ICT-2009.7.3 ICT for Governance and Policy Modelling

FP7-ICT-2009-4 Support Action (SA) Project

Deliverable D4.3

Final Roadmap

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Foreword

When we started working on the roadmap on ICT for Governance and Policy Modelling, we initially considered these two domains as juxtaposed, coming out of complicated committee negotiation rather than sharing a well-defined identity. They seemed, at first sight, as simply two domains that shared the fact of "not being dealt with by other FP7 priorities".

Yet, during the course of the project, we came to realise how much these two domains share, and how much the actual culture of the people working on these themes is similar. There is a kind of anthropological similarity between the two communities. Basically, both complex systems models and collaborative governance share a refusal of traditional IT and economic thinking.

Both communities are against "IT automation", where IT substitutes humans through online services, decision support systems, knowledge management tools. Instead, they embrace the view of IT as an augmenting, human-centric tool, in the sense of Engelbart [33].

In economics and social science, they are against general equilibrium theory, which assumes that all individuals are rational and that market tools are the most efficient tools to reflect preferences, and that future systems behaviour can be induced by the past in a linear way. So, these approaches can be described by a following matrix:

	Traditional / Reductionist / Modern	**Non-traditional / Complex / Postmodern**
IT	IT automating The more users, the less performing the application is User needs are predictable ex-ante	IT augmenting Network effects - applications get better the more people use it User-needs are dynamically and iterative integrated into development
Economics	General equilibrium theories Humans considered as rational and average Linear models can predict future	Agent-based modelling Human considered as diverse and accounting for social influence Non-linear effects are generated from agent interaction and system dynamics

Instead, both these two communities share two positive principles:

a) that humans are diverse, non reduceable, and not substitutable by machines and,
b) that complex, non-linear results can be generated by very simple network interaction.

This roadmap does not aim at choosing one approach versus the other, but simply at presenting an integrated and consistent view of the existing research challenges, and of the opportunities that they entail.

Executive summary

This document is the final version of the Research Roadmap on Governance and Policy Modelling, which lists and describes research themes to be supported by future public funding through Science & Technological Roadmapping. The roadmap is one of the concluding documents of the CROSSROAD project realised within the research priority on "ICT for Governance and Policy Modelling".

The main goal of the CROSSROAD Project was to build a Roadmap to provide strategic directions for the future of research in the domain of ICT for Governance and Policy Modelling. This roadmap constitutes:

1. A shared vision, able to inspire collaborative and interdisciplinary research, and between academia, business, civil society and government.
2. A useful tool, able to provide support and orientation to policy-modelling also after the end of the project.

The roadmap presented in this deliverable has been generated through the discussion in the Samos 2010 Summit and by the desk research of the authors, validated at EGOV 2010 Workshop in Lausanne and at the ICT 2010 Networking Session as well as during the online deliberation process, and building on the other CROSSROAD work-packages results (State of the Art, Visionary Scenarios, Gap Analysis).

The report is divided into two parts:

- Part 1 - Introducing the Roadmap provides an outlook of the roadmapping exercise results.
- Part 2 - The Grand Challenges gives a more detailed description of all research challenges.

Grand Challenges summary

The four grand challenges composed of several research challenges which were identified in the collaborative and peer-reviewed process are as follows:

I. GC1 Model-based Collaborative Governance

The GC1 Model-based Collaborative Governance deals with the development of advanced tools and methodologies, following the vision of a radically different context for policy modelling and simulation, where standardisation and reusability of models and tools, system thinking and modelling applied to policy impact assessment has become pervasive throughout government activities.

It encompasses the following research challenges:

- **RC1.1: Integrated, composable and re-usable models** to create more comprehensive and complex models by using smaller building blocks or existing objects/models. This implies both model interoperability and the definition/identification of proper modelling standards, procedures and methodologies.
- **RC1.2: Collaborative modelling** encompassing participation of all stakeholders in the policy-making process through the implementation of Internet-based easy-to-use tools for all the levels of skills.
- **RC1.3: Easy access to information and knowledge creation** with a

particular focus on elicitation of information which, in turn, during the overall model building and use processes will help decision makers to learn how a certain system works and ultimately to gain insights and understanding in order to successfully implement a desired policy.

- **RC1.4: Model validation** in order to guarantee the reliability of models and, consequently, of policies that are crucial for policy makers who need and use information that results from the simulations to develop more effective policies.
- **RC1.5: Interactive simulation** concentrating on the fact that the larger is the model in terms of size and complexity, the larger is the resulting amount of data to analyse and visualize. In particular, the RC refers to the issue of integration of visualisation techniques within an integrated simulation environment, in order to dramatically increase the efficiency and effectiveness of the modelling and simulation process, allowing the inclusion and automation of some phases (e.g. the output and feedback analysis) that were not managed in a structured way up to this point.
- **RC1.6: Output analysis and knowledge synthesis** refers to output analysis of a policy model and, at the same time, to feedback analysis in order to incrementally increase and synthesise the knowledge of the model (and consequently of the policy).

II. GC2 Data-powered collective intelligence and action

There are several complementary research areas in ICT for governance and policy modelling that have the opportunity to address the need for collaboration and behavioural change throughout different technological layers: enhanced data availability through public linked data and participatory sensing, analytical capability through opinion mining and visual analytics, and action-oriented tools such as simulation and serious gaming.

For this vision to become a reality, substantial research effort is needed in the following research challenges:

- **RC2.1: Privacy-compliant participatory sensing for real-time policy-making** refers to the use of sensors, usually embedded in personal devices such as smartphones allowing citizens to appropriately feed data of public interest.
- **RC2.2: Real-time, high-quality, reusable open government data** calls for simplification and lower costs of open data publication.
- **RC2.3: Federated dynamic identity management** addresses the eIdentity-related issues for secure public service provision, citizen record management and law enforcement.
- **RC2.4 Peer-to-peer public opinion mining** points out to the explosion of user-generated content, which widens the application scope of public opinion mining tools and to the fact that these tools need to become more pervasive and available to the majority of citizens.
- **RC2.5: Intuitive, collaborative visual analytics of data for policy-making**

refers to the research focused on making sense of large datasets, such as those provided as open government data.

- **RC2.6 User-generated simulation and gaming tools for public action** underlines that serious gaming is still requiring high level of engagement and, therefore, progress in usability and attractiveness in order to widen the group of participants is needed.
- **RC2.7: New institutional design of collaborative governance** recalls that collaborative governance is developing without an appropriate reference framework.

III. GC3 Government Service Utility

The Grand Challenge GC3-Government Service Utility has adopted the key concepts of a utility, such as Ubiquitous nature, Usability, Federation, Co-generation, and De-regulation, and is aligned to the philosophy of collaboration, openness and innovation. It aims to cultivate a vision of the Internet of the Future, where public organisations, citizens, enterprises and non-profit organisations can collaboratively shape public services at design-time and runtime, in order to be delivered as a utility-like offering at their own ends, to the channels they prefer and in the context and situation they are. In this context, the research challenges that should be addressed in the long-term perspective include:

- **RC3.1: User-driven innovation shaping Public Services** during their whole lifecycle in order to be delivered to their beneficiaries at their own ends, in ways and means they prefer.
- **RC3.2: Change the DNA of Public Services** in the direction of the 1-1-1 concept that supposes that «Every public service can be provided in one-stop, within one second, with one euro cost, to any device and by anything».
- **RC3.3: Digital Public Services Value Proposition for All** which defines and assesses the impact for all stakeholders within a complex public services ecosystem.
- **RC3.4: Massive Public Information as a Service** promoting a service-oriented attitude to the public sector information (PSI).

IV. GC4 Science Base of ICT for Governance and Policy Modelling

The general aim of this challenge is to establish the initial foundation of ICT for Governance and Policy Modelling as a new science, complementing those of Informatics and Political Science, which is envisaged to benefit from all developments of the neighbouring field.

It consists of following research challenges:

- **RC4.1: Multidisciplinary issues and relations with neighbouring domains**, that investigates possible links with other scientific areas and attempts to structure the domain according to other successful domains.

- **RC4.2: Metrics and Assessment Models, Decision Support, Modelling & Simulation Tools,** that aim to bring together the technological and the societal aspects of the domain of ICT for governance and policy modelling towards more concrete, holistic and accurate decision support models.
- **RC4.3: Formal methods and tools**, which aim at the setting the foundations for the new proposed scientific domain.

Roadmap's conclusions

The Roadmap's final conclusions focus on the place of the innovative challenges in the policy-cycle, on the benefits (why) of the ICT for Governance and Policy Modelling tools for policy makers as well as on the future steps to further advance research in this domain (how).

Closing the loop of policy-making

Today's society and economy is more than ever interconnected, unstable, and unpredictable. The current tools available for policy design, implementation and evaluation are ill-suited for capturing this complex and interconnected nature. Moreover, they base on an abstract and unrealistic vision of the human being: rational (utility maximising), average (not heterogeneous), atomized (not connected), wise (thinking long-term) and politically committed. To address these challenges, CROSSROAD has identified a set of emerging innovative solutions, which are the building block for the next generation policy-making. The technology model, which the project has adopted, focuses on three layers: data, analysis and decision/action:

- The data layer provides new information that was previously not available. It presents enhanced possibilities for data collection that will increase dramatically the level of data available with the open data movement and participatory sensing tools.
- The analysis layer provides a new perspective and understanding of data. At this level, we encounter several technological innovations that help making sense of the large amount of data available, such as policy modelling, visual analytics and opinion mining.
- The behavioural change layer acts on the incentives and barriers to action and behaviour. The final step of the policy-making process is the action and implementation, i.e. the present behavioural change layer, which encompasses such promising fields as persuasive technologies, serious gaming and social network analysis.

Furthermore, the important feature of this model is the fact that all three layers are relevant for both government and citizens. Finally, the CROSSROAD model identifies these opportunities across different policy domains.

Reflecting on the benefits

The online discussion and interviews conducted with policy makers and public administration representatives showed that the benefits of using ICT in policy-making are significant and tangible. As a result, three main potential benefits deriving from a wider usage of ICT for Governance and Policy Modelling were identified:

1. Quality of policy-making
2. Speed of policy-making
3. Evidence-based policy decision

What is more, the practitioners' experience suggests a careful design of the implementation process of those tools in governmental organisations in order to maximise the benefits. Albeit from an academic/research perspective the advantages of those technologies are quite evident, their adoption in a public policy decision-making process and organisational processes has to be carefully introduced to make the changeover as smooth as possible, avoiding friction with the current practices. Finally, the use of those technologies can support long-term planning, beyond the traditional focus on short-term benefits that policy-makers (but also citizens) often chase and respond to.

Other roadmapping activities

Furthermore, the review of other roadmapping activities in the neighbouring domains showed that the specific application domains related to the ICT for Governance and Policy Modelling field focus on similar issues to those gather under the labels of the four CROSSROAD grand challenges.

New research instruments

The research challenges presented in this report question the viability of existing research instruments that are employed to address them. It is increasingly recognised that the determining variables for successful ICT innovation do not lie in the domains and areas to be funded (the "what"), but in the nature of the mechanisms in place (the "how"). No matter how well formulated and accepted by the wide research community the research challenges are, they will not be met if we do not design the appropriate funding instruments to support research.

Some of the features of the research challenges presented above are not always fully compatible with the FP7 type of research. In particular they are:

1. User-driven and demand-driven
2. Highly multidisciplinary, with particular involvement of non-technological disciplines.
3. Not clearly divided between research and innovation
4. Serendipitously innovative

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Part A. Introducing the Roadmap

1 Introduction

This deliverable is the final version of the research roadmap on Governance and Policy Modelling, which lists and describes research themes to be supported by future public funding through Science & Technology Roadmapping (S&T R&D).

It will be followed by the Policy Recommendations report (D4.4), which will advance concrete policy recommendations and tools to implement the proposed roadmap. In other words, while the roadmap describes the "what", the final deliverable will integrate these findings by looking at "how" the roadmap could be implemented.

1.1 Scope

The role of government has substantially evolved over the last thirty years. Broadly speaking, it has changed from a government that "rows" to a government that "steers": while its role in service provision has diminished, its regulation activity is continuously growing. As the OECD review of 2005 puts it: "*Government has a larger role in the OECD countries than two decades ago. But the nature of public policy problems and the methods to deal with them are still undergoing deep change. Governments are moving away from the direct provision of services towards a greater role for private and non-profit entities and increased regulation of markets. Government regulatory reach is also extending in new socio-economic areas. […] This expansion of regulation reflects the increasing complexity of societies.*"

Yet, regulation proves to be an increasingly challenging task, as the recent financial crisis has shown. The world has become increasingly interconnected, complex, and fast-evolving: the effects of individual behaviour and of policy choices are much less predictable. In fact, unpredictability and complexity are two distinguishing characters of our society, as widely recognised in the literature about complexity science, chaos theories and non-linear systems. We are increasingly dealing with highly improbable events and "wicked problems", which are outside the range of predictability based on past behaviour.

The paradox is that at the same time, the amount of data available to governments for making sense of the socio-economic environment has increased exponentially, either provided through sensors, such as with pervasive computing and Internet of Things, or through "crowdsourced" citizens' reports, such as in the case of wildfire reports via Twitter. Yet governments clearly struggle to make sense of such large amounts of data.

During the last years, the European Commission has decided to invest heavily in research on these areas, through the research priority on "ICT for Governance and Policy Modelling". Within this framework, the main goal of the CROSSROAD Project is to build a Roadmap to provide strategic directions for the future of research in the domain of ICT for Governance and Policy Modelling.

This roadmap constitutes:

1. A shared vision, able to inspire collaborative and interdisciplinary research, and between academia, business, civil society and government.

2. A useful tool, able to provide support and orientation to policy-modelling also after the end of the project.

The present deliverable is the final version the research roadmap on ICT for Governance and Policy Modelling, as it has been generated through the discussion in the Samos 2010 Summit and by the desk research of the authors, validated at the EGOV 2010 CROSSROAD workshop in Lausanne and at the ICT 2010 CROSSROAD networking session as well as during the online deliberation process, building on the other work-packages as described in section 2.2.

1.2 Structure of the Document

The structure of the present deliverable is as following:

- Part 1 Introducing the Roadmap strives to provide an outlook of the roadmapping exercise results.
  - Section 1 introduces the context and scope of this exercise.
  - Section 2 illustrates the key questions to be addressed, the methodology and the process adopted.
  - Section 3 provides a summary of the roadmap grand challenges and conclusions.
- Part 2 The Grand Challenges gives a more detailed description of all research challenges:
  - In Sections 4, 5, 6 and 7, the corresponding four Grand Challenges are described in detail.

2 Methodology

In this section, the methodological approach of the roadmap building is briefly outlined. In particular, the key questions, the process and the methods adopted are presented.

2.1 The key questions

The CROSSROAD project aimed at answering a clear set of questions:

1. What is the present state of the art in the field of governance and policy modelling: Which are the most advanced implementation initiatives in this field, and the challenges encountered? What are the present issues to be addressed?
2. Taking into account possible future scenarios, maybe radically different, what are the future needs for ICT tools for governance and policy modelling?
3. Comparing present status and future needs, as they also derive from the possible results of other FP7 projects, which can be identified the specific gaps and grand challenges in the domain?
4. Between the challenges emerging from present needs and future scenarios, which are related to research, rather than implementation?
5. Which logical relationships (such as originality, redundancy or complementarity) are there between on-going research and also with other application domains? In particular, which of the application fields of governance and policy modelling is likely to be at the frontier of technological innovation, compared to the other application fields?
6. For those research challenges identified, what kind of research support measures should be adopted?

The first three questions have been effectively answered by the State of the Art Analysis (WP1), the Visionary Scenarios (WP2) and the Gap Analysis (WP3), respectively. The present Final Roadmap (WP4) deals with the remaining three questions. In particular this deliverable deals with question 4 and 5, while question 6 will be dealt with in the final deliverable Policy Recommendations (D4.4), which will be completed in December 2010.

2.2 The methodological approach

Technology roadmapping (TRM) is a strategic planning approach to identify the actions and funding decisions needed to boost technological development and innovation. It has become a widely used tool for individual companies, entire industries and governmental policy makers in the past decades. The use of the term "roadmap" conveys the main purpose of this approach, namely to chart an overall direction for technology development or usage. In the most traditional sense, TRM aims at supporting the development of new products by establishing causal or temporal relations between the technological possibilities and choices and the business objectives thereby highlighting the necessary

steps to reach the market with the right products at the right time. Indeed roadmapping is gradually developing into a new discipline as numerous studies have been devoted to the theory and methodology of roadmapping [27], [28], [121].

A standard definition of the science and technology roadmapping approach does not exist, and an examination of roadmaps that have been created indicates that there is considerable diversity among practitioners as to what constitutes a roadmap and which are the roadmapping techniques employed. Amidst this plurality of methodologies, previous projects such as eGovRTD2020 (2006-2007) and PHS2020 (2009) adopted a policy-oriented approach including a foresight element by combining roadmapping with scenario building techniques. This is considered more appropriate for holistic roadmaps focussed on highly complex multi-layered and multi-players domains.

The potential of roadmapping is significant in the domain of ICT for governance and policy modelling as it can constitute an important input in the selection of future research priorities by highlighting the emerging themes and key technological applications (ICT tools) likely to impact on policy in the coming years. In a recent benchmarking study, roadmapping was highlighted as one of the "recommended best practices" for the selection of priorities in R&D programmes since it does not only identify the bottlenecks that need to be addressed within a realistic time frame, but it can also lead to a high degree of consensus if potential beneficiaries are involved in the agenda-setting process [64].

In sum, science & technology roadmapping for policy intelligence has a longer time horizon, must integrate roadmapping and scenario building techniques and start from a main societal challenge in order to look beyond technology development at scientific research and at socio-economic factors. Given the complex interactions and challenges related to ICT for governance and policy modelling, we are strongly convinced that the roadmapping approach must follow such a holistic approach and look at the technological, scientific and broader socio-economic, socio-cultural and political-institutional trends, and should therefore integrate both roadmapping and scenario building techniques.

The approach chosen by CROSSROAD, therefore, is characterised by the following principles:

- Open, in order to involve the wider sets of intelligence to build on the roadmap as a platform. In order to achieve this, all main deliverable are published firstly in draft format for comments by the CROSSROAD Experts Scientific Committee and by the broader Validation group on LinkedIn.
- Iterative, so that insights progressively gained in the course of the project from different scientific communities, from the demand and supply side are fully integrated.
- Open-ended, taking into account different possible future scenarios characterised by different normative visions.
- Technology-focused but not technology-driven, aiming at detecting technological research challenges but taking full account of the multidisciplinary nature of these challenges, so that technology becomes a necessary, but not sufficient research area to be addressed.

Concretely, these principles have been applied on a well-established process, articulated through a state of the art assessment, scenarios elaboration and deriving gap analysis.

2.3 Summary of the previous steps – State of the Art, Visionary Scenarios and Gap Analysis

The adopted CROSSROAD approach is summarized in the following figure.

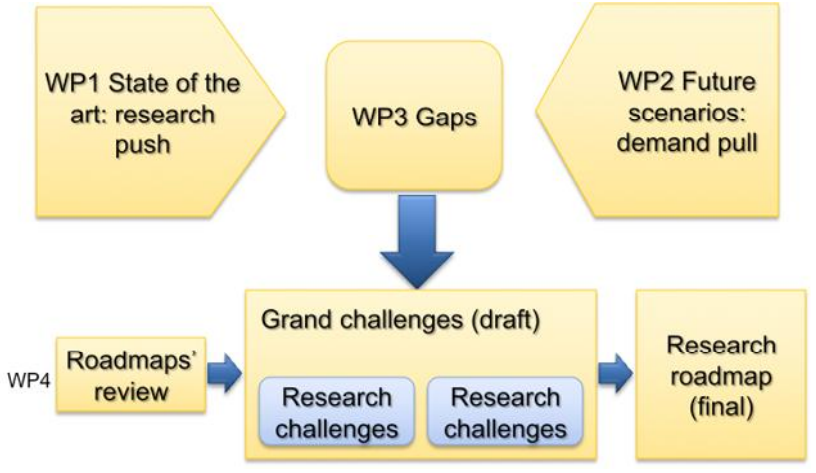

Figure 2-1: The CROSSROAD Approach

Taking a closer look into the CROSSROAD results so far, the first activity – State of Play (WP1) provided a substantial and wide review of the State of the Art, which gave a consistent definition of the research domains affected. A key output was the CROSSROAD taxonomy, which for the first time brought under a common structure disparate research fields such as agent-based modelling, online deliberation or visual analytics (see a summary of results in Annex B). For each research area, an analysis of the current status of research policy and practice was provided. This provided a snapshot of the future research directions, in continuity with current research. In other words, it delivered a research-push insight on the element that would constitute the roadmap.

The taxonomy, which now consists of the following 5 Research Themes (RTs) was discussed and validated by the Experts Scientific Committee that closely follows CROSSROAD advancements, as well as by relevant EU-funded projects in this domain:

- RT.1: Open Government Information & Intelligence for Transparency is a data- and knowledge- oriented research theme.
- RT.2: Social Networks, Citizen Engagement and Inclusion infuse the social dimensions of the Governance and Policy Modelling.
- RT.3: Policy Making is clearly positioned towards ICT-enabled policy-making.
- RT.4: Identity Management and Trust in Governance is driven by the need to safeguard citizens' and public authorities' digital presence from misuse.
- RT.5: Future Internet for Collaborative Governance embraces the Internet evolution and entails transparent and multichannel service provision.

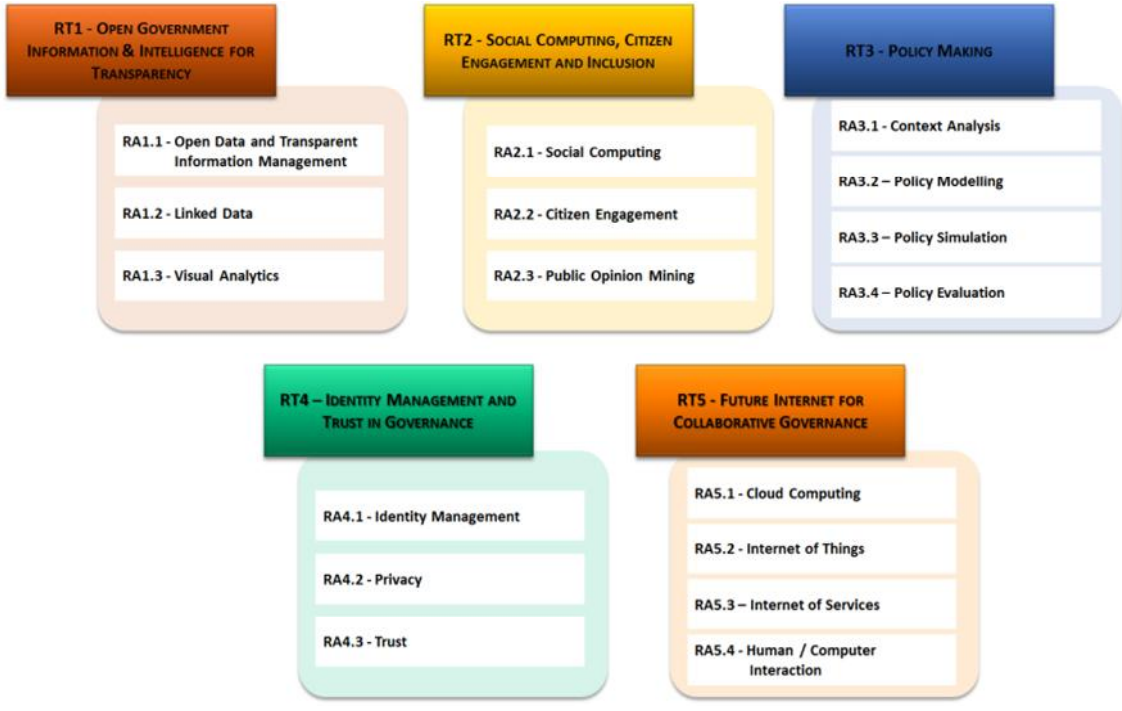

Figure 2-2: The CROSSROAD Taxonomy (as in the gov2pedia wiki, www.gov2pedia.com)

Visionary Scenarios Building (WP2), the second step of the project, resulted in more open-ended scenarios on the future of governance and policy modelling, and the deriving technological needs in order to grasp the opportunities and avoid the challenges (see Annex C for a summary). In short, the Visionary Scenarios report presented the general societal trends and a deeper analysis of policy trends, which are considered central for understanding and mapping ICT research for governance and policy modelling in future perspective, within the context of the evolving European public sector. The combination of the elements resulting from the trends analysis, together with brainstorming and creative thinking, provided the CROSSROAD partners with inputs for the shaping of the axes of the visionary scenario design framework which have been further validated through the review of emerging and forthcoming research trends and discussed during a restricted CROSSROAD Workshop with Experts that took place in Seville at IPTS on April 29-30, 2010.

Based on the scenario design framework defined, the visionary scenarios depicted for the future of governance and policy modelling of Digital Europe at the horizon 2030 encompassed:

1) **Open Governance:** characterised by High Openness and Transparency and High Integration in Policy Intelligence.
2) **Leviathan Governance:** characterised by Low Openness and Transparency and High Integration in Policy Intelligence.
3) **Privatised Governance:** characterised by Low Openness and Transparency and Low Integration in Policy Intelligence.
4) **Self-Service Governance:** characterised by High Openness and Transparency and Low Integration in Policy Intelligence.

Finally, the report offered an overview of the opportunities and risks linked to various scenarios, in order to support identifying the key future research challenges in ICT for governance and policy modelling and how these could help drive the European society to achieve the proposed vision for a digital Europe in 2030. In this way, the project looked at future needs through the demand-side.

From the integrated analysis of the State of the Art and the Future scenarios, the Gap Analysis under WP3 identified an exhaustive list of specific gaps, where the on-going research activities are not going to meet the long-term needs outlined by the future scenarios. The gaps were established by initial desk research by comparing the results of the state-of-the-art analysis (WP1) and the visionary scenarios analysis (WP2). These gaps were assessed according to their relevance and impact for achieving the five principles of Good Governance (Openness, Participation, Accountability, Effectiveness, and Coherence). This initial list was later on complemented and amended with the input received from the Experts Scientific Committee (ESC) during the Samos workshop, as well as with the results of the gap analysis online validation. The summary of this exercise can be found in the Annex D. The figure below enlists the gaps related to each of the research themes from the taxonomy as well as gaps related to visionary scenarios. The subsequent figure locates those gaps over the time horizon as well as arranges them in the order of importance.

Figure 2-3: Final list of gaps

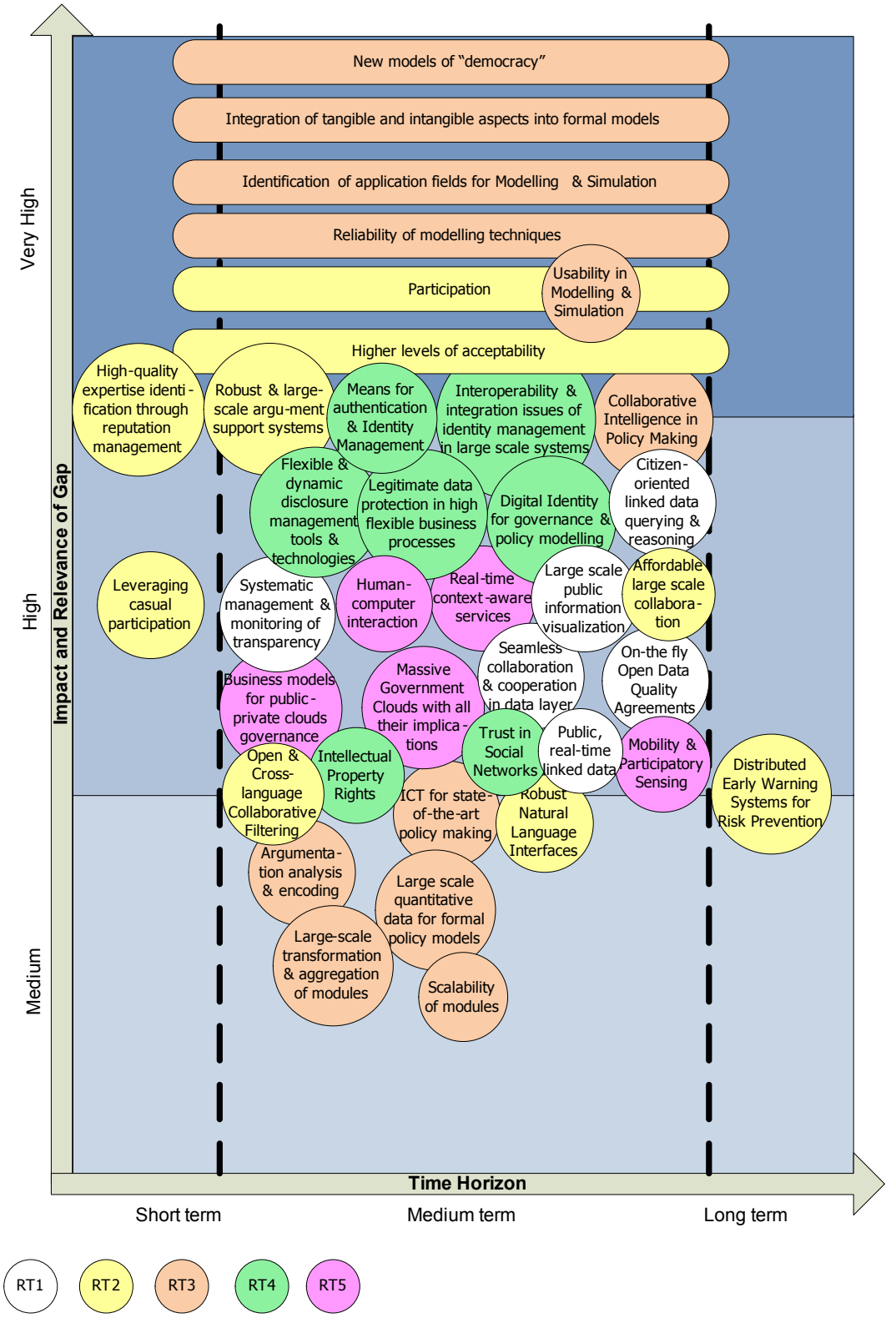

Figure 2-4: Overview of the horizon and impact assessment of the gaps

The present deliverable builds on the results of the State of the Art (SotA), the Visionary Scenarios and the Gap Analysis, by bundling the identified gaps in a limited number of Grand Challenges. These Grand Challenges should follow the following principles:

They should:

1. Be understandable, visual and inspire research ideas.
2. Be bold and disruptive but strongly rooted in the State of the Art and addressable by 2020.
3. Contain significant critical mass of research.
4. Address gaps across multiple Research Themes.

