing are used to analyse and to make decisions based on (often unstructured) data from multiple sources: environmental and smart city sensors, information from human actors (voice and message data from emergency support lines), as well as textual and visual data from social media.

Furthermore, the AI-aided Monitoring System does not only aggregate data and provide reports to the human officials to act upon. The System also actively makes decisions based on the incoming data. In the case of an unfolding emergency situation, we envision the following areas, where the decisions may be made by the System:

1. *Realtime traffic management.* Traffic flow may be diverted or managed in a way that allows best access to the affected areas for the emergency forces. This is already achievable with the current level of technology that can be used for real-time traffic management (Abduljabbar et al., 2019).
2. *Emergency forces management.* Organisation of large-scale effort may be aided by planning based on the incoming information.
3. *Issuing advice to citizens.* Specific advice for the citizens can be formulated and updated regularly in natural language based on the available information.
4. *Evidence-based policy making.* In the long run, the data analysed by the System can be used to improve public policy, or to formulate new laws and regulations.

In order to be trustworthy, the system needs to be transparent, being able to provide detailed justification for any action it takes at any given moment. In case some decisions need to be corrected, the system also needs to offer a capability to override actions and decisions by the responsible officials.

4.1.2 Scenario 2: Intelligent citizen portals connected across Europe using chatbot interface for easy interaction with citizens

The scenario "Intelligent citizen portals connected across Europe using chatbot interface for easy interaction with citizens" details a possible use of AI and machine learning coupled with natural language processing technology, realizing a chatbot interface for better cross-border public services. Figure 5 illustrates a scenario when a citizen wants to relocate to a different country. Relocating to another country or similar action involving two or more different countries often carry high administrative burden. Citizens not only have to organize many documents over a short period of time, but also have to consider the different regulations of their home compared to the destination country. In the future, the use of intelligent citizen portals with chatbot interface simplifies the organisation of complicated procedures involving authorities in multiple countries.

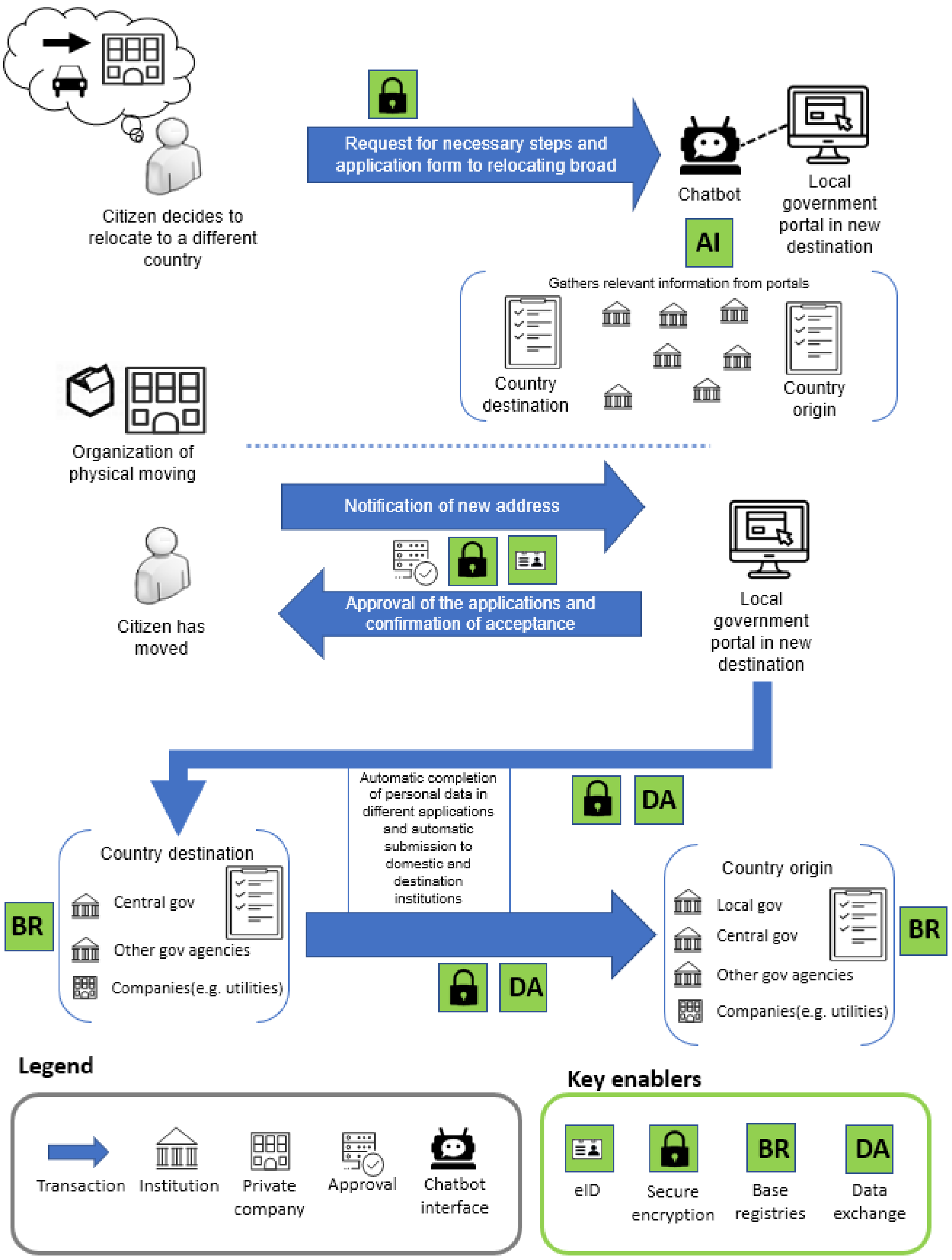

Figure 5. Scenario "Intelligent citizen portals connected across Europe using chatbot interface for effective interaction with citizens"

A citizen uses a smartphone to contact the government chatbot and requests help with the process. The citizen can send messages written in natural language without the need to use specific commands. The chatbot then processes the text using Natural Language Processing and AI to understand the meaning of the request and provides relevant answer. In further future, the chatbot can even process the voice commands and provide answers. The chatbot acts as an interface connecting a citizen to the intelligent portal. The portal is designed in a way to interoperate with other portals and databases across Europe. If eID is used by the citizen, the portal application can then use it to access the relevant information across borders (according to the Once Only Principle). The application can also identify the missing information required for the relocation of the citizen and ask necessary questions to gather this information. Furthermore, the intelligent portal can automatically complete foreign forms and help with understanding the specific terms, aiding through the conversation with a chatbot.

Based on the Once only principle, AI, NLP and the intelligent citizen portal, relocating abroad (and other similar cross-border formalities) is no longer a complicated matter for the citizen and for public authorities. Additionally, the chatbot itself can be realised as a service module, which can be easily integrated in different city/regional portals all over Europe, thus promoting code reuse, cutting costs and improving efficiency.

4.1.3 Scenario 3: Virtual and Augmented Reality for emergency training

The scenario "Virtual and Augmented Reality for emergency training" describes how the AR and VR technologies with some gamification elements can be used to facilitate emergency training, specifically training for handling emergencies inside the public buildings.

In a case of emergency, people in public buildings (e.g. schools, hospitals) have to be rescued quickly and efficiently. Possible emergencies include fires, earthquakes, floods, other natural disasters and terrorist attacks. In many EU countries, all employees in public buildings have to participate in mandatory emergency trainings. Those trainings take place at least once a year and the participants learn how to implement first aid measures and how to handle the alarm equipment and fire extinguisher. Additionally, public buildings are required to perform fire drills or evacuation drills, which take place at least once a year. In some cases, the fire brigade and police officers are called in for support.

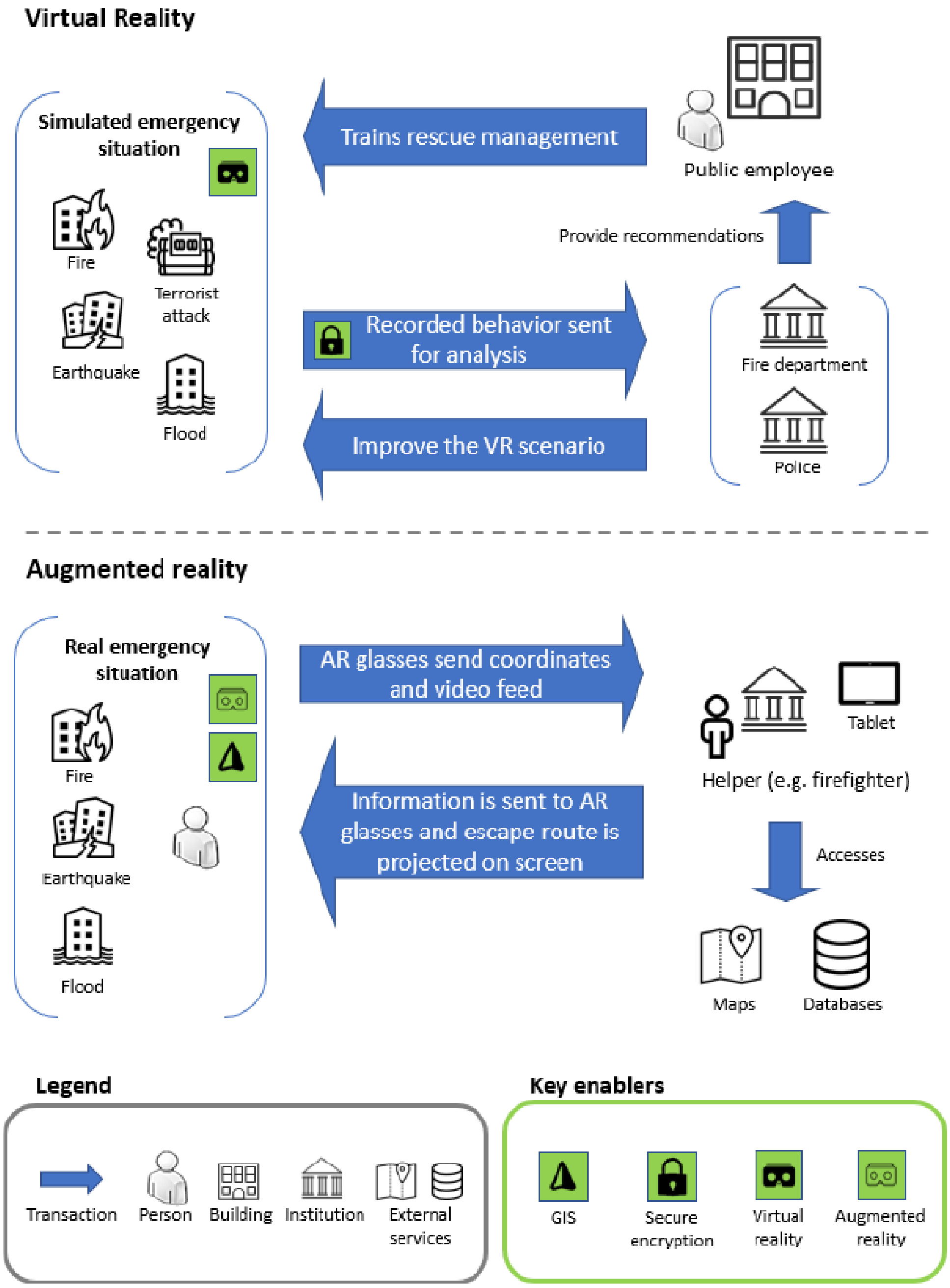

Figure 6. Scenario "Virtual Reality and Augmented Reality for emergency training"

In the future (Figure 6), public employees are able to translate the learned theoretical knowledge into practice through using virtual reality. The whole public building is displayed in virtual reality simulation, where different crisis scenarios could be played out. While the instructions are currently only theory-based, with the help of virtual reality the employees can experience and train the evacuation in a practical setting. Gamification approach can also help make the simulation more immersive. To achieve a realistic surrounding and higher plausibility, multiple human senses are addressed. The VR glasses could display dense smoke in the public buildings and corridors in case of an alarm. Additionally, the sense of smell could be stimulated through artificial fragrances, the sound of the fire, sirens or voices of other people could be recorded, and radiant heaters could be used to stimulate the aural and temperature sensation. The employee's behaviour and the interactions between the employees and with other persons who are in the building (e.g. patients) will be recorded and analysed by special consultants from fire and police force. Those specialists will give improvement suggestions to the employees. Thus, they can implement them in the next training which takes place twice a year. It is also possible to include situations when something does not go “according to the book”, for example if there are missing or injured people. If there is such an emergency in the reality, those who participated in the virtual reality training may react better. They might be calmer because they have already experienced such a situation several times.

Augmented reality in turn is implemented to aid the public employees in case of real emergency situations. The employees wear AR glasses which will be connected to the coordinators from the rescue force. The AR glasses are provided with a GPS module to determine and transmit the exact position. The GPS data are sent to the coordinators at emergency services; thus, they know the exact position and are able to navigate the employees using a map or a building plan. They can also use external databases to get more information about certain important aspects for the situation (e.g., piping, electrical wiring, etc.). Furthermore, the coordinators can receive additional data from sensors placed in different areas of the building (such sensor may sense heat for example near a specific exit). This allows the rescue coordinator to determine the fastest and safest way out of the building. More efficient than just voice support, the helper will send the exit route to the employee's AR device and the glasses display it.

4.1.4 Scenario 4: Open Data lifecycle: maximizing OGD benefits

A Ministry of Health fulfills many duties in which they work with data - the keep the health records of citizens, sanction pharmaceutical products to be used in the country, keep track of receipts, manage budget and expenses of hospitals and so on. In this scenario, with the introduction of the new Freedom of Information Act, the Ministry is now required by law to release Open Governmental Data – something it has not done before (Figure 7).