The introduction to the Grand Challenges is presented in this deliverable, in section 3.1. For each Grand Challenge, a subset of specific Research Challenges have been identified and analysed in detail in the sections 4-8. The Grand Challenges and the related Research Challenges constitute the core roadmap, which is presented in this document in the Part 2.

2.4 Collaborative deliberation process

The first draft of the roadmap (D4.1) presenting the initial description of Grand Challenges and the related Research Challenges was followed by the collaborative deliberation process, which entailed:

- **Offline consultation** at the CROSSROAD Networking Session in Brussels where the session participants had the possibility of validation and rating the research challenges.
- **Online consultation**: an online consultation was set up on crossroad.uservoice.com, which aimed at discussing and rating the research challenges.
- The **validation** by the Experts Scientific Committee of the **full draft of the roadmap**.

The CROSSROAD Networking Session was organised in the conjunction with the ICT 2010 Conference in Brussels and took place 27th of September 2010. More than 100 participants attended the meeting, which aimed at creating feedback and reaching community consensus on the research roadmap on ICT for governance and policy modelling. After the introduction to the CROSSROAD aims and the presentation of the Grand Challenges, the participants were asked to rank the research ideas within the challenges according to their importance for future advancements in the domain. The ranking results confirmed the preference of the community for a user-centred and collaborative approach in the ICT for Governance and Policy Modelling domain as well as the importance of the Policy Modelling and Simulation research.

An online deliberation was also opened and announced at the CROSSROAD Networking Session. The platform was available for a month (until 29 October 2010) and hosted on the uservoice platform. All the Grand Challenges received considerable amount of votes with the GC2 *Data-powered collective intelligence and action* receiving the highest score, which repeated the results of the workshop ranking results. Each of the research ideas within the four grand challenges received also a high number of votes. To sum up, the online deliberation process resulted in the validation of the research ideas by the large community of experts who took part in this exercise.

The workshop and online deliberation results showed that that the Grand Challenges, validated already during the Samos 2010 Summit and the EGOV 2010 CROSSROAD workshop in Lausanne, answer well the research community needs and expectations for further research. Furthermore, there were no research ideas (within the Grand Challenges) that were rejected or ranked as unimportant albeit the votes' distribution was not equal. Finally, the new ideas and comments showed the interest of the community in this exercise and enriched the final version of the roadmap. It needs to be noted that the results of deliberation process were at full length described in the CROSSROAD D4.2 Deliberation Results deliverable.

Finally, the reviews submitted by the Experts Scientific Committee provided the Roadmap Draft authors with further insights and suggestions on how to improve the structure and the content of this document.

3 The Core Roadmap

This section represents the summary of the roadmap grand challenges and final conclusions. It firstly presents the process to the identification of the grand challenges, and then it summarises each Grand Challenge. The summary is followed by a set of final conclusions giving an introduction to policy recommendations, which will be the core subject of the final deliverable Policy Recommendations (D4.4).

3.1 From Gaps to Grand Challenges

As mentioned in section 2.3, the results of the Gap Analysis illustrate a comprehensive and exhaustive list of gaps in each Research Theme. However, these gaps are not simply to be listed and analysed separately. In fact, they can be easily seen as complementary and interrelated.

As a first exercise, we have mapped the gaps in each research theme alongside a traditional model of technological layers, going from data collection to data validation, analysis, representation and decision. As depicted in Figure 3-1, each research theme[1] is present in different layers of the model. This highlights the strong complementary nature of these gaps and helps us integrating them in Grand Challenges.

USER: Citizen & Government					
Decision and action	Collaborative production	Social networking	Civic hacking	Visualiz. for behavioural change	Serious games
Data representation	Visual analytics	Augmented reality	Natural User Interface	Argument mapping	Multi-channel
Data analysis	Non-linear models	Social simulation	Forecasting	Models interoperability	Opinion mining
Data validation	Collaborative filtering	Reputation management systems	Authentication / Security	Privacy	Social Network Analysis
Data collection	Sensors / IoT / smart cities	Open gov / linked data	Citizens generated data	Serious Games	Cloud Data Exposure
PRODUCER: Citizen & Government					

Figure 3-1: Mapping gaps across technological layers (each colour represent one research theme)

[1] The red colour represent the RT1 Open Government Information & Intelligence for Transparency, yellow colour - RT2 Social Networks, Citizen Engagement &Inclusion, blue - RT3 Policy Modelling, green - RT4: Identity Management and Trust in Governance and orange - RT5: Future Internet for Collaborative Governance.

The strong complementarities highlighted in Figure 3-1 suggest that if properly addressed, solutions to these gaps could prove to be not only effective in addressing the specific gaps, but mutually reinforcing the others. In other words, the overall impact of the measures taken to address the gaps could be well superior to the sum of its parts, leading to a paradigm shift in the nature and quality of policy-making.

This paradigm shift can be further illustrated and summarised by the simultaneous three complementary disruptive techno-economic trends illustrated in the following figure (see also D2.2 Visionary Scenarios).

- Firstly, there is an explosion in the quantity of data available. As in the lower layer of Figure 3-2, Open government data, sensor and citizens' generated data and the digitization of processes are already producing what has been defined as "the data deluge".
- Secondly, citizens are taking a proactive role in contributing to the policy-making process, by authoring and elaborating the data increasingly made available. Geo-referencing and visualisation tools and ad hoc applications are being used to make sense of these data.
- Thirdly, simulation and modelling techniques are becoming more affordable and accurate, enabling a strong growth of adoption in different policy contexts.

Most importantly, these three trends are not only converging towards enhancing the quality of policy-making, but mutually reinforcing, thereby suggesting the opportunity of a paradigm shift, leading to radically new ways to design, implement and evaluate policies.

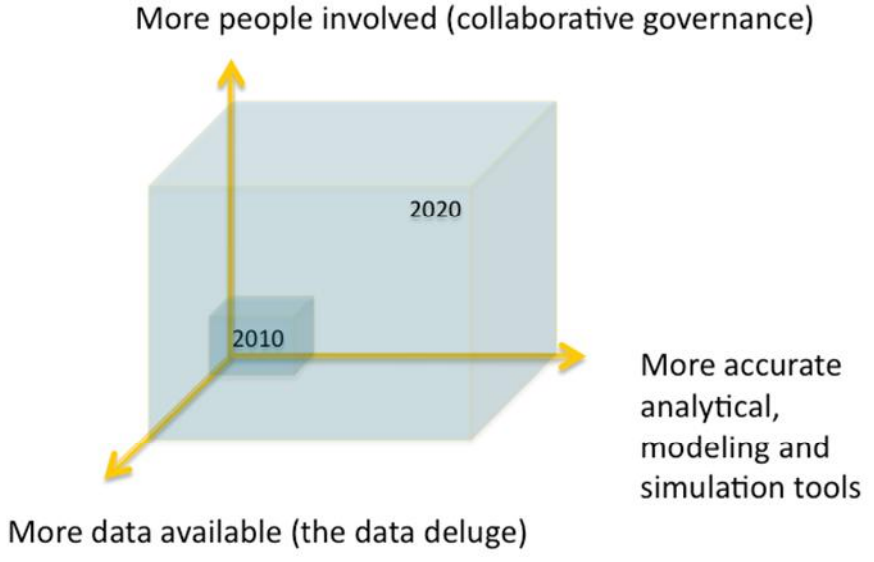

Figure 3-2: Three trends leading to a paradigm shift in policy-making

In order to grasp these opportunities, we are convinced (and supported by the overall consent of the experts as expressed in the deliberation process), that the following Grand Challenges have to be met:

1. **Model-based collaborative governance**: How to assist policy makers in taking evidence-based decisions in our complex, unpredictable world? Existing econometric models are unable

to account for human behaviour and unexpected events. New policy modelling and simulation are fragmented, single-purposed and work at micro-level. There is a need for robust, intuitive, reusable collaborative modelling tools that can be integrated into daily decision-making processes.

2. **Data-powered collective intelligence and action**: How can we make sure that increased transparency translates into actual more open and more effective policy-making? Current tools require high involvement and attention, therefore engaging only the very committed people. They are designed to facilitate conversations, rather than action. There is a clear need for more intuitive collaborative tools that are able to engage also less interested people, maximizing the impact of short attention span and low-engagement, as well as for ICT based feedback mechanism that are able to encourage real action and behavioural change.
3. **Government Service Utility**: How to provide high-impact services to citizens, businesses and administrations in a way that allows for co-design, public-private collaboration, citizen interaction and service co-generation that allows for 1-stop, 1-second service delivery at very low cost and administrative burden and for completely new services, through mash-up and interoperability-by-design?
4. **Scientific base of ICT-enabled governance**: How to make ICT-enabled governance a rigorous scientific domain, by providing formal methods and tools? The systematic classification of problems and solutions and description through formal languages, in an effort to make diagnosis and prescription of solutions a scientific process that will allow building on top of existing knowledge.

These challenges can be depicted as three key pillars crowned by the fourth overarching challenge, as illustrated in the figure below.

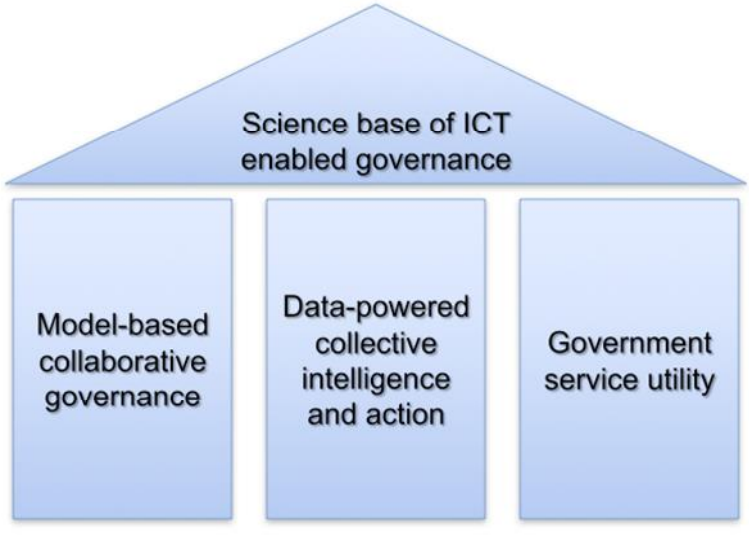

Figure 3-3: Schematic illustration of the four Grand Challenges

In the next section, the Grand Challenges and the deriving Research Challenges will be described in more detail.

3.2 Grand Challenges summary

This section recapitulates the content of the second part of the report, i.e. the detailed description of the Grand Challenges along with their respective research challenges.

3.2.1 GC1 Model-based Collaborative Governance

Our rapidly changing and complex society requires an efficient and effective decision-making process, able to anticipate future events, promptly detecting emergencies and evaluating the impact of different policy choices, reflecting the real-life complexity while making it simpler and addressable. The GC1 Model-based Collaborative Governance focuses on the development of advanced tools and methodologies in order to pursue the above-mentioned goals. It follows a vision of a radically different context for policy modelling and simulation, where standardisation and reusability of models and tools, system thinking and modelling applied to policy impact assessment has become pervasive throughout government activities. GC1 aims at enabling the engagement of all stakeholders (even without expert skills) in collaborative policy model building, simulation and evaluation process. This implies a great effort to improve state-of-the-art ICT tools and methodologies in order to guarantee the efficiency of policy modelling process. The improvements, in terms of usability and consequently time and cost consumption, the effectiveness of the process as well as in terms of reliability and knowledge of both models and policies should be introduced.

In this context, the research challenges that should be addressed with a long-term perspective include:

- **RC1.1: Integrated, composable and re-usable models** to create more comprehensive and complex models by using smaller building blocks or existing objects/models. This implies both model interoperability and the definition/identification of proper modelling standards, procedures and methodologies.
- **RC1.2: Collaborative modelling** encompassing participation of all stakeholders in the policy-making process through the implementation of Internet-based easy-to-use tools for all the levels of skills.
- **RC1.3: Easy access to information and knowledge creation** with a particular focus on elicitation of information. The simplification of access would, during the overall model building and use processes, help decision makers to learn how a certain system works and ultimately to gain insights and understanding in order to successfully implement a desired policy.
- **RC1.4: Model validation** in order to guarantee the reliability of models and, consequently, of policies that are crucial for policy makers who need and use information that results from the simulations to develop more effective policies.
- **RC1.5: Interactive simulation** concentrating on the fact that the larger the model is in terms of size and complexity, the bigger is the resulting amount of data to analyse and visualize. In particular, the RC refers to the issue of integration of visualisation techniques within an integrated simulation environment, in order to dramatically increase the efficiency and effectiveness of the modelling and simulation process, allowing the inclusion and

automation of some phases (e.g. output and feedback analysis) that were not managed in a structured way up to this point.

- **RC1.6: Output analysis and knowledge synthesis** refers to output analysis of a policy model and, at the same time, to feedback analysis in order to incrementally increase and synthesise the knowledge of the model (and consequently of the policy).

3.2.2 GC2 Data-powered collective intelligence and action

The current citizen participation scene is characterised by an engagement of highly interested people only, and by an engagement that rarely stimulates genuine action. There are several complementary research areas in ICT for governance and policy modelling that have the opportunity to address the need for collaboration and behavioural change throughout different technological layers: enhanced data availability through public linked data and participatory sensing, analytical capability through opinion mining and visual analytics, and action-oriented tools such as simulation and serious gaming. These trends mutually reinforce each other to offer a new opportunity for future ICT for governance and policy modelling.

The collaborative governance vision, proposed as an alternative, includes citizens in all the phases of the governance: in collecting relevant data through participatory sensing tools; in analysing the data through simulation and visualisation software; in acting upon these data through bottom-up self-organized action which accompanies, anticipates and stimulates government policies.

For this vision to become a reality, substantial research effort is needed in following research challenges:

- **RC2.1: Privacy-compliant participatory sensing for real-time policy-making** refers to the use of sensors, usually embedded in personal devices, such as smartphones, allowing citizens to feed data of public interest.
- **RC2.2: Real-time, high-quality, reusable open government data** calls for simplification and lower costs of the open data publication.
- **RC2.3: Federated dynamic identity management** addresses the eIdentity-related issues for secure public service provision, citizen record management and law enforcement.
- **RC2.4 Peer-to-peer public opinion mining** points out to the explosion of user-generated content, which widens the application scope of public opinion mining tools and to the fact that these tools need to become more pervasive and available to the majority of citizens.
- **RC2.5: Intuitive, collaborative visual analytics of data for policy-making** refers to the research focussed on making sense of large datasets, such as those provided as open government data.
- **RC2.6 User-generated simulation and gaming tools for public action** underlines that serious gaming is still requiring high level of engagement and therefore progress in usability and attractiveness in order to widen the group of participants is needed.
- **RC2.7: New institutional design of collaborative governance** recalls that collaborative governance is developing without an appropriate reference framework.

3.2.3 GC3 Government Service Utility

The dawn of a new era which highlights service creation and delivery as its principal ingredient has started to influence the public sector that now needs to drive public services towards Future Internet advancements. The Grand Challenge GC3-Government Service Utility has adopted the key concepts of a utility, such as Ubiquitous nature, Usability, Federation, Co-generation, and De-regulation, and is aligned to the philosophy of collaboration, openness and innovation. According to the CROSSROAD vision, it aims to cultivate "... a vision of the Internet of the Future, where public organisations, citizens, enterprises and non-profit organisations can collaboratively shape public services at design-time and runtime, in order to be delivered as a utility-like offering at their own ends, to the channels they prefer and in the context and situation they are".

In this context, the research challenges that should be addressed in the long-term perspective include:

- **RC3.1: User-driven innovation shaping Public Services** during their whole lifecycle in order to be delivered to their beneficiaries at their own ends, in ways and means they prefer.
- **RC3.2: Change the DNA of Public Services** in the direction of the 1-1-1 concept that supposes that «Every public service can be provided in one-stop, within one second, with one euro (or minimum) cost, to any device and by anything».
- **RC3.3: Digital Public Services Value Proposition for All** which defines and assesses the impact for all stakeholders within a complex public services ecosystem.
- **RC4.3: Massive Public Information as a Service** promoting a service-oriented attitude to the public sector information (PSI).

3.2.4 GC4 Science Base of ICT for Governance and Policy Modelling

The general aim of this challenge is to establish the initial foundation of ICT for Governance and Policy Modelling as a new science, complementing those of Informatics and Political Science, which is envisaged to benefit from all developments of the neighbouring field.

The Grand Challenge encompasses the following Research Challenges

- **RC4.1: Multidisciplinary issues and relations with neighbouring domains**, that investigates possible links with other, related scientific areas and attempts to structure the domain according to other successful domains.
- **RC4.2: Metrics and Assessment Models, Decision Support, Modelling & Simulation Tools,** that aim to bring together the technological and the societal aspects of the domain of ICT for governance and policy modelling towards more concrete, holistic and accurate decision support models.
- **RC4.3: Formal methods and tools**, which aim at setting the foundations for the new proposed scientific domain.

Alongside, this challenge includes also the vision of building an active community, i.e**. community formation**, which will be the main motivator that will work towards the establishment and the evolution.

3.3 Crossing boundaries: other roadmapping activities from the neighbouring domains

In order to check the alignment of the Grand Challenges with roadmaps in other parallel application domains, the review of following roadmapping activities was carried out:

- VisMaster, Mastering the Information Age Solving Problems with Visual Analytics 2010 (http://www.vismaster.eu/)
- Roadmapping Personal Health Systems: Scenarios and Research Themes for Framework Programme 7th and beyond, 2009 (http://ec.europa.eu/information_society/newsroom/cf/itemdetail.cfm?item_id=5555&utm_campaign=isp&utm_content=tpa-23)
- eGovRTD2020. Roadmapping eGovernment Research. Visions and Measures towards Innovative Governments in 2020, 2008 (http://www.egovrtd2020.org/)
- The Future of Cloud Computing, Opportunities for European Cloud Computing Beyond 2010, 2009 http://cordis.europa.eu/fp7/ict/ssai/docs/cloud-report-final.pdf
- White Paper: "World Society Modeller" (S Gaia), FET Flagship Proposal within the FutureIcT stream, 2010 (http://cordis.europa.eu/fp7/ict/fet-proactive/docs/flagshipcons09-01_en.pdf)
- Internet of Things. Strategic Research Roadmap, 2009 (http://ec.europa.eu/information_society/policy/rfid/documents/in_cerp.pdf)
- Living Roadmap of Complex Systems, RNSC, 2008-ongoing (http://css.csregistry.org/tiki-index.php?page=Living+Roadmap)

The review results showed that the specific application domains related to the ICT for Governance and Policy Modelling domain focus on similar issues to those gathered under the four CROSSROAD grand challenges (the full review is provided in Annex D).

Table 3-1: Review of roadmapping activities. Summary

<table>
<tr><th>Model-based collaborative governance</th><th>Data-powered collective intelligence and action</th><th>Government Service Utility</th><th>Scientific Base for ICT-enabled Governance</th></tr>
<tr><td colspan="2">VisMaster</td><td></td><td></td></tr>
<tr><td colspan="2">PHS Roadmap</td><td></td><td></td></tr>
<tr><td></td><td colspan="2">eGovRTD2020</td><td></td></tr>
<tr><td></td><td></td><td colspan="2">Future of Cloud Computing</td></tr>
<tr><td>World Society Modeller</td><td></td><td></td><td>World Society Modeller</td></tr>
<tr><td></td><td colspan="3">Internet of Things</td></tr>
<tr><td colspan="2">Living Roadmap of Complex Systems</td><td></td><td></td></tr>
</table>

The ***VisMaster*** roadmapping activity stresses **the importance of developing tools and methods for integration of heterogeneous, dynamic and large datasets**. Moreover, there is a need for further research on the possibilities of real-time analysis of multi-level, spatio-temporal data. Further to that, it calls for solutions enabling effective and easy collaboration as well as for interactive and intuitive interfaces for wider audience. The roadmap also stresses the importance of designing the visual analytics systems using the state-of-the-art knowledge. Finally, it underlines the need for infrastructure including multi-scale analysis or functionalities enabling the overview of partial analysis. The VisMaster is linked first and foremost to the Model-based Collaborative Governance and Data-powered collective intelligence and action.

The **Roadmapping Personal Health Systems** (PHS) project concluded with recommendation on further research on infusion of clinical evidence and of molecular and genetic data, advancement in the development of sensors, more sophisticated algorithms and data processing solution capable of turning inert data and information into knowledge and knowledge into wisdom as well as development of interfaces and channels of interaction maximising inclusiveness and users friendliness. Amongst all these recommendations, **the further research on sensors, the call for intelligent PHS data processing and user-inclusive PHS interfaces** are the most important for the CROSSROAD roadmap activity. The PHS roadmap results are linked to the Model-based Collaborative Governance and Data-powered collective intelligence and action.

Albeit the **eGovernment Roadmapping** project (GovRTD2020) was focused rather on the overarching directions of research in eGovernment, many of the recommendations match the CROSSROAD Grand Challenges. This project recommended, among others, **further research on possibilities on semantic and cultural interoperability of public services to facilitate cross-organisational collaboration among the various users, trust in eGovernment, ontologies and intelligent information and knowledge management to achieve information quality and economy and developments of tools, further exploration of methods of enhancing eParticipation and citizens engagement as well as tools and methods for protecting citizens' personal data and personal identity**. Roadmapping eGovernment Research conclusions are closely related to the Data-powered collective intelligence and action and Government Service Utility challenge.

The **Future of Cloud Computing** report as the most important challenges beyond 2010 identifies the **scale and elastic scalability of the cloud, data management solutions as well as trust, security and privacy issues related to the multi-tenancy, different legislation regimes and remote control over data**. Moreover, it calls for large-scale research and experimentation test beds, development of joint programmes that encourage expert collaboration groups and encouragement of the development and production of cloud interoperation standards and an open source reference implementation. These recommendations on further research and legislation developments refer mostly to the Government Service Utility and Scientific Base for ICT-enabled Governance Grand challenges.

The **World Society Modeller White Paper** calls for an interdisciplinary ecological framework for the progress of science and engineering. This new science of computational socio-geonomics will develop new forms of computational science, technologies and infrastructures. The White Paper aims also at developing a **global virtual world modelling and simulation environment** (alias

global/cloud computing), i.e. meta model of society and an ubiquitous event based processing infrastructure, that handles complex emergent phenomena in socio-technical systems. Finally, it has the ambition of creating new paradigms of social engagement that can be termed "computer human confluence". These future research aims correspond to those of Model-based Collaborative Governance challenge as well as to the Data-powered collective intelligence and action and Scientific Base for ICT-enabled Governance challenges.

The **Internet of Things report** concludes with an identification of the set of research needs for this domain, including **identification, communication, network, security and privacy technology** as well as **IoT Architecture and Hardware systems**, **devices and circuits**. The authors envisage that IoT will allow people and things to be connected Anytime, Anyplace, with Anything and Anyone, ideally using Any path/network and Any service. These recommendations are linked closely to the Government Service Utility as well as to some extent to the Data-powered collective intelligence and action.

Finally, **Living Roadmap of Complex Systems** posits several challenges grouped in 10 topics focussed on **epistemology, collective behaviour studies, multiscale governance, artificial complex system design (simulations and models), theory and measure of networks**. These future research aims correspond, above all, to the challenge of Model-based Collaborative Governance and to the Data-powered collective intelligence and action as well as the Scientific Base for ICT-enabled Governance challenges.

Table 3-2: Grand Challenges in view of other roadmapping activities recommendations

Roadmapping activity	Recommendations	Relation to Grand Challenges			
		Model-based collaborative governance	Data-powered collective intelligence and action	Government Service Utility	Scientific Base for ICT-enabled Governance
VISMASTER	Scalability, uncertainty of the data and real time analysis				
	Meeting the user's needs				
	Designing the visual analytics systems using the state-of-the-art knowledge				
	Technology – providing the infrastructure needed				
PHS	Third generation PHS				

Roadmapping activity	Recommendations	Relation to Grand Challenges			
		Model-based collaborative governance	Data-powered collective intelligence and action	Government Service Utility	Scientific Base for ICT-enabled Governance
	sensors				
	Intelligent PHS data processing				
	Interfaces and channels of interaction maximising inclusiveness and users friendliness				
eGovRTD2020	Trust in eGovernment				
	Semantic and cultural interoperability of public services				
	Information quality				
	eParticipation, citizen engagement and democratic processes				
	Ontologies and intelligent information and knowledge management				
	Data privacy and personal identity				
Future of Cloud Computing	Scale and elastic scalability				
	Regulatory framework				
	Large-scale research and experimentation test beds				
	Joint programmes				
	Open source reference implementation				

Roadmapping activity	Recommendations	Relation to Grand Challenges			
		Model-based collaborative governance	Data-powered collective intelligence and action	Government Service Utility	Scientific Base for ICT-enabled Governance
	Promoting the European leadership position through commercially relevant open source approaches				
S-GAIA	New science of computational socio-geonomics				
	Meta-model of society				
	New paradigms of social engagement that can be termed "computer human confluence				
Internet of Things	IoT architecture and technology				
Living Roadmap of Complex Systems	Formal epistemology, experimentation, machine learning				
	Stochastic and multiscale dynamics, instabilities and robustness				
	Collective behaviour in homogeneous and heterogeneous systems				
	From optimal control to multiscale governance				
	Reconstruction of multiscale dynamics,				

Roadmapping activity	Recommendations	Relation to Grand Challenges			
		Model-based collaborative governance	Data-powered collective intelligence and action	Government Service Utility	Scientific Base for ICT-enabled Governance
	emergence and immergence processes				
	Designing artificial complex systems				
	Emergence in physics: collective behaviour and fluctuations out-of-equilibrium				
	Theory and Measure of Networks				
	"Prediction" versus "Understanding"				

4 Conclusions: closing the loop of policy-making

In this section, we provide a summary and a unitary perspective of the CROSSROAD roadmap. We first identify the key challenges, and then the opportunities offered by research and innovation in ICT for governance and policy modelling.

4.1 The challenges of reductionist policy-making

Contrary to common wisdom, the size of government has not decreased in the course of the 20th century. It has increased continuously until the 70s, and remained stable all through the next 30 years, despite privatisation. We have seen a move from a service provision role towards a regulatory one, often in new areas such as environment, telecom and technology [81]. As such, the role of government today is much more about "steering" than about "rowing". The policy-maker's job has become more difficult because of new challenges.

First, today's society and economy is more than ever interconnected, unstable, and unpredictable. As Taleb [113] puts it, we live in the age of "extremistan", a world of "tipping points" and "power laws" where extreme events are "the new normal". There are many indications of this extreme instability, not only in negative episodes such as the financial crisis but also in positive development, such as the continuous emergence of new players on the market epitomised by Google.

The current tools available for policy design, implementation and evaluation are ill-suited for capturing this complex and interconnected nature. Policy models oversimplify reality through a reductionist approach, and work mostly under the assumption of linear developments, predictability and general equilibrium in the long run. Alternative tools, built in the realm of complexity science and enabled by the explosion in data availability, are used only at micro level and for niche areas.

Secondly, the policy issues of today can only be met through the collaboration of all the components of the society, including the private sector, individual citizens and the civil society. Climate change, low carbon economy, respecting consumable resources, sustainability of the health system, all require the proactive involvement and action of all stakeholder, and changes in the daily behavior of citizens. Low carbon can only be achieved if everyone changes the small daily choices on things such as energy consumptions. Preventing sky-rocketing health costs can only be achieved by more healthy behavior by everyone, day by day. Some researchers talk about the need for an "empathic civilisation"[95]. Top-down policies are unlikely to generate effective impact. As the UK Prime Minister puts it, "the success of the Big Society will depend on the daily decisions of millions of people".

Furthermore, citizens are increasingly expecting to have a voice in complex policy decision-making. Current decision support tools work under the assumption that government have the data, analyses it and then takes a decision. To change this, the emergence of the "Gov 2.0 paradigm" has offered interesting opportunities for citizens to enter into data production, analysis and decision-making, but its impact is far from striking. Too often, gov2.0 collaboration ends in conversations on social networks, blog and twitter but real impact has only been achieved in specific, highly advertised cases which led to high mobilisation. Furthermore, participation in collaborative activities remain limited to

those very highly motivated in policy issues: gov2.0 involves the "Lisas Simpson" and not the "Barts". Just as too often government policies assume a simplified, utility-maximizing individual, failing to account for emotions and other incentives and drivers of behavior, in the same way gov2.0 initiatives assume that citizens "should" be interested in policies, which is clearly not the case for the vast majority. Using the words of Danah Boyd, "transparency is not enough". Or as Lawrence Lessig puts it: "with the ideal of naked transparency alone--our democracy, like the music industry and print journalism generally, is doomed. The Web will show us every possible influence. The most cynical will be the most salient. Limited attention span will assure that the most salient is the most stable. Unwarranted conclusions will be drawn, careers will be destroyed, alienation will grow."[73]

This touches upon the key issue of the diversity of individuals, and the difficulty of policy makers to represent and to take decisions which are successful and impactful for such diverse groups. Too often decision-support tools assume uniform behaviour of the "average" citizen not accounting for diversity.

Finally, the problems we are facing are rooted in the short-term nature of human nature and our difficulty to take due account of long-term impact of our choices. Short-term impacts are more predictable and more visible, but in an increasingly interconnected world the actual long-term impact of the choice can be unintended and opposite to the expectations.