To grow up to this challenge, the Ministry is now working on identifying the skills and competencies they have to make sure their staff has. To maximize the value of their data and their work, they don't only consider Open Data processes that happen in the Ministry, but also how they can support data use outside of their organization - directly or indirectly. The Ministry must identify skills and competencies on all stages of the Open Data lifecycle – creation/collection, preparation, publishing, and usage, collaboration and feedback by Open Data users.

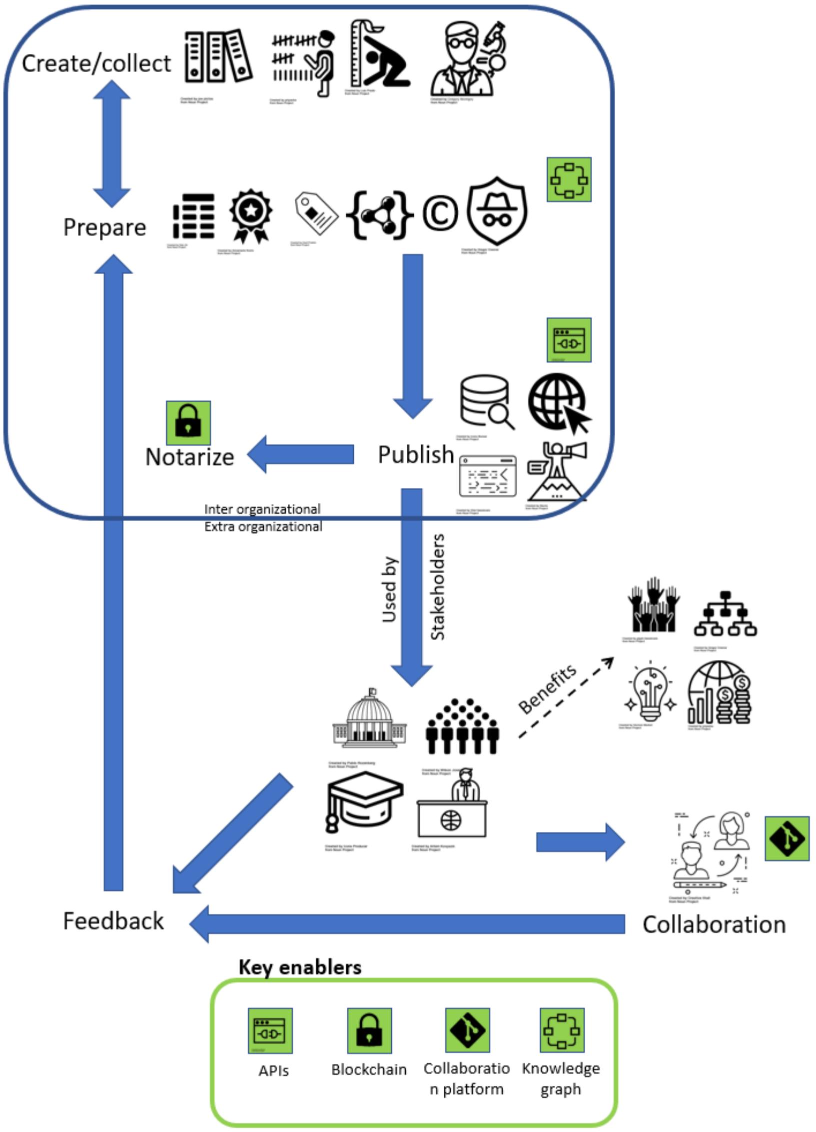

Figure 7. Scenario "Open Data lifecycle: maximizing OGD benefits"

Managing Open Data is a complex challenge that requires a variety of skills and competences. The Ministry has to think of what users of Open Governmental Data really need, comply with relevant laws, deal with technical tasks, review internal processes and organizational structure, etc. to make sure that OGD achieves maximum benefit.

During the data creation and collection phase, the skills and competencies of archivists, surveyors, data scientists are necessary for the Open Data-specific tasks, along with those of domain-specific background. While preparing data for release as Open Data, data scientists are needed to guarantee adequate formatting, linkability, and data quality, as well as metadata. Metadata quality can also benefit from the expertise of digital humanities experts. Legal professionals should, in this stage guarantee proper licensing as well as oversee privacy-related issues with data. Publishing Open Data should be done by web developers and designers, as well as database designers, developing websites, APIs, and connecting to Open Data Portals. Public relation skills are useful in disseminating and popularizing the published datasets at this stage.

As people from academia, private sector, as well as students, journalists, etc. use Open Data, the Ministry may utilize professionals to help these users achieve better value from Open Data. Educators and domain experts can help users get started with or make better sense of the content of Open Data. The Ministry might provide platform for collaboration – either in form of an online collaboration platform, or hackathons, coding clubs, conferences, to enable co-creating and better data exploitation. Community organizers, web developers, educators, and domain experts are all useful in this effort. To make sure that users' opinions of and experiences with Open Data are heard by the publishing organization – the

Ministry – the skills and competences of community organizers, but also ones related to organizational, change and project management are useful. If user feedbacks are heard, learned from and if relevant, implemented the Open Data lifecycle is achieved.

4.1.5 Scenario 5: Digital government through Cloud Computing

The proposed scenario (Figure 8) suggests a way to organise the digital government services taking advantages of the cloud computing and ensuring modularity of the services. Over the years with decreasing costs of hardware and internet bandwidth, cloud computing has become more and more affordable. This led to the emergence of IaaS (Infrastructure as a Service), PaaS (Platform as a Service) and SaaS (Software as a Service) concepts, which outsource different aspects of the service management and functionality to the cloud service providers.

In the scenario, the services offered by the public service providers make use of PaaS (Platform as a Service) offerings, which allow to provide consistently high-quality services to the administrations at different scales: from smaller municipalities to the public services on the national level. In this model servers, storage, networking, operating system and middleware are all managed by the PaaS provider and authorities pay only for the resources they actually use.

The services are realised using the modular structure of software building blocks (BBs), which allow quick development of new services and modification of specific shared aspects of the existing services. E.g., if the new authentication method needs to be added (new citizen ID), then the re-usable authentication module is modified and not every application that has authentication separately.

Such approach is especially beneficial for local authorities that lack the resources and capabilities to develop digital government products in-house. Highly professional developers, managers and architects engaged in the development applications for PaaS digital government would be able to create services complying with the most advanced security and privacy guidelines.

At the local level, authorities would only need to create web interface (or use a standard building block) that interacts with PaaS applications via the API. This will require far less resources and will allow to concentrate on the usability and user friendliness of the digital government services. Similarly, if a local authority offers mobile app, specific services can be called from the app using the API. PaaS-based services can also become part of the Smart City as different components can interact with these services using API. Immediate challenges in this regard concern the modification of the existing digital services and realising the communication between the PaaS-based applications and legacy on-premise applications, with the final objective of transitioning away from on-premise services.

As (ideally) authorities deal with the same types and formats of data, the solutions can be standardized, using the same applications for the provision of services. This standardization can even transcend borders once the Once only principle is realised. Of course, realising such cloud-based services across borders inevitably leads to significant concerns related to security, privacy and data ownership, which need to be addressed before any such scenario will be possible. Still, if realised, this vision will lead to significant cost savings and improvement in the quality of service for the end-user.

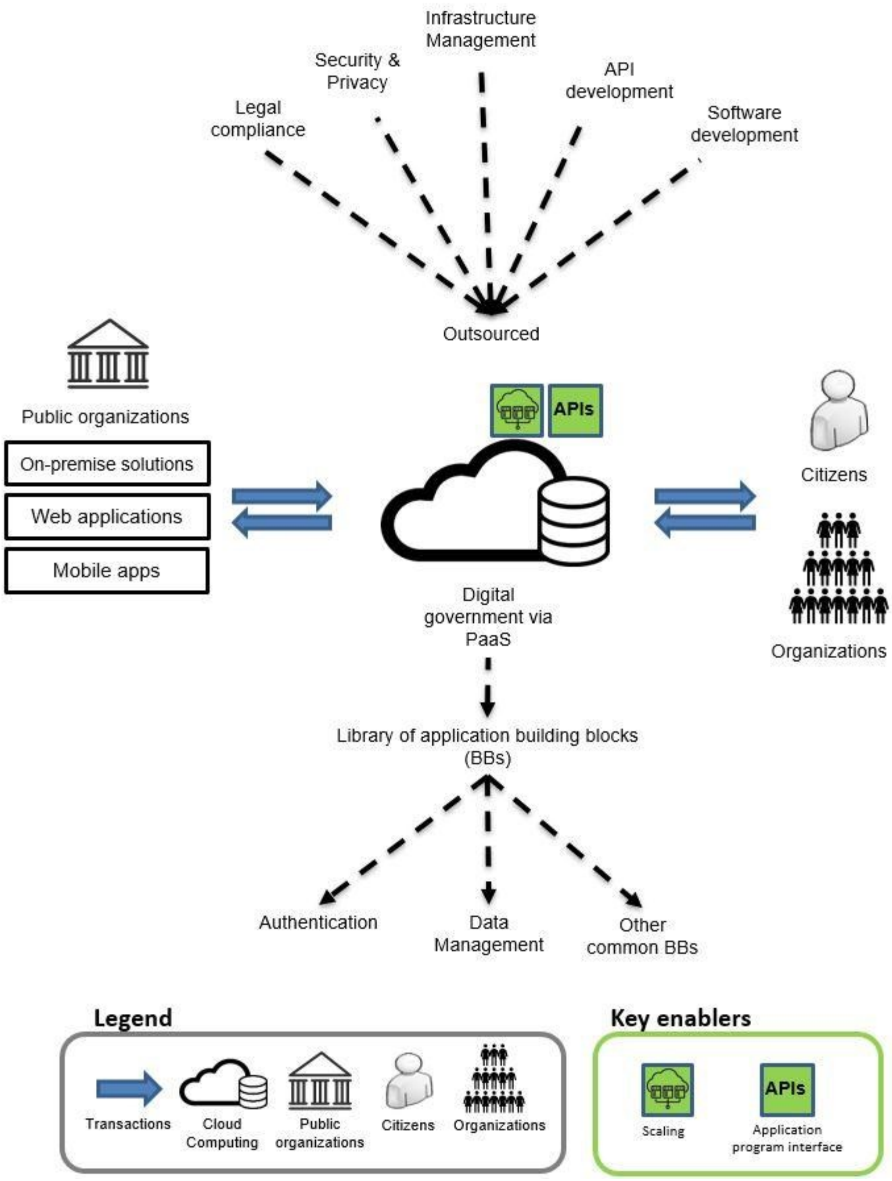

Figure 8. Scenario "Digital government through Cloud Computing"

4.1.6 Scenario 6: Using IoT to monitor soil erosion and degradation

Scenario "Using IoT to monitor soil erosion and degradation" (Figure 9) describes possible application of IoT for soil monitoring. In this scenario, sensors, data loggers and other IoT devices are used to collect the data on the quality of soils in different areas (both farmlands and forests). A remote system is implemented to keep track of the conditions of soil moisture and mineral holding capacity. The system collects data at specified intervals from points of interest on the network through data loggers, about the levels of carbon (C), nitrogen (N) and phosphorus (P), as well as pH levels. These data are then transmitted and analysed automatically (using AI technology, machine learning). Since we do not deal with any personal or sensitive data, there is no need to take extra measures for data privacy. However, the transfer of data should be reliable, since data loss can result in false assumptions that can harm decision making. The received data is analysed from a team of experts in forestry, agriculture and geology. The software application also provides the possibility to use big data analysis techniques and Artificial Intelligence to automatically perform analysis of the data. This can include for example the use of ML to identify patterns over several months and compare them to the data from previous years or other territories to identify possible problems or abnormalities. When the levels of the measured data reach threshold points or

AI system predict reliably negative changes in the future (e.g., pattern of changes that have led to the threshold points in the past), the team of experts decides on restoration techniques and action plans are developed. Again, as the system is widely implemented and used, ML can be consequently also used to provide suggestions for the courses of actions, based on outcomes of previous decisions (e.g., realising long-term planning based on evidence from previous interventions rather than just on the available current data).

This system will be implemented both in forests and private farming lands. In the cases, where forests are affected from soil erosion, the intervention plans will be further on deployed from the ministry of forestry and agriculture. For farming lands, the action plan must be first discussed with farmers and then revised based on their feedback. After it has been agreed upon a final plan, the farmers have to take actions accordingly and are the ones in charge.

Through the implementation of this system, the monitoring of forests and farmlands are now easier for the government. It also reduces the costs compared to manual monitoring. The interventions are made before the actual erosion or degradation happens, which better preserves the soil. The benefits of it are enriched lands, better crop yields, good financial returns, and a balanced environment.