In summary, traditional policy making tools are limited insofar as they assume an abstract and unrealistic human being: rational (utility maximizing), average (not heterogeneous), atomised (not connected), wise (thinking long-term) and politically committed (as Lisa Simpson).

We see now the opportunities for an ICT-enabled policy-making model that takes full account of human nature.

4.2 The opportunities: the CROSSROAD model

Faced with these challenges, the CROSSROAD project has identified a set of emerging innovative solutions, which are the building block for the next generation policy-making.

None of these blocks is already mature, but each of them is developing at high pace. The combination of these accelerating trends is likely to achieve an impact far bigger than the sum of its part, if properly integrated and addressed in a strategic perspective.

We here adopt a technology layer model [26], with three layers: data, analysis and decision/action. The two bottom layers are traditional: data collection and data analysis to support decision. However it is highly necessary to add a final layer, leading to actual decision, action and behavioural change. All three are important:

- The data layer provides **new information** that was previously not available.
- The analysis layer provides a new perspective and **understanding** of data.
- The behavioural change layer acts on the **incentives** and **barriers** to action and behaviour.

Typically, ICT is considered as a useful tool to obtain and process large amount of data. It assumes a rational, average, atomized human being that takes utility maximising decision - an unrealistic assumption. Instead, we argue that ICT can help to fill the "last mile" in order to generate true impact. All too often governments do not take the correct decisions even when the decision is made, because of political pressure and lack of foresight. All too often citizens' online collaboration remains

at the level of conversation and does not translate it into real action. We argue, on the basis of the roadmap building process, that ICT is not only important for decision support, but can modify the incentives to actual action and behaviour, based on technologies that account for human nature.

Table 4-1: The role of ICT in policy-making

	Traditional role of ICT	**Role in the CROSSROAD model**
Action and behavioural change	Not important, left to human behaviour	Important, by changing the incentives and reducing costs of action
Data Analysis	Important	Important
Data Collection	Important	Important

A further, important feature of this model is that is that all three layers are relevant for both government and citizens. In the traditional 20th century government, we were used to have the government collecting the data, analysing them and taking decisions/actions autonomously. Citizens' participation was limited mostly to the act of voting every 4-5 years. The Government 2.0 model, which emerged in the last three years, instead suggests that government should simply collect data and expose them for citizens to analyse and build applications on top of that, while government then implements the decisions taking into account the insight gained by citizens. As Sunlight Foundation puts it, "government should be providing the data in usable formats and focusing primarily on that. External entities will always give the data more exposure and treatment than government can[2]."

The CROSSROAD model goes beyond this perspective and postulates that in order to address the large-scale, systemic challenges of today, we should include citizens input at all level of the value chain, not only at the analysis layer:

- At the level of data collection, by enabling citizens to produce data through participatory sensing. This accounts for many criticisms of the "asymmetric" nature of the government 2.0 model (http://blogs.gartner.com/andrea_dimaio/2009/11/11/fighting-the-asymmetry-of-government-2-0/)
- At the level of action, by acting on the incentives to action and behavioural change by government and citizens.

Table 4-2: The role of citizens and government in policy-making models

	Traditional policy making (yesterday)	**Policy-making 2.0 (today)**	**CROSSROAD policy making model (tomorrow)**
Action and behavioural change	Government	Government	Citizens/ Government

[2] http://sunlightlabs.com/blog/2009/should-datagov-visualize-probably-not/

	Traditional policy making (yesterday)	Policy-making 2.0 (today)	CROSSROAD policy making model (tomorrow)
Data Analysis	Government	Citizens	Citizens/ Government
Data Collection	Government	Government	Citizens/ Government

Finally, the CROSSROAD model identifies these opportunities across different policy domains. We are currently seeing a rapid adoption and innovation of these tools in different policy domains but without clear cross-cutting connection. We propose to build a unified research approach across all policy domains, bringing together the research and innovation effort which is ongoing in diverse fields such as governance, public health and environment.

Table 4-3: Relations between three layers and policy domains

	Governance	Public Health	Environment
Action and behavioural change	Usage of geo-tagging for Haiti relief effort	Persuasive technology for physical exercise	Serious gaming for less energy consumption
Data Analysis	Wheredoesmymoneygo.org	Agent-based modelling of epidemics	ABM for traffic and energy/water consumption
Data Collection	Data.gov portals	Nanotechnology for measuring glucose in blood	Sensor-based data collection of pollution

We summarise in the next sections the evolution and implications of the technological opportunities of each layer, as depicted in the figure below.

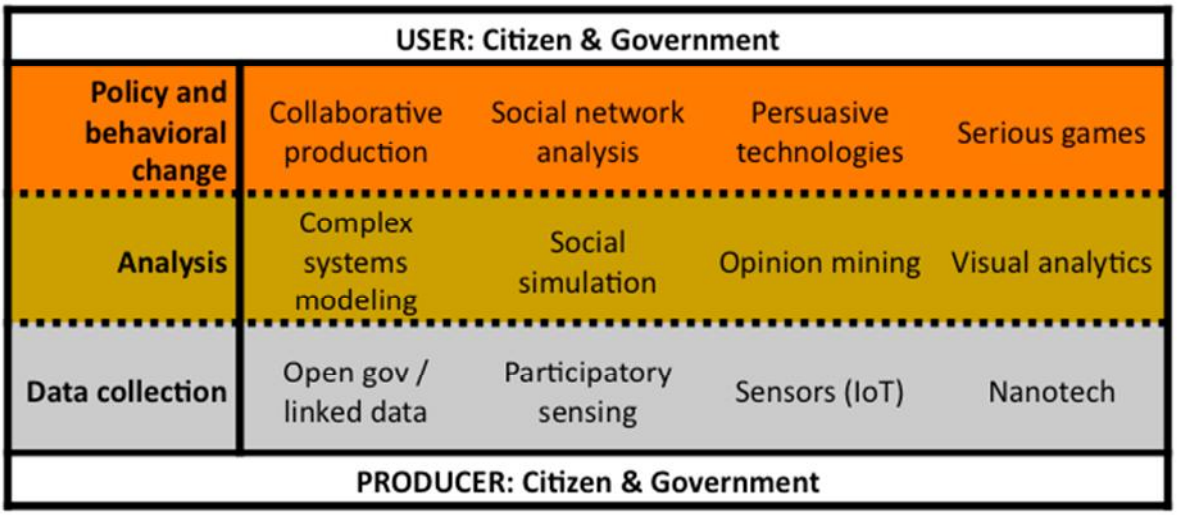

Figure 4-1: The CROSSROAD model of ICT for governance and policy modelling

4.2.1 The data layer

The bottom layer constitutes enhanced possibilities for data collection that will increase dramatically the level of data available. We are already seeing the effect of this "data deluge"[5], caused by an increased amount of electronic action performed (such as using social networks online) and the progressive pervasive reach of IT in all devices, such as cars and smartphones. It is already changing the way science is performed: «faced with massive data, this approach to science — hypothesize, model, test — is becoming obsolete» [5].

The first of this trend is the so called "open data" movement. All across Europe and the US, governments are increasingly publishing their data repositories for other people to access and use it. The UK and the US have led the way in publishing "data catalogues" but in order to make sense of this data the publication process is being streamlined. There is large scope for innovation, such as implementing and advancing the W3C "Linked Data" model based on semantic technologies, tools for creating and integrating heterogeneous datasets, privacy-enhancing technologies. The same trend is visible in other related field such as science, where the results and underlying data publicly funded research are increasingly released for public access.

At the same time a vast amount of data is made available by citizens through "participatory sensing". Citizens take a proactive role in publishing their comments and complaint on line, through sites as fixmystreet.org and patientopinion.org.uk. They also increasingly use technology to record additional information, such as photos or audio recordings, typically through smartphones. The cost reduction of consumer technology is increasingly making sensor-based devices cheaper and more popular. In the field of personal health systems, devices to measure one's data such as pressure and heartbeat enable continuous self-monitoring. Furthermore, these devices are become increasingly "smart" and pervasive, enable "opportunistic sensing" [66], where the users no longer proactively provide the data but simply carry around devices that without effort collect and transmit relevant data.

Sensors are becoming embedded in everyday non-ICT, such as cars or the urban landscape. They are also becoming increasingly small, and in the field of health we are already seeing the first

nanotechnology devices that measure continuously the patient health status, for example the glucose levels in diabetes patients.

This explosion in data availability is not only quantitatively changing the amount of data available, but qualitatively changing the nature of evidence-based policy making. The granularity of data, in terms of detail and temporal distance between measurements, is enabling a new kind of real-time policy-making.

Furthermore, these data, as well as government data, are not only collected by citizens but now made available to citizens so that new information becomes available. This enhanced information availability in itself can change the behaviour of government, by exposing its behaviour through transparency; and can change the behaviour of citizens, by providing them new information, for example on how money is spent to clean up graffiti in the streets. However, this behavioural change concerns only truly motivated people and people who can build applications on top of data.

To meet these opportunities, it is necessary to address the specific research challenges analysed in the roadmap, for example in terms of data quality, completeness and integration, privacy and portability.

But even when these problems are resolved, we encounter the limits in the capacity to analyse and make sense of such a large amount of data, this issue will be further investigated in the next section.

4.2.2 The analysis layer

At the level of data analysis, we encounter several technological innovations that help making sense of the large amount of data available and we refer to innovative emerging fields such as policy modelling, visual analytics and opinion mining.

Policy modelling and simulation, in particular through the methodologies developed within complexity theory such as system dynamics and agent based modelling, enable to make sense of large-scale human systems and to predict possible policy impacts by including the full scale of human complexity, rather than through a reductionist approach that postulates the existence of an average, utility-maximising citizen. Rapid development of modelling and simulation software includes a more open and collaborative model building that embraces all relevant expertise and stakeholders in the modelling process, as well as a more intuitive interface for simulating different policy impacts. In this way, even less technology and modelling savvy individuals, both in and outside government, can understand the potential impact of different policy options. A system dynamics approach allows including the dynamic interactions and feedback loops of the widest set of actors, going beyond the linear and sector-based approach of most traditional policy models. Finally, these approaches allow to better capture and anticipate possible tipping points and unexpected events. In general, simulation is crucial in ensuring a clear anticipation of long-term and systemic unintended consequences of today's choices.

Visual analytics allows turning the information overload into an opportunity. In the policy context, it allows for more meaningful, evidence-based policy debate that engages also non-experts. Visualisations prove to be particularly effective in making sense of large datasets, such as those provided as open government data. Multiple visualisation allow for illustrating multi-faceted problems,

such as policy-related issues, thereby facilitating informed debate. Ensuring appropriate visualisations can therefore be considered a key component of a mature democracy.

For example, complicated matters such as Facebook privacy provisions can be made much more understandable through visualisation, as in the following figure. This enables a better and wider understanding of key issues, thereby removing many barriers to participation.

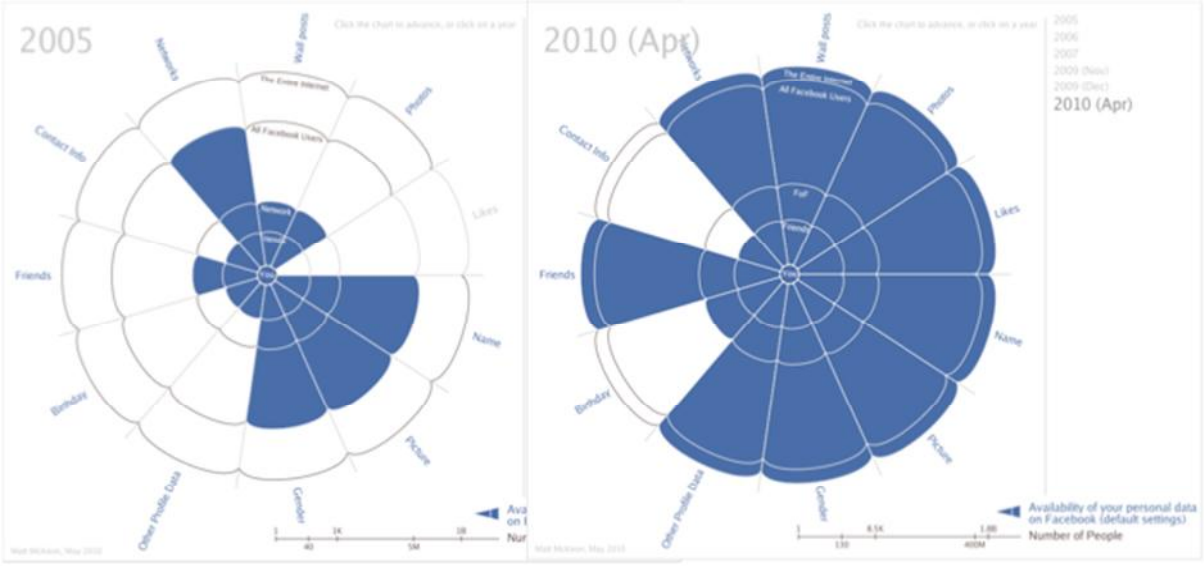

Figure 4-2: The evolution of Facebook privacy 2005-2010

The limits of human attention, combined with the existing simple interfaces available for browsing discussion and comments, often leads to low levels of engagement and flaming wars, driving to polarisation of arguments and enhanced risks of conflicts. To address this challenge, opinion mining differs from pure data and text mining insofar it deals with subjective statement. In this sense, it is a specific development of a discipline dealing with unstructured information extraction (IE) that was previously mainly working with objective data such as natural disasters or bibliographic information. The explosion of user-generated content widens the application scope of public opinion mining tools, which are becoming more pervasive and available to the majority of citizens.

Current research efforts are ongoing to translate and reuse lexicons across languages, while multi-lingual opinion mining tools are not mature. A specific hard challenge for policy debate is the detection of ironic judgements.

Additionally, public opinion mining is to become increasingly real-time and focussing on identifying not only representative opinions but also high-quality and highly influential ideas through a combination of semantic and statistical analysis with Social Network Analysis and recommendation systems.

In summary, these tools make it radically easier for both citizens and government to have a clearer, more complete, systemic and long-term view of the key policy challenges we face. They provide new evidence to make rational decisions and as such, they are fundamental tools for the most motivated and virtuous government and citizens («the Lisa Simpsons»). They help also reducing the attention burden for the less committed, as visualisation, simulation and opinion mining make information more

intuitive and easier to understand. As such, they substantially lower the barriers to entry in collaborative policy-making.

But still they leave implementation exclusively to human action, because they do not act on the incentives to act. We now see an emerging array of innovative ICT solutions that help translating knowledge into impactful action and change.

4.2.3 The action and behavioural change layer

The final step of the policy-making process is the action and implementation. In the CROSSROAD project, this final step can also benefit highly from the development of innovative technologies which act on the incentives to change human behaviour. Rather than assuming a rational human, they play with the subtilty of human psychology and in particular with human "vices" such as vanity, peer pressure, imitation, fun and competition. They assume that action and change does not pertain to government only, but to the daily decisions of people.

A promising research area is "persuasive technologies". This refers to ICT applications and devices that "nudge" people to act and behave in a certain way. The notion of "nudging" refers to the liberal paternalism outlined by [114]. The field of persuasive technologies is currently growing strongly in number of applications, in particular for smartphones that help people quitting smoking or exercising or behaving «greener». They provide feedback and nudge users in the desired direction. There is substantial evidence that users respond to these psychological stimuli (such as smiles) more than to dry factual information. Persuasive technologies have been used in such diverse fields of health (in order to promote healthy behaviour, exercise and posture), environment (to control energy and water use) and privacy (to limit information exposure). However, there is little integration between experiments on-going in different policy-relevant fields. There is a need for a more integrated and self-consistent approach to the usage of persuasive technologies for addressing the collective challenges that our society faces. In order to generate behaviour, persuasive technologies act on the incentives to act, and on human feelings such as anger, vanity, imitation, competition.

Serious gaming is one particular kind of persuasive technologies that introduces a competition and fun dimension that transforms a perceived cost in a benefit. For example, the Toyota Prius control panel suggests a competition to induce the user to consume less fuel and more electric power.

Persuasive technologies are particularly impactful when used in combination with social network analysis, which allows for a better understanding of network effects. One of the main motivations of human behaviour is its social aspect. The point is that one’s behaviour is affected by what other people do, and in particular by the choices of one’s trusted contacts, rather than being based on rational arguments only. This is a long-established notion in behavioural economics, known as bandwagon effects. ICT-based social network analysis allows to better understand the structure of the network and the influences between the agents, thereby allowing for a better understanding on how policy could impact behaviour through network effects and trusted contacts. For example, policies to encourage people to act more healthily would be far more effective by providing for example information about the behaviour of trusted contacts. An individual would be far keener to go jogging if he could share this behaviour with his social contacts.

4.2.4 Acting on the incentives to participation

We here analyse in more detail how innovative ICTs can modify the incentives to human behaviour.

We need to distinguish between incentives to use the applications, and incentives to actually change behaviour. We can easily envisage situations where users play with an application but then fail to act accordingly.

Secondly, we need to distinguish between motivated and non-motivated users – which we named Lisa and Bart Simpson according to the characters from The Simpson TV series. Generally, there are more Barts than Lisas. These are obviously only two fictionary characters, two caricatures or ideal types. In reality, they represent a continuum on which each human being can be placed. Furthermore, each person is Lisa or Bart depending on the specific topic: one could be highly committed to protecting mistreated women but not care at the same level about nuclear energy.

We need finally to distinguish between rational and irrational incentives. Obtaining the data and analysing them in order to show the long term effect of a specific behaviour, say eating chips for breakfast, acts on the rational side. Nudging and suggesting behaviour through vanity, fun, peer pressure instead act on the irrational side. Typically, rational side is sufficient for motivated users (Lisa) but non-motivated users (Bart) need incentives on the irrational side.

Table 4-4: Type of citizens benefiting from innovation

Layer	Type of citizen	Drivers
Action and behavioural change	The non-committed (Bart Simpson)	Irrational (fun, peer pressure, vanity, competition)
Data Analysis	The committed (Lisa Simpson)	Civic commitment and rational decision
Data Collection	The geek	Rational decision and technical problem-solving

In all these situations, ICT plays a role, which we will now illustrate.

In terms of incentive to adopt and participate in persuasive technologies, for motivated users this should not be a problem. For non-motivated users, there could be non-ICT incentives, such as financial incentives, obligation or persuasive action by doctors or campaigns. ICT can play a role by leveraging vanity, fun and peer pressure. For example, participation could be shown on a Facebook or Twitter page, so that friends see and are encouraged to imitate. Or, the persuasive technology could be designed in a fun and attractive way, so that participation is actually a benefit rather than a cost. Furthermore, ICT enable participation "on-the-fly", exactly at the time and place where there is the interest to participate – for example through apps on a mobile phone.

Let's now consider incentives to actual behavioural change. In this case, ICT acts on different incentives.

With regard to motivated users, ICT collects and shows information that was previously not available, such as for example the amount of fuel consumed, the carbon footprint of travelling, or the damage done in the long-term to the body. In this way, it provides information on the basis of which rational decision can be taken.

With regard to non-motivated users (as this is the really high-potential opportunity), ICT provides immediate feedback and immediate satisfaction from an action: for example, a specific virtuous action would gain you some points or badges in the game immediately, even though the real benefits are long-term. Virtuous actions are also made public (Facebook and Twitter), so that vanity provides an incentive to action. Similarly, competition, fun, peer pressure are all other incentives to actual behavioural change.

Finally, ICT lowers the costs of participation and engagement, and basically lowers the motivation threshold from doing an action. For example, there are many initiatives that enable computers to be used remotely, when not in use, in order to process large amount of data, for example for cancer research. This kind of virtuous behaviour is almost costless to users, and there are several similar examples enabled by ICT. Furthermore, the "anywhere/anytime" service availability allows users to engage and participate exactly at the time when there is the will to participate, basically making the most of the scarce human energy. For example, a person could feel bad about eating too much, and then exactly at that time download and activate a serious game on its phone – rather than go home, forget about it and leave it until the next time.

Obviously, these solutions do act on the incentives to participation, but are not the ultimate magic solution. What is new is they act on the irrational side, not only on the rational one as typically ICT was perceived.

Table 4-5: Typology of citizens regarding skills and intentions

	Skilled and virtuous	**Non-skilled and virtuous**	**Non-skilled and non-virtuous**
Action and behavioural change			
Data Analysis			
Data Collection			

4.3 The business case: WHY use the ICT tools for Governance and Policy Modelling?

What are the advantages of using ICT tools to support policy modelling and governance? Or better, why we should urge governments and public administration to widely adopt those tools? A project that sustains the need of further research in this domain should (at least try to) answer to the question of beneficiaries of those tools. Promoting a roadmap to increase and improve research on ICT for governance and policy modelling should include a reflection on the identification of benefits that this research will bring. This section is aimed at discussing those benefits.

The challenges the governments must face in the modern society are complex. They are characterised by many interactions between different actors, each one having different (and often contrasting) interests. Taking decisions in such a scenario is difficult. Taking the "right" decision is even harder. Example of such complex decisions is the response to the current financial crisis or the management of air traffic during the recent volcanic ash cloud. But we can also consider less disruptive situations: the impact of changes in demographic population on pension systems as well as the impact of the change of the pension system on future generations or, internationally, the impact of development policies on poverty distribution. And finally, the global decisions on environmental policies aimed at reducing the climate change. There are also "ordinary", every day decisions, the public administration take to ensure the better life for their citizens: budgeting projects and initiatives, urban development planning and designing territorial policies. Also those daily decisions may be improved.

In sum, there is an increasing need for a higher quality of the public decision-making. The decisions should be based on better forecast and more accurate evaluation of the impact they have on the different facets of the society. More information and facts are needed in support of those decisions.

What is more, those decisions are today thoroughly scrutinized by different stakeholders (citizens, business, third sector organisations) external of the traditional decision-making apparatus, and this process has steadily increased in the recent years. Nowadays, decision-makers have to face challenges concerning the acceptance of their decisions by those "external" actors, which are more and more informed, knowledgeable, and determined to have their voices heard.

In this view, it is clear that we need better and more transparent decisions, in shorter time, and duly accompanied by sufficiently strong evidences. How can governments satisfy the need to have a higher quality of the decision making process, in the complex scenario described above?

In the recent years, the ICT-based tools and practices have emerged in both the Collaborative Governance (citizens' engagement, mass conversation, and collaboration tools enabled by the availability of open data) and Policy Modelling (forecasting, agent-based modelling, simulation and Visualisation) domains. Such tools aim at the common goal of improving public decision-making in the age of complexity; at making the policy-making and governance more effective and more intelligent. They help us through:

- Releasing public data, linking them and producing visual representations able to reveal unanticipated insights.
- Using social computing to promote engagement and citizens' inclusion in policy decision, and exploit the power of ICT in mining and understanding the opinions they express.

- Analysing policies and producing models that can be visualised and run to produce simulations able to show the effects and impacts from different perspectives such as political, economic, social, technological, environmental and legal facets.

The use of these technologies in policy-making and collaborative governance is growing continuously even if they still remain a "novelty" for the majority of governments. As the research roadmap in this document shows, there is still a need for research on those technologies and in particular on how to apply them to reality of social systems and public policies. Also, the use of those technologies in government is still in its infancy and not all the implications of their use are understood by the end users.

The use of those technologies in governments includes: the involvement of communities in relevant budgeting decision; the use of visualisation in engaging citizens on the decision process for urban planning; the growing use of policy impact analysis in large organisations to support the decision making; the increasing use of simulation in shaping policies in areas like education and pensions or tax and benefits.

Even if a long-term assessment of the benefits that ICT for governance and policy modelling could bring is not yet possible (being the majority of use cases still young, and the general adoption still in its infancy), to look at some of the current practices can significantly shed light on those benefits.

In the CROSSROAD project we have engaged a number of public officials in an online discussion to understand what kind of benefits they gained by using the ICT tools for governance and policy modelling and what are the lessons learnt.

Four interviews with public administration representatives who took part in this online discussion were carried out. The interviews explored the following initiatives:

- On participative budgeting in City of Cologne (DE), interview with Dirk Baluhut, CIO of E-government).
- On simulation use in City of Verona (IT), interview with Arnaldo Vecchietti, Director of Quality Training and Development Department.
- On 3D visualisation use in City of Apeldoorn (NL), interview with Rick Klooster, Head of Visualisation Team.
- On serious gaming in World Bank, Washington D.C. (US), interview with Robert Hawkins, Senior Education Specialist, World Bank.

The paragraphs below offer the interviews' summary.

Enlarging the decision making process outside government boundaries ([1])

The experience carried out in Cologne (DE) falls into the category of providing citizens with the power to influence the policy decision process through the introduction of a people's budget initiative.

The basic objective the city's government wanted to achieve was to exploit the experience and knowledge of citizens about their neighborhood and the problems that affected it. In time of budget constraints, it had been considered fundamental to guarantee that the government was going to meet high priority challenges.. In order to achieve this goal, the citizens of Cologne were asked to propose, comment and vote proposals in following policy areas - "highways/byways/public spaces", "green spaces" and "sport" (both in terms of expenditure and cuts). This assessment procedure provided a kind of "social control mechanism" that ensures that only widely supported proposals (which are able to generate wider benefit for citizens) were considered.

The most supported proposals were checked in details for feasibility and submitted to the city council. Keeping this process short (proposal, council decision, and implementation) is essential to assure citizens that their contribution was taken seriously. It also enforces the democratic "loop" between citizens and elected representatives.

The experiences succeeded in involving about 10% of citizens which, considering the one million population of Cologne, is a very remarkable result. But more importantly, it showed that opening the decision making process to external actors is a feasible and what is more a successful option.

The benefits, in terms of the decision making process, the city obtained from this experience are mainly linked to the increase of the quality of the decision process, that by including citizens provided the contribution in setting the priorities in the policy decisions. As stated by the Mayor of Cologne "our experience is that people respond very sensibly, not asking for castles in the air", they demonstrated their capability to be responsible co-decision-makers (about 16% of the proposal regarded cuts in the municipal expenses). The initiative also enhanced the democratic relationship between citizens and the local government. The citizens accepted that the last decision remains in the hands of the city council since the decision-making process was transparent and their opinion was duly taken into account.

The future challenge is to expand this initiative on wider policy areas and to see if it is possible to scale it to higher levels of government.

([1]) Excerpts from the interview with Dirk Baluhut, CIO of e-government, City of Cologne (DE)

Using simulation to support decision making process ([2])

The main objective in introducing the use of the simulation, based on the approach of the System Dynamics, in the municipality of Verona (IT), was to provide public officials and politicians with a tool able to provide them evidence of the impact of their decision-making.

The simulation has been introduced in two contexts within the city.

Firstly, as a support tool in the operational "micro" decisions that are taken within the projects that the city develops. In the project life cycle, each time a relevant decision has to be taken, a specific unit of the city supports the project team with a simulation model. According to the views of different team members (possibly from different departments, so bringing complementary views of the process and decision) the model is discussed, adapted and then run to provide insight on the impact of the decision in the given scenario.

Secondly, the specific unit supports the highest-level decision process within the Municipal Council, by providing scenarios on the future of the city and the implication of the decision to be taken. This use of the simulation is intended to provide support in the definition of the priorities that are assigned to the Municipality.

It is important to underline that the intention has never been to use simulation and its claimed objectivity, as a substitute of the decision process, but as a support tool that "eliminates" from the possible decisions the uncertainty as much as possible (at least at the degree of which this can be done). The simulation contributes to clarify the decision process and, according to the activity of the city, the result is not only the product of the process (i.e., the result of the simulation), but the process itself as a collaborative effort of understanding the participants views and modelling the scenario. This improved the quality of the decision process and it can be considered also as having "an educational" fallout.

The most relevant benefits of using simulation obtained by the city are in the area of evidence-based policy decision. The use of simulation models represents a common ground on which discussions and decision are taken. Participants in the decision feel that they are using a common language that facilitates the reciprocal understanding.

An important lesson learnt from the use of simulation was that the proposed simulation had been easily accepted, especially by politicians, "ex ante" before the modelling and simulation starts, but it is sometime received with disappointment "ex post", when the decision process goes in a different direction.

([2]) Excerpts from the interview with Arnaldo Vecchietti, Director of Quality Training and Development Department, City of Verona (IT)

Using 3D visualisation as a communication tool to enable better decision-making ([3])

In the city of Apeldoorn (NL) the city visualisation team decided to explore the potential of evolving the current 2D visual information towards a 3D paradigm. The team started to implement a "virtual world" platform where local projects participants could set up their 3D model, and use it as a support for the communication with citizens, or as a tool to support internal discussion and decisions.

The platform allows for the 3D representation of a situation "as is" and the situation "to be", allowing for evaluation and alternatives. But more importantly, the platform allows for the opening of the discussion of the project by involving citizens and supports this discussion with chat and forum.

The power of the "virtual world" representation had a deep impact on the process of decision-making, whenever those decisions involved the consideration of the citizens' opinion. According to the responsible of the project, each time when in a public consultation the virtual model is shown, there is an immediate sense of relief among the audience "… oh, that's how it's going to look like …", and suddenly the discussion starts over on a new base: there is less prejudices and individual interpretations of the issue involved, the discussion is based more on the representation of the facts. To give an idea of this power of the visualisation: a project of the market square renovation that had stalled for nearly 10 years, after the introduction of the "virtual world" technology was discussed and put into action in about 2 months. Another example is related to the plans for placing windmills in an industrial area in Apeldoorn. At first, the neighborhood council was strongly against them. After seeing the virtual world visualisation which has shown that the effect on the landscape will be minimal, the council withdrew their objections.

The platform allows the visitors of the virtual world (citizens, public official, or designers) to discuss the model they are viewing.

Another interesting benefit that was observed is the possibility of collaborative design that can come by using virtual world technologies. Once the virtual model is set up, external experts can "walk through" the virtual model and check the quality of the design.

An important lesson that comes from the use of virtual world in communicating with the citizens is that it has important implications for both public official and politicians. Public officials and politicians are sometimes reticent to use this technology because it imposes on them very precise identification and definition of what they are promising to realise. No ambiguity is allowed anymore.

([3]) Excerpts from the interview with Rick Klooster, Head of Visualisation Team, City of Apeldoorn (NL)

Serious gaming to engage in meeting global challenges ([4])

The ideas for the EVOKE project emerged during the discussion in Africa on the need to reform education. The reform was meant to transform the education system based mainly on theory and curriculum to one more connected with Africa's real problems and capable of infusing some of the 21st century central skills: critical thinking, collaboration, creativity.

A number of educational institutions in Africa already had some "community learning programs", where as part of extra-curriculum activities those goals were also included. But those programs were neither scalable nor sustainable. Therefore, the idea was to shift the general educational approach giving more emphasis to social entrepreneurship and social innovation skills.

The decision to opt for a gaming approach rather than a traditional information-sharing platform was chosen also in order to explore the potential of games to develop internal motivations for learning as well as the potential of ICT combined with games to foster social networking and peer collaboration as a learning tool. Moreover, the intention was to verify the potential of narrative as a pedagogical device.

The results in term of participation largely exceeded the expectations, and more importantly the quality of dialog and interaction was higher than expected. Also there were a large number of "extra-games" activities, that weren't planned but emerged from the participants' behavior.

Benefits encompassed the process of democratisation, i.e. bringing in a lot of voices to share and propose solutions. This was reinforced by the focus on real actions and real outcomes. An important factor that stimulated participation was the idea of asking participants to act in their community and not only to discuss theoretically in an online environment.

The gaming methodologies proved to be efficient in producing behavioral incentive, pushing people to bring in content (23.000 blog posts in 10 weeks' time of the game). The presence of a collaborative environment, based on the peer evaluation of the ideas encouraged participants to spend more time in developing their own ideas. The internal motivation to spend more time working incited the participants to become more proficient in the issues at hand. In brief, it confirmed the existence of a link between game methodology and skills acquisition.

From the perspective of policy-making, gaming tools can be seen as having two possible roles.

On one side, the use of gaming as a tool to engage people external to the traditional decision process allow the "collective thinking", stimulates the better understanding of issues both by citizens and policy makers and, in some cases, also the generation of new, original ideas on how to address those issues.

On the other side, the use of gaming as a collaborative environment could radically innovate the way in which organisations, and people within organisations, interact and cooperate in policy-making process. The experience of EVOKE showed that people involved in gaming are more willing to collaborate, produce content and ideas. What is more thanks to this exercise they improve their critical thinking skills and creativity - exactly the skills needed for innovative policy makers.

([4]) Excerpts from the interview with Robert Hawkins, Senior Education Specialist, World Bank, Washington D.C. (US)

As stated above, the number of practices and the state of the technology development which we are considering in the domain are not sufficient to draw final conclusions about the benefits of adopting those ICT tools in policy-making process. And no easy "recipes" can be provided.

Nevertheless, looking at the practices and considering the wider online discussion that emerged during the project duration (on LinkedIn - http://www.linkedin.com/groups?mostPopular=&gid=2594136), we can identify three kinds of potential benefits deriving from a wider usage of ICT for governance and policy modelling:

- *Quality of policy-making*: Using tools for wider engagement of non-governmental actors in the process can radically improve the quality of policy-making. It allows a wider evaluation of all the interest at stake and reduces the risk of missing some, sometimes crucial, aspects or consequences of the decision. Collective thinking stimulates creativity and generates original solutions of the given issue and provides a suitable environment for rapid evaluation of those alternatives and their feasibility. Last but not least, involving all the interested actors in the decision process allows for a smoother implementation process.
- *Speed of policy-making*: More information, especially in visual form can favour a faster decision-making process. Evidence, especially when supported by advanced visualisation has the power to eliminate ambiguity and prejudices related to the decision that should be taken. It allows for concentrating on real issues and provides a better understanding of those issues. Wider consultations can be carried out more easily (and timely) by using ICT-supported platforms. All this contributes to reducing significantly the amount of time needed for the decisions-making process.
- *Evidence-based policy decision*: Tools for scenario design, simulation and forecasting allows a better understanding of the effects and consequences of policy decisions, especially when policy models are designed to capture different effects. They enable timely evaluation of alternatives (especially when assisted by models and visualisation techniques). The availability of evidences is important for the daily decisions that constitute the core of government activities, but is particularly relevant for a number of global issues (global warming, financial crisis, epidemiological emergencies), where the importance of the decision is strongly connected to the complexity of the problem at hand (for which, in fact traditional modelling approaches are not anymore adequate, and methodologies based on the "science of complexity" are under development).

In the following table we have tried to identify, on the basis of the case studies and online discussions, the possible level of relevance of the innovative ICT tools and the benefits in policy-making as identified above. Yet again, the number of cases does not allow for a definitive establishment of these connections, but it provides a first snapshot of this developing field.

Table 4-6: Relation between the innovative ICT-based approaches and their benefits for policy-making

	Quality of policy-making	Speed of policy-making	Evidence-based policy decision
Open and linked data Visualisation	●	◖	◖
Social computing Citizens engagement Opinion mining	●	●	◖
Policy modelling Simulation Impact analysis	○	○	●

● High
◖ Medium
○ Low

To conclude, albeit from an academic/research perspective the advantages of those technologies are quite evident, their adoption in the public policy decision-making process and organisational processes has to be carefully introduced in order to make the changeover as smooth as possible, avoiding friction with the current practices. Also, even though the advantages of such tools seems to be easily understandable, all efforts have to be made to translate them in a form of easy "graspable" from the perspective of policy makers (that not always coincides with the one of the academia/research community).

When involving external actors in the decision process, with the intention of gaining the above-identified benefits, this involvement process has to be carefully designed. Citizens have to feel that they are devoting their time and energy to contribute into decision-making process that is relevant for them ("to strike a chord with the everyday lives of citizens within the community", an expression used in the online discussion). The absence of a strategy may frustrate the participants and produce a counterproductive effect on quality and effectiveness of policy-making.

Finally, the use of those technologies can support long-term planning, beyond the traditional focus on short-term benefits that policy-makers (but also citizens) often chase and respond to. System dynamics tools, simulation, serious gaming can help users to understand, visualise and be accountable for the long-term impact of their action. This is very important in the view of the strong need for long-term reflection and impact evaluation to address the grand societal challenges such as ageing, climate change, poverty reduction, diseases' effect.

In summary, the discussion with policy makers and public administration representatives showed that the benefits of using ICT in policy-making are significant and tangible. Moreover, the practitioners' experience suggests a careful design of implementation process of those tools in governmental organisations in order to maximize the benefits.

4.4 Towards policy recommendations: HOW to do research policy in a complex world

The research challenges presented in this report question the viability of existing research instruments that are employed to address them. It is increasingly recognised that the determining variables for successful ICT innovation do not lie in the domains and areas to be funded (the "what"), but in the nature of the mechanisms in place (the "how"). No matter how well formulated and accepted by the wide research community the research challenges are, they will not be met if we do not design the appropriate funding instruments to support research. Even at a first glance, the very notion of a roadmap gives the impression of a linear process, apparently contradicting the non-linear approach of agent-based modelling. For this reason, we emphasize the iterative and open nature of the present roadmap.

In particular, some of the features of the research challenges presented above are not always fully compatible with the FP7 type of research. In particular they are:

- User-driven and demand-driven: the tools are developed by people directly involved and interested. In the field of computational science, it is the scientist, who develops the model and the algorithm; in collaborative governance, that are citizens and civil society organisations who develop innovative applications, often as open source.
- Highly multidisciplinary, with particular involvement of non-technological disciplines. Psychology, political sciences, art and design are fundamental components of research in fields such as visual analytics and serious games.
- Not clearly divided between research and innovation: the agile development of these applications benefits from new re-compositions of existing tools as well as development of new functionalities. Market release (in beta) is not the end of the research process but a part of it. Placing a rigid border between what is research and what is not, is simply meaningless in this context and likely to be counterproductive in terms of marketable innovation.
- Serendipitously innovative: research in rapidly developing, complex and demand-driven applied research fields cannot be planned linearly, three years in advance. On the contrary, it has to be adjusted iteratively in order to respond to new needs, unforeseen technological opportunities and market development. How can the three years funding model of typical FP7 project be compatible with a one weekend development time of a typical barcamp? In such a context, open and more flexible funding models should be applied therefore not only to basic research (as in the case of the European Research Council and Future and Emerging Technologies), but also to applied research.

These features are not "by definition" incompatible with current research programmes, but they are "de facto" very marginally present. Most of the research challenges are building on research currently being developed in the contest of the FET (Future and Emerging Technologies) area, which is itself designed somewhat differently, in terms of funding instruments, from other FP7 ICT research themes.

The CROSSROAD Policy Recommendations (Deliverable D4.4) will directly look into the possible research instruments to be used, taking into account alternative models for research funding such as FET, ERC and prizes.

Part B. Analysis of the Grand Challenges

5 GC1: Model-based Collaborative Governance

5.1 Description

In a rapidly changing world, anticipation and timely decision-making are necessary to ensure positive outcomes, stability and safety. Anticipating future events, promptly detecting emergencies and evaluating the impact of different policy choices before they are implemented are necessary features of good governance. On the other hand, the increased complexity of society and economic trends calls for models that at the same time reflect this complexity while making it simpler and addressable.

In recent years, tools available to government to anticipate trends and policy impacts have been rapidly developing. In particular, the anticipation of future trends and impacts of different policies through impact assessment tools have become a standard activity for the most relevant policy decisions, such as fundamental regulatory initiatives in economic and environmental domains. Yet, complex human systems are difficult to predict while understanding the limits of predictability is necessary to avoid judgment errors. The biggest mistake is to presume than we know more that we know.

Current practice for policy modelling and simulation is centred on traditional forecasting mathematical models and linear econometric tools based on General Equilibrium theory, which suffer from a number of shortcomings when applied in the public policy context. They are traditionally short-term and not effective in elucidating the variety of human behaviour, especially taking into account non-rational forces, tipping points and non-linear processes. These socio-economic models begin with unrealistic simplified assumptions in order to produce formally correct, consistent and tractable models. The underlying assumption is that the economy can be understood by reference to a single so-called 'representative agent', who takes decisions to maximise his/her utility over an infinite time horizon, thereby ignoring the variety of individual reactions which are the key variable in determining the impact of policies. For example, the failure to anticipate the most recent (or any previous) financial crisis showed the limitations of top-down linear forecasting. Furthermore, those models are highly resource-intensive and purpose-specific, which limits its application to major policy decisions.

While abstract mathematical models tend to result in high-level predictive outputs, computational agent-based models offer finer degrees of granularity. Yet, there is a wide gap between macro and micro models approaches. Still, micro-simulation models are powerful means to predict both the short-term and long-term effects of policies as well as micro effects of demographic processes. Moreover, they are well suited for distributed and uncertain environments and account for individual behaviour and interrelation between behaviours, including imitation.

The use of software agents in simulation models for behavioural and social simulation allows for a more descriptive representation of the behaviour of actors, than the mathematical or statistical models offer. Originally developed for natural sciences, they proved to be particularly suitable in the context of social sciences to explain human behaviour. The software agents are now being applied in the public policy science, especially in areas of strategic regulatory importance such as tax and transfer policy, energy, transport, disaster recovery and water management. Because of their

systemic approach, they are also beneficial in terms of integration across government departments, to overcome silos effect and highlight interdependencies between sector-specific government policies.

On the downside, the major drawbacks associated with using agent simulation are the complexity of the resulting control system that needs to be debugged, the lack of facilities to adequately represent/trace knowledge contained by each agent and the selection of tactics used by the agents. Social modelling and simulation tools, in general, suffer from lack of scalability to the macro level, being built ad-hoc for specific purposes. These tools require high level of technical competence, and are therefore struggling to capture the knowledge and the opinion of domain specialists. Models and simulation too often are perceived as black boxes, unintelligible to the user: this is a particular challenge in the field of public policy, where decisions have to be taken on the basis of transparent information. The recent controversies over climate change predictions and models showed the risks of this lack of transparency when dealing with highly complex issues. Furthermore, computational scientists do not adopt timely the most advanced software engineering tools, so that advances in computing power have not been matched by advances in software development techniques, and time-to-solution in many cases is increasing, rather than decreasing. Finally, there is a tendency to reinvent and develop "own" models and simulation tools, and very few policy-oriented modelling software solutions are available, so that adoption of a policy modelling approach still demands a lot of resources.

5.2 Vision

Our vision for 2030 embodies a radically different context for policy modelling and simulation. Thanks to standardisation and reusability of models and tools, system thinking and modelling applied to policy impact assessment has become pervasive throughout government activities, and is no longer limited to high-profile regulation. Model building and simulation is carried out directly by the responsible civil servants, collaborating with different domain experts and colleagues from other departments. Visual dynamic interfaces allow users to directly manipulate the simulation parameters and the underlying model.

Policy modelling software becomes productized and engineered, and is delivered as-a-service, through the cloud, bundled with added-value services and multidisciplinary support including mathematical, physics, economic, social, policy and domain-specific scientific support.

Cloud-based interoperability standards ensure full reusability and composability of models across platforms and software.

System policy models are dynamically built, validated and adjusted taking into account massive dataset of heterogeneous data with different degrees of validity, including sensor-based structured data and citizens-generated unstructured opinions and comments. By integrating top-down and bottom-up agent based approaches, the models are able to better explain human behaviour and to anticipate possible tipping points and domino effects.

5.3 List of relevant gaps

The gaps analysis carried out in D3.2 has outlined a comprehensive list of gaps to be addressed across the research themes. We hereby list and assess the gaps, which are addressed in the context of this Grand Challenge.

Research Theme 1: Open Government Information & Intelligence for Transparency	**Assessment of relevance for GC1[3]**
→ *Systematic management and monitoring of transparency*	x
→ *On-the fly Open Data Quality Agreements*	x
→ *Public, real-time linked data*	xx
→ *Citizen-oriented linked data querying and reasoning*	xxx
→ *Seamless collaboration and cooperation in data layer*	xxx
→ *Large-scale public information Visualisation*	xx
Research Theme 2: Social Computing, Citizen Engagement and Inclusion	
→ *Open and cross-language collaborative filtering / attention economy tools*	x
→ *High-quality expertise identification through reputation management*	x
→ *Distributed Early Warning Systems for risk prevention*	xxx
→ *Affordable large-scale collaboration*	xxx
→ *Leveraging casual participation*	xxx
→ *Robust and large-scale argument support systems*	x
→ *Robust Natural Language Interfaces*	xx
→ *Participation*	x
Research Theme 3: Policy Making	
→ *ICT for state-of-the-art policy-making*	xx
→ *Large-scale quantitative data for formal policy models*	xxx
→ *Argumentation analysis and encoding*	xxx
→ *Scalability of modules*	xxx
→ *Large-scale transformation and aggregation of modules*	xxx
→ *Collaborative Intelligence in policy-making*	xxx
→ *Usability in modelling and simulation*	xxx
→ *Identification of application fields for modelling and simulation modelling*	xx
→ *Reliability of modelling techniques*	xxx
→ *Integration of tangible and intangible aspects into formal models*	xxx
→ *New models of "democracy"*	xx
Research Theme 4: Identity Management and Trust in Governance	

[3] X – low relevance, xx – medium relevance, xxx – high relevance

→ *Interoperability and integration issues of identity management in large-scale systems*	xx
→ *Means for authentication and Identity Management*	xx
→ *Legitimate data protection in high flexible business processes*	x
→ *Digital identity for governance and policy modelling*	x
→ *Flexible and dynamic disclosure management tools and technologies*	x
→ *Trust in Social Networks*	xx
Research Theme 5: Future Internet for Collaborative Governance	
→ *Massive Government Clouds*	xx
→ *Business models for public-private clouds governance*	x
→ *Mobility and Participatory Sensing*	x
→ *Real-time context-aware services*	x
→ *Human-computer interaction*	x

5.4 Research Challenges

The identified sub-research challenges that build up the Grand Challenge of Model-based Governance basically consist of the following:

- RC1.1: Integrated, composable and re-usable models
- RC1.2: Collaborative modelling
- RC1.3: Easy access to information and knowledge creation
- RC1.4: Model validation
- RC1.5: Interactive simulation
- RC1.6: Output analysis and knowledge synthesis

5.4.1 RC1.1: Integrated, composable and re-usable models

Description and link with the state of the art

This research challenge seeks to find the way to model a system by using already existing models or composing more comprehensive models by using smaller building blocks (sometimes also called "molecules" - which are models themselves) either by reusing existing objects/models or by generating/building them from the very beginning. Therefore, the most important issue is the definition/identification of proper (or most apt) modelling standards, procedures and methodologies by using existing ones or by defining new ones. Further to that, the present challenge calls for establishing the formal mechanisms by which models might be integrated in order to build bigger models or to simply exchange data and valuable information between the models. Finally, the issue of model interoperability as well as the availability of interoperable modelling environments should be tackled.

The reference Research Areas in the State of the Art are RA 3.2 - Policy Modelling and RA 3.3 - Policy Simulation.

Current status

The current practice in composing and re-using models is still not sufficiently widespread. In relation to Model Reuse, this is mainly due to the fact that little to any repository actually exists. Moreover, the publicly available models are not "open" to modification or re-use. Some modelling environments (or modelling suites) provide some examples and small libraries of ready-to-use models, but in most cases, they are not completely open nor any explanation is provided on how to reproduce them (their structure, parameters, etc.). The Model Composition horizon is even more clouded as the potential advantages resulting from the possibility of composing bigger models from smaller ones have been shown only recently. It is essentially due to the problem of interoperability and integration of different vendors' (thus proprietary) model formats and to the lack of standards allowing to perform composition tasks. Another problem stems from the fact that many models are still too dependent on their implementation methodology. For example, it is quite difficult to compose a model by using an Agent-based model developed in a certain environment or suite with a Discrete-Event model or/and with a System Dynamics one developed in completely different environment/suite. Moreover, model integration is at present almost non-existing. Very few modelling environments/suites provide the import/export functionalities and a standard language for model interoperability is not currently available. Most of the current practice for data communication or information transfer is performed by means of third party solutions (e.g.: interoperability in most cases is achieved by transferring data via electronic spreadsheets or, only in rare cases, by using Database Management Systems (DBMS) or Enterprise Resource Planning (ERP) systems.

Current research, as well as previous research, has not yet worked on (with the exception of just a few cases) the problem of different models integration. At present, due to the plethora of different modelling/simulation environments/suites many competing file formats exist. It is possible that vendors perceive the modelling practice as a very small market niche (as the users stem mainly from Academia and to a very small extent from private companies where a Decision Support Systems is used, what is more the Public Administration share is negligible) and therefore are reluctant to introduce interoperable features.

Also, current research, as well as previous research, has only recently begun to explore the following issues:

- Open-source modelling and simulation environments (there are open environments that are rising in importance in the research community albeit in most cases they only provide the possibility to implement and simulate a model according to the modelling methodology they refer to).
- Communication of data among models developed in different proprietary (or open) environments by depending on third party solutions (e.g.: interoperability is in most cases only achieved by transferring data by means of electronic spreadsheets or, only in rare cases, by using a DBMS or an organisation's ERP).
- Open visualisation of results stemming from model simulation (e.g.: online visualisation of simulation results in a browser by interfacing - only in a few cases - the simulation engines or - as it is more often the case - by connecting to a third party mean, as described in the previous bullet point).

Future research should therefore focus on:

- Definition of standard procedures for model composition/decomposition, e.g. how to deductively pass from a macro-description of models to the fine definition of its building-blocks or molecules (top-down approach), how to inductively conceive a progressive composition of bigger models by aggregating new parts as soon as they are needed (bottom-up approach) or by expanding already existing objects (1).
- Proposition of a minimum set of archetypical structures, building blocks or molecules that might be used according to the proper level of decomposition of the model (e.g. systemic archetypes, according to the Systems Thinking / System Dynamics approach, might be useful to describe the overall behaviour thanks to the main variables in the system to be modelled at a macro-to-middle level). The procedures to implement, validate and redistribute any further improvement of these "minimal" objects should be investigated. (3)
- Definition of open modelling standards, as the basis for interoperability, that is defining common file formats and templates (i.e.: by means of XML) which would allow the models described by means of these XML files to be opened, accessed and integrated into every (compliant) model-design and simulation environment (2).
- Interoperability, also intended in terms of Service Oriented Architectures (e.g.: certain stand-alone and always operative models might expose some "services" in order to make available either their endogenous data or bits of information, or some peculiar function or structural part, while some other may request to use those services when needed. In consequence, it creates a need for a definition of model repositories, a list of operative models and the functionalities that they might expose which finally, entails the definition of a SOA among interoperable models). (5)
- Definition and implementation of model repositories (and procedures to add new objects to them), even if they are restricted to hosting models developed according to a specific methodology (Agent Based, System Dynamics, Event Oriented, Stochastic, etc...) (4)
- Definition and implementation of new relationships that are created when two models are integrated. All possible important relationships resulting from a model integration/composition should be identified and eventually included in the new deriving integrated model. (1)
- Input / Output definition / re-definition: the integration of modelling techniques is a pertinent issue in the scope of this challenge. The multi-modelling tools should be, in future, available not only to experts but also to lay users. Moreover, at present, only a few of the actually available modelling/simulation suites are able to provide the possibility to build a model by referring to a different modelling methodology. (6)

Thus, research in the context of this challenge, is fundamentally related to:

1. "Object-oriented" model implementation, in analogy to what has happened during the last 20 years in software development in computer science (*Implementation*)
2. Procedural research, in order to pursue a progressive model refinement, from macro to micro descriptions or according to the different strategic, tactical and operational levels (*Continuation of Research*)
3. Formal model description and implementation (*Continuation of Research*)

4. Simulation, as a general theme, since the integrated / composed / reused models will likely have to be simulated in order to derive some insights on their use and on the potential outcome of the system that integrates / makes use of them (*Continuation of Research*)
5. Open source, as the open standards for model interoperability are concerned, specifically as the idea underlying the concepts of model accessibility, inspection and redistribution (*Continuation of Research*)
6. Service Oriented Model Architectures (in analogy to what has happened during the last 10 years to software development in computer science) and the deriving arguments and research themes - e.g.: definition of a sort of modelling XML to allow model interoperability and integration (*New Research*)

Type of research (disciplines)

The disciplines that might help in the context of this RC are the following ones:

1. ICT & Computer Science
2. Mathematics & Operations Research
3. Modelling & Simulation

Relationships with other research in parallel fields

Model composition and model reuse are inherent aspects of modelling. Thus, this RC is related to virtually any research field that needs modelling and simulation.

According to the general need for policy assessment and evaluation, there are some specific issues stemming from the Models Reuse, which are strongly related to governance:

- The public software and / or public data reuse policies: the concept of data and software reuse should be further extended to models reuse. The ones belonging to Governmental Bodies should be freely redistributed inside the Public Administration or made freely available to those PAs that might request their use (redistributing in turn, any eventual modification/upgrade/update).
- The entire shape of the given public policy might not be completely clear to a decision-maker from the start, thus a progressive model description might be necessary. In consequence, decision-makers might find helpful to have at hand several different libraries of building blocks to build their policy from.

Model Integration becomes also an inherent part of the modelling and simulation. There are several aspects of this research challenge that are strongly linked to Governance:

- Different public administrations might have developed different models (different here is understood as a difference in the used modelling methodology or a difference in the level of description of the models) which may be later integrated to build a completely new model;
- Different entities may decide, for manageability purposes in the modelling process, to subdivide very complex and complicated models into smaller and more tractable sub-models, which might be later integrated to build up the originally designed one;

- Also, different institutional levels might find it useful to develop their own perspective of the model (at the level of detail proper to their institutional level), so that it would be easy afterwards to integrate the various "niveaux" into a scalable model
- Cloud computing

Timeline

Five to 15 years in order to achieve meaningful results:

- Definition of standard procedures for model composition/decomposition (2/3 yrs);
- Interoperability (definition of open modelling standards) among models (5/10 yrs);
- Proposition of a minimum set of archetype structures, building blocks or molecules (3/5 yrs);
- Definition and implementation of model repositories, as well as procedures to add new objects to them (3/5 yrs).
- Service Oriented Model Architectures (5/10 yrs);
- Multi-modelling tools (3/5 yrs);
- Cloud models (5/15 yrs).

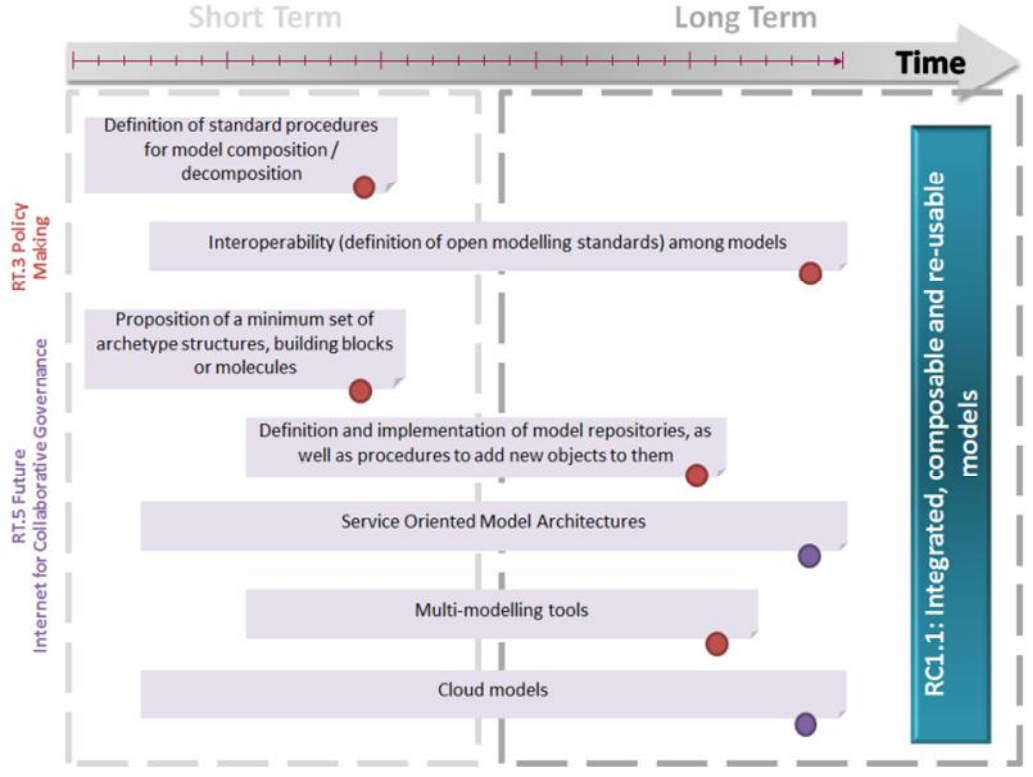

Figure 5-1: Timeline for RC1.1 Integrated, composable and re-usable models

Possible research instruments

Strengthening current EU R&D efforts within the EU Framework Programme, in particular with Specific Targeted Research Projects (STREPs), testbeds and coordination and liaison activities among the portfolio of EU research projects of the neighboring domains.

5.4.2 RC1.2: Collaborative modelling

Description and link with the state of the art

This research challenge is related to the process of collaboratively defining and implementing a model, with a particular reference to the public policy modelling. It is, thus, connected with the public aspect of every citizen's life, from a decision maker to an average citizen. Collaborative modelling calls for the definition of the citizen's role in the public policy modelling process (e.g.: the mass participation issues and processes have been already researched in depth by the e-Participation research programs). In order to guarantee participation there are some prerequisites that should be fulfilled:

- All citizens who access ICT services in order to participate should represent the views of communities affected by the given policy.
- All citizens are able to take part in the modelling process via intuitive IT systems that enable them an effective and efficient contribution.
- All citizens possess proper skills (or are assisted) to purposely follow a process of group model-building in order to avoid/abate wrong mental models and thus ultimately reach a shared vision of the problem.

The reference Research Themes in the State of the Art are RT2 - Social Computing, Citizen Engagement and Inclusion, RT3 - Policy Making, RT4 - Identity Management and Trust in Governance as well as RT5 - Future Internet for Collaborative Governance.

Current status

In current practice, collaborative modelling is mainly performed offline; still the rules and guidelines for session processes are not yet sufficiently widespread. In fact, the abatement of wrong mental models and the creation of knowledge from information usually imply the dialogue of people with different views of the problem as well as the need for critical skills. Further to that, the information that occurred in a discussion has to be grounded and definitively transferred to the formal model. Thus, e-Participation might be of help in achieving a critical mass of data and information exchange online but in itself does not solve the problem of mass cooperation and collaboration in a formal modelling process. Even more, the participation in this process entails, at present, a thorough knowledge on modelling processes or tools that an average citizen does not have. Therefore, there is an urgent need for Intuitive Interfaces, Modelling Wizards and guided simplified approaches to modelling.

According to current research, the following issues are being explored:

- Group model building and systems thinking
- Web 2.0 tools for collaboration

As far as future research is concerned, it should be focused on:

- Collaborative Internet-based modelling tools, allowing more than one modeller to cooperate, at the same time, on a single model.
- Definition of frameworks allowing even "low-skilled" citizens to provide their contribution (even if in a discursive way) to the modelling process

- Design of more intuitive and accessible Human-Computer Interfaces

Thus, the research in the context of this challenge is fundamentally related to:

1. Collaborative modelling tools (*Continuation of Research*)
2. Definition of a mass-participation framework (*Continuation of Research*)
3. Intuitive and guided interfaces to the (mass-) modelling process (*Continuation of Research*)

Type of research (disciplines)

The disciplines that might help in the context of this RC are the following ones:

1. ICT & Computer Sciences
2. Cognitive & Social Sciences
3. Mathematics & Operations Research
4. Organisational Sciences

Relationships with other research in parallel fields - what is specific about governance

This research challenge is connected to the research on Web 2.0 and the next generation web. As far as the Policy Modelling in Governance is concerned, this research challenge bridges the gap between citizens and decision makers. It permits an early stage evaluation of the decision maker mental models by opening a dialogue with citizens and allows for an exchange of perspectives. It finally enables the collaboration in the public policy modelling process with the use of a rigorous and formal scientific process.