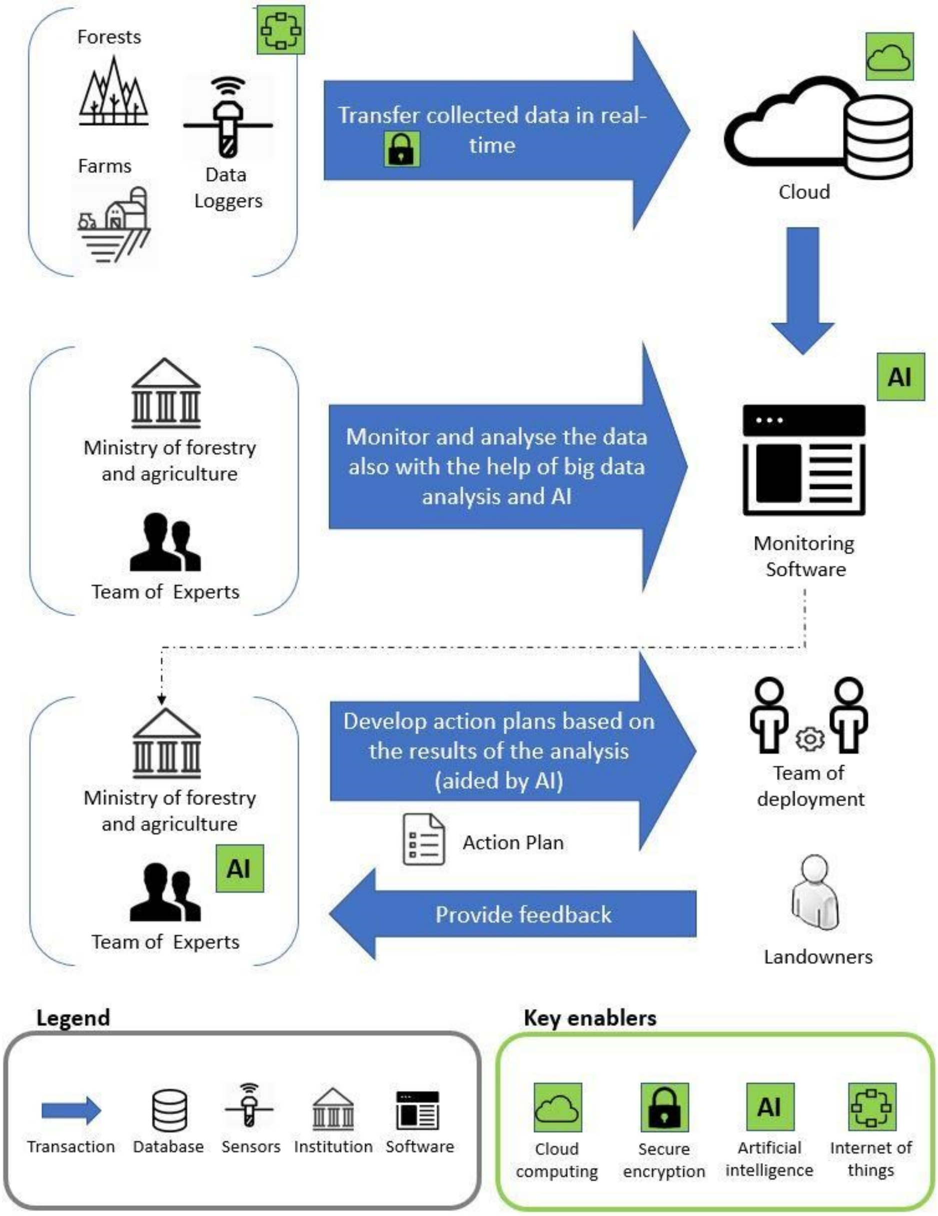

Figure 9. Scenario "Using IoT to monitor soil erosion and degradation"

4.1.7 Scenario 7: Gamification in energy consumption

“Going green” is the adoption of a different but a better way of life that embraces an environmentally mindful lifestyle, helps preserve and protect the environment. Going green can be expressed in many ways and can be affected by citizens’ daily habits and initiatives. The reduction of energy consumption is one of the habits which are friendly to the environment. Lowering the energy consumption reduces the amount of the released toxic fumes which are necessary to generate energy (e.g., through burning gasoline, gas), and can lead to a healthier world.

In the scenario (Figure 10), gamification is used to promote environmental awareness to citizens and to reduce power consumption as a result. For the goals of this scenario to be achieved, smart electric meters for homes and businesses, as well as corresponding mobile applications are used.

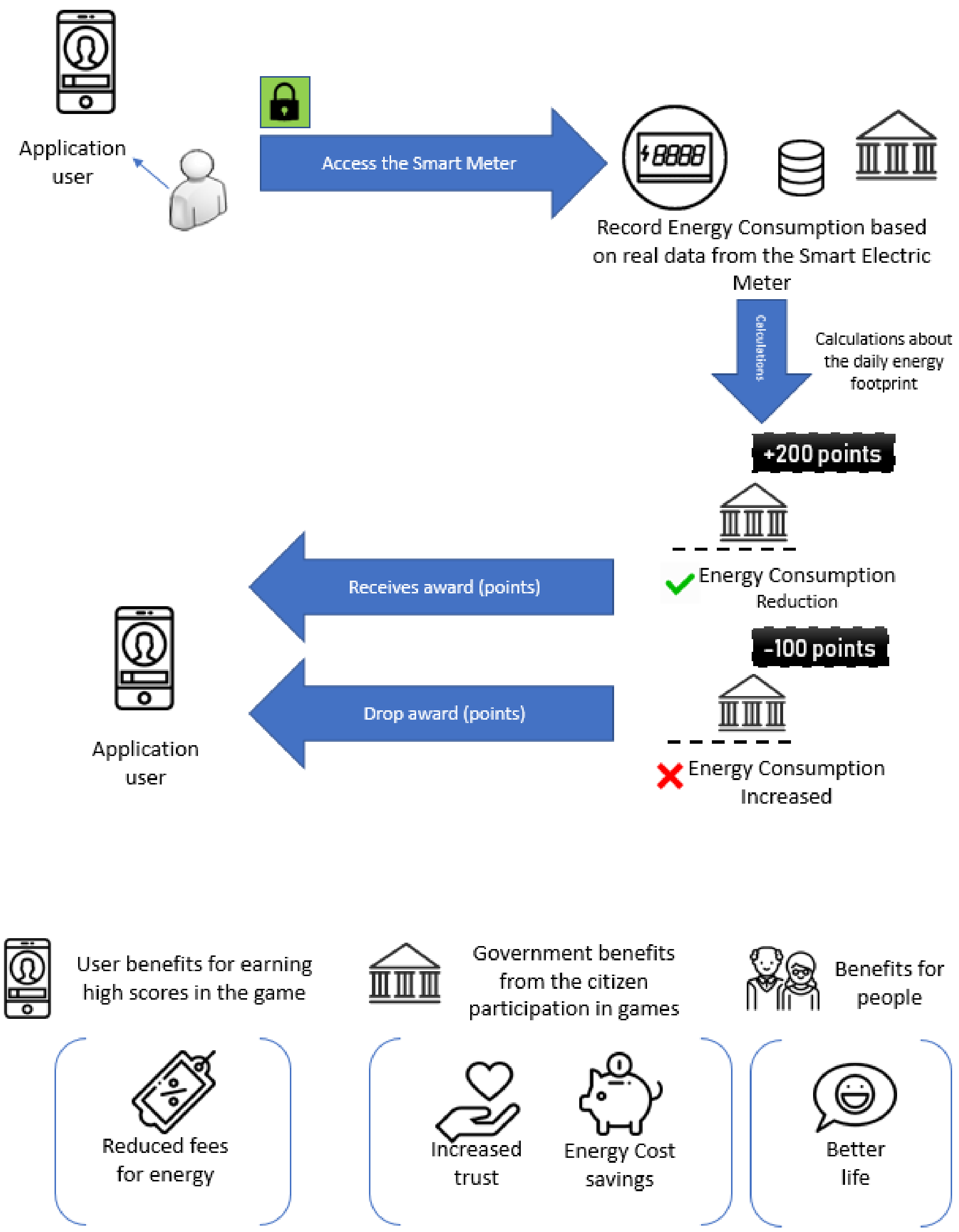

Figure 10. Scenario "Gamification in energy consumption"

A citizen/ business uses the application to view their score compared to others in their regions and the best score nationally/ worldwide. The score only changes in cases of reduction of the energy consumption (score is increased) and in cases in which the energy consumption is increased (score is decreased). Based on the score each player earns or loses points which earned points can be used to reduce their personal fees (e.g., by 10% of the energy cost). A smart electric meter is used to count the daily consumption of energy per home/ business.

4.1.8 Scenario 8: Gaming-based simulation and policy modelling

Worldwide, governments have to model a new policy concerning the criminality of a city without evidence about the reaction of citizens and businesses. Especially, when a city has increased number of crimes, governments may, for instance, either open new police stations or hire additional police officers in order to decrease the crime rate. This policy modelling usually has positive impact on society because citizens and businesses feel safer in the city. However, if a government takes an action in different areas of the urban management, citizens and businesses may be happier and more satisfied. Scenario (Figure 11) suggests a way of exploring the outcomes of different urban policies without actual need of implementing the policies or running pilots.

In the scenario, gaming-based simulation is used to (1) observe the reaction of citizens in business in an area with high criminality, (2) provide information to governments about the opinion of citizens and businesses (depending on their actions and feelings) in the field of safety, and (3) help governments to find the best way of applying their new policy in the same field.

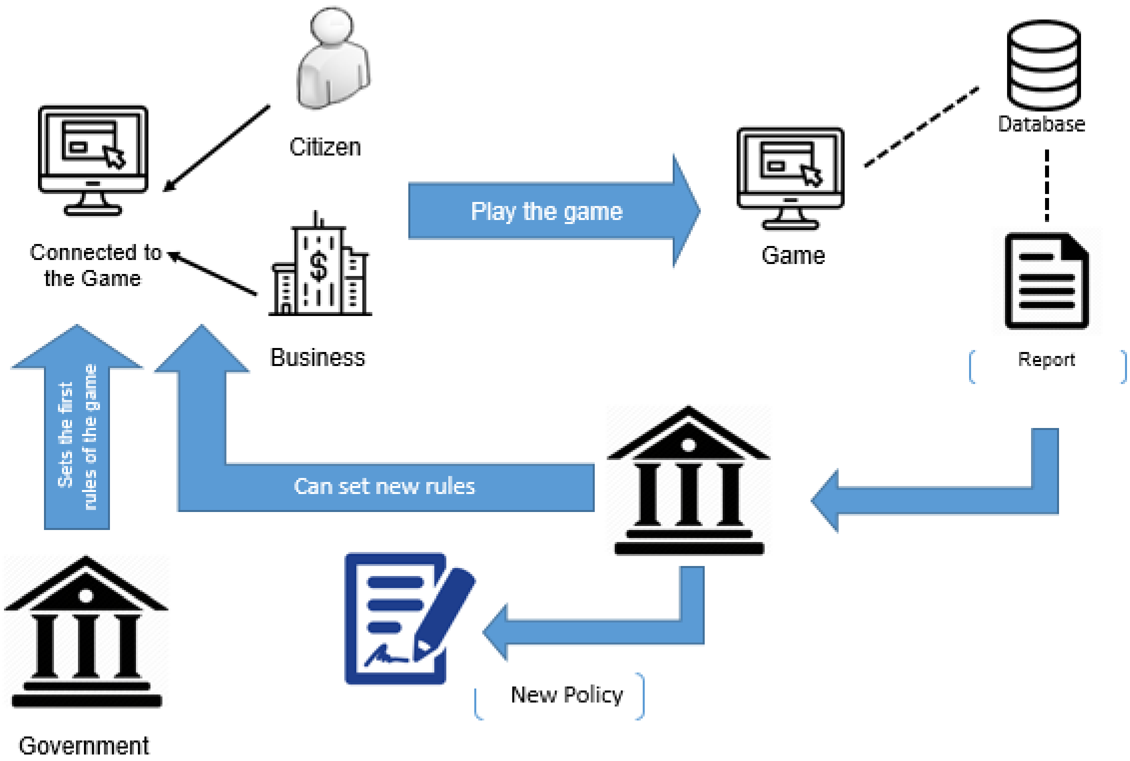

Figure 11. Scenario "Gaming-based simulation and policy modelling"

A group of citizens and businesses plays a simulation game in order to interact with the game rules and changes. The changes and the rules are applied by the public administrators who execute the government policy (for example, Government decide to open new police stations in the neighbourhoods of the city with high crime rates and public administrators apply this policy in the game). This simulation game is fed with real data about the criminality of a city which is the target of the government policy. Players (citizens and businesses) are playing this game for 4 hours of real time game (2 virtual years) and interact within the game. The government is monitoring the reaction of players through automatically generated reports which are produced periodically (e.g., every 6 in-game months). Finally, Governments then have the information about reactions of citizens and businesses, which can be used to evaluate the effectiveness of the new suggested government policy and then they can make decisions based on data.

4.1.9 Scenario 9: Natural Language Processing in tourism

Tourism is one of the most "web-based" markets worldwide where tourists generate and use large volume of data. There is a plethora of websites and platforms that tourists can use for planning and organizing their travel. Aside from the tourist-specific websites and platforms there are a lot of social networks, forums and blogs, which include tourist information and reviews and can be used for identifying points of interests (e.g., museums). But searching and querying such a big data by standard search engines may be difficult.

In this scenario (Figure 12), Natural Language Processing is used to (1) automatically interpret collected data concerning the museums, (2) provide information to governments concerning the disadvantages museums face, based on the collected data, and (3) provide personalised information to tourists based on their comments and preferences (information entered into the system (if any).