Timeline

Five to 15 years in order to achieve meaningful results:

- Collaborative modelling tools (5/10 yrs);
- Definition of mass-participation frameworks (5/10 yrs);
- Intuitive and guided interfaces to the (mass-) modelling process (10/15 yrs)
- Design of more intuitive and accessible Human-Computer Interfaces (3/5 yrs)

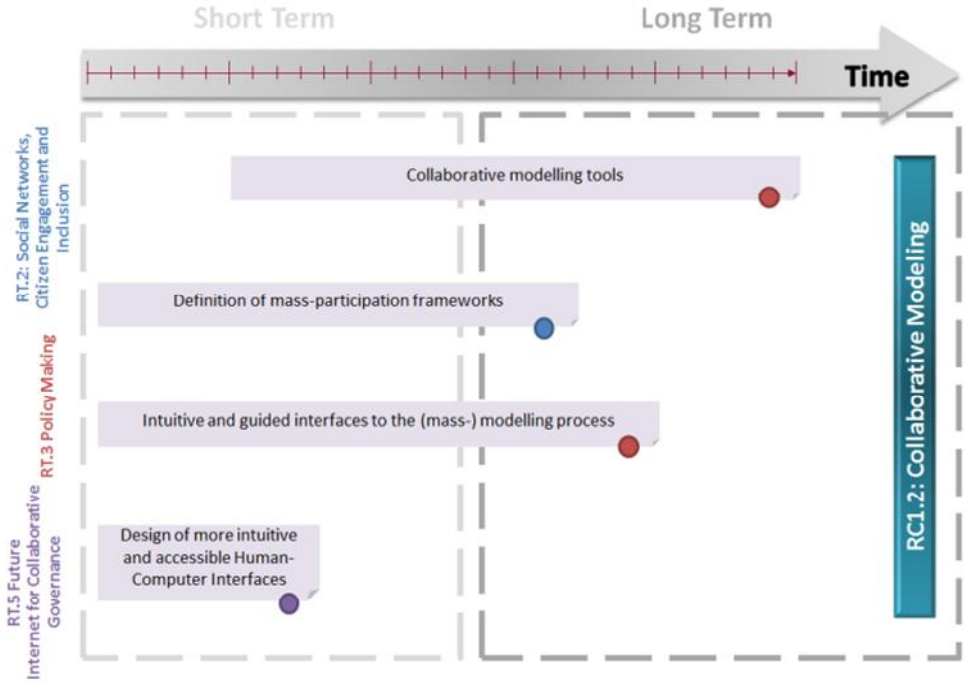

Figure 5-2: Timeline for RC1.2 Collaborative modelling

Possible research instruments

Strengthening current EU R&D efforts within the EU Framework Programme, in particular with Specific Targeted Research Projects (STREPs), large testbeds, coordination and liaison activities among the portfolio of EU research projects of the neighboring domains.

5.4.3 RC1.3: Easy access to information and knowledge creation

Description and link with the state of the art

According to a cybernetic view of intelligent organisations [105] knowledge supersedes 1. the facts, 2. data (statements about facts) and 3. meaningful information (what changes us), the last also defined as "the difference that makes the difference". Knowledge most often defined as "whatever is known, the body of truth, information and principles acquired" by a subject on a certain topic. Therefore knowledge is always embodied in someone. It implies insight, which, in turn, enables orientation, and thus may be also use as a potential for action (when we are able to use information in a certain environment, then we start to learn, which is the process that helps developing and grounding knowledge). Two more concepts come after knowledge on the same scale [107], and are Understanding and Wisdom. Understanding is the ability to transform knowledge into effective action, i.e. in-depth knowledge, involving both deep insights into patterns of relationships that generate the behaviour of a system and the possibility to convey knowledge to others, whereby wisdom is a higher quality of knowledge and understanding the ethical and aesthetic dimensions.

The research challenge is related to the elicitation of information which, in turn, during the overall model building and use processes will help decision makers to learn how a certain system works and ultimately to gain insights (knowledge) and understanding (apply the extracted knowledge from those processes) in order to successfully implement a desired policy.

It is important to note that other research fields (in particular, ICT disciplines) tend to misuse the word "knowledge" and invert it with "information".

The reference Research Themes in the State of the Art are RT1 - Open Government Information and Intelligence for Transparency as well as RT2 - Social Computing, Citizen Engagement and Inclusion, and RT5 - Future Internet for Collaborative Governance.

It needs to be noted that this Research Challenge is closely related to the GC2: Data-powered collective intelligence and action and in particular to the RC2.2 Real-time, high-quality reusable open government data.

Current status

As already discussed, there is a current misuse of the concepts of knowledge and information.

In current practice, information is drawn from data stored in different types of media (mainly DBMS/ERPs). Web 2.0 has further transformed the way we create data and elicit information from data. Data availability ceased to pose problems as a result of:

- The Internet growth and its uptake
- User Generated Content in Social Networks
- Cooperation of IT systems from different organisations thanks to the Service-Oriented Architectures (even among old legacy systems), which resulted also in private data availability
- Public Administration Transparency and Public Data use/reuse

The knowledge is still mostly created and passed on by formal methods of teaching, even though the advents of the e-Learning field allow for an increased possibility to perform Distance Learning on the Web.

But, since knowledge is developed and grounded by the learning process through action in the environment, the learning in real life comes from committing mistakes. In the field of real life governance, it entails implementing a wrong policy and observing the positive and negative consequences that this policy generates (for example due to a system's "policy resistance"). At present, thanks to the increasing data availability, information elicitation process is much easier, either by tacitly bringing users (data generators) to provide data in a guided way (according to a pre-set framework for data input) or with a help of a specific process (e.g.: consultations in e-Participation tools).

According to current research, the main focus is put on the Knowledge Management field or also (more properly, as in our case) to the Knowledge Elicitation field. The latter basically encompasses the following steps:

- Data retrieval and extraction
- Data analysis and interpretation (which usually produces information)

- Data/information adaptation and integration (this is particularly the case where information needs to be used in a model)

However, there is still a large field to be explored – the methods of extraction of meaningful information from unstructured sources of data, e.g. when analysing free texts, which applies to all sources of User-Generated Content (forums, wikis, social networks, etc.), where the semantic dimension is essential to derive meaningful information rather than just quantitatively analysing the syntax of text. In general, a lot of data is generated by citizens and particularly by their behaviour online, so that the available aggregated data sets contains information on what a citizen does, what s/he likes, how s/he behaves in certain environments, and so on. This data is considered very valuable both for private and public organisations (even though under privacy restrictions which have to be properly addressed). Also, according to the knowledge creation and development of understanding (regarding a specific system), there is some research currently carried out on how to improve the learning process via the use of e-Learning systems. Yet, what is still missing is the availability of micro-worlds, i.e. complex virtual environments where reality is somehow reproduced and where a decision maker is trained in order to implement his/her strategies and hypothesis and perform what-if analysis without the need to necessarily learn from mistakes in real life.

Future research will thus have to focus on the following issues:

- Information elicitation by analysing and interpreting data, also taking into account the semantic point of view.
- Creation of proper micro-worlds (or ILEs, Interactive Learning Environments), where the acquired information on a certain system is used (by means of actions), and knowledge is developed by observation of the outcomes of the actions. Also, ILEs will have to be integrated into LMS (Learning Management Systems) in order to extend the potential of distance learning practices, eventually also in a cooperative way (mass learning).
- Interoperability of data sources in order to integrate/aggregate different types of data and be able to automatically infer information from more meaningful datasets.
- In view of the "Internet of Things", the provision of "portable" models/tools for citizens in order to gather valuable data based on citizens" real behaviours. Moreover, these models and tools would enable citizens to check the results of their actions by analysing in real-time the response of the model to the information they are contributing to generate, and thus evaluating the eventual benefits they are receiving from their virtuous behaviour or harm they are creating either to their environment or to themselves (e-Cognocracy).

Thus, the research in the context of this challenge, is fundamentally related to:

- Information elicitation (*Continuation of Research*)
- Micro-worlds integration (*Continuation of Research*)
- Interoperability of data sources for automatic information generation (*Continuation of Research*)
- User-behaviour information generation (*Continuation of Research*)
- Internet of Things (*Continuation of Research*)

Type of research (disciplines)

The disciplines that might help in the context of this RC are the following ones:

1. ICT & Computer Sciences (IoT)
2. Electronics (Technology Improvements)
3. Telecommunications
4. Cognitive & Social Sciences

Relationships with other research in parallel fields - what is specific about governance

Proper information acquisition and knowledge development are the key aspect in all research fields, so this RC has a horizontal importance for research in general. According to the general need for policy assessment and evaluation, there are some specific issues stemming from this research challenge, which are strongly related to governance:

- Public data use and thus public information elicitation (by citizens)
- Citizens' behavioural data which are gradually becoming essential for any policy assessment process
- Interoperability of public IT systems
- Creation of a common understanding on a certain system's behaviour (by means of learning) in order to develop a shared vision on the problems that a certain policy might want to overcome

Timeline

Five to 15 years in order to have meaningful results for the items listed under Future Research, which basically are:

- Information elicitation (5/10 yrs);
- Interoperability of data sources for automatic information generation (3/5 yrs);
- User-behaviour information generation (10/15 yrs)
- Mass interactive learning environments (5/10 yrs).
- IoT (5/10 yrs.)

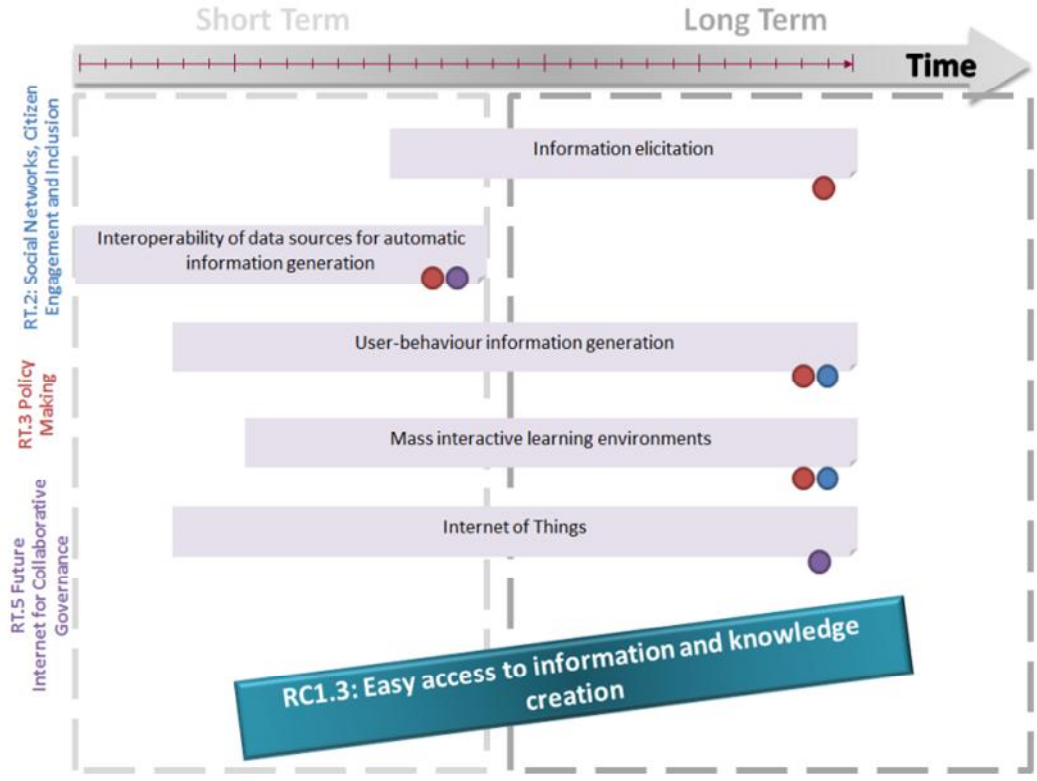

Figure 5-3: Timeline for RC1.3 Easy access to information and knowledge creation

Possible research instruments

Strengthening current EU R&D efforts within the EU Framework Programme, in particular with Specific Targeted Research Projects (STREPs)

Coordination and liaison activities among the portfolio of EU research projects of the neighboring domains.

5.4.4 RC1.4: Model validation

Description and link with the state of the art

Policy makers need and use information stemming from simulations in order to develop more effective policies. Accordingly, citizens, public administration and other stakeholders are affected by decisions based on these models. Therefore, the reliability of models plays a crucial rule in the policy modelling and simulation phases. Model validation can be defined as ”substantiation that a computerised model within its domain of applicability possesses a satisfactory range of accuracy consistent with the intended application of the model” [108]. A policy model should be developed for a specific purpose (or context) and its validity determined with respect to that purpose (or context). If the purpose of a model is to answer a variety of questions, the validity of the model needs to be determined with respect to each question. A model is considered valid for a set of experimental conditions if the model’s accuracy is within its acceptable range, which is the amount of accuracy

required for the model's intended purpose. The substantiation that a model is valid is generally considered to be a process and is usually part of the (total) policy model development process [105]. For this purpose, specific and integrated techniques and ICT tools are required to be developed for policy modelling.

Model validation is composed of two main phases:

- *Conceptual model validation*, i.e. determining that the theories and assumptions underlying the conceptual model are correct and that the model's representation of the problem entity and the model's structure, logic, and mathematical and causal relationships are "reasonable" for the intended purpose of the model.
- *Computerised model verification* that ensures that the computer programming and implementation of the conceptual model are correct, as well as that the overall behaviour of the model is in line with the historical data available.

Current status

In current practice, the most frequently used approach for validating a model is a subjective decision of the development team itself based on the results of the various tests and evaluations conducted as part of the model development process.

However, there are three basic decision-making approaches. Each of them requires from the model development team to conduct a formal validation as part of the policy model development process. This is extremely time-consuming. If the size of the policy model development team is not large, a better approach is to have the users of the model to decide of the validity of the model. In this approach, the focus of determining the validity of the simulation model moves from the model developers to the model users. Even though this approach increases the model credibility, in the actual policy development environment, ICT tools seem to be able to effectively and efficiently support policy makers' commitment (as model validation is very time consuming).

For this reason, the present research challenge is strictly connected to the Policy-making research theme [RT3].

Yet, another approach uses a third party to take a decision of the model validity. The third party is independent of both the model development team and the model users. This approach is recommended when developing large-scale simulation models, as these developments usually involve several teams and seems to be more suitable in a group model-building environment. However, the third party needs to have a thorough understanding of the intended purpose of the simulation model in order to conduct an effective model validation.

Finally, the scoring model can be used for testing the model's validity (e.g. see [9], [38] and [40]). Scores (or weights) are determined subjectively when conducting various aspects of the validation process and then combined to determine category scores and an overall score for the simulation model. A simulation model is considered valid if its overall and category scores are greater than some passing score.

Typically all these approaches are applied after the simulation model has been developed. In this case, the evaluation performed can range from simply evaluating the validation conducted by the model development team to performing a complete validation effort. Performing a complete validation

effort after the simulation model has been developed is both extremely cost and time consuming. Conducting model validation concurrently with the development of the simulation model enables the model development team to receive inputs from the validation team when the model is being developed. This method of model validation entails that the development of a simulation model does not progress to the next stage of development until the model has satisfied the verification and validation requirements in its current stage. Therefore, ICT tools for speeding up, automating and integrating model validation process in policy model development process are necessary to guarantee the validity of models with an effective use of resources.

The scientific corpus of work identifies a large number of subjective and objective validation techniques. These techniques are used for verifying and validating the submodels and the overall model.

Sargent [98] provided a review of the most relevant ones that are as follows: Animation; Comparison to Other Model; Degenerate Tests; Event Validity; Extreme Condition Tests; Face Validity; Historical Data Validation; Historical Methods; Internal Validity; Multistage Validation; Operational Graphics; Parameter Variability / Sensitivity Analysis; Predictive Validation; Traces; and Turing Tests.

The standard validation generally uses a combination of these techniques.

Future research and practice on Model Validation should explore the following issues:

- In order to speed up and reduce the cost of a model validation process, user-friendly and collaborative statistical software should be developed, possibly combined with expert systems and artificial intelligence.
- Due to the big gap between theory and practice, the considerable opportunity exists for the study and application of rigorous verification and validation techniques. In the current practice, the comparison of the model and system performance measures is typically carried out in an informal manner.
- Complex simulation models are usually either not validated at all or are only subjectively validated; for example, animated output is eyeballed for a short while (an example reported by [14] of the detailed microscopic traffic simulations). Therefore, complexity issues in model validation may be better addressed through the development of more suitable methodologies and tools.
- Model validation is not a discrete step in the simulation process. It needs to be applied continuously from the formulation of the problem to the implementation of the study findings as a completely validated and verified model does not exist. Validation and verification process of a model is never completed.
- As the model developers are inevitably biased and may be concentrated on positive features of the given model, the third party approach (board of experts) seems to be a better solution in model validation.
- Considering the ranges that simulation studies cover (from small simulation models to very large-scale simulation models), further research is needed to determine with respect to the size and type of simulation study (i) which model validation approach should be used, (ii) how should model validation be managed, (iii) what type of support system software for model validation is needed.

- Validating large-scale simulations that combine different simulation (sub-) models and use different types of computer hardware such as in currently being done in HLA (Higher Level Architecture). A number of these VV&A issues need research. For example, the issue of how does one verify that the simulation clocks and event (message) times (timestamps) have the same representation (floating point, word size, etc.) and validate that events having time ties are handled properly.

Thus, the research in the context of this challenge is fundamentally related to:

- Complex and large-scale model validation (*Continuation of Research*)
- Consolidation of validation techniques for policy modelling (*New Research*)
- Expert systems and artificial intelligence to be incorporated in validation support systems (*New Research*)
- Real case validation (*Continuation of Research*)

Type of research

The disciplines that might help to develop this RC are the following ones:

1. ICT & Computer Sciences
2. Mathematics & Operations Research
3. Artificial Intelligence
4. Simulation

Relation with other research in parallel fields - what is specific about governance

Model Validation is connected both to modelling and simulation. According to the general need for policy assessment and evaluation, there are some specific issues stemming from the Model Validation, which are strongly related to governance:

- Reliability of models: policy makers use simulation results to develop effective policies that have an impact on citizens, public administration and other stakeholders. Model validation is fundamental to guarantee that the output (simulation results) for policy makers is reliable.
- Acceleration of policy modelling process: policy models must be developed in a timely manner and at minimum cost in order to efficiently and effectively support policy makers. Model validation is both cost and time consuming and should be automated and accelerated.
- Composable and re-usable models: when a policy model developer decides to re-use models or compose them, s/he has the problem of understanding the reliability of these models. Model validation can be used for certifying this reliability and creating a database of validated models.

Timeline

Ten to 15 years in order to have meaningful results for the items listed under Future Research, which basically are:

- Consolidation of validation techniques for policy modelling (3/5)

- Real case validation (5/10 yrs)
- Complex and large-scale model validation (5/10 yrs)
- Expert systems and artificial intelligence to be incorporated in validation support systems (10/15 yrs)

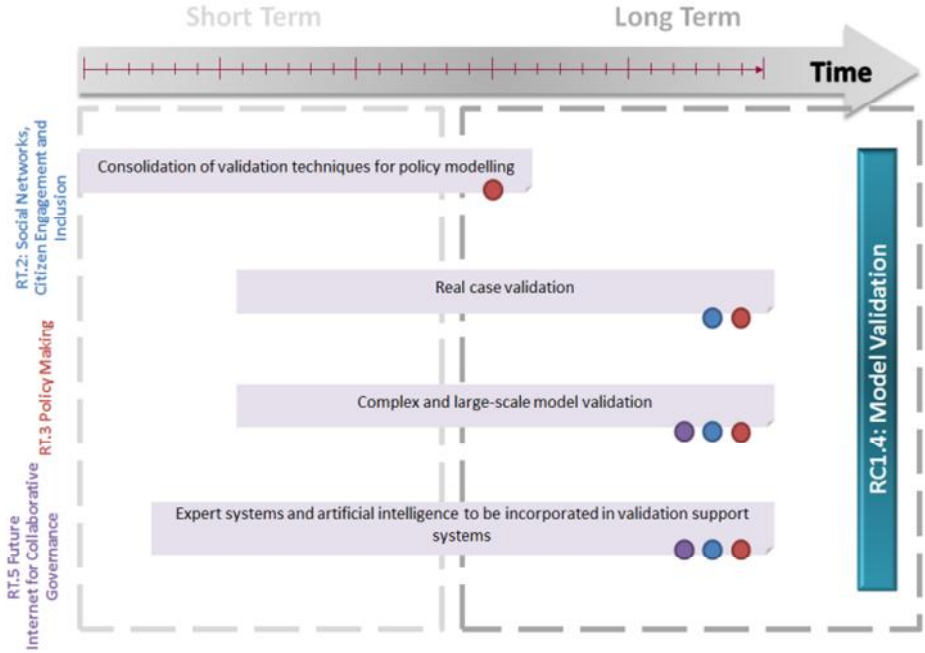

Figure 5-4: Timeline for RC1.4 Model Validation

Possible research instruments

Strengthening current EU R&D efforts within the EU Framework Programme, in particular with Specific Targeted Research Projects (STREPs)

5.4.5 RC1.5: Interactive simulation

Description and link with the state of the art

As policy models grow in size and complexity, the process of analysing and visualising the resulting large amounts of data becomes an increasingly difficult task. Traditionally, data analysis and visualisation were performed as post-processing steps after a simulation had been completed. As simulations increased in size, this task became increasingly difficult, often requiring significant computation, high-performance machines, high capacity storage, and high bandwidth networks. Computational steering is an emerging technology that addresses this problem by "closing the loop" and providing a mechanism for integrating modelling, simulation, data analysis and visualisation. This integration allows a researcher to interactively control simulations and perform data analysis while avoiding many of the pitfalls associated with the traditional batch / post processing cycle. This research challenge refers to the issue of the integration of visualisation techniques within an

integrated simulation environment. This integration plays a crucial role in making the policy modelling process more extensive and, at the same time, comprehensible. In fact, the real aim of interactive simulation is, on the one hand, to allow model developers to easily manage complex models and their integration with data (e.g. real-time data or qualitative data integration) and, on the other hand, to allow the other stakeholders not only to better understand the simulation results, but also to understand the model and, eventually, to be involved in the modelling process. Interactive simulation can dramatically increase the efficiency and effectiveness of the modelling and simulation process, allowing the inclusion and automation of some phases (e.g. output and feedback analysis) that were not managed in a structured way up to this point.

Current status

In current practice, data analysis and visualisation, albeit critical for the process, are often performed as a post-processing step after batch jobs are run. For this reason, the errors invalidating the results of the entire simulation may be discovered only during post-processing. What is more, the decoupling of simulation and analysis/visualisation can present serious scientific obstacles to the researcher in interpreting the answers to "what if" questions. Given the limitations of the batch / post processing cycle, it might be advisable to break the cycle and improve the integration of simulation and visualisation. Implementation of an interactive simulation and visualisation environment requires a successful integration of the many aspects of scientific computing, including performance analysis, geometric modelling, numerical analysis, and scientific visualisation. These requirements need to be effectively coordinated within an efficient computing environment. Recently, several tools and environments for computational steering have been developed. They range from tools that modify performance characteristics of running applications, either by automated means or by user interaction, to tools that modify the underlying computational application, thereby allowing application steering of the computational process. However, the development of these tools is still based on model developers needs and therefore a gap still exists between requirements of policy makers and those of developers. In a collaborative modelling environment, interaction is fundamental in order to speed up the process and make ICT tools user-friendly for all the stakeholders involved in the policy model development process.

In the current research, interactive visualisation typically combines two main approaches: providing efficient algorithms for the presentation of data and providing efficient access to the data. The first advance is evident albeit challenging. Even though computers continually get faster, data sizes are growing at an even more rapid rate. Therefore, the total time from data to picture is not decreasing for many of the problem domains. Alternative algorithms, such as ray tracing [80] and view dependent algorithms [73] can restore a degree of interactivity for very large datasets. Each of those algorithms has its trade-offs and is suitable for a different scenario. The second advance is less evident but very powerful. Through the integration of visualisation tools with simulation codes, a scientist can achieve a new degree of interactivity through the direct visualisation and even manipulation of the data. The scientist does not necessarily wait for the computation to finish before interacting with the data, but can interact with a running simulation. While conceptually simple, this approach poses numerous technical challenges.

With regard to future research, interactive simulation plays a crucial role in a collaborative modelling environment. The trade-off between the possibility of enlarging models and including several kinds of data, and the number of people that can understand and modify the model should be deeply analysed. For this purpose, some fundamental issues must be approached:

- Systems should be modular and easy to extend within the existing codes.
- Users of the systems should be able to add new capabilities easily without being experts in systems programming.
- Input / output systems should be easily integrated.
- Steering systems should be adaptable to hardware ranging from the largest of supercomputing systems to low-end workstations and PCs.

Thus, the research in the context of this challenge is fundamentally related to:

- Usability: easy-to-use policy modelling and simulation tools so as to accelerate the process both for modellers and for other stakeholders and, at the same time, to involve non-experts not only in the analysis of simulation results, but also in the other phases of modelling and simulation process. (*Continuation of Research*)
- Input / output system integration: integration of systems that generate / collect data and information that are inputs for policy models and systems which allow to analyse simulation results and to modify inputs, models, simulation parameters, etc. through a structured feedback mechanism. (*New Research*)
- Computational steering: emerging technology that addresses the problem of providing a mechanism for integrating modelling, simulation, data analysis, and visualisation. (*Continuation of Research*)

Type of research

The disciplines that might help in the context of this RC are the following ones:

1. ICT & Computer Science
2. Mathematics & Operations Research
3. Cognitive Sciences & Human-Computer Interface

Relation with other research in parallel fields - what is specific about governance

Interactive simulation is a particular aspect of simulation. As far as the Policy Assessment in Governance is concerned, this challenge may:

- Accelerate the simulation process: policy makers would be able to analyse simulation results, eventually run new scenarios and make decisions as soon as possible and at the minimum cost.
- Collaborative environment: the bigger is the number of stakeholders involved in policy modelling and simulation process, the greater is the necessity of an interactive simulation environment that allows non-experts to use the model and understand results as well as permit experts to easily understand new requirements and consequent modification.

- Citizen engagement: interactive simulation tools help to engage citizens in policy-making process and to display to them in a simple way the results.
- Data integration: interactive simulation tools allow better managing of a large number and different types of data and information, both for input and output/feedback analysis.

Timeline

Ten to 15 years in order to have meaningful results for the items listed under Future Research, which basically are:

- Usability (3/5 yrs)
- Input/output system integration (5/10 yrs)
- Computational steering (10/15 yrs)

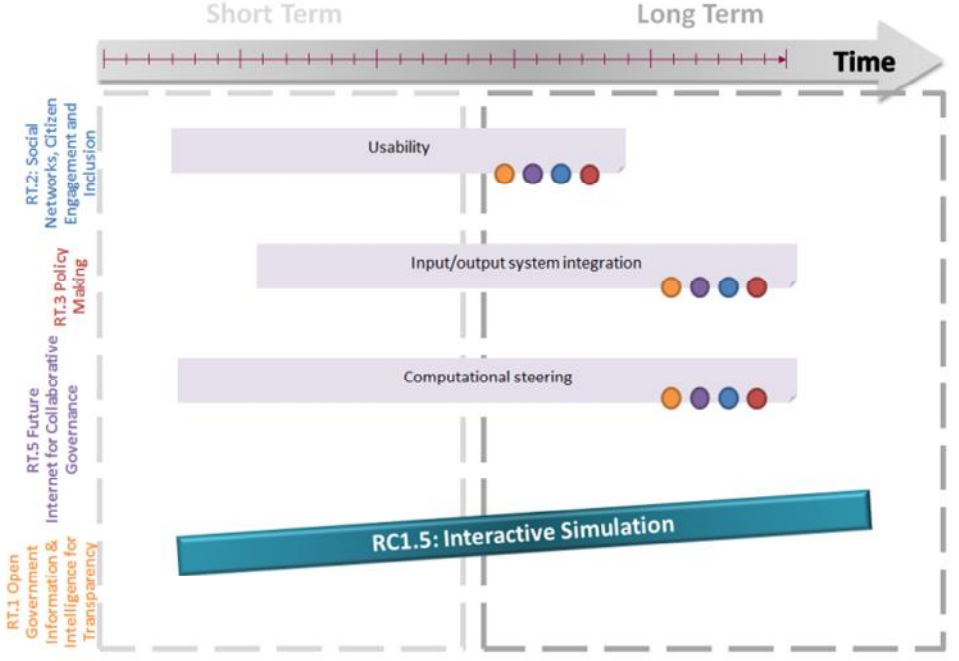

Figure 5-5: Timeline for RC1.5 Interactive Simulation

Possible research instruments

Strengthening current EU R&D efforts within the EU Framework Programme, in particular with Specific Targeted Research Projects (STREPs) testbeds and coordination and liaison activities among the portfolio of EU research projects of the neighboring domains.

5.4.6 RC1.6: Output analysis and knowledge synthesis

Description and link with the state of the art

Inputs driving a simulation are often random variables. For example, in a simulation of a manufacturing system, the processing times required at a station may have random variations or the arrival times of new tasks may not be known in advance. In a bank, customers arrive at random times and the amount of time spent at the counter is not known beforehand. In financial simulations, future returns are unknown. Because of the randomness in the components driving simulations, the output from a simulation is also random, so statistical techniques must be used to analyse the results. However, output is obviously related with the input, according to the assumption that it is basically the structure of a system to drive its behavior. In particular, the output processes are often non-stationary and auto-correlated and classical statistical techniques based on independent identically distributed observations are not directly applicable. In addition, by observing a simulation output, it is possible to infer the general structure of a system, so ultimately gaining insights on that system and being able to synthesise knowledge on it. There is also the possibility to review the initial assumptions by observing the outcome and by comparing it to the expected response of a system, i.e. performing a modelling feedback on the initial model. Finally, one of the most important uses of simulation output analysis is the comparison of competing systems or alternative system configurations.

Visualisation tools are essentials for the correct execution of this iterative step. The present research challenge deals with the issue of output analysis of a policy model and, at the same time, of feedback analysis in order to incrementally increase and synthesise the knowledge of the system.

Current status

In the current practice a large amount of time and financial resources are spent on model development and programming, but little effort is allocated to analyse the simulation output data in an appropriate manner. As a matter of fact, a very common way of operating is to make a single simulation of somewhat arbitrary length run and then treat the resulting simulation estimates as being the "true" characteristics of the model. Since random samples from probability distributions are typically used to drive a simulation model through time, these estimates are realisations of random variables that may have large variances. As a result, these estimates could, in a particular simulation run, differ greatly from the corresponding true answers for the model. The net effect is that there may be a significant probability of making erroneous inferences about the system under study. Historically, there are several reasons why output data analysis was not conducted in an appropriate manner. First, users often have the unfortunate impression that simulation is just an exercise in computer programming. Consequently, many simulation studies begun with heuristic model building and computer coding, and end with a single run of the program to produce "the answers." In fact, however, a simulation is a computer-based statistical sampling experiment. Thus, if the results of a simulation study are to have any meaning, appropriate statistical techniques must be used to design and analyse the simulation experiments and ICT tools must be developed to make the process more effective and efficient. In addition, there are some important issues of output analysis that are not strictly connected to statistics. In particular, an evident gap in literature regards the analysis and integration of feedbacks in modelling and simulation process. Actually, stakeholders are involved, in a post-processing phase, in order to analysis the results (more often only the elaboration of them) and

understand something about the policy. Sometimes they are able to give a feedback on the difference between their expectations and the result but the process is not structured and effective tools are lacking. The development of tools for analysing and integrating feedbacks should be explored in order to enlarge the number of stakeholders involved and, at the same time, to allow efficient and effective modification at each phase of the process, incrementally increasing the knowledge of the model and, consequently, of the given policy.

In current research, main references are [68], [80], [3], [47], [59], [4], [46], [69].

For output analysis, there are two types of simulations:

- *Finite-horizon simulations*. In this case, the simulation starts in a specific moment and runs until a terminating event occurs. The output process is not expected to achieve steady-state behavior and any parameter estimated from the output will be transient in a sense that its value will depend upon the initial conditions (e.g. a simulation of a vehicle storage and distribution facility in a week time).
- *Steady-state simulations*. The purpose of a steady-state simulation is the study of the long-run behavior of the system of interest. A performance measure of a system is called a steady-state parameter if it is a characteristic of the equilibrium distribution of an output stochastic process (e.g. simulation of a continuously operating communication system where the objective is the computation of the mean delay of a data packet).

A fundamental issue for statistical analysis is that the output processes of virtually all simulations are non-stationary (the distributions of the successive observations change over time) and auto correlated (the observations in the process are correlated with each other). Thus, classical statistical techniques based on independent identically distributed observations are not directly applicable. At present, there are still several output-analysis problems for which there is no commonly accepted solution, and the solutions that are available are often too complicated to apply. Another impediment to obtaining accurate estimates of a model's true parameters or characteristics is the cost of the computer time needed to collect the necessary amount of simulation output data. Indeed, there are situations where an appropriate statistical procedure is available, but the cost of collecting the amount of data dictated by the procedure is prohibitive.

Referring to previous cited works and in particular to [45], future research should further explore following issues:

- ICT tools for supporting or automating output/feedback analysis
- Allowing an incremental understanding of the model (knowledge synthesis)
- Adapting Design Of Experiment (DOE) for policy model simulation
- Use and integration of more-sophisticated variance estimators
- Better ranking and selection techniques

Thus, research in the context of this challenge, is fundamentally related to:

- Automated output/feedback analysis (*Continuation of Research*)
- Knowledge synthesis (*New Research*)
- Design Of Experiment (DOE) for policy model simulation (*New Research*)
- More-sophisticated variance estimators (*Continuation of Research*)

- Ranking and selection techniques (*Continuation of Research*)

Type of research

The disciplines related to the RC are as follows:

1. ICT and Computer Sciences
2. Mathematics and Operations Research
3. Social Sciences

Relation with other research in parallel fields - what is specific about governance

Output analysis is a specific aspect of simulation. According to the general need for policy assessment and evaluation, there are some specific issues stemming from the output analysis, which are strongly related to governance:

- Acceleration of policy assessment process: automated output analysis tools would help policy makers to efficiently and effectively analyse the impacts of a policy even if the large number of simulation data must be taken into account
- Citizen engagement: user-friendly automated tools for output analysis can be offered to citizens in order to share the simulation results and better engage them in policy-making process.

Timeline

Ten to 15 years in order to have meaningful results for the items listed under Future Research, which basically are:

- Design Of Experiment (DOE) for policy model simulation (3/5 yrs)
- Ranking and selection techniques (3/5 yrs)
- More-sophisticated variance estimators (5/10 yrs)
- Automated output/feedback analysis (10/15 yrs)
- Knowledge synthesis (10/15 yrs)

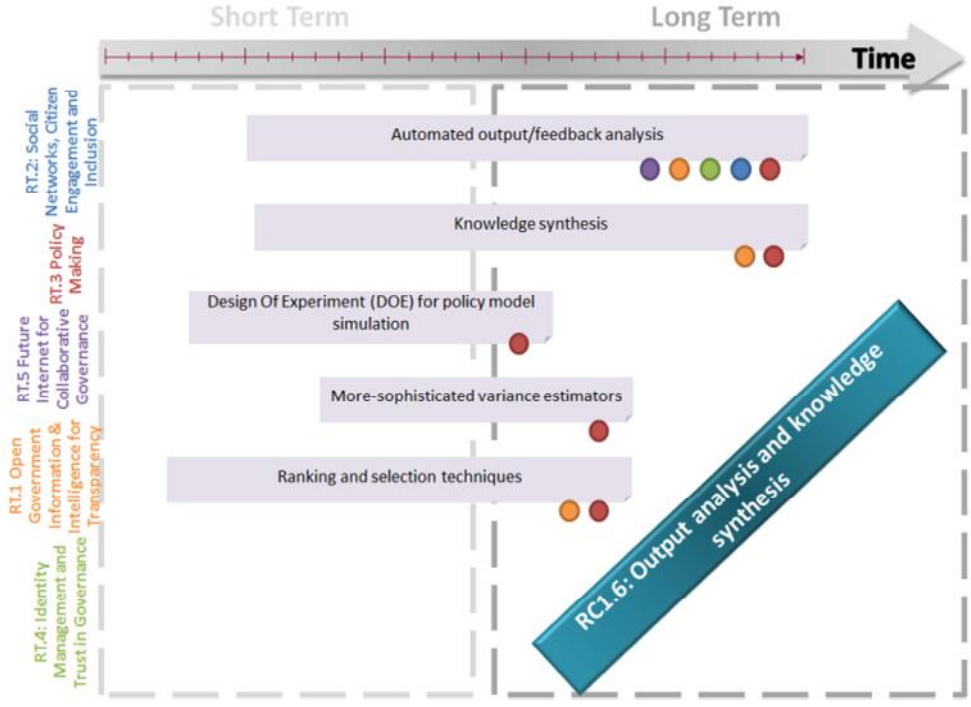

Figure 5-6: Timeline for RC1.6 Output analysis and knowledge synthesis

Possible research instrumentsCoordination and liaison activities among the portfolio of EU research projects of the neighboring domains.

Strengthening current EU R&D efforts within the EU Framework Programme, in particular with Specific Targeted Research Projects (STREPs)

5.5 Other Challenges

Realising the vision of the Model-based collaborative governance would meet further practical and implementation challenges that require focused action, such as:

- *Training*. This GC focus on the definition of new modelling and simulation tools and methodologies in order to make policy modelling easier for users with low skills, enabling collaboration at different levels of the process. But this goal would be really hard to be reached without spending effort in training programs aimed at improving basic skills in modelling, simulation and statistical analysis.
- *Financial Sustainability*. This GS calls for the development of software application for policy modelling and simulation that entails a significant need of resources in the long run with first relevant results only after several years. Therefore, a funding scheme for model-based collaborative modelling should be foreseen in order to make this GC financially sustainable.
- *Awareness*. In order to allow the transition to model-based collaborative governance and facilitate the diffusion of collaborative tools and methodologies, a number of dissemination activities should be carried out to increase the awareness of citizens, public institutions and private firms to this direction. Dissemination activities should be based on online and

electronic delivery channels as well as offline channels. This type of activities will guarantee a high degree of dissemination of the message to all stakeholders.

5.6 Actors to be involved

The Grand Challenge GC.1 Model-based Collaborative Governance brings together in a collaboration mode the following actors:

- *Government officials* at all levels that would participate in the model-based collaborative governance, providing crucial data and information and eventually directly being involved in the policy-making process.
- *Policy-makers* that would extend their control on the policy-making process, actively participating in modelling and simulation phases (not just as modellers' customers but as a modellers themselves).
- *Industry*, in particular the ICT sector that would collaborate with Academia in order to develop tools for model-based collaborative governance.
- *Academia and Researchers* that would collaborate with Industry, providing and improving state-of-art methodologies and techniques in order to develop tools for model-based collaborative governance. This would involve researchers from Computer Science, Mathematics and Operations Research, Statistics, Economics and Social Sciences.
- *Citizens and enterprises* that, as the main beneficiaries of developed policies, would be able to actively participate in model-based collaborative governance trough Internet-based collaborative tools.

5.7 Benefits

In the vision of our GC, Model-based collaborative governance will be extremely beneficial to all key stakeholders in terms of:

- Implementing more comprehensive and complex models by reusing consolidated basic building blocks, existing models and knowledge on modelling.
- Allowing any stakeholder to contribute to the policy-making process without requiring expert skills.
- Propagating "culture" of modelling towards the ultimate goal of decisions assessment.
- Using already existing knowledge from every level of population and from every stakeholder.
- Describing policy models with a level of detail comparable to the institutional level at which the model itself gets described, allowing to proceed in a process of further detailing by scaling down the various institutional levels of an organisation.
- Providing tools with different levels of usability and difficulty adapted to different users' skills.
- Retrieving information related to user behaviors, thus helping the way in which also soft variables might affect a model.
- Allowing the various stakeholders to access and inspect data from different sources.

- Making the policy modelling process more efficient through the development of interactive decision support systems, which would reduce costs and time consumption.
- Making the policy modelling process more effective, certifying the reliability of simulation results and their usefulness for policy-making process, through the continuous application of model validation at each step of the process, from the formulation of the problem to the implementation of the study findings.
- Making the policy modelling process more effective trough development of ease-to-use and automated tools for feedback analysis and integration.
- Engaging citizens through the development of user-friendly tools for better understanding policies.
- Improving the understanding of models and, consequently, of policies.

5.8 Summary

Our rapidly changing and complex society requires an efficient and effective decision-making process, able to anticipate future events, promptly detecting emergencies and evaluating the impact of different policy choices, reflecting the real-life complexity while making it simpler and addressable. The GC1 Model-based Collaborative Governance deals with the development of advanced tools and methodologies in order to pursue these goals, following the vision of a radically different context for policy modelling and simulation, where standardisation and reusability of models and tools, system thinking and modelling applied to policy impact assessment has become pervasive throughout government activities. GC1 aims at enabling the engagement of all stakeholders (even without expert skills) in a collaborative policy model building, simulation and evaluation process. This implies a great effort to improve state-of-the-art ICT tools and methodologies, in order to guarantee the efficiency of the policy modelling process, in terms of usability and consequently time and cost consumption, and its effectiveness, in terms of reliability and knowledge of both models and policies.

In this context, the research challenges that should be addressed with a long-term perspective include:

- **RC1.1: Integrated, composable and re-usable models** to create more comprehensive and complex models by using smaller building blocks or existing objects/models. This implies both model interoperability and the definition / identification of proper modelling standards, procedures and methodologies.
- **RC1.2: Collaborative modelling** encompassing participation of all stakeholders in policy-making process through the implementation of Internet-based easy-to-use tools for all the levels of skills.
- **RC1.3: Easy access to information and knowledge creation** with a particular focus on elicitation of information which, in turn, during the overall model building and use processes will help decision makers to learn how a certain system works and ultimately to gain insights and understanding in order to successfully implement a desired policy.

- **RC1.4: Model validation** in order to guarantee the reliability of models and, consequently, of policies that are crucial for policy makers who need and use information that results from the simulations to develop more effective policies.
- **RC1.5: Interactive simulation** concentrating on the fact that larger is the model in terms of size and complexity, the larger is the resulting amount of data to analyse and visualize. In particular, this RC refers to the issue of integration of visualisation techniques within an integrated simulation environment, in order to dramatically increase the efficiency and effectiveness of the modelling and simulation process, allowing the inclusion and automation of some phases (e.g. output and feedback analysis) that were not to this point managed in a structured way.
- **RC1.6: Output analysis and knowledge synthesis** refers to output analysis of a policy model and, at the same time, to feedback analysis in order to incrementally increase and synthesise the knowledge of the model (and consequently of the policy).

In particular, **RC1.1** relates to the modelling process, which follows the decision of assessing a certain policy and the assumptions that underline it. The modelling process can be conducted by creating a scalable model from the very beginning (at different organisational levels) as well as by aggregating/re-using and then integrating already existing models or parts of the model under construction. It is by all means important for the modelling process to be carried out in a collaborative way (**RC1.2**), allowing the involvement of different stakeholders (from government to citizens), in different organisations or at different levels of the same organisations. The modelling process is also strictly connected to the availability of data (**RC1.3**), which is needed in order to populate the model and give correct values to the variables included in the model itself. Moreover, the availability of historical time-series allows for a validation (**RC1.4**) of the model itself. A validation is needed in order to assess the formal "rightness" of the model, before assessing a policy's assumptions. Once the model has been validated, simulations may begin. These simulations conducted interactively by changing decisions (data value) during the course of the simulations themselves (**RC1.5**), may in consequence produce new data or modify existing data over time. This data needs to be analysed (**RC1.6**) in order to assess the validity of the simulations and eventually, provide a feedback either on the simulation process or in some cases on the modelling process. When, ultimately, a satisfying result has been achieved or when a complete understanding (due to feedbacks on RC1.1/RC1.2, RC1.3, RC1.4 and RC1.5) of the system has been gained, the knowledge synthesis allow for updating the data sources (RC1.4) in order to ultimately produce/create knowledge about the system. In results, on a basis of the outcome, the decision whether the certain policy that had been tested should be eventually implemented can be taken.

6 GC2: Data-powered collective intelligence and action

6.1 Description

The State of the Art outlines the emergence of collaborative Governance. Tools and applications developed by civil society and government start to leverage collaboration and collective intelligence, building on government and citizen-generated data. However, the limitations and bottlenecks are also evident and hinder the possibility to achieve maximum impact.

Firstly, the collaborative tools are successfully engaging only those who already display a high level of interest. Therefore, the Government 2.0 tools are developed and used mostly by technological and intellectual elites. Since to collaborate in public value creation, high levels of digital literacy and interest in policy-making are needed. Transparency and open data are necessary but not sufficient requirements for reaping the benefits of collaborative governance. As Lawrence Lessig, one of the founding fathers of the transparency movement, in his article *Against Transparency* puts it: "*with the ideal of naked transparency alone - our democracy…is doomed…Limited attention span will assure that the most salient is the most stable. Unwarranted conclusions will be drawn, careers will be destroyed, alienation will grow.*" (2009). Engaging citizens remains the main challenge of collaborative initiatives. Without attention and interest, openness and collaboration are unlikely to drive benefits. Using the metaphor of the TV Simpson series, current government 2.0 has been able to involve diligent Lisa Simpson, but not remiss and disrespectful for authority Bart. This is not to refer to two specific user profiles (high versus low-engaged citizens), but rather to a specific use case, as each citizen can be in a "high engagement" situation for one specific issue, and on "low engagement" for others. One of the key challenges of future collaborative governance is to address the information overload also known as filter failure.

Secondly, even in cases where attention occurs, it often remains at the level of online or offline discussion and rarely spurs into real action and provides impact. In government, too often consultations do not result in real modification in policy actions. But in case of collaborative governance, there are not only governments who are in charge. On the citizens' side, the bottom-up collaboration may well generate concrete applications, but they struggle to go beyond the "cool" effect to deliver change and impact. Today's complex societal challenges require citizens collaborative action and behavioural change: for example, the transition to a low carbon economy can only take place through the collaborative action of all relevant stakeholders and changes into the daily life of citizens.

In summary, the current situation is characterised by an engagement of highly interested people only, and by an engagement that rarely stimulates genuine action. As we will see in the following section, the ICT research offers opportunities to address these two issues.

There are several complementary research areas in ICT for governance and policy modelling that have the opportunity to address the need for collaboration and behavioural change throughout different technological layers: enhanced data availability through public linked data and participatory sensing, analytical capability through opinion mining and visual analytics, and action-oriented tools

such as simulation and serious gaming. These trends mutually reinforce each other to offer a new opportunity for the future ICT for governance and policy modelling.

6.2 Vision

We envisage advanced ICT tools that allow for collaborative governance with progressive degrees of participation, from high to low interest, and making maximum use of short attention spans and weak forms of participation.

Data availability would continue to grow exponentially, thanks to greater than ever opening of public data and increased production of citizens-generated and sensor-generated data. The validity and authenticity of produced information (by government, citizens and sensors) would be guaranteed by federated identity systems and third party cross-validation of content.

Advanced filtering and opinion mining tools would facilitate the reduction of information overload while avoiding "tunnel" effects and group thinking by including data and opinions external to the users' community. Collaborative solutions tool-kits would allow for different levels of users engagement: more active forms of participation and manipulation of data would be accompanied by weaker forms of participation enabled by low-engagement tools. In addition, interoperable reputation management tools would support engagement through interrogation of identified experts.

Maximum usage would be made of short attention spans through context-aware data collection and data representation through ubiquitous computing. Data from citizens would be collected at once, on-the-fly, and conveyed to the relevant data repository. Taste-sharing tools such as Facebook "iLike" button will collect preferences in real-time in relation to any sort of digitisable event, including the use of non-computing devices. Collective preferences aggregation would be based on a qualitative message and on attention data at a very granular level, such as for individual sentences in large documents or specific visualisation of large datasets.

Low-engagement tools would include opportunistic participatory sensing, such as machine-generated data on citizens behaviour and preferences (nano-feeds). Through the Internet of Things, devices and natural interfaces, citizens' gestures and behaviour would be captured as preferences and opinions, but under a rigid user-controlled data disclosure framework.

Besides easily expressing their preferences, mobile, always on devices, citizens would have instant access to relevant information filtered by context. Information would be context-relevant and dynamically visualised in order to allow for different views. Citizens would be able to produce new data views and share visualisations with contacts. Visualisations will be filtered and provided based on the other users' context. Opinion mining and visual analytics tools would be available, usable and used by the majority of citizens.

On the top of available information, both citizens and government would be able to obtain real-time feedback on the long-term systemic effects of their choices, including non-actions. The systemic impact of sub-optimal choices will become immediately visible to citizens and government, thereby reducing the scope for short-term behaviour. Committed citizens and civil servants would be able to build toolkit-based custom applications for simulation and gaming, in order to raise awareness on specific issues.

In summary, the overarching vision is spelled out in the table below. Traditionally, the governance model is the one, where data collection, data analysis and deriving action are carried out by government, with specific moments of opening up such as in consultation processes. The collaborative governance vision, proposed as an alternative, includes citizens in all the phases of the governance: in collecting relevant data through participatory sensing tools; in analysing the data through simulation and visualisation software; in acting upon these data through bottom-up self-organized action which accompanies, anticipates and stimulates government policies.[4]

Table 6-1: Use cases of Data Powered Collective Action across technological layers

Actor / Layer	Government	Citizens
Collaboration and Action	Policy impact simulation Collaborative policy-making	Individual behaviour simulation, gaming Collaborative policy-making
Analysis and representation	Opinion mining, visual analytics apps	Opinion mining, visual analytics apps
Data collection and validation	Open government data	Citizens feedback and participatory sensing

The table does not represent two separate parallel tracks. The highest benefits will come from integrating meshing up resources across the two domains, such as analytical tools provided by citizens on top of government data that lead to better decision-making by governments. This is sometimes referred to as the symmetric nature of collaborative governance.

This model is directly linked to the traditional policy-making cycle, as the three layers outlined above represent a cycle that runs alongside the policy cycle. In particular, the data collection and analysis level are the keys to the activities of policy design and policy evaluation, while collaboration and action is more relevant for the policy design and policy implementation phases.

For this vision to become a reality, substantial research effort is needed alongside a set of research challenges that address the research gaps illustrated in the gap analysis.

6.3 List of relevant gaps

The gaps analysis carried out in the CROSSROAD D3.2 Updated Gap Analysis Report has outlined a comprehensive list of gaps to be addressed across the research themes. We hereby list and assess the gaps, which are addressed in the context of this Grand Challenge.

[4] It is a well-recognized and repeated fact that the complexity of today's challenges cannot be met by government action alone, but through leveraging the collaboration of a wider set of stakeholders.

Research Theme 1: Open Government Information & Intelligence for Transparency	Assessment of relevance for GC2[5]
→ *Systematic management and monitoring of transparency*	xx
→ *Public, real-time linked data*	xx
→ *Citizen-oriented linked data querying and reasoning*	xxx
→ *Large-scale public information visualisation* i	xxx
Research Theme 2: Social Computing, Citizen Engagement and Inclusion	
→ *Open and cross-language collaborative filtering / attention economy tools*	xxx
→ *High-quality expertise identification through reputation management*	xx
→ *Distributed Early Warning Systems for risk prevention*	xx
→ *Affordable large-scale collaboration*	xxx
→ *Leveraging casual participation*	xxx
→ *Robust and large-scale argument support systems*	xx
→ *Robust Natural Language Interfaces*	xx
→ *Higher levels of acceptability*	xx
→ *Participation*	xx
Research Theme 3: Collaborative Policy Modelling	
→ *Large-scale quantitative data for formal policy models*	xx
→ *Collaborative Intelligence in policy-making*	xx
Research Theme 4: Identity, Privacy and Trust in Governance	
→ *Interoperability and integration issues of identity management in large-scale systems*	xx
→ *Means for authentication and Identity Management*	xx
→ *Digital identity for governance and policy modelling*	xx
Research Theme 5: Future Internet for Collaborative Governance	
→ *Mobility and Participatory Sensing*	xx
→ *Real-time context-aware services*	xx

6.4 Research Challenges

Based on the integrated review of gaps and on the discussions held in the Samos 2010 Summit and validated during the EGOV 2010 CROSSROAD Workshop in Lausanne and the CROSSROAD ICT 2010 Networking Session in Brussels as well as through the online deliberation process, we identify the following research challenges. We focus only on those tools and layers that require substantial research effort; we do not offer an exhaustive list for a fully-fledged collaborative governance system. For example, collaborative authoring tools do not seem to entail governance-specific research effort, and are therefore not listed here.

[5] X – low relevance, xx – medium relevance, xxx – high relevance

Table 6-2: Research challenges per technological layer

Layer	Research Challenge
Collaboration and Action	User-generated simulation and gaming for public action New institutional design for collaborative governance
Analysis and representation	Collaborative visual analytics for policy-making Peer-to-peer public opinion mining
Data collection and validation	Federated dynamic identity management Real-time, high-quality, reusable open government data Privacy-compliant participatory sensing for real-time policy design and evaluation

The technological relationships illustrated by this table do not simply represent the flow of data, but highlight the systemic complementarities between the different research challenges. In other words, progress on one layer is likely to generate additional benefits and challenges for the other layers. Therefore, the integrated research approach including all the layers is expected to generate benefits that go beyond the simple sum of the individual benefits of this layer.

6.4.1 RC2.1: Privacy-compliant participatory sensing for real-time policy-making

Description and link with the state of the art

Participatory sensing refers to the usage of sensors, usually embedded in personal devices such as smartphones to allow citizens to feed data of public interest. This could include anything from photos to passive monitoring of movement in the traffic. Participatory sensing involves higher commitment from citizens in contrary to opportunistic sensing, where user may not be aware of active applications. The diffusion of mobile phones significantly lowers the barriers of participation and data input by citizens, with automated geo-tagging and time-stamping: given the right architecture, they could act as sensor nodes and location-aware data collection instruments. While traditional sensor nodes are centralised, these sensors are under the owners' control. This would give way to data availability at an unprecedented scale.

Participatory sensing radically improves the data availability for evaluating the effect of public policies and how individual behaviour is changing, provided adequate privacy provisions are in place. Devices should assure enhanced users' control over data, i.e. which data is being sent, when and how it is treated, as well as possibility for enhanced data anonymisation.

Furthermore, design of participatory sensing should be placed in the framework of policy contexts, allowing inference of policy impact from data. Future platforms should combine participatory sensing, mass moderation, personalised feedback and social network analysis to assess the interplay between perception, data and social interaction.

Participatory sensing is related to the State of the Art research areas Opinion mining (under RT2) and the Internet of Things (under RT5).

Current status

Small-scale experiments are being carried out in different domains, mainly dealing with environmental and health data. Applications in the field of urban planning are particularly promising, yet there is no structure link between participatory sensing and policy models. Larger scale deployment would require more granular privacy compliance and user-control, adequate incentives to participation and deriving business models. There is no formalisation of the requirements and the design of opportunistic versus participatory sensing, including sampling design for participants recruitment.

Current practice

Pilot initiatives for environmental / health monitoring and citizens reporting (Fixmystreet iPhone app)

Current research

- Aggregating and validating citizens generated and government data resource discovery,
- Selective sharing, and context verification mechanisms, as well as application-level support for data gathering campaigns,
- Incentives for participatory sensing,
- Evaluation of human agents as sensors

Type of research (disciplines)

Sensor networks, location services; psychology, economics of participation; privacy.

Relation with other research in parallel fields - what is specific about governance

Participatory sensing is already used in "public sphere" activities such as environment and health. However the specific issue of evaluating public policies has been so far little researched, with particular regard to the implications for privacy, large-scale deployment and bias management on citizens sensing.

Timeline

Short-term research

- Sensing coverage, sensor calibration and sensor context for opportunistic sensing.
- Quality verification for participatory sensing
- Privacy-compliant sensing and sharing
- Business models for participatory sensing
- Intelligently recruiting collaborators and deploying data collection protocols.
- Anonymous, transparent use of human-carried sensing devices
- Evaluating behavioural change through participatory sensing

Long-term research

- Enhanced analytical techniques to make more accurate inferences from mobile phone-supplied data such as location and images and to automatically detect and respond to subtle events;
- New personal-scale sensors to expand the range of information that individuals can track and use
- Privacy by design in participatory sensing

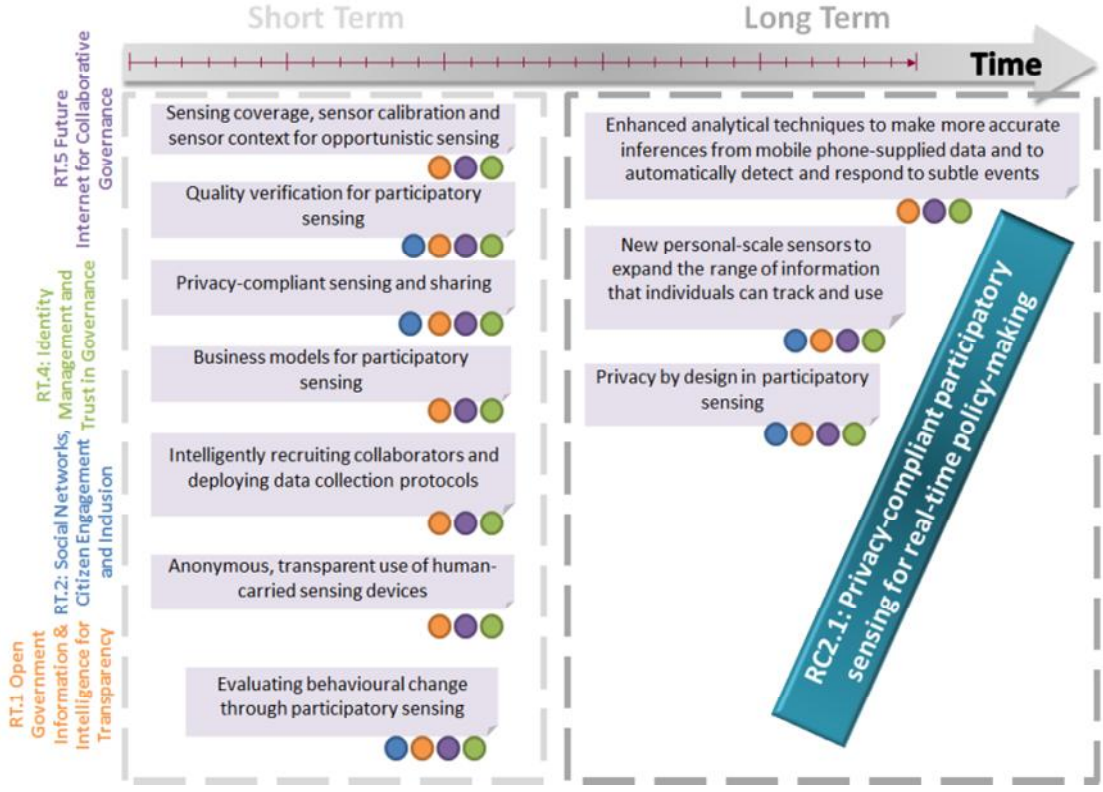

Figure 6-1: Timeline for RC2.1 Privacy-complaint participatory sensing for real-time policy-making

Possible research instruments

Testbeds and living labs, STREPs

6.4.2 RC2.2: Real-time, high-quality, reusable open government data

Description and link with the state of the art

The current emergence of open data portals in the government context is opening great opportunities for collaborative government, but it is happening in a scattered way leading to sub-optimal data reuse and impact. Open data publication needs to meet requirements for timely publication but at the same time to ensure sufficient data quality. At a more advanced level, publication of linked data requires significant effort and has encountered unequal success, but the benefits are high in terms of data interoperability and deriving reuse and data quality. Linked data refers to a set of best practices for exposing, sharing, and connecting structured pieces of data, information, and knowledge on the Web. Simplifying and lowering costs of open data publication is indeed a key area of research.