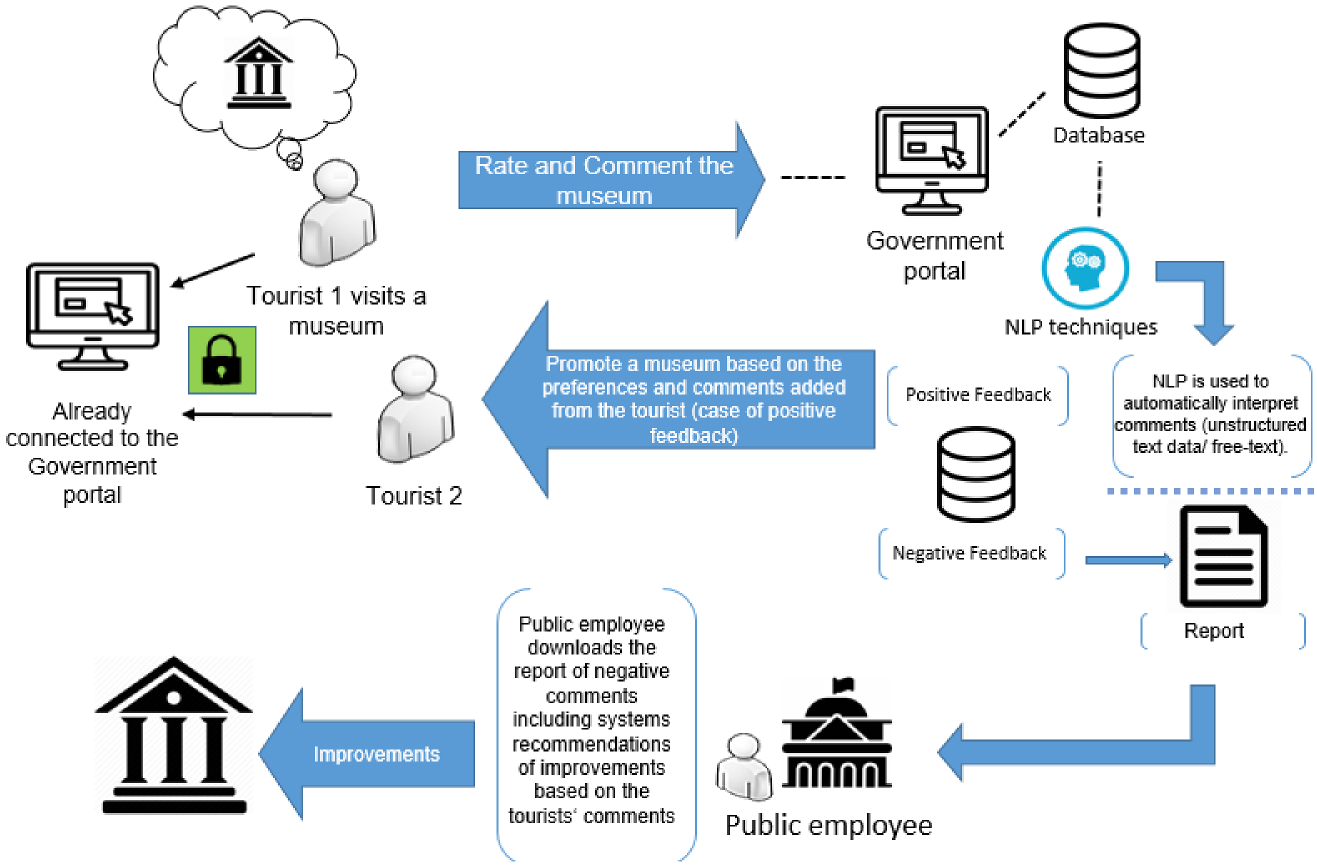

Figure 12. Scenario "Natural Language Processing in tourism"

A tourist uses the system developed by the government system, where he or she can rate and comment on any museum after the visit. The developed system uses Natural Language Processing firstly to understand whether a comment is positive or negative and afterward to provide information to the government regarding the possible improvements to museums (in cases of a negative comment) and to tourists to advertise points of interests based on their preferences (in case of a positive comment). Government employees use a different interface than tourists where they have access to the system's report which includes all the negative comments with the proposed solution based on the comments (e.g., "the museum was dirty, you should clean it"). The system can process different European languages to ensure considering as much information as possible.

Museums have the power to contribute to the economy, social capital and the well-being of a local community. Governments can react to the discontent expressed by the visitors (e.g., negative comments which indicate that maintenance of the building is needed) and thus the attractiveness and the attendance of the museum will be improved. At the same time, less-known museums will be advertised to the tourists.

4.1.10 Scenario 10: Blockchain for vehicle lifecycle management

During its lifecycle a vehicle undergoes various phases and activities such as test, repair, loan and changes of ownership. This process often includes registrations and taxes, therefore governmental institutions are a frequently involved stakeholder. One of the critical activities related to a vehicle's lifecycle is the shift of private ownership when a car is traded and the ownership changes from one person to another. For this to happen, the involved parties are required to fill out an official registration to know the owner, and thus collect the associated taxes. When trading a car, an imbalance of information appears between seller and buyer. The buyer must believe that the seller is providing the correct registration certificate. This implies a risk of the car being undesirably modified, in debt or even stolen property. The seller, on the other hand, has to trust that the buyer registers the car. Among other things, this implies a risk of the buyer driving on levies paid by seller or further that buyer uses the car for undesirable matters, in worst case illegal matters (Berryhill et al., 2018).

It is possible to develop a solution beneficial to all the involved stakeholders (Figure 13), using blockchain to manage the vehicle lifecycle (Berryhill et al., 2018; Schwabe, 2019). All data concerning the car is saved in a blockchain and creates one shared record of the vehicle history. The advantages of the blockchain solution are the following: no vehicle information inconsistency, information security, integrity and validity, leading to increased efficiencies, improved resilience with mitigation from cybersecurity and fraud risks, elimination of manual processes tied to registration and thus minimise existing operational costs. The government regulator can populate the registration for the new vehicles onto the blockchain. The smart contract protocol can be used to ensure that only the regulator can do this. The regulator then transfers the ownership of the vehicle to the manufacture by invoking a transaction on the blockchain. The transaction is verified if consensus exists. The manufacturer adds the model, VIN and other information of the car. This update is visible to all members of the system with the right permission. Transfer of a vehicle's ownership is done securely when seller initiate the transfer, by using the VIN number of the vehicle, the receiver's personal id or VAT and the terms of transfer such as price and time of expiration. Thereby the receiver is notified and accept the deal or decline it. When the receiver fulfils all terms, the seller of the vehicle can seal the deal. Hence, the vehicle is transferred to a new owner. The advantages of this system are achieved through the cryptography, consensus mechanisms, real time transactions and completely transparency of the history of the vehicle (Berryhill et al., 2018).

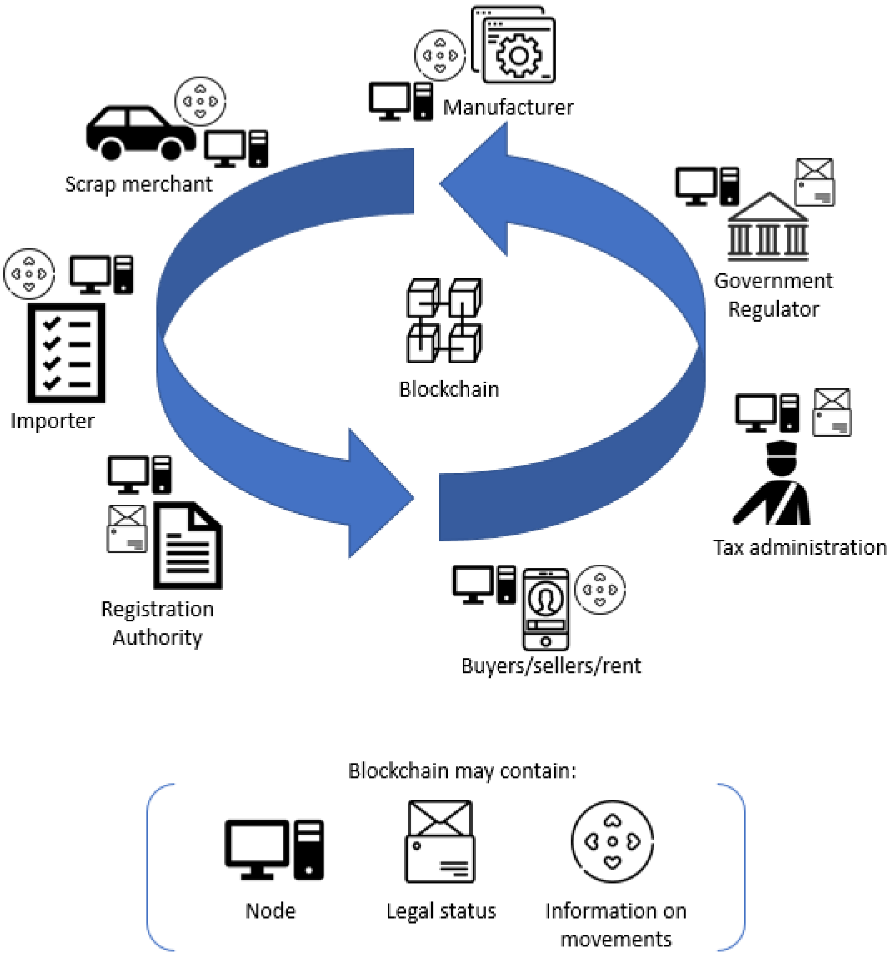

Figure 13. Scenario "Blockchain for vehicle lifecycle management"

4.1.11 Scenario 11: Using e-ID and e-Signature for verified health data sharing

Future applications of e-Identity/e-Signature will possibly enhance aspects of existing digital systems (i.e., the choice, speed and security of digital transactions). One such future application might come from the relationship between e-Identity/e-Signature and data provenance. e-Identity/e-Signature does not only answer the question 'how can you prove that you are who you say you are?', but it can equally provide answer to the question 'how can I be sure where this data comes from?' or even, 'how can I be certain who this data belongs to?'. The impacts of this on the value of data (personal and nonpersonal) and where it accrues, could be profound.

A possible application scenario is related to health data (Figure 14). Using wearable sensors, 'smart' devices and digital personal diaries, an individual may be able to collect a vast amount of personal health data. This individual could be asked to share, or could offer to share, that data with, say, a healthcare provider or health research body. At this point, a choice could be presented to them as to whether their data is used solely to build aggregated data sets and effectively anonymised or destroyed thereafter, or whether it is permanently attached to them, allowing for more data, including more contextual data, to be added in the future.

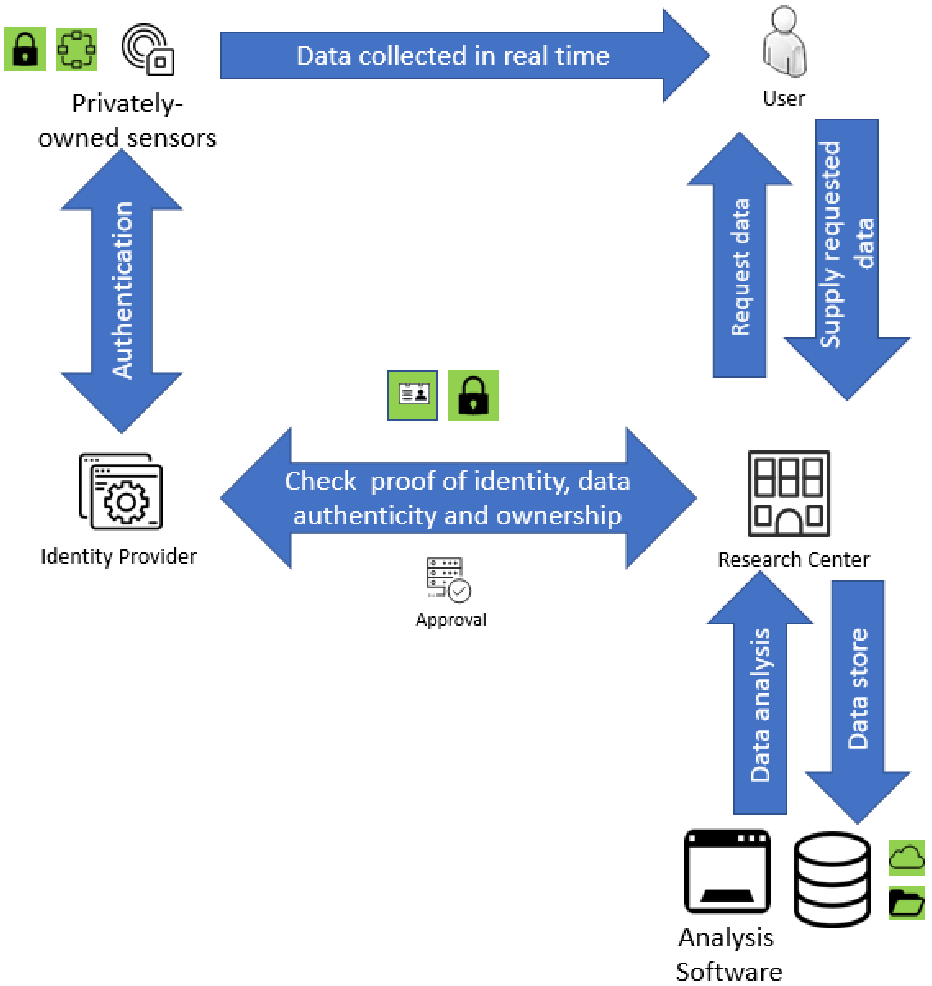

Figure 14. Scenario "Using e-ID and e-Signature for verified health data sharing"

By allowing the data to be attached to them, the individual would be greatly enhancing its value. Assuming that the data collector can be sure that the data does indeed come from the same person and can also be sure that any future data from that person can be attached to it, they can learn a great deal more from it. Likewise, for the individual there is the possibility of being provided with a much more highly personalised and therefore effective healthcare service.

It is around the degree of confidence that the health researchers have in the provenance of the data that a digital identification comes in. Digital identification could be used at both ends of such a transaction, validating the consumer's identity during data collection by sensors, and then during the sending of the data to the data collector. Theoretically, a digital identification could be used to share other verified data (in the form of identity attributes) providing even greater context to the original health data, and again increasing its value to the researchers (Future Agenda, 2019).