Curating tools (selecting, aggregating and presenting) and on-the-fly data quality agreements will reduce the cost and time of data quality assurance. Finer grained data privacy solutions will also contribute to increase the amount of public data being published, as well as enable real-time publication of data.

This Research challenge refers to items under the research area 1.1 (Open Data and Transparent Information Management) of the State of the Art.

Current status

Current emerging practice focuses on the publication of open government data in machine-readable format, possibly through open standards. More innovative implementation includes publication of linked data but little research is carried out in the governance context. Other lighter-weight forms of interoperability focus on RESTful interfaces. Furthermore, because of privacy concerns, the only data provided are aggregated and anonymised.

Existing research focuses mainly on publishing tools for linked data, converting data in RDF, linking RDF data sources and creating semantic vocabularies for linked data.

Current practice

- Data.gov repositories
- Linked data in data.gov repositories
- Machine-readable formats
- RESTful interfaces

Current research

- Government data
- Catalogues vocabularies
- Open data interoperability
- Capturing and publishing linked data
- Curating tools for data quality

Type of research (disciplines)

Technological research: semantics, interoperability, privacy-enhancing-technologies.

Relation with other research in parallel fields - what is specific about governance

Data openness has resulted in some application in the commercial field, but by far the most relevant applications are created in the context of government data repositories. With regard to linked data in particular, most research is being undertaken in other application domains such as medicine. Government starts to play a leading role towards a web of data. However, current research in the field of open linked data for government is limited.

Timeline

Short-term research

- On-the-fly data quality agreements
- Easy and privacy-compliant data publication tools
- Open dataset integration and quality check

Long-term research

- Web of data
- Privacy-by-design compliancy in open data
- Real-time publication of linked data

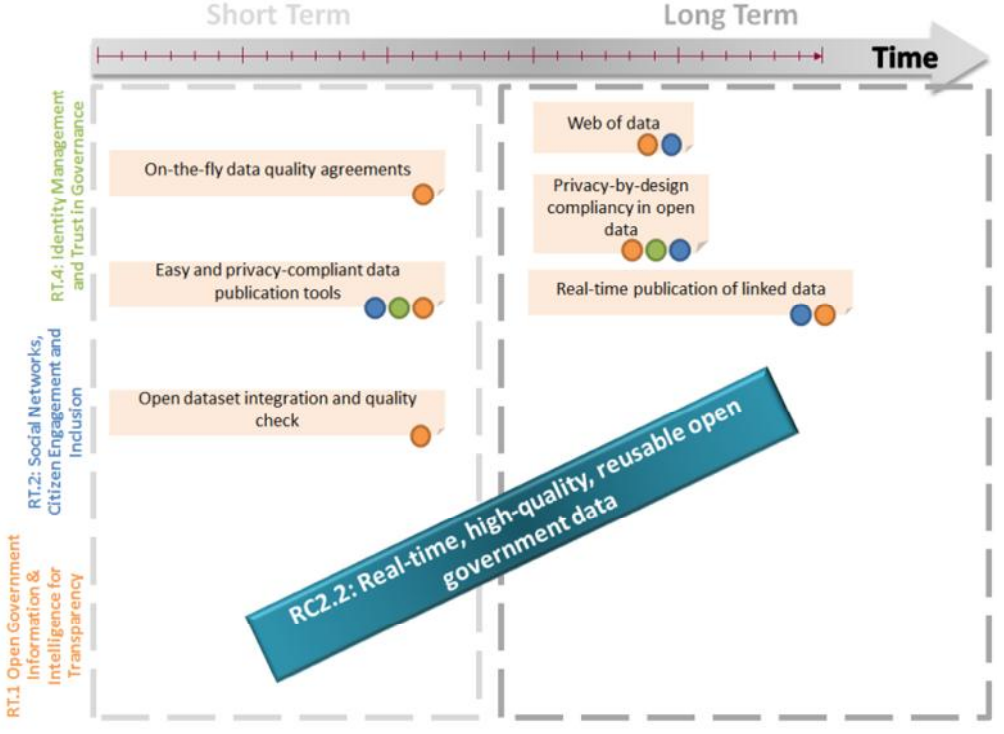

Figure 6-2: Timeline for RC2.2 Real-time, high-quality, reusable open government data

Possible research instruments

Testbeds and living labs, STREPs

6.4.3 RC2.3: Federated dynamic identity management and privacy control

Description and link with the state of the art

Digital identity management has long been a policy priority in the EU Member States, and large-scale investments have been deployed. In the context of collaborative governance, digital identity constitutes a fundamental pillar of trustworthy cooperation. Identity management systems include control and management of credentials used to authenticate one entity to another, and authorise an entity to adopt a specific role or perform a specific task. Global in nature, they should support non-repudiation mechanisms and policies; dynamic management of identities, roles, and permissions; privacy protection mechanisms and revocation of permissions, roles, and identity credentials. Furthermore, all the identities and associated assertions and credentials must be machine processable and human understandable.

At the EU level, the goal is to provide an interoperable privacy protecting infrastructure for eID that is federated across countries, with multiple levels of security for different services, relying on authentic sources, and usable in a private sector context.

Alongside this, a flexible, context-dependent and interoperable identity management system is required for large-scale deployment. In particular, federated identity management systems that ensure flexible deployment and seamless integration of users' preferred identities, including commercial (such as Facebook connect) and open source solutions (such as OpenID) are needed. Particular focus should be put on usable delegation of privileges, which is very important for workflows and integrating services.

Electronic identity management should identify non-humans (devices, sensors) as well as humans, in order to ensure validated identity in the context of participatory sensing and the Internet of Things.

At the same time, eIdentity management should take into account the risks of information centralization in terms of data privacy and security. Cost-benefit considerations of centralised versus federated systems remains a key issue. Identity federation can be accomplished in any number of ways, some of which involve the use of Internet standards, such as the OASIS Security Assertion Markup Language (SAML) specifications, with the use of open source technologies and/or other openly published specifications.

This challenge refers to Research area 4.1 (Identity Management) in the SoA.

Current status

The role of Identity Management is vital in the context of ICT for Governance and Policy Modelling. The importance of addressing eIdentity-related issues for secure public service provision, citizen record management and law enforcement has made Identity management a strategic issue for governments at both a local and international level. Research for the design and implementation of

privacy preserving digital identity, as well as for its supporting management infrastructures, and delegation of authority, has reached a satisfactory level. Nevertheless, one of the greatest problems in Identity Management is lack of interoperability of digital identities and identity management systems between proprietary systems and standards-based ones, and between organisations and governments.

Research in identity is currently fragmented along disciplinary lines, although this is far from a technological issue, since the specifications and nature of a Digital Identity is often dictated by the social and political environment of the country of issuance. Moreover, strong regulations and policies are required in order to address the increasing number of electronic identity-related crimes (identity fraud, identity theft, impersonation). These issues call for policies, directives and frameworks that fully defend and guarantee the legitimacy of eIdentities and respect the human rights of citizens.

Current practice

- Electronic ID creation at national level
- Pilots in cross-border interoperability of eId in EU (STORK project)

Current research

- Cultural-dependent identity systems
- Mobile and biometrics in eIdentity
- Privacy protecting identity management systems
- User-centric identity, delegation of authority

Type of research (disciplines)

Legal, technological, social, economic

Relation with other research in parallel fields - what is specific about governance

Identity certification is one of the core tasks of government, and therefore pertains specifically to the governance context. This is reinforced by Meta Group (2002), who views the implementation of identity management "not as a differentiator but as mandatory security consideration, a business imperative and a non-negotiable user expectation".

Timeline

Short-term research

- Quantitative research on cost-benefit analysis of interoperable identity
- Dynamic user-controlled identity disclosure
- Formal verification of identity management systems
- Governance and legal issues, levels of assurance

Long-term research

- Context-dependent identity management

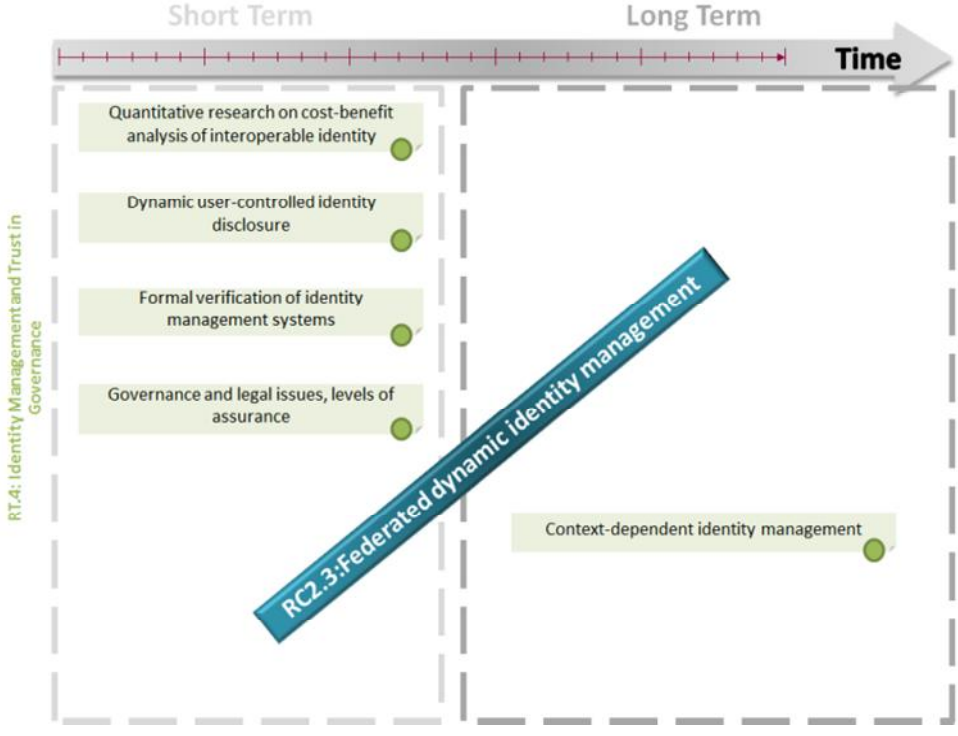

Figure 6-3: Timeline for RC2.3 Federated dynamic identity management

Possible research instruments

Testbeds and living labs, STREPs

6.4.4 RC2.4: Peer-to-peer public opinion mining

Description and link with the state of the art

Current public governance debate is limited by the large amount of comments and opinions, which overtake human possibilities for participating in the debate. The limits of human attention, combined with the existing simple interfaces available for browsing discussion and comments, often leads to low levels of engagement and flaming wars, driving to polarisation of arguments and enhanced risks of conflicts.

Public debate is characterised by evaluative judgement, rather than hard data. In this sense, it differs from pure data and text mining insofar it deals with subjective statement. In this sense, it is a specific development of a discipline dealing with unstructured information extraction (IE) that was previously mainly working with objective data such as natural disasters or bibliographic information. The explosion of user-generated content widens the application scope of public opinion mining tools, which need to become more pervasive and available to the majority of citizens.

The first challenge is the identification of opinionated subjective document (in the contrast to an objective one). Existing opinion mining applications act on textual information and in specific languages, while research efforts are on-going to translate and reuse lexicons across languages, while multi-lingual opinion mining tools are not mature. A specific hard challenge for policy debate is the detection of ironic statements.

Additionally, public opinion mining has to become increasingly real-time and focus on identifying not only representative opinions but also high-quality and highly influential ideas through a combination of semantic and statistical analysis with Social Network Analysis and recommendation systems.

A further challenge is the identification of the policy context (explicit and implicit) of the relevant statement. A formal preliminary hypothesis of the policy context and of the most relevant contents needs to be developed to allow for content analysis.

As per the SotA Research Area 2.3 (Public Opinion Mining), opinion mining can be defined as a sub-discipline of computational linguistics that is concerned with the opinion that a document expresses. Sentiment classification is about determining the subjectivity, polarity (positive/negative) and polarity strength (weakly positive, mildly positive or strongly positive) of an opinion text.

Current status

Large-scale opinion mining tools are currently being implemented mainly for commercial applications and in security areas. Technologically, they rely on a mixture of semantics and statistical analysis based on lexicon and semantic corpus of words, still demanding high level of human involvement. Diminishing the amount of human effort necessary on top of machine-generated extraction and classification is a key area of research.

Because of these tools limitations, vendors target mainly commercial companies or large government departments that seek to monitor citizens' opinions. Moreover, citizens have no access to similar applications in order to monitor what other citizens think. Mostly used freely available tools (such as blogs but also idea-storm platforms such as uservoice) list comments in temporal order or binary ratings (like/dislike), which lead to polarisation of debate and burying of innovative ideas under other, less original comments.

Despite the explosion of audio-visual content on the web, most opinion mining solutions are currently working for text content only.

Current practice

- Security agencies monitoring potential suspect through semantic and statistical analysis
- Commercial services for machine/human powered opinion mining
- Ranking tools
- Linear comments
- Highly human-intensive analysis

Current research

- Statistical analysis

- Semantic analysis through lexicon/corpus of words with known sentiment for sentiment classification
- Identification of policy opinionated material to be analysed
- Computer-generated reference corpuses in political/governance field
- Visual mapping of bipolar opinion
- Identification of highly rated experts

Type of research (disciplines)

Data mining, Language extrapolation, Information Extraction, Psychology, Design, Social Network Analysis.

Relation with other research in parallel fields - what is specific about governance

Most research has been carried out in relation with commercial applications such as customers' reviews of products. However, a fast-growing corpus of research has been developed in the particular area of citizens' opinion and comments. In some areas, such as audiovisual mining, the first applications (developed by Google) have been used during the US presidential debate.

Timeline

Short-term research

- Visual representation
- Audiovisual opinion mining
- Real-time opinion mining
- Machine learning algorithms
- Natural language interfaces
- SNA applied to opinion and expertise
- Bipolar assessment of opinions
- Multilingual reference corpora
- Comment and opinion recommendation algorithm
- Cross-platform opinion mining

Long-term research

- Multilingual audiovisual opinion mining
- Usable, peer-to-peer opinion mining tools for citizens
- Non-bipolar assessment of opinion
- Automatic irony detection

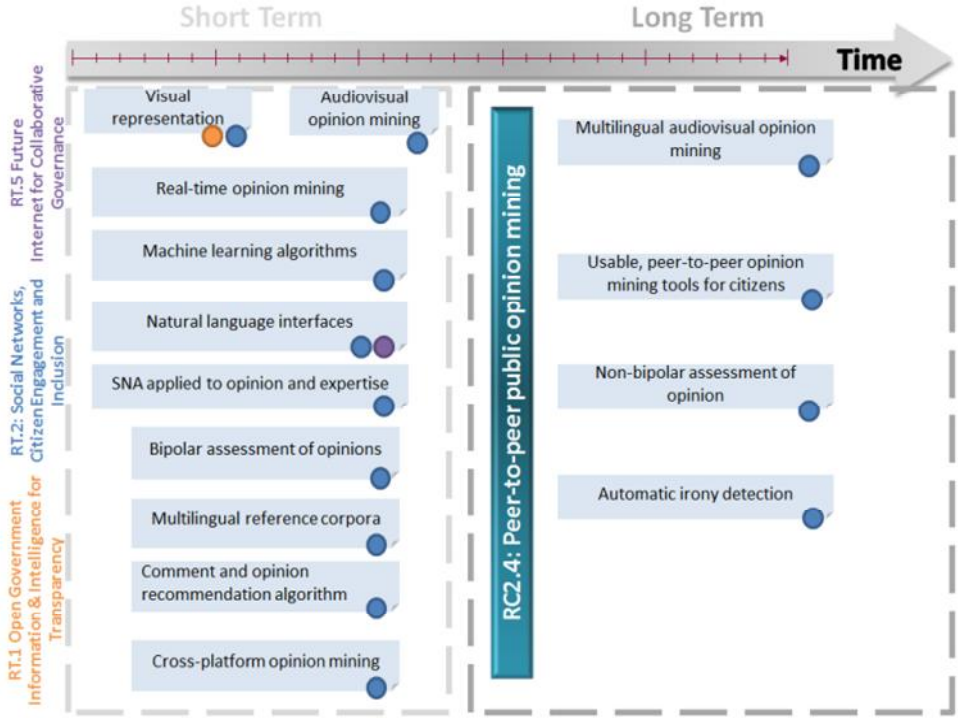

Figure 6-4: Timeline for RC2.4 Peer-to-peer public opinion mining

6.4.5 RC2.5: Intuitive, collaborative visual analytics of data for policy-making

Description and link with the state of the art

Visual analytics permits to turn information overload into an opportunity. In the policy context, it allows for more meaningful, evidence-based policy debate that engages also non-experts. Visualisations prove to be particularly effective in making sense of large datasets, such as those provided as open government data. Multiple visualisation enable illustrating multi-faceted problems, such as policy-related issues, thereby facilitating informed debate. Ensuring appropriate visualisations can therefore be considered a key component of a mature democracy.

In contrast with visualisation traditionally seen as the output of the analytical process, visual analytics considers visualisation as a dynamic tool that aims at integrating the outstanding capabilities of humans in terms of visual information exploration and the enormous processing power of computers to form a powerful knowledge discovery environment. It proves particularly relevant to make public data such as government spending meaningful for non-experts, but it also allows experts to dig into data in order to extract patterns and validate models. It is above all effective when dealing with complex and non-predictable patterns, such as those related to assessing and anticipating public policy impact. This would be applied both to data and text, objective data and subjective data, for example supporting the analysis of the output of Opinion Mining tools. Policy advisors especially need advanced tools to quickly and iteratively analyse data and their implication without necessarily specific knowledge about underlying algorithms. In addition, visual analytics can be applied at personal level for visualising personal behaviour, thereby leading to potential action and behavioural change.

Notably, the fast pace of change and increased instability in areas of regulation requires rapid decision making able to draw on the wider amount of available evidence in real-time. Visual analytics require particular technological advances, as traditional data mining tools are unsuitable for some necessary functionalities such as the algorithm speed required for iterative visualisation. Future developments of visual analytics include the fields of enhanced collaboration capabilities, more intuitive interaction, support of non-computing devices, as well as the integration of quantitative and qualitative data.

In addition, for policy measures to be effective data integration should be carried out in real-time and integrate citizen-generated data.

In the State of the Art, this refers to RA1.3 (Visual Analytics), but should be considered in strict integration with other research areas, such as modelling and simulation, social network analysis, participatory sensing and open linked data.

Current status

Visual analytics is already applied and researched in particular in the area of security, environment and life sciences. In the public context, visual analytics of public data is an exploding field, with particular relation to the open data movement, in order to monitor policy context and evaluate government policies. Most basic mash-up tools are available to visualise government data, and more advanced applications lie for example in visualising financial markets dynamics in real-time. Nevertheless, most applications remain at the level of visualisation only, with limited analytical functionalities. Geo-visualisation is a fast growing application area in the government context, but there is little integration with other related areas such as participatory sensing.

Current practice

- Simple visualisations of static data sets such as those in Many Eyes Dynamic visualisation such as Gapminder
- Advanced applications for security and defence.

Current research

- Close the loop of information selection, preparation and visualisation
- Simultaneous multiple visualisation
- Integration of visualisation with comments / wiki / blogs
- Collaborative platform display
- Interaction between visualisation and models
- Mobile visual analytics tools
- Geo-visualisation of government data
- Integration with opinion mining and participatory sensing
- Evaluation framework for visualisation effectiveness
- Visualisation infrastructures for policy modelling issues

Type of research (disciplines)

Human-Computer Interaction (HCI), Usability Engineering, Cognitive and Perceptual Science, Decision Science, Information Visualisation, Scientific Visualisation, Databases, Data Mining, Statistics, Knowledge Discovery, Data Management & Knowledge Representation, Presentation, Production and Dissemination, Statistics, Interaction, Geospatial Analytics, Graphics and Rendering, Cognition, Perception, and Interaction.

Relation with other research in parallel fields - what is specific about governance

Information visualisation is a generic research field, with most advanced applications in the context of scientific research as well as defense and security. With regard to the governance context, most advanced research areas are related to financial markets monitoring. There is a significant research gap in the integration between new opportunities for data collection, such as open data and participatory sensing, policy modelling and visual analytics tools.

Timeline

Short-term research

- Re-usable, mashable tools for visual analytics
- Tighter integration between automatic computation and interactive visualisation
- Bias identification and signalling in visualisation
- Perceptual, cognitive and graphical principles
- Efficiency of the visualisation techniques to enable interactive exploration interaction techniques such as focus & context
- Impact evaluation of visual analytics on policy choices

Long-term research

- Learning adaptive algorithm for users intent
- Advanced visual analytics interfaces
- Intuitive affordable visual analytics interface for citizens
- Development of novel interaction algorithms incorporating machine recognition of the actual user intent and appropriate adaptation of main display parameters such as the level of detail, data selection, etc. by which the data is presented

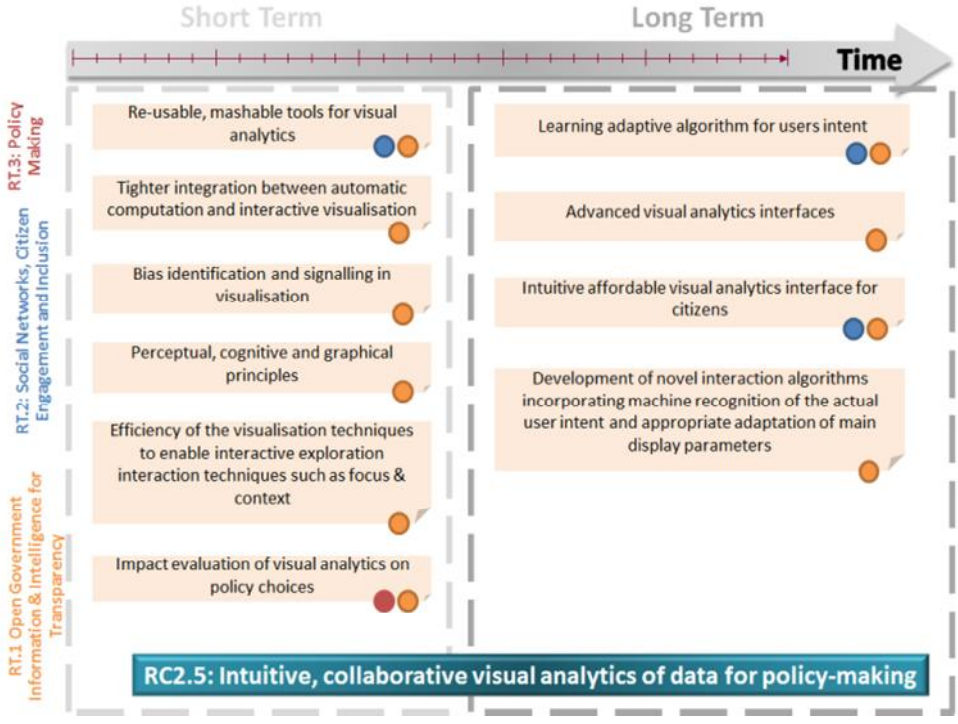

Figure 6-5: Timeline for RC2.5 Intuitive, collaborative visual analytics of data for policy-making

Possible research instruments

Visualisation is largely a demand- and design-driven research area, which struggles to be compatible with existing FP7 instruments. Additionally, a strong lightweight collaboration with designers and visual artists is difficult to fit in existing policy tools.

6.4.6 RC2.6: User-generated simulation and gaming tools for public action

Description and link with the state of the art

So far, collaborative ICTs have dramatically augmented the capacity of people to connect and collaborate. Yet, less impact has been achieved in terms of actual change and action, as most collaboration remain confined to an elite of highly-motivated individuals and faces the traditional limits of human attention and motivation. As illustrated in other challenges, ICT can improve data collection and analysis, but if attention and motivation are not present, little impact can be achieved. This challenge deals with the closing loop of collaboration and depicts ICT solutions that enable behavioural change and action. Even when citizens and government are fully aware of necessary policy choices, they might irrationally choose short-term benefits.

Simulation and serious gaming offer opportunities to impact on personal incentives to action and showing long-term and systemic effects of individual choices, thereby lowering the engagement barrier to collaborative governance and augmenting its impact. In particular, serious gaming have

been developed for educational purposes and raising awareness on particular issues while not requiring high levels of engagement.

Simulation tools enable users to see the systemic and long-term impact of their action in a very concrete and tangible form, thereby encouraging more responsible behaviour and long-term thinking. Gaming engages users through the "fun" and "social" dimension, thereby providing incentives towards action. Feedback and simulation systems include both individual and government behaviour, thereby allowing policy-makers and citizens to detect the impact of both individual and policy choices.

Engagement of domain experts is a crucial issue for building reliable games and simulation tools. Toolkits and modules enable a wider audience of stakeholders to take a direct, active role in games development, thereby enabling all relevant knowledge to be elicited and captured by the simulation and gaming scenarios and models. Pre-built toolkit enables the creation directly by thematic experts and not by technology experts.

This challenge relates to items 3.3 (Policy Simulation) and 3.2 (Policy Modelling) of the State of the Art.

Current status

Simulation and gaming have started to be applied in different policy contexts in order to engage wider audiences. Games are developed "on purpose", by highly skilled developers, in the public sector and by civil society, therefore requiring significant investment and without the specific thematic knowledge of the field. Furthermore, existing serious games lack flexibility to allow for unpredictable developments and non-linear behaviours, where scenarios evolve and adapt to users choices rather than being rigidly prescribed. Commercial solutions that turn long-term effects into short-term feedback are available, but still lack usability as well as the fun dimension of games and finally require high levels of engagement. They are designed for individual feedback and do not cover the complexity of systemic interactions, which are typical of public governance issues.

To sum up, serious gaming is still requiring high level of engagement, and progress is needed in terms of usability and appeal in order to reach "casual gamers" including, immersive and emotion aware games.

Current practice

- Purpose-built gaming and simulation for understanding of policy issues and of individual behaviour

Current research

- Kit-based serious games
- Integration between policy models and simulation
- Design of appealing, adaptive and context-aware interfaces. Impact of simulation and gaming on individual behaviour
- Unconscious impact of feedback systems

Type of research (disciplines)

Human-computer interaction, sensors, information visualisation, sensor design, psychology, pedagogy, public policy

Relation with other research in parallel fields - what is specific about governance

Most applications of simulation and gaming are developed into the context of education and learning, while more interactive feedback producing systems have been applied to personal health and energy conservation. The specific challenges of gaming for public policy awareness and action are currently less researched, but are very specific because of their large-scale interaction and systemic effects of individual behaviour, which characterised this field.

Furthermore, the availability of a simulation toolkit is necessary to empower a diverse and inclusive simulation landscape, where the most diverse set of ideas can be influential and listened to.

Timeline

Short-term research

- Citizens- and experts-generated gaming
- Immersive interfaces
- Large-scale collaboration in development
- Casual serious gaming
- Ethical issues in serious gaming
- User-controlled simulation and gaming
- Non-linear and adaptive scenarios for gaming in policy context
- Integrated analysis of information and behavioural change
- Impact of simulation and gaming on systemic behaviour

Long-term research

- Augmented reality citizens-generated gaming and simulation
- Ubiquitous feedback systems on public governance
- Model and display long-term systemic effects of individual choices on public policy topics
- Interplay between different feedback systems and other information outputs

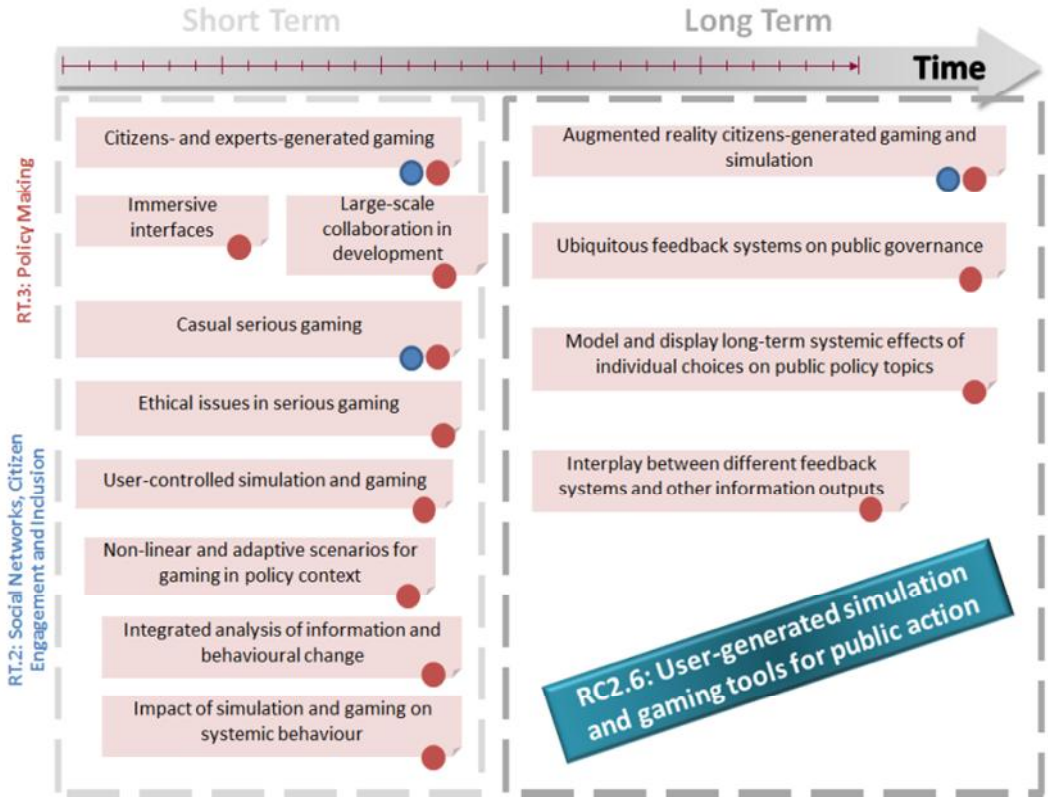

Figure 6-6: Timeline for RC2.6 User-generated simulation and gaming tools for public action

6.4.7 RC2.7: New institutional design of collaborative governance

Description and link with the state of the art

While all challenges provide opportunities for a more effective large-scale collaboration in public action, the relevant institutional design is far from being introduced. The formal inclusion of citizens input in the policy-making process, the deriving institutional rules, the legitimacy and accountability framework are all issues that have so far been little explored. The kind of instant, open governance that we described in the Visionary Scenarios (CROSSROAD D2.2 deliverable) implies a substantial increase in feedback loops that are of a different scale with respect to the present context. Any system stability is affected by the number, speed and intensity of feedback loops, and the institutional context has been designed for less and slower loops.