4.1.12 Scenario 12: Co-creation of APIs using OGD

The future scenario for co-creation is depicted in Figure 15. The starting point is collection of data from the government, which are then stored in databases and made available in open databases (this can be realized using a cloud-based system, but it is not critical for the scenario). Consequently, the data can be re-used by citizens and businesses (through an API), aimed to provide an informational base for data-based decision making and long-term policy development. The benefits for citizens and the government itself are multifold. Citizens benefit from having more user-centric devices. They also benefit from having their contribution recognized (e.g., in volunteering), and finally the government benefits from the participation of the citizens in the public service creation, from the one end due to the increase in trust, and on the other hand co-creation increases the efficiency of the service, therefore boosting cost saving.

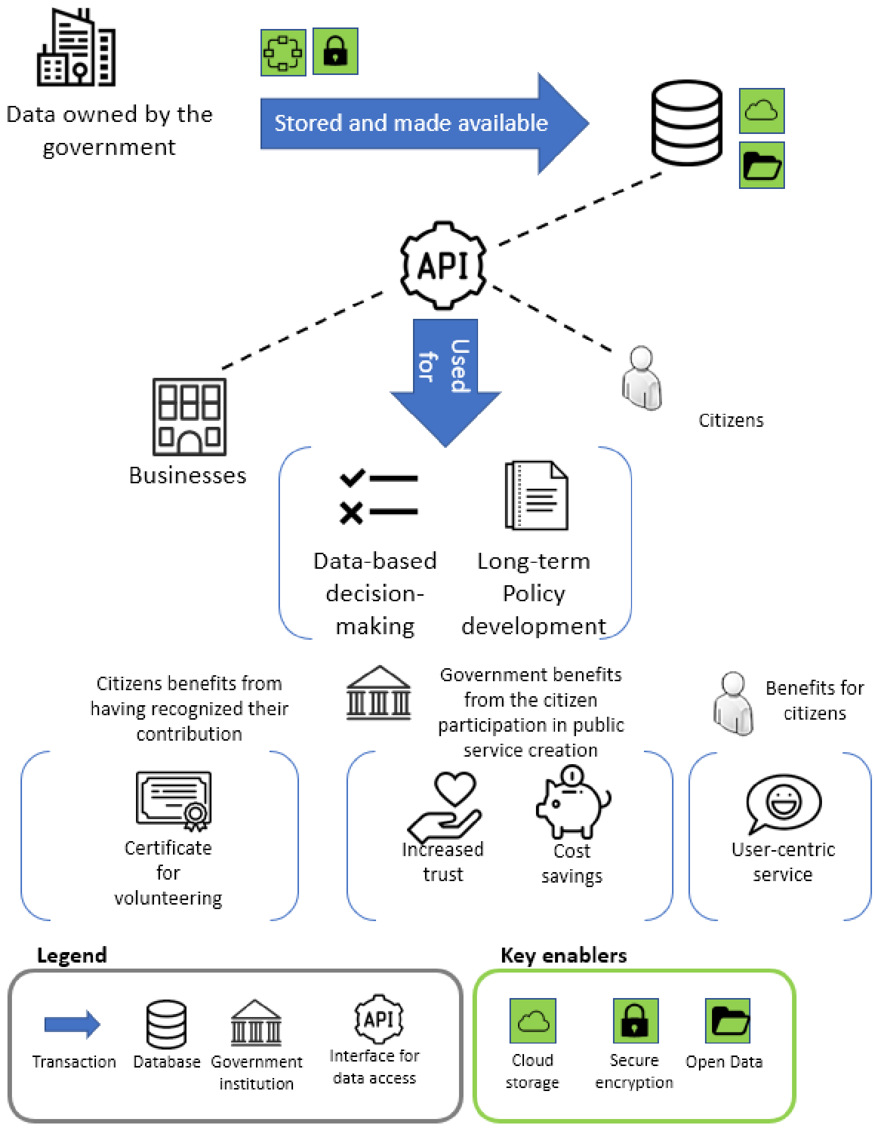

Figure 15. Scenario "Co-creation of APIs using OGD"

4.1.13 Scenario 13: Community Awareness Platforms for behavioural change

In the future scenario for community awareness platforms for behavioural change, data from linked open government databases, social networks and sensors (Internet of Things, mobile phones, smart meters), are aggregated and interpreted into online platforms as shown in Figure 16. Therefore, the citizens are involved in using such platform, which on one hand can increase their awareness of the certain issues, and, on the other hand, nudge their behaviour in a way that is positive for the society.

The underlying idea is to create a feedback loop between citizens, who provide new data, and the platform. An example of an already existing community awareness platform for behavioural change is provided by hackAIR, which is an open platform for measuring and publishing outdoor air pollution levels. This platform pushes citizens towards behavioural change, provides information for data-based decision making, as well as an information base for long-term policy development. Naturally, CAPs can be used to promote positive change in many other aspects of life: e.g., disclosing regional statistics about speeding infractions, bad habits (e.g., smoking, alcohol-related crimes) can lead to behaviour change of the citizens who exhibit behaviour below the average in their neighbourhood (i.e. driving over the speed limit, while most their neighbours don't).

Furthermore, the community awareness platforms can also be used to co-create policy decisions by providing evidence for the need for certain decisions or illustrating the positive changes brought by the same policy changes elsewhere.

Depending on the types of data used, challenges may include privacy and security concerns as well as concerns about profiling, digital exclusion and automated decision making. This concerns need to be addressed before the CAPs are implemented.

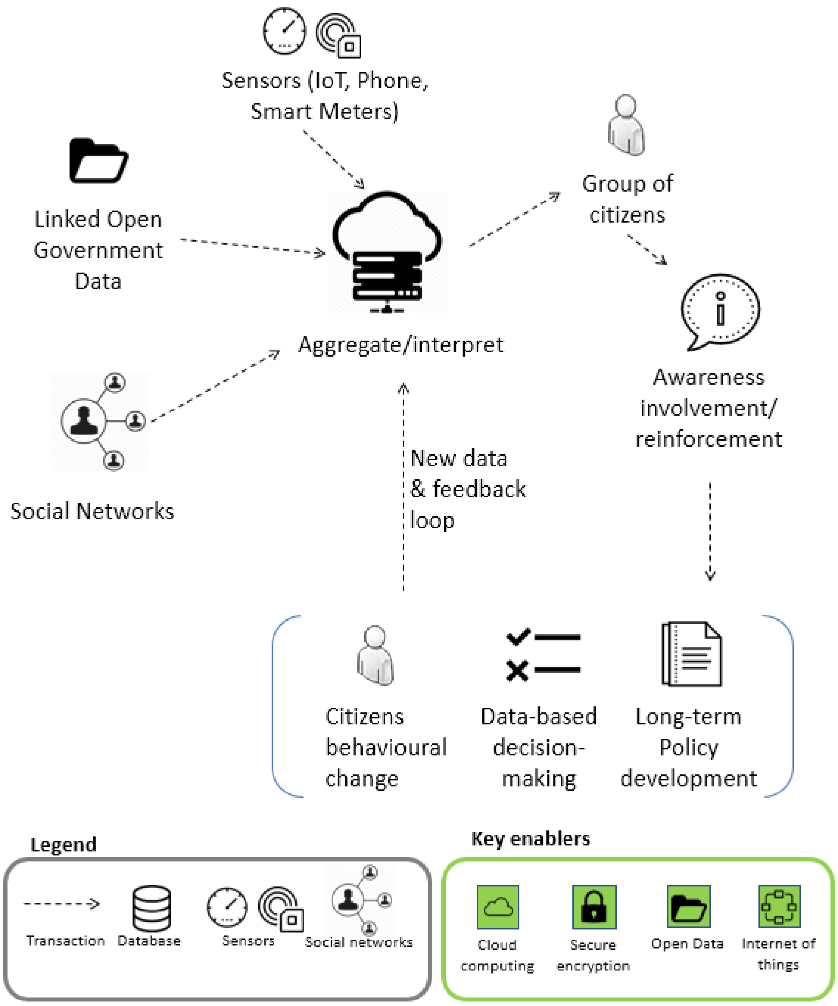

Figure 16. Scenario "Community Awareness Platforms for behavioural change"

4.2 Research and training needs in the future scenarios

Based on the expert analysis of the future scenarios presented in Section 4.1 (based on the methodology described in section 2.1.2), a number of research and training needs have been identified and summarised along the technologies/concepts in Table 19. Research and training needs are listed with the scenario number serving as a source for the need indicated in brackets.

Table 19. Research and training needs identified during the scenario analysis

Technology/ concept	Identified research needs (scenario number)	Identified training needs (scenario number)
Big Data	Data Accuracy (1)	Data quality (1)

	Social media data analysis (1, 13) Data quality (1,4)	Data analysis (1) Data modelling (6)
Open Linked Data	Stakeholder engagement (4) Data quality (4) Open Data lifecycle (4) Organisational change (4)	Data quality (4) Data analysis (4) Open data collection and aggregation (4) Managing Open Data (4) Data collection (4) Stakeholder engagement (4)
IoT	Data Accuracy (1, 6) Standardization of sensors (6) Cost-benefit analysis of IoT solutions (6) Optical recognition, advanced sensing (6) Maintenance and sustainability of sensors (6) Legislation in IoT domain (6) Blockchain for data storage (6)	Maintenance and sustainability of sensors (6) Legislation in IoT domain (6) Deployment of IoT sensors (6) Public sector innovation (6)
Smart City	Making sense of large amounts of urban data (1) Real time data-based decision-making (1) Decision support systems (1) Public trust (1)	Public trust (1) Algorithms of automated decision making (1) Data ownership (1)
AI/ML	Real time urban data analysis (1) Transparency of decision-making (1) Analysis of unstructured data from Social Media (1) Policy-making based on data (6) (Real time) decision making (1, 6) Legal issues in automated decision-making (1,6) Ethical decision making (1)	Data analysis (1) Decision making theory (1, 6) Monitoring of autonomous systems (1) Algorithms of automated decision making (1, 6) Decision systems modelling (1)
AR/VR	Data privacy (3) 3D mapping technologies (3, Modelling of environments in VR (3) Use of beacons for AR (3)	Data privacy (3) Use of VR/AR technologies (3) Modelling of environments in VR (3) Training the trainers (3)
Cloud Computing	Organisational change (5) Cloud services privacy and security (5) Legal aspects (5)	Cloud services security (5) Legal aspects (5) Cloud management (5)
Co-creation	Co-creation in specific areas of digital government (12) Liquid democracy tools (12) Citizen engagement strategies (12) User-centric services (12)	Public sector innovation (12) Citizen trust (12) Citizen engagement strategies (12)
OOP	OOP-related technologies (2) OOP methodologies (2) OOP regulation (including private sector) (2) Data privacy (2)	Different areas of application of OOP in public administration (2) Data privacy (2) Data regulation (2) Data ownership (2)
Service Modules	Re-using service building blocks (2)	
CAPS	Community building (13) Citizen engagement strategies (13) Network analysis (13) Social Media data analysis (13)	Use of CAPS (13) Data Privacy (13) Data ownership (13)
Gamification	Citizen engagement strategies (7, 12) Behavioural change (7, 12)	Environmental awareness (7) Citizen engagement strategies (7)

GBS, Policy Modelling	Game theory (8) Game development (8) Decision support systems (8)	Citizen engagement strategies (8) Computer science (8) Statistics (8) Innovation (8)
NLP	Analysis of Social Media postings (1, 9, 13) Sentiment analysis (9) NLP in multiple languages (9) Opinion mining (9)	Analysis of Social Media postings (1) Sentiment analysis (9) Service innovation (9) Software engineering (9)
Blockchain	Blockchain regulation (10) Stakeholder engagement (10) Benefits/drawbacks of blockchain in digital government (10) Ethics (10)	Cryptography (10) Smart contracts (10) Distributed systems (10) Blockchain ecosystems in government (10) Application of blockchain in different areas (10)
eID/eSignature	Interoperability, standards (11) Personal data use across different databases (11) Ethics (11) Biometric technologies (11) Encryption techniques (11)	Interoperability, standards (11) Responsible research (11) Distributed systems (11)

Further, the research and training needs identified during the scenario analysis are compared with the needs identified and addressed by the research projects in Section 3 along the specific technologies and concepts. The results of comparison are synthesized and presented in Section 5.1, where the specific roadmap entries related to the identified needs are formulated. The resulting roadmaps are presented in sections 5.2 and 5.3.

5. Roadmap of Government 3.0

5.1 Identifying research and training needs for the roadmaps

The results of the comparison of the research and training needs collected during the project analysis (Section 3) to the scenario-derived research and training needs (Section 4) allowed identifying gaps in research and training. These gaps are translated into the specific roadmap actions presented below and ordered in two roadmaps (Sections 5.2 and 5.3).

5.1.1 Research roadmap actions

The mapping of the research roadmap actions to specific technologies is provided in the Figure 17. The specific research roadmap actions are explained in detail in the following subsections dealing with three types of the actions: general (5.1.1.1), technology-specific (5.1.1.2) and soft issues-related (5.1.1.3) research actions.

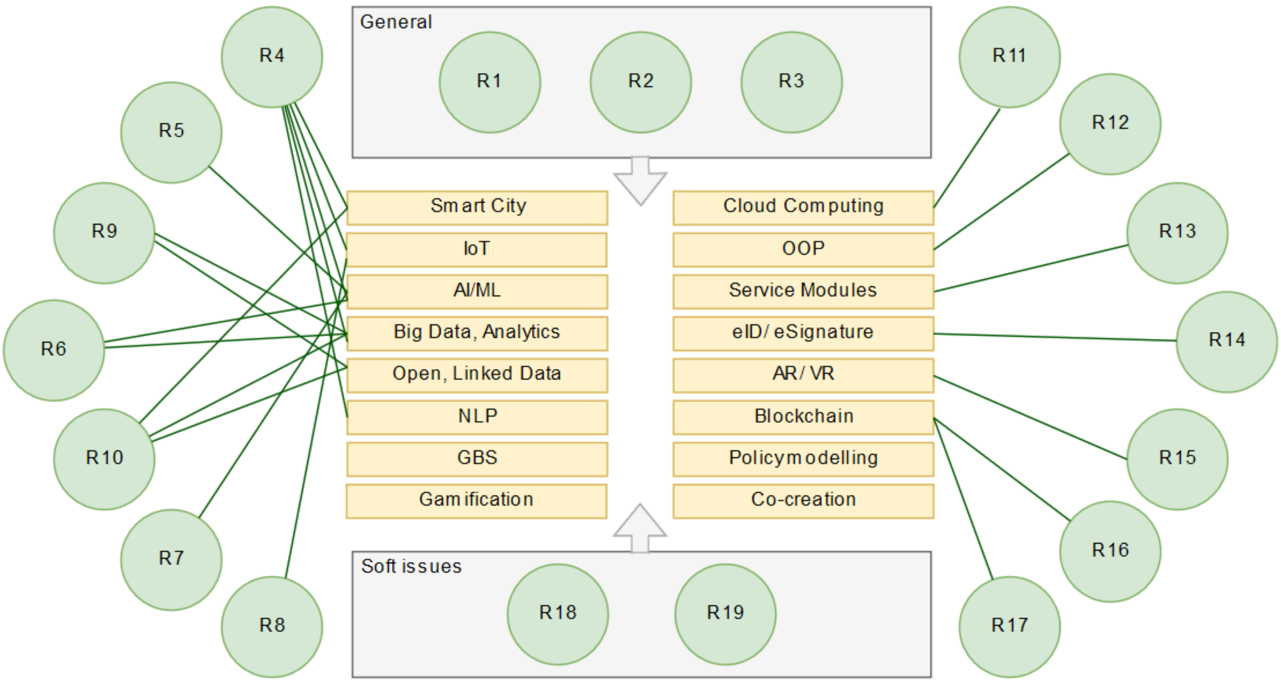

Figure 17. Mapping of research roadmap actions to technologies

5.1.1.1 General disruptive technologies research actions

The first three roadmap actions are not limited to specific technologies, and concern all of them. As the disruptive technologies are continuously adapted by the governments worldwide, it is necessary to study the cases and identify best practices and tools on the one hand, and possible barriers and issues on the other. **Roadmap action 1** suggests that "Analysis of first implementations" may be useful in further developing and fleshing out the concept of Government 3.0. This analysis should involve the study of initiatives taking advantage of the disruptive technologies in different areas of digital government. Lessons learned during this step can also prove useful in addressing the other steps in the roadmap. Similarly, the benefits of disruptive technologies in different areas of digital government may vary. Thus, it is also necessary to focus on the specific benefits of the disruptive technologies by areas of application. **Roadmap action 2** "Analysis of application areas for the disruptive technologies" suggests deeper research in the practical application of the disruptive technologies. The topic can be addressed through empirical research where sufficient data are available, otherwise the theme can be addressed theoretically using previously developed relevant theory or surveying the opinions of experts.

It is also necessary to look into possible negative impacts of disruptive technologies introduction. Apart from ethical issues arising during the implementation of automated decision making in government, there are risks of digital exclusion of specific populations, who lack relevant skills or access to technologies, disruptive changes in job market and decreasing trust in digital government systems. To be able to anticipate these issues and develop appropriate mitigation actions,

Roadmap action 3 suggests further research targeting negative impacts of digital government disruption brought on by the introduction of new technologies.

5.1.1.2 Technology-specific research actions

Smart City. As described in 3.4.2, the two main overarching issues tackled by the projects are the data collection and making sense of the collected data. In the end, the main goal would be the integration of these two large strands of the research: uniting the big data research and decision-making research in context of smart cities with the goal of having more efficient, standardised and interoperable sensors, whose data then can be effectively employed for making better decisions and better use of available infrastructure. Now, projects mostly concern the decision-support systems and different ways that data can be used to make best possible decisions in the specific situations. There is only limited understanding of fully autonomous decision-making, when data is collected, processed and results in the decision by an autonomous entity (AI-aided monitoring system in case of Scenario 1). Such objective would require overcoming the challenges of time (i.e., system should work in real-time, in emergency setting above all others, time is a huge asset), accuracy (i.e., the decisions need to be significantly more accurate than decisions made by humans) and transparency (i.e., it should be possible for system to “explain” why a decision has been made). Only adequately addressing these three issues would allow to ensure public trust and citizen support of such a system. Extrapolating to the other domains of Smart City governance, where autonomous decisions can be applied, all these issues still remain relevant, so the following research roadmap entries can be suggested: **Roadmap action 4** suggests research of "Real time analysis of data coming from multiple sources", particularly important for the use in the Smart City context, where the data from sensors, IoT devices, citizensourcing and social media data can be used together to manage the Smart City. **Roadmap action 5** "Universal automated decision algorithms in smart city environment" suggest the requirement to formulate adequate and universally applicable rules for automated decision in smart cities that can be used by the designers of Smart City systems, ensuring both the transparency and interoperability of solutions.

AI/ML. As the automated decision making is one of the defining aspects of Government 3.0 as reflected in its definition, the next two roadmap actions address specific needs in this area. **Roadmap action 6** suggests the need to research and formulate transparency requirements for automated algorithms for the use in digital government, ensuring that ML-based decisions are understandable by the public affected by them. **Roadmap action 7** suggests researching the legal issues stemming from the automated AI-based decision making in government. Properly realising these two actions will help to ensure the public’s support of Government 3.0 by addressing the issues of transparency and accountability of government in the age of data-driven decision making.

IoT. Standardisation and interoperability are important factors for some of the disruptive technologies. Developing a common standard for sensors and ensuring the interplay between sensors of different types and from different producers are important research needs of IoT in digital government. **Roadmap action 8** “Standards of IoT for data collection and interoperability” is particularly important for citizen sourcing and citizen science projects, where data from private sensors are used. To ensure the usability and accuracy of these data, standards need to be developed and agreed upon.

Big, Open and Linked data. While BOLD has been a very popular research topic and project analysis review identified a large number of different projects, the majority of technology-related research and training needs have been addressed in different projects. There is however a need to address the organisational changes brought along with the increase of Open Data use and production within government. **Roadmap action 9** "Organisational change and adaptation of government processes to the pervasiveness of BOLD in government" suggests looking into how the administration processes need to be adapted and modified in the age of Government 3.0. Similarly, **Roadmap action 10** "Data governance in the age of data-based decision-making" aims to address the need to ensure that the proper data governance strategies are used for dealing with increasing amounts of data collected and used by Smart City systems and other digital government implementations.

Cloud Computing. While technological cloud solutions have been extensively studied for the use in digital government, the focus is often put on efficiency and optimisation of the government processes. Citizen-related issues like privacy, security, usable and personalised services are the target of the **Roadmap action 11.** This action suggests addressing also the specific challenges associated with adoption of PaaS or SaaS models.

OOP. Potential increase of the scope of OOP to some areas of private sector, including some of the information stored by private companies (like car insurance information as in case of the Scenario 2), would be potentially beneficial for improving the digital government services. Research however is needed to study risks and implications of such changes. **Roadmap action 12** suggests the research of potential uses of OOP in relation to the information stored by private sector companies.

Service Modules. Creating service modules that integrate disruptive technologies and can be effectively and quickly implemented in different digital government systems will contribute to the adoption of disruptive technologies and lower the costs for their implementation. From the research side, **Roadmap action 13** suggests developing standards and frameworks to be used to describe and develop the service modules.

eID/eSignature. Very much connected to the OOP action, **Roadmap action 14** supposes studying the cross-border interoperability in relation to eID and eSignature. While eID/eSignature are not Government 3.0 technologies, they are important for realisation of the vision of cross-border services and some of the scenarios envisioned in Government 3.0.

AR/VR. The adoption of AR and VR is steadily increasing, bringing along the research of augmented and virtual reality systems. Most of the research however is still focused on the technological aspects of the two technologies. Both the AR and VR have potential to be used in government, but at the time the research in this area of application is scarce. One of the aspects of the use of these technologies that need to be carefully addressed is the collection and storage of sensitive user data. **Roadmap action 15** "Developing guidelines and recommendation of data collection in AR/VR systems" suggests researching recommendation and formulation of regulation for data collection and aggregation from AR/VR systems. As application of such systems in government services is still uncommon (and mostly limited to pilot projects), timely formulation of recommendations will ensure that most of the implemented systems will offer privacy and security "by design".

Blockchain. Two blockchain-related roadmap actions have been identified: one concerning the realization of blockchain solutions and another about the regulation. **Roadmap action 16** suggests identification of the main drivers to enable governments to create a scalable distributed network with blockchain technology, with appropriate performance and security. **Roadmap action 17** requires deeper research of appropriate regulation of blockchain technology, especially the analysis of the compliance of blockchain technology with General Data Protection Regulation (GDPR) and how to deal with the right to be forgotten.

5.1.1.3 Soft issues

Ethics is a significant need that has been identified as such for many technologies. Ethical issues are especially evident in automated decision-making and when dealing with personal sensitive information. Possible ethical concerns include: exclusion of certain individuals, algorithmic bias, datasets that lead to the bias in ML, issues of transparency and accountability in automated decision making, decisions based on incomplete or extrapolated data and others. However, actual research in this field is relatively scarce. **Roadmap action 18** suggests researching ethical concerns in disruptive technologies implementation to find adequate solutions to the identified ethical issues.

Citizen engagement strategies is another issue that requires careful attention. Technologies like VR, AR, immersive game-based simulations for policy modelling pose new problems of engagement, but also offer new solutions. Exploring the ways to increase the rate of government services adoption by the citizens should be one of the research priorities. **Roadmap action 19** suggests researching different models for citizen engagement with focus on co-creation and disruptive technology-specific methods.

5.1.2 Training roadmap actions

Analysis of training gaps from the projects and scenarios revealed the training needs on all levels. The suggested training roadmap actions are structured along the education levels, from higher education (Bachelor, Master levels) to vocational, professional training and finally end-user training. For each of the training roadmap actions several focal points have been identified, presented in the roadmap (Section 5.3) and explained in more detail below.

Roadmap action T1 “Development of the new courses on the undergraduate level” suggests fostering general understanding of digital Government stages among undergraduate students, at the same time addressing the legal aspects of the digital government processes, citizen engagement, data quality, analysis and collection, data privacy and security. Here the focus is not on the creation of new study programmes, but rather on embedding the important topics from Government 3.0 into the existing curricula. Addressing specific issues arising from the application of disruptive technologies will allow to prepare the students better for the postgraduate digital government programme and to the professional life in the time of Government 3.0.

Roadmap action T2 "Development of the new study curriculum on the postgraduate level" suggests specific focus on automated decision making, use of AI and ML in government services and disruptive technologies generally. Here, both the understanding of technologies and soft issues are important. On the soft issues side ethics of automated decision making, stakeholder management, accountability and trust are the main aspects to be addressed. Unlike the undergraduate programme, here the creation of entirely new Master Programmes is a targeted action, with focus on the disruptive technologies of Government 3.0.

Roadmap action T3 "Vocational training on the application of the disruptive technologies" recommends professional training of public officers regarding the use of disruptive technologies. This includes training on maintenance, monitoring and use of automated decision systems, decision making theory, data governance, change management and citizen engagement. Technology-specific training (e.g. AR/VR use and management) is also part of this roadmap action. In general, while actions T1 and T2 are general programs addressing multiple topics at once aiming to foster a holistic understanding of the digital government domain and of Government 3.0, vocational training is meant to be very specific, depending on the needs of the public administration in question.

Roadmap action T4 "Training the trainers" recommends training those responsible for educating public officers and citizens about the disruptive technology uses and their effective management in the public sector. Issues include data collection, data governance, managing and realising distributed systems, use of VR/AR technologies, monitoring and use of automated decision systems in government.

Finally, **Roadmap action T5 "End-user training"** suggests training of the citizens for the use of Government 3.0 services. This action aims at promoting both the general understanding of disruptive technologies and the use of specific services based on these technologies. The end result of this action will be more knowledgeable citizens, able to understand the challenges and limitations of the new technologies and manage risks. Better understanding of the new technologies will contribute to decrease in digital divide, increased trust towards digital government and higher adoption rates of the new technologies.

5.2 The Research Roadmap

Based on the analysis conducted in Section 4, the roadmap has been developed, formulating a list of specific actions to be realised in order to address the identified needs connected to the developments in the disruptive technologies in the context of Government 3.0. Structurally, the actions are grouped into two roadmaps, one describing actions in research and another concerning actions in education and training.

Government 3.0 Research Roadmap presented in Table 20 describes the research actions connected to the identified research gaps of the Government 3.0 domain. The actions of the roadmap are focused on building up knowledge and addressing research challenges in the field. The first column in the table is colour-coded according to the distinction between general, technology-specific and soft issues roadmap actions, as described in Section 5.1.

Government 3.0 Education and Training Roadmap (Table 21) focuses on the training needs, outlining a number of specific steps needed to properly address them in education and vocational training.

The tables with roadmap action include the following information regarding each step in the roadmap:

- **Key Action** is a short name of the roadmap action.
- **Description** is the justification of the action and short explanation of the problem the action is addressing.
- **Objective** outlines the aim of the action. What is to be achieved with the completion of the roadmap action?
- **Risks** describe possible issues in the domain of public service in case the roadmap action is not carried out.
- **Actors** indicate the stakeholders responsible for the realisation of a particular action.
- **Impact** denotes the implications of the action for the field generally.

Table 20. Government 3.0 Research Roadmap

No.	Key Action	Description	Objective	Risks	Actors	Impact
R1	Analysis of first implementations	Analysis of cases of first exploitations of disruptive technologies in government. Realised through case-study research of the first implementations.	Better understanding of benefits and negative aspects of the disruptive technologies in public sector, as well as objectives of such implementations.	Lack of understanding of the disruptive technologies may lead to underwhelming implementations of services based on these technologies in digital government.	Researchers	Understanding of the benefits and risks of particular technologies, allows to make better decision about the use of disruptive technologies in government.
R2	Analysis of application areas for the disruptive technologies	Deeper research in the practical application of the disruptive technologies. The topic addressed through empirical research where sufficient data are available, otherwise the theme can be addressed theoretically using previously developed relevant theory or surveying the opinions of experts.	Identification of application areas for disruptive technologies, targeted benefits of their implementation	Missed opportunities: failure to use disruptive technologies in the domains, where they could be beneficial.	Researchers	Using the disruptive technologies in the digital government, where they will bring most benefits.
R3	Negative aspects of the introduction of services based on disruptive technologies	Research of the negative aspects of the use of the disruptive technologies in government. This includes the negative aspects affecting the specific domains (e.g., increased costs of the transition) as well as society as a whole (e.g., increasing digital divide). Short- and long-	Identification of possible drawbacks of the implementation of the disruptive technologies and conditions under which such implementations may not be justified.	Introduction of the new technologies for the sake of new technologies may lead to increased costs and lower service quality.	Researchers, Government institutions	Possibility to minimise the negative aspects of the introduction of the new technologies. Implementation of the new technologies where they would be most effective.

		term effects are to be considered.				
R4	Real-time analysis of data coming from multiple sources	In the Smart City context, data from many different sources can be collected, aggregated and analysed as an input for decision making. Real time analysis of heterogenous data poses unique challenges, which need to be addressed through the development of new approaches, technologies and algorithms.	New approaches, technologies and algorithms, facilitating real time aggregation and analysis of data in Government 3.0 services	Failing to take into consideration available data will lead to suboptimal decisions and/or delays.	Researchers	More efficient approaches to real time data analysis, particularly in the context of smart city government.
R5	Universal automated decision algorithms in Smart City environment	In order to ensure ethical and transparent use of data for decision making in smart cities, it is necessary to formulate adequate universal rules for automated decision in smart cities that can be used by the designers of Smart City systems, ensuring both the transparency and interoperability of solutions between different implementations.	Clear rules regarding the creation of algorithms for automated decision making.	The grounds for AI decisions may be difficult to justify and explain to general public, negatively affecting trust in such systems.	Researchers	Improved transparency and accountability of decision making in Smart Cities.
R6	Transparency of algorithms used for automated decision making	Need to research and formulate transparency requirements for automated algorithms for the use in digital government, ensuring that ML-based	Ensuring transparency of algorithms that are used for automated decision making in Government 3.0 services. Transparent and understandable by general	Algorithms for making decisions in Smart City remain opaque, diminishing the public	Researchers	Improved transparency will lead to increased citizen trust through better understanding

		decisions are understandable by the public affected by them.	public algorithms will ensure public trust towards the systems.	trust in the fairness of automated decisions.		of the decision making processes.
R7	Legal issues of automated AI-based decision making in government	Research of the possible solutions to the legal issues arising during the implementation of the automated decision making in government. Formulating legal requirements for the AI systems used in digital government in terms of accountability of autonomous agents and transparency of decisions made by algorithms. In some situations (e.g., emergencies), the consequences of the decisions may be very significant, so clear regulation is necessary.	Develop legal frameworks addressing the new legal challenges arising from the application of the implementation of AI system for automated decision making, addressing the issues of accountability, transparency and ethics.	Automated decision making is not properly regulated by law, so the application of the AI in digital government remains limited.	Researchers, policy makers	Clear legal framework for AI systems in digital government will allow to design inclusive and fair systems.
R8	Standards of IoT for data collection and interoperability	As more IoT devices and sensors are developed it is necessary to ensure common standards and interoperability guidelines for the devices and data collected. This action is particularly important for citizensourcing and citizen science projects, where data from private sensors are used. To ensure the usability and accuracy of these data,	Developing a common standard for sensors and ensuring the interplay between sensors of different types and from different producers	Implementing systems that involve heterogeneous sensors and devices associated with significant interoperability problems.	Researchers, policy makers	Accepted standards will ensure interoperability and facilitate the development of systems involving large number of interconnected IoT devices.

		standards need to be developed and agreed upon.				
R9	Organisational change and adaptation of government processes to the pervasiveness of Big Open and Linked Data (BOLD) in government	Research into how the administration processes need to be adapted and modified in the age of Government 3.0. Pervasiveness of big open and linked data used for various purposes in digital government may lead to the disruption of the established processes in administration.	Existing processes need to be adapted and new processes developed to accommodate changes brought on by the introduction increased use of BOLD.	Organisational processes remain ill-adapted for the increased use of BOLD in government, leading to the decreased efficiency.	Researchers, government institutions, policy makers	More effective and efficient use of resources in government, better integration of BOLD in government processes.
R10	Data governance in the age of data-based decision-making	Both the increased amounts of data used by the government and higher standards of accuracy of data need to be accounted for when developing standards, methods and processes of data governance in digital government. Efficient use of citizen data should be ensured by data governance standards compliant to GDPR and other regulations.	Ensure that the proper data governance strategies are used for dealing with increasing amounts of data collected and used by Smart City systems and other digital government implementations.	Poor data governance may lead to the issues with data use, security and privacy. Possible data breaches lead to decrease of public trust in government.	Researchers, policy makers	More efficient data governance will ensure security of citizen data and increase citizen trust.
R11	Citizen-oriented implementation of cloud computing in government services as PaaS	Citizen-related issues like privacy, security, inclusivity, usable and personalised services are to be researched in the context of the use of digital government using Platform as a	To develop guidelines and approaches for the best implementation of citizen-oriented distributed PaaS-based services in digital government. Usability, security and privacy are the main	Cloud computing implementations in digital government do not consider individual concerns of the citizens.	Researchers, policy makers	Improving public perception and public trust towards digital government services through more inclusive, private and secure cloud-based services.

		Service (PaaS). Including the implementation of digital cloud-powered services across borders.	requirements for the implementation of these services.			
R12	Uses of OOP in relation to the information stored by private sector companies	Research of risks and implications of the potential increase of the scope of OOP to some areas of private sector, including some of the information stored by private companies (like insurance information).	Theoretical understanding and guidelines for the possible uses of private-owned data within the Once Only Principle approach.	Some further potential benefits of OOP are not achieved.	Researchers, policy makers	Cross-border administrative services that involve the use of information from private sources are improved.
R13	Creation of digital government service modules, implementing disruptive technologies	Research of the possibilities of implementing disruptive technologies within service module approach: creation of building blocks leveraging disruptive technologies, which can be implemented by different digital government platforms.	Development of guidelines and requirements for the creation of service modules that use disruptive technologies for realisation of their functions. Realisation of the roadmap action will facilitate the development of the services modules that can aid in the realisation of Government 3.0 concept.	Implementation of disruptive technologies in governments remains costly and difficult for smaller administrative entities.	Researchers	Disruptive technologies can be integrated in digital government solutions in form of service modules, leading to more efficient use of resources and money savings.
R14	Cross-border interoperability of eID and eSignature technologies	Research of cross-border interoperability of eID and eSignature. While eID/eSignature themselves are not Government 3.0 technologies, they are important	Conceptual understanding of eID and eSignature use within Government 3.0.	The use of eID and eSignature across borders remains problematic, impeding implementation of some cross-border services.	Researchers	The use of eID and eSignature across borders is made easier, better solutions in this area can be developed.

		for realisation of the vision of cross-border services.				
R15	Developing guidelines and recommendation of data collection in AR/VR systems	As more digital government services use AR and VR as a technology, it is necessary to develop the recommendations concerning the collection and storage of sensitive user data, acquired with the help or through the use of Augmented and Virtual reality technology. These includes behavioural data, personal data (including visual likeness) or any other type of identifiable personal information.	Formulation of recommendation regarding the collection and storage of data, acquired during the use of VR/AR-based systems.	Absence of recommendations regarding the collection and storage of data means that implementation of VR/AR is problematic	Researchers, policy makers	More secure and privacy-conscious implementation of government services based on AR and VR.
R16	Identification of drivers to enable Governments to create a scalable distributed network with blockchain technology	Addressing the challenge of creation of a scalable distributed network with blockchain technology, with appropriate performance and security, through identification of the main drivers enabling the realisation of the concept within Government 3.0.	Clear formulation of drivers that would enable a creation of a blockchain solution for digital government.	The implementation of blockchain solutions in digital government remains problematic.	Researchers	Possibility to implement a blockchain solution for digital government.
R17	Regulation of blockchain technology in digital government, compliance with GDPR, right to be forgotten	There is a need to develop an appropriate regulation of blockchain technology, especially the analysis of the compliance of blockchain	Regulation of blockchain technology implementation in digital government is developed, taking into account the compliance with GDPR and appropriately realising the EU	Absence of regulatory framework addressing blockchain impedes the use of blockchain in digital government where the use of	Researchers, policy makers	Regulatory framework will allow the use of blockchain on a wide scale for record keeping in digital government.

		technology with GDPR and the realisation of the right to be forgotten in the blockchain-based services.	citizens' "right to be forgotten".	technology contradicts GDPR provisions.		
R18	Ethical concerns in disruptive technologies implementations	Ethics is a significant need in relation to the implementation of disruptive technologies, especially in relation to the automated decision making and use of sensitive individual data. Possible ethical concerns to be addressed include: digital exclusion, algorithmic bias, data manipulation, issues of transparency and accountability in automated decision making, decisions based on incomplete or extrapolated data and others. Ethical concerns need to be appropriately addressed for every realisation of Government 3.0 service.	Creation of clear ethical framework that contains the guidelines for the addressing the ethical concerns during the implementation of government services making use of disruptive technologies.	Implementation of disruptive technologies raises ethical concerns by possibly contributing to widening digital gap, algorithmic bias in AI decisions, opaque and unfair decisions.	Researchers, Government institutions	Ethical framework will facilitate addressing ethical issues in the Government 3.0 projects to ensure inclusive, fair and accountable citizen services.
R19	Different models for citizen engagement using disruptive technology-specific methods	Technologies like VR, AR, immersive game-based simulations for policy modelling pose new problems of engagement at the same time offering new solutions. It is necessary to research different approaches for citizen engagement with focus on co-	Novel approaches to citizen engagement are developed, taking into account the peculiarities and specific challenges of the disruptive technologies.	The existing models of citizen engagement do not take into account the peculiarities of disruptive technology and fail to make use of possible advantages brought on by these technologies.	Researchers	Disruptive technology-specific engagement approaches will allow to increase the use of the Government 3.0 services, adoption and participation.

		creation and disruptive technology-specific methods.				

5.3 The Training Roadmap

Table 21. Government 3.0 Education and training roadmap

No.	Key Action	Description	Objective	Risks	Actors	Impact
T1	Development of the new courses on the undergraduate level	Expanding the current study programmes with further modules on the disruptive technologies in public services. The focus here is on: the understanding different stages of digital government, legal aspects of the digital government processes, citizen engagement, data quality, analysis and collection, data privacy and security. Many of these subjects are already part of the existing digital government curricula offered at the universities around the world, so the crucial part of this action is not the development of the brand new courses but rather enriching and improving existing courses with content relevant to the Government 3.0. The aim is to both improve the understanding of the recent technological developments and to prepare the	Prepare future researchers and practitioners in e-government domain.	Outdated or irrelevant content may negatively influence the future public officials.	Higher education institutions	Skilled public officials, and decreased need for vocational training.

		students to the more advanced in-depth postgraduate government 3.0 programmes (T2). This action also includes development of training programmes taking advantages of the blended learning approach: those incorporating MOOCs and virtual classrooms.				
T2	Development of the new study curriculum on the postgraduate level	Creation of the new postgraduate programme focusing on the use of the disruptive technologies in e-government. The programme must address the following key points relevant to the development of the digital government domain: 1. Internationalisation. When examining the digital transformation, it is crucial to consider both national and international levels. Cross-border cooperation and services (Once Only principle, eIDas) become an important areas of digital public service development	Preparation of the future researchers and practitioners in e-government domain who understand both the theoretical developments in the domain and the technological advancements that have potential to disrupt the provision of the public services.	Government 3.0 is not properly addressed as a new stage in the e-government development.	Higher education institutions	Proper understanding of specific benefits and challenges of the implementation of the disruptive technologies in government.

		2. Bridging the gap between different regions in the European Union. 3. Innovation aspects (the implementation of disruptive technologies in public services) 4. Combining technology training and soft skills education (the need to consider legal, managerial and ethical issues of the introduction of new technologies and services based on these technologies)				
T3	Vocational training on the application of the disruptive technologies	Public officers need to be familiar with the new disruptive technologies. In contrast to the undergraduate (T1) and postgraduate (T2) education, the vocational training would be focused on the specific aspects of digital government relevant for the practitioners offering short-time training programs focusing on: maintenance, monitoring and use of automated decision systems, decision making theory, data governance, change management and citizen	Improvement of the professional performance of employees or service providers. Increased productivity and efficiency.	Decreased quality of service because of the insufficient knowledge of the disruptive technologies.	Higher education institutions, Government institutions	Enhanced competence development. Efficient and satisfied employees.

		engagement. Technology specific training (e.g., AR and VR use) is also part of this action. The goal here is to enable acquiring new skills by the practitioners rather than building a comprehensive understanding.				
T4	Training the trainers	Training the people responsible for teaching/training both public officials and end-users (citizens) regarding the management and use of services leveraging the disruptive technologies. The focus here is on: data collection, data governance, managing and realising distributed systems, use of VR/AR technologies, monitoring and use of automated decision systems in government. Successful realisation of this action will allow quick uptake of new technologies and greater flexibility of the public sector.	More efficient transfer of knowledge about the use of specific disruptive technologies, capacity building in government.	Slow uptake of the new technologies, decreased efficiency in government.	Government institutions, public and private bodies	Better trained and thus more efficient public officials. Public services are quicker to adapt to the technology changes.
T5	End-user training	Training the citizens on how to use the services based on the new technologies. The focus here is on: both the general understanding of	Capacity building, arming the users with the necessary knowledge to work with the new services.	Low user acceptance of Government 3.0 services, decrease in transparency, erosion of trust in government institutions.	Local administrations, public bodies	More knowledgeable citizens, able to understand the challenges and limitations of the new technologies and manage risks. Better

		disruptive technologies and the use of specific services based on these technologies. For this action special attention should be paid to guaranteeing inclusion of the representatives of the vulnerable groups, including senior citizens and minorities.				understanding of the new technologies contributing to decrease in digital divide, increased trust towards digital government and higher adoption rates of the new technologies.

5.4 Limitations

Finally, it is necessary to acknowledge some of the potential limitations of the presented roadmaps. As mentioned before, scenario technique used to develop the roadmap is a heuristic method in its nature, it is not meant to present the final and definitive view of the future in the domain, but rather serves as a means for exploration of potential futures. Therefore, the findings from applying the scenario method provide only a slice of possible issues that need to be addressed in relation to disruptive technologies in Government 3.0. This shortcoming is compensated by balancing the projects against the future scenarios and by involving experts for further input. The opinion of experts and practitioners of digital government allowed fleshing out and specifying better the findings of the future scenario methodology, ultimately formulating them in the form of the concrete roadmap actions.

We also acknowledge that the presented list of research and training actions is not exhaustive and with continuing development of the disruptive technologies (and even introduction of the new technologies), the roadmap needs to be reviewed and adapted to reflect this development. Still, the current 18-action roadmap is a result of work of experts in digital government and provides an important contribution to the understanding of the future evolution of the digital public services and specifically the role of disruptive technologies in this evolution.

6. Recommendations

6.1 Research roadmap recommendations

Below, the summarised recommendations from the research roadmap (5.2) per identified stakeholders are presented. The correspondence between the roadmap stakeholders and roadmap action is presented in Figure 18. As it is a research roadmap, all actions involve researchers as stakeholders to some degree. Involvement of other stakeholders is limited mostly to the creation of regulations and standards (e.g., actions 7, 8, 15) or participation in elaboration of recommendations (as is case with adaptation of government processes in actions 9 and 18).

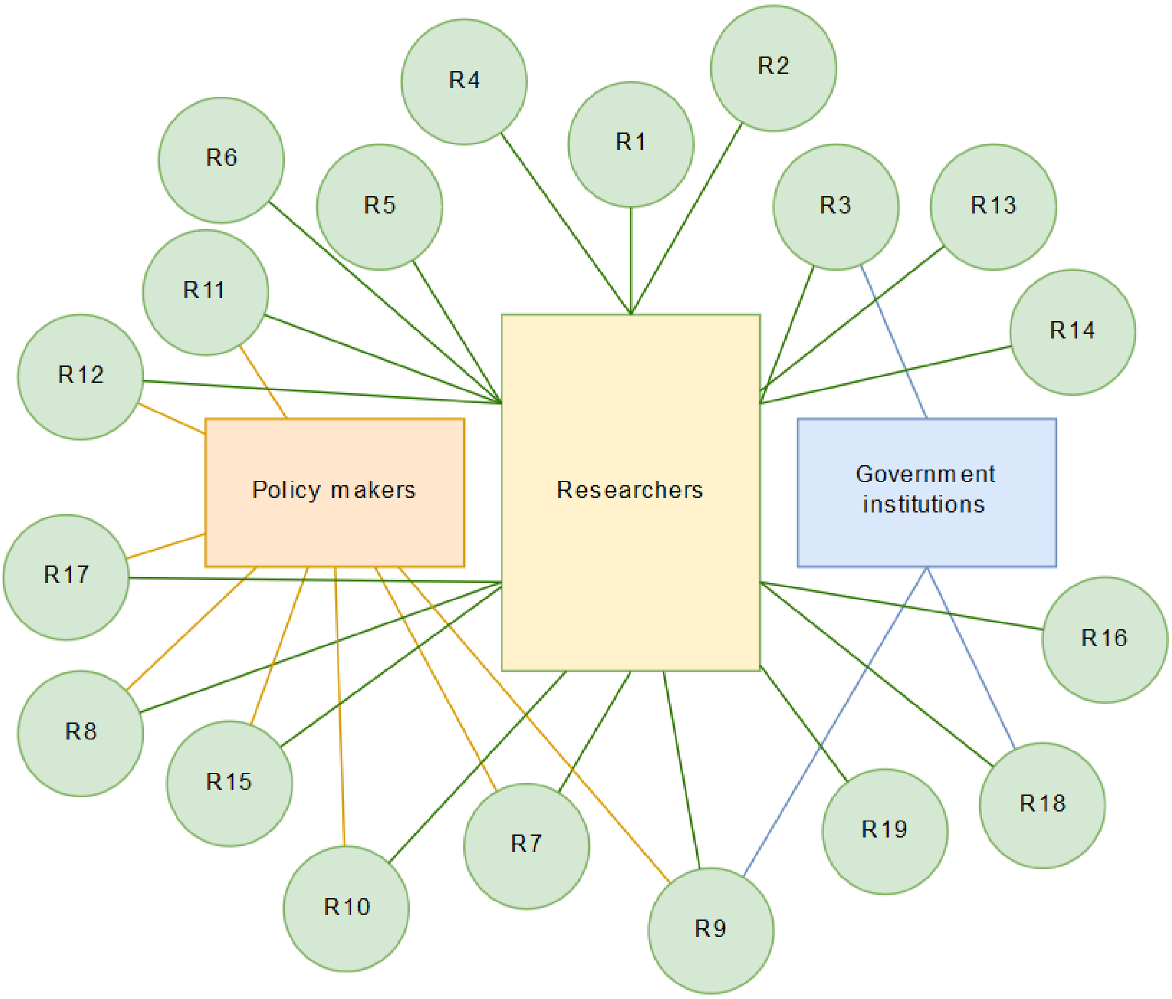

Figure 18. Correspondence between the research roadmap actions and responsible stakeholders

Researchers. Researchers are responsible for the realisation of all of the research roadmap actions. While many of the individual disruptive technologies has been extensively researched (see D 1.1 of the project for more information on that), the implications of the use of the technologies in digital government domain are often not studied precisely. Still, not only the possible uses of the technologies in government should be studied (R1, R2), but also the organisational changes needed to accommodate growing reliance of governments on the Big, Open and Linked data (R9), growing demands for secure data storage and use (R10), distributed systems (R11) interoperability (R8) and cross-border services (R12, R14). Automated decision making as the central concept in Government 3.0 is associated with further research gaps, related to the algorithms for decision making (R5, R6), data analysis (R4), legal (R7) and data governance issues (R10). Creation of regulations and developing common standards should be prioritized as they are crucial for realisation of services based on disruptive technologies. Technical and regulatory barriers need to be addressed before such services are implemented on a large scale (R15, R16, R17). Some of the actions explicitly require interdisciplinary and inter-stakeholder collaboration, like elaboration of an ethical framework for disruptive technologies use in digital government (R18), while others would benefit from closer partnership with government actors and policy makers (R7, R10, R11, R12, R17).

Policy makers. Policy makers (on local and international levels) are important stakeholders for some of the research actions that involve development of guidelines (R9, R15), standards (R8), regulations (R10, R11, R17) and laws (R7, R12). After the guidelines for the use of the technologies are developed, they need to be implemented in form of policies, laws and official standards. Clear standards will accelerate the development of new solutions based on disruptive technologies and improve the quality and efficiency of Government 3.0 services.

Government institutions. For some actions, public administrations need to be involved. For R9, for example, there is a need to develop pilot projects to test new governance models, before they are implemented on the larger scale. Similarly, R3 requires input and cooperation from public administration to produce results. Collaboration with public officials is crucial for tailoring the recommendations to the real-life situations and reducing the gap between theory and practice. Ethical concerns (R18) is another area where the input of the government institutions is crucial.

6.2 Training roadmap recommendations

Training roadmap actions involve four types of stakeholders: higher education, educational bodies in public sector, private sector, and local administrations. Some of the actions are limited to one type of stakeholders (higher education for T1 and T2), while others may involve collaboration of multiple stakeholders.

Higher education institutions. Universities and other higher education institutions are involved in the realisation of T1 and T2 of the training roadmap. We suggest the following tentative structure of the study programmes on different levels based on the identified training needs in project and scenario analysis.

- *Undergraduate level* should include general information about digital government domain and tools to build up the expertise in digital government. Focus should be on the understanding of the concept of governance and how digital government services are embedded in the existing governance processes. Courses from adjacent disciplines like law, computer science, management and administration should allow building the understanding necessary for working in the public sector or continuing with postgraduate education. Furthermore, as described in Table 21, more generally the issues of internationalisation and bridging the gap between different regions in the European Union should be considered, thus undergraduate courses should not be limited to the digital government in the country or region where programme is taught, but rather provide a broader overview of the digital government realised around Europe.
- *Postgraduate level* focuses more on the disruptive technologies and other specific aspects of Government 3.0. It is recommended that the Master level programme includes courses on (1) disruptive technologies (AI, ML, IoT, NLP, VR, AR and big data technologies), (2) relevant concepts like interoperability, co-creation, gamification, citizen engagement and policy modelling, (3) other aspects of digital government that promote holistic understanding of the field (good governance, digital transformation, collaborative government, etc.). Focus should be put on the disruptive technologies and how they can contribute to the realisation of evidence-based data-driven decision-making, the core characteristic of Government 3.0. Apart from that combining technology training and soft skills education on this level is another important aspect of the postgraduate education.

The actions of the roadmap regarding the postgraduate training will be further implemented within the WP 5 of the project. The MOOC and a joint Master course will be elaborated to target the identified training needs. Furthermore, for actual content of the undergraduate and postgraduate courses, findings of the Deliverable 1.2 of the project will be also considered.

Education bodies in government and private sector are to be involved in actions T3, T4 and T5 of the training roadmap. Both public and private organisations can be involved in Training the trainers (T3) and Vocational Training (T4) actions. Solutions based on disruptive technologies are much more common and mature in the private sector, particularly many start-ups make use of technologies like blockchain, AI and ML, NLP, AR and VR to bring benefits to various domains. Accumulated experience by the business may be useful for providing both vocational training to government officers and training the people who would then provide training to public officers. Therefore, it is recommended that private sector companies are involved in the training. The realisation of T3 and T4 will improve the acceptance of the new technologies by the public service employees and make the public service provision more efficient and effective.

End-user training is an action that may be realised to the greater degree by the public institutions (such as **local administrations**) as it needs to be platform- and tool-specific: so, training citizens on-site will be most efficient. Getting citizens familiar with disruptive technologies will contribute to public trust and increase the technology adoption rates.

7. Conclusions

In this report, the results of roadmapping activities of the Government 3.0 project have been documented. The methodology of project analysis combined with future scenarios and expert analysis was used to identify the research and training needs along the technologies and concepts, related to the realisation of Government 3.0 concept.

The relevant disruptive technologies and concepts were previously identified in Deliverable 1.1. The research and training needs were extracted from 281 analysed projects involving 14 technologies and concepts. Subsequently, 13 future scenarios were constructed to illustrate the possible uses of these technologies in digital government. The needs in research and training left unaddressed by the existing projects were then used to outline the research and training roadmap actions, addressing these needs. Similar needs between technologies were subsequently combined in broader roadmap actions. For each action the following information was provided: description, objective, risks, stakeholders involved in realisation and impact.

A total of 19 research actions and 5 training actions were listed in the research and training roadmaps. The research actions relate to the different aspects of disruptive technologies implementation, with particular focus on automated data-based decision making in government. Suggested actions in research include:

- analysis of first implementations, identification of application areas and possible negative impacts of disruptive technologies generally;
- research of real-time analysis of data, automated decision algorithms, the requirements for transparency of such algorithms and their legislative regulation;
- formulation of standards and regulations for IoT and blockchain;
- research in organisational change in government, data governance, citizen-oriented cloud solutions, the OOP use for private data, cross-border interoperability for eID and eSignature;
- creation of guidelines for service modules implementing disruptive technologies and the use of private data collected with AR/VR systems;
- researching the ethical implications of disruptive technologies and elaboration of ethical framework that can be used to address arising ethical concerns.

The identified training actions include the development (and update) of undergraduate and postgraduate courses in digital government/ Government 3.0, vocational training in the use of the disruptive technologies, training of the future trainers and end-user training on the level of local administrations.

Furthermore, some recommendations for the implementation of the roadmap actions have been outlined. The recommendations include involving multiple stakeholders to accelerate the realisation of actions connected to elaboration of standards and laws, interdisciplinary research, and leveraging the private sector experience in disruptive technologies for training of government professionals.

The implementation of all 24 roadmap actions is recommended to achieve the promise of Government 3.0.

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