The definition and design of public sector role is being directly affected by the radical increase in bottom-up collaboration, deriving from the lower cost of self-organisation. There are also important questions to be answered – where does the legitimacy come from, how to gain and maintain the trust of users, how to identify the users online. There is also a very important issue of how to take into the account the diversity of the standpoints, i.e. how to achieve a consensual answer to controversial social issues, especially when we do not offer alternatives (ready-made options) but start from an open question and work throughout different options proposed by participants. Furthermore, the trade-off between direct or representative model of democracy will have to be analysed in this

context. It is far from being proved that the open and collaborative governance is really inclusive and representative of all the social groups, including the disadvantaged and of all standpoints. There is a visible risk that online collaboration increases the divide, rather than reduces it.

The management of institutional bodies is changing: innovative ideas and insight coming from employees and citizens are key resources to be exploited, and meritocracy and transparency are entering an once stable and conservative workforce. Enhanced collaboration with citizens and private third parties should be accompanied by adequate legal and accountability frameworks, mapping incentives to participation and enabling business models for different stakeholders.

The privacy paradigm is changing and appropriate, more dynamic frameworks have to be designed, taking into account the willingness of citizens to share information and at the same time ensuring their full awareness of the implications and their control over the data usage.

Current status

The current status is characterized by practice-driven implementation, accompanied by little scientific reflection. Guidelines and soft regulation are being created from scratch and by building on other institutions examples. The development of collaborative governance is growing rapidly without an appropriate reference framework.

Current practice

- Made-up guidelines and behaviour

Current research

- Analysing the compatibility of new collaborative behaviour with existing institutional framework

Type of research (disciplines)

Political sciences, public administration, law, sociology, and other social sciences in general (including institutional economics for example), as well as organisational, network, innovation theories, etc.

Relation with other research in parallel fields - what is specific about governance

This is a governance-specific research field.

Timeline

Short-term research

- Updated institutional framework

Long-term research

- New models of governance and service provision

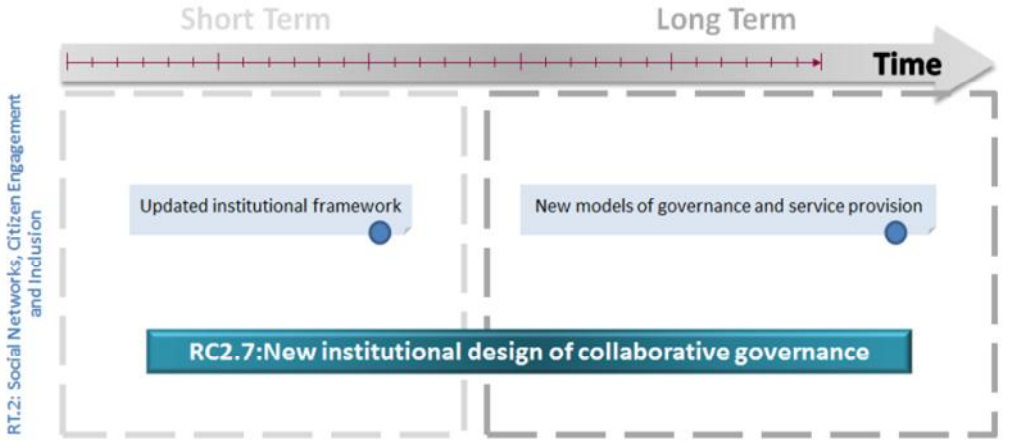

Figure 6-7: Timeline for RC2.7 New institutional design of collaborative governance

Possible research instruments

Thematic networks, Support Action

6.5 Other Challenges

For the Data-powered collective intelligence and action challenge vision to come into being, the following practical and implementation issues should be solved:

- Training and Skills. In order to achieve wide and inclusive participation and collaboration, the level of ICT skills as well as critical skills has to be increased. The digital divide as well as public participation remains a challenge to be tackled simultaneously with the advents of ICT tools.
- Awareness. A number of dissemination and awareness-raising activities should be carried out to increase the understanding of the benefits of collaboration and possibilities of participation. Moreover, citizens should be made fully aware of security and privacy aspects of their Internet presence and other ICT-enabled activities (opportunistic sensing, various use of mobile devices, etc).
- Last but not least the Financial Sustainability of the above-mentioned research streams is needed. Specific, innovative, interdisciplinary funding schemes adopted to the needs of Data-powered collective intelligence and action challenge that guarantees the sufficient resources, takes into consideration the risks and examines the role of the funding sources throughout the policy making lifecycle.

6.6 Actors to be involved

This Grand Challenge depends on engagement of the following actors:

- Business intelligence community (IBM, E3)
- Government: intelligence agencies; transport
- Academia: Computer Science, Applied Social Sciences: Sociology, Economy, Political Science
- Public communication consultancies
- Open source developers

6.7 Benefits

Materialisation of the vision of Data powered collective intelligence and action challenge will bring following benefits for all the above-mentioned stakeholders:

- Improvement in quality of governance
- Increased transparency
- New reference framework for open governance
- Better monitoring of events, distributed early warning system
- Higher quality data
- Radically increased data availability for evaluating the impact of public policies
- Development of new commercial applications for government data
- Better effectiveness of policy measures
- Better understanding of citizens' feedback
- Guidelines and incentives for citizens' involvement
- Increased citizen participation and engagement
- Wider participation
- Inclusion of disadvantaged groups
- Higher degree of collaboration
- Larger scale and more impactful collaboration
- Closer relation between government and citizens
- Better self-organisation by citizens
- Empowerment of citizens to act on specific challenges
- Less bipolar and more open policy discussion
- Enhanced privacy paradigm

6.8 Summary

The current situation is characterised by an engagement of highly interested people only, and by an engagement that rarely stimulates genuine action. There are several complementary research areas in ICT for governance and policy modelling that have the opportunity to address the need for collaboration and behavioural change throughout different technological layers: enhanced data availability through public linked data and participatory sensing, analytical capability through opinion mining and visual analytics, and action-oriented tools such as simulation and serious gaming. These trends mutually reinforce each other to offer a new opportunity for future ICT for governance and policy modelling.

The collaborative governance vision, proposed as an alternative, includes citizens in all the phases of the governance: in collecting relevant data through participatory sensing tools; in analysing the data through simulation and visualisation software; in acting upon these data through bottom-up self-organized action which accompanies, anticipates and stimulates government policies.

For this vision to become a reality, substantial research effort is needed in following research challenges:

- **RC2.1: Privacy-compliant participatory sensing for real-time policy-making** refers to the use of sensors, usually embedded in personal devices such as smartphones allowing citizens to feed data of public interest.
- **RC2.2: Real-time, high-quality, reusable open government data** calls for simplification and lower costs of open data publication.
- **RC2.3: Federated dynamic identity management** addresses the eIdentity-related issues for secure public service provision, citizen record management and law enforcement.
- **RC2.4 Peer-to-peer public opinion mining** points out to the explosion of user-generated content, which widens the application scope of public opinion mining tools and to the fact that these tools need to become more pervasive and available to the majority of citizens.
- **RC2.5: Intuitive, collaborative visual analytics of data for policy-making** refers to the research focussed on making sense of large datasets, such as those provided as open government data.
- **RC2.6 User-generated simulation and gaming tools for public action** underlines that serious gaming is still requiring high level of engagement and therefore progress in usability and attractiveness in order to widen the group of participants is needed.
- **RC2.7: New institutional design of collaborative governance** recalls that collaborative governance is developing without an appropriate reference framework.

7 GC3: Government service utility

7.1 Description

The Grand Challenge GC3 «Government Service Utility» is about shaping the government services of the future as a utility which is provided in a simple, collaborative, ubiquitous and fit-to-purpose manner to all stakeholders inclusively. It seeks to investigate the concepts, methods and technologies flowing from the philosophy of the Future Internet to address the inherent problems of the current public services, and leveraging the general conception that services is the name of the game in today's economy.

Currently, public services are neither user-driven, nor sufficiently sophisticated to support seamless, real-time collaboration between the service consumers and the service providers. They are provided in a rigid, linear manner, without taking into consideration the individual characteristics and needs of each beneficiary. Such traditional public services have not delivered their promised added value or lived up to the expectations of citizens and enterprises for actual cost-effective, one stop-shop provisions. Citizens rarely have direct access to create context-aware services they actually need at their own means for personal, civic or business use.

At the same time, services are converging and moving from the physical into the digital world, universally accessible on any device, such as smartphones, tablets, personal computers, digital radios or high-definition televisions. The majority of traditional public services still depend on the exchange of vast amount of needless printed or electronic paperwork, closing the eyes to modern channel delivery technologies that could significantly enhance the citizen's and business experience and satisfaction. Government clouds are also still in their infancy hindering their actual potential on public service provision and still having to overcome potential risks related to interoperability, privacy and security.

In this context, according to CROSSROAD, a Government Service Utility is a vision of the Internet of the Future, where public organisations, citizens, enterprises and non-profit organisations can collaboratively shape public services at design-time and runtime, in order to be delivered as a utility-like offering at their own ends, to the channels they prefer and in the context and situation they are. As public services increasingly bridge real with virtual life, new value proposition models shall emerge enabling a win-win situation among all stakeholders. Within this forward-looking landscape that extends the current scope of the Government-as-a-Platform, all stakeholders, assuming the role of prosumers, are empowered to assemble their own services and to reap benefit from the simplified, meaningful public services. However, as this change of philosophy and the penetration of the Internet of Services in the public sector are just beginning to proliferate, there are many pending research issues to be resolved in the context of ICT for Governance and Policy Modelling.

It needs to be noted that research challenges that generally touch upon the Internet of Services, Cloud Computing and the Internet of Things and do not have any governance specific issues are not within the scope of the present roadmap.

7.2 Vision

The Government Service Utility envisions a diversity of continuously evolving and collaborating ecosystems of public bodies, industries, enterprises, citizens and non-profit organisations built on top of public services which fit to specific purposes, life events and business episodes. As technology becomes more and more embedded into the business and economic fabric of society, the Government Service Utility evolves into a routine, a "given" – and not a costly luxury – for social, business and economic operations within the public services ecosystem. Public services quickly become a part of this functionality, driving user-driven innovation and value creation that all beneficiaries can leverage.

Specifically, a government service utility will be offered to all in an inclusive and collective way that bears the following distinctive features:

- *Ubiquitous nature*: public services are in principle available everywhere, if a beneficiary has a proper device to access the Internet, appropriately adapting to his special requirements and dynamic context.
- *Necessity*: public services need to directly cover a specific «final» need that is driven by a citizen's life event, an enterprise's business episode and a public administration's requirement.
- *Usability*: it is simple to connect to the public services network at (very) low cost and with high performance, provided that, like in the electricity case, a beneficiary has a device with a standard «plug» / electronic identity to connect (different from country to country, sometimes).
- *Federation*: stakeholders don't really know where / how services are created within a complex network of Interoperable Clouds that cross borders and sectors in a scalable and reliable way.
- *Co-generation*: all stakeholders presume the role of prosumers, being customers and providers, at the same time.
- *De-regulation*: although Governments set the regulations and may own some utilities, the market is competitive and public services are not controlled or owned by any single public or private entity.

In this context, the overall service utility system comprises a common set of core and registry services for delivering basic functionality to citizens and enterprises, independent of their dynamic contexts and situations. The utility metaphor is to indicate that citizens should be able to expect and afford basic, government services as an absolute necessity in their everyday lives, just as water, electricity, and indeed the Internet and the Web. This infrastructure is envisaged to be particularly useful and attractive for non-IT-savvy citizens and start-up enterprises, as well.

In this direction, indicative examples that promote the Government Service Utility concept mention that:

- The public Service Store: The Government Service Utility allows for service composition and consumption from the Public Sector, private enterprises and citizens in parallel (service co-generation).

- The society-driven town hall (self-service government): Citizens utilize real-time context-aware public services to compose interoperable, complex service systems in their everyday life.
- Fight against corruption: Multiple government, private and hybrid clouds manipulate massive data provided by citizens, that can be cross-checked by federated registries and validated by ubiquitous devices.
- Crisis Management: Services can be provided through multiple channels, allowing for cloud infrastructure sharing and load balancing in times of crisis.

7.3 List of relevant gaps

The present Grand Challenge is related to the following research gaps as defined in the CROSSROAD D3.2 Updated Gap Analysis Report.

Research Theme 1: Open Government Information & Intelligence for Transparency	**Assessment of relevance for GC3[6]**
→ *On-the fly Open Data Quality Agreements*	xx
→ *Public, real-time linked data*	xx
→ *Citizen-oriented linked data querying and reasoning*	x
→ *Seamless collaboration and cooperation in data layer*	xx
→ *Large-scale public information Visualisation*	x
Research Theme 2: Social Computing, Citizen Engagement and Inclusion	
→ *Affordable large-scale collaboration*	xx
→ *Leveraging casual participation*	x
→ *Robust Natural Language Interfaces*	X
Research Theme 3: Policy Modelling	
→ *Collaborative Intelligence in policy-making*	Xx
Research Theme 4: Identity, Privacy and Trust in Governance	
→ *Interoperability and integration issues of identity management in large-scale systems*	x
→ *Means for authentication and Identity Management*	x
→ *Legitimate data protection in high flexible business processes*	x
→ *Digital identity for governance and policy modelling*	x
Research Theme 5: Future Internet for Collaborative Governance	
→ *Massive Government Clouds*	xxx
→ *Business models for public-private clouds governance*	xxx
→ *Mobility and Participatory Sensing*	xxx

[6] X – low relevance, xx – medium relevance, xxx – high relevance

7.4 Research Challenges

The Grand Challenge «Government Service Utility» includes a set of targeted research challenges that aim to prove how Collaboration and Interoperability can turn a "introvert" public sector into a citizen-oriented one that leverages Future Internet technologies into its everyday operation. The research challenges that are analysed in the following paragraphs can be summarised into:

- RC3.1: User-driven innovation shaping Public Services
- RC3.2: Change the "DNA" of Public Services
- RC3.3: Digital Public Services Value Proposition for All
- RC3.4: Massive Public Information as a Service

7.4.1 RC3.1: User-driven innovation shaping Public Services

Description and link with the state of the art

Today the ever growing visibility of the Web as a medium that exhibits the potential to attract and maintain together enterprises' and citizens' involvement puts forward the need for more user-centric, user-driven novel tools that provide their users with the capability to create, promote and streamline public services over this new medium.

In this context, the Research Challenge «User-driven innovation shaping Public Services» envisions public services defined by and for people. Citizens and enterprises that typically constitute the final passive recipients and beneficiaries of public services obtain a prominent role in shaping services in order to be delivered to them at their own ends, in ways and means they prefer. In contrast to the past when public administrations delivered public services according to their strict, non-flexible and bureaucratic procedures, future public services adopt an extrovert approach based on smart collaboration between all stakeholders during the services' lifecycle at design-time and runtime.

With regard to future research, public services are viewed as "real" public service systems that emerge as the result of public-public or public-private partnerships. Citizens and enterprises are able to engage themselves and influence all phases within the public service's lifecycle based on the situation and context they are in, as well as the need they need to cover. The principles of collaboration, transparency and custom-fit (influenced by the long tail effect on the private sector) drive the Service Conceptualization phase, the Service Design phase, the Service Delivery phase, the Service Orchestration phase, the Service Management phase, the Service Evaluation phase and the Service Evolution phase.

This paradigm shift in public services engineering philosophy unleashes a wave of user-driven innovation that will become a major driver (and in some cases probably the main driver) of a new functional stakeholders' ecosystem in the public sector bringing on the same page citizens, enterprises, industry, non-profit organisations, policy makers and public administration at all levels. Applying the concept of prosumers who play the parallel role of consumers and providers that negotiate services with the public administration according to their needs and purposes, projects a win-win situation in the boundaries of such a public services ecosystem. In this context, all stakeholders have a unique capability to drive innovations around services by collaborating at design time, engineering and aggregating services originally offered for public, private, personal and civic use at run-time and seamlessly by multiple devices.

More targeted issues that should be addressed by the research community in the years to come include:

- Participative public service systems engineering
- Dynamic, life-event based, citizen-generated public services
- Stakeholders context influence on tailor-made public services
- Re-usable service components orchestration during co-creation
- Smart service stakeholders ecosystems building
- Intuitive and reliable public-public and public-private partnerships regulating public service provision

- Model-driven collaboration on public services lifecycle management
- Integrated visual analytics into public services
- Agile service legality and compliance in service co-creation
- Theoretical foundations and new models for shaping public services

The research challenge RC1: User-driven innovating shaping Public Services is mainly associated with the Research Theme 5 RT.5: Future Internet for Collaborative Governance and in particular with the Research Area 5.3 Internet of Services and 5.2 Internet of Things. It is also related to the Research Themes RT.1: Open Government Information & Intelligence for Transparency as far as Visual Analytics is concerned, RT.2: Social Networks, Citizen Engagement and Inclusion for enabling collaborative work in RA-2.1 Social Computing, and RT.4: Identity Management and Trust in Governance in terms of the research area 4.3 Trust.

Type of research (disciplines)

The present Research Challenge requires mainly technological research in terms of methodologies, frameworks and tools for public service co-engineering, as well as organisational theory and public administration, social and legal research investigating the implications of creating large ecosystems of stakeholders around services and of revolutionizing the way the public services are provided in a way that is compliant with the underlying legal framework.

Relation with other research in parallel fields - what is specific about governance

In the context of the Seventh Framework Programme (FP7) - ICT Programme for Research and Development Workprogramme 2009/2010, Objective 1.2 "Internet of Services, Software and Virtualisation" and "Service and Software Architectures, Infrastructures and Engineering" is funding research to realise the "Internet of Services" vision. Despite the close relation to the research on service engineering undertaken in Objective 1.2, there are open research challenges that mainly apply to the collaborative public services' lifecycle and require dedicated research in the domain of ICT for Governance and Policy Modelling.

Timeline

Addressing the specific research challenge «User-driven innovation shaping Public Services» requires 5 to 10 years of core research towards service co-creation, co-engineering, co-generation, co-monitoring, co-evolution, co-mashups, co-delivery, and co-orchestration. Within this time frame, research undertaken in other disciplines and related to Cloud Computing, Internet of Services and Social Computing also needs to be effectively applied in the public sector.

In more detail, the timeline for implementing the specific research challenges is depicted in the following figure.

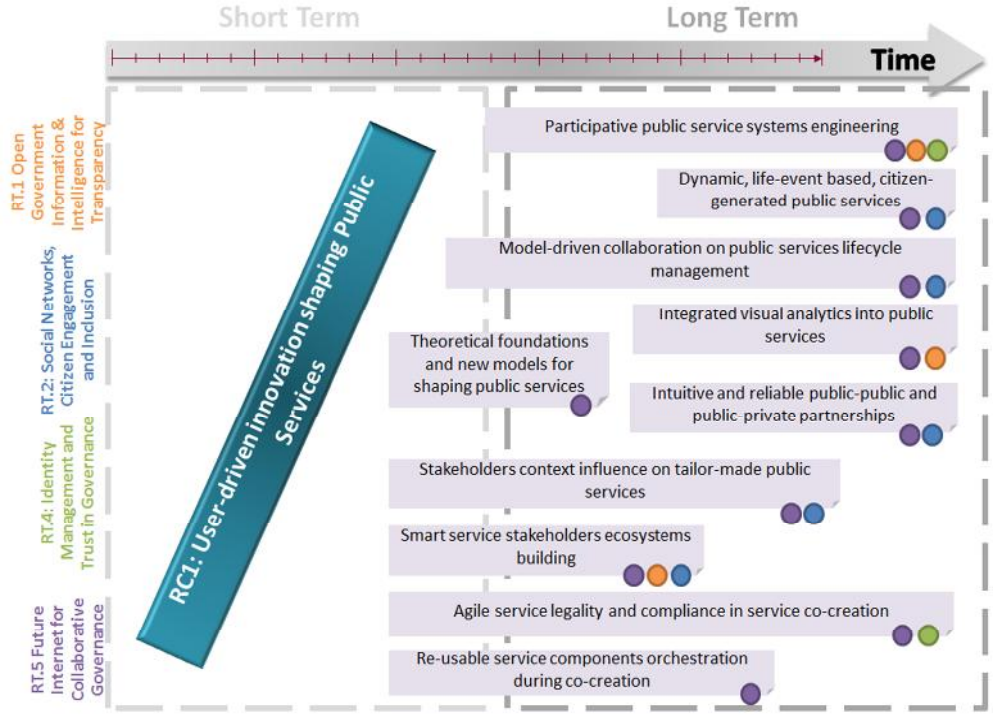

Figure 7-1: Timeline for RC3.1 User-driven innovation shaping Public Services

Possible research instruments

- Strengthening current EU R&D efforts within the EU Framework Programme and in particular with Integrated Projects (IPs) and Specific Targeted Research Projects (STREPs) that directly target Governance needs.
- Investing in national long-term research and innovation necessary to rethink public services.
- Pushing socio-economic research to ensure societal and economic factors are taken into account in future public services design.
- Investigating supporting regulatory environments and resolving legal implications in order to fully reflect a new reality built around web-based public services.
- Coordination and liaison activities among the portfolio of EU research projects focusing on issues related to Governance, the Internet of Services and Future Internet in general.
- Establishing public-private partnerships with strong application focus on Governance and aiming at proactively exposing all stakeholders to novel technologies and services.
- Implementing large scale testbeds and living labs where various stakeholders may meet and influence each other's work.

7.4.2 RC2: Change the DNA of Public Services

Description and link with the state of the art

Taking into account that the Internet has evolved into a key enabler for services, offering a unique capability to communicate to the user in real time the dynamicity of services and of their context, and to allow the user to react immediately to this dynamicity, the Research Challenge entitled «Change the DNA of Public Services» aims to overcome the inherent limitations of public services and revolutionize them into a utility-like offering. In principle, this radical shift is driven by the 1-1-1 concept envisioning that «Every public service can be provided in one-stop, within one second, with one euro (indicating minimum) cost, to any device and by anything».

In current practice, by general confession, conventional services have just been «electronified» without any concerns for their actual impact to the citizens and enterprises. In parallel, constructive practitioners' research in the direction of interoperability, identity management, service repositories, cross-country and cultural alignment of public services does not streamline or inject into public services the current research streams towards service mash-ups, service quality agreements, service infrastructures and cloud computing which are empowered by other research communities.

With regard to future research, public services need to launch a new era of simplicity, adaptability, fairness and tailorability to citizens' and enterprises' actual needs breaking the long-established tradition of cost, bureaucracy and inflexibility generators. The underlying plethora of public services in each country and public administration needs to be shrinked into a set of services that are meaningful to their beneficiaries, fit to a specific purpose, life event or business episode, and create satisfaction to all stakeholders upon their consumption due to their high quality and high return.

In this context, public services are instant, proactive, adaptable, reliable, interoperable at national and cross-country level, pervasive and secure on top of public, private or hybrid clouds. Services are not massively addressed to citizens or with a primitive type of portal personalization via their profiles, but instead cover the long tail phenomenon of their dynamic needs, situations, and social and device contexts.

More targeted issues that should be addressed by the research community in the years to come include:

- Public service delivery in a uniform and reliable way
- Citizens situation social context defining needs on public services
- Public services invoked by any object or device
- Secure and privacy-preserving data sharing on the cloud
- Governance of public services residing in various clouds as All-in-One
- Unique public service experience
- Seamless and widely-accepted authentication
- Real-time public service negotiation and adaptation to citizens' situation
- Greater stakeholders' proximity to relevant public services

The research challenge RC2: Change the DNA of Public Services is mainly associated with the Research Theme 5 RT.5: Future Internet for Collaborative Governance and in particular with the Research Areas 5.3 Internet of Services, 5.1 Cloud Computing, 5.2 Internet of Things and 5.4

Human-Computer Interaction. It is also related to the Research Themes RT.1: Open Government Information & Intelligence for Transparency as far as Linked Data are concerned, RT.2: Social Networks, Citizen Engagement and Inclusion for mining social context in 2.1 Social Computing and 2.3 Public Opinion Mining, and RT.4: Identity Management and Trust in Governance in terms of the research area 4.1 Identity Management and 4.2 Privacy.

Type of research

The present Research Challenge requires mainly technological research in terms of methodologies, frameworks and prototype implementations. However, in order to achieve such disruptive changes in the philosophy of public services, technological research needs to be accompanied by social and public administration research that will promote a broader cultural change in the public sector.

Relation with other research in parallel fields - what is specific about governance

In the context of the Seventh Framework Programme (FP7) - ICT Programme for Research and Development Workprogramme 2009/2010, Objective 1.2 "Internet of Services, Software and Virtualisation" and "Service and Software Architectures, Infrastructures and Engineering" is funding research to realise the "Internet of Services" vision, while Objective 1.4 "Trustworthy ICT" targets at built-in security and privacy protecting service infrastructures. Despite the close relation to the research undertaken in these objectives, there are open research challenges that mainly apply to the public services combined, all-in-one qualities and require dedicated research in the domain of ICT for Governance and Policy Modelling.

Timeline

Addressing the specific research challenge «Change the DNA of Public Services» requires 5 to 10 years of core research towards the 1-1-1 concept in order to produce meaningful results. More than 10 years will be required though in order to actually apply the research results in a considerable set of public administrations.

In more detail, the timeline for implementing the specific research challenges is depicted in the following figure.

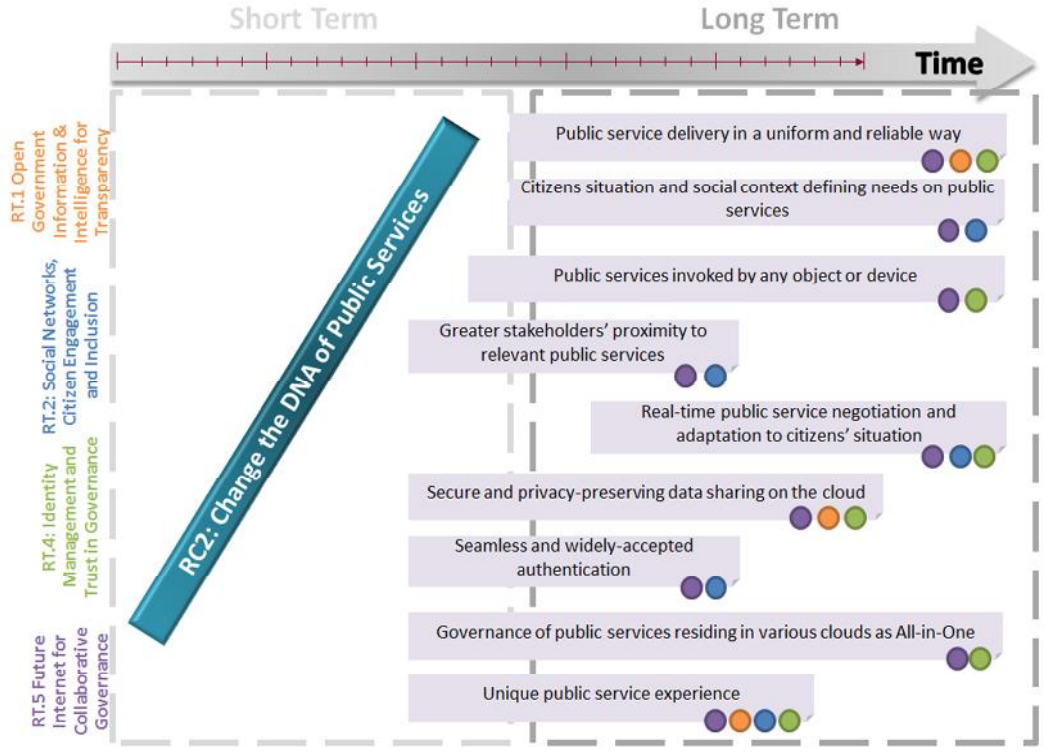

Figure 7-2: Timeline for RC3.2 Change the DNA of Public Services

Possible research instruments

- Strengthening current EU R&D efforts within the EU Framework Programme and in particular with Integrated Projects (IPs) and Specific Targeted Research Projects (STREPs) that directly target Governance needs.
- Investing in national short- and long-term research.
- Coordination and liaison activities among the portfolio of EU research projects focusing on issues related to the Internet of Services and Future Internet in general.
- Mobilizing the industry around the Public Services by establishing multi-stakeholder partnerships in the Governance application sector. Such PPPs should follow an open ecosystem approach allowing for active engagement of all stakeholders.
- Implementing large scale testbeds and living labs where various stakeholders may meet and influence each other's work.

7.4.3 RC3.3: Digital Public Services Value Proposition for All

Description and link with the state of the art

In the late 20th century, creating value for governments was primarily associated with economies of scale, internal efficiency and adherence to legal rules and policy directives with as little variation and as little discretion as possible. Moving towards the early 21st century of increased transparency, openness and collaboration, fixed and predictable environments for the public sector to conduct its business and create value behind closed doors are no longer the actual state of play. In order to spur value innovation, public administrations must be open to interoperate and adapt, rather than lock in their status quo, and promote new ways of achieving collective added-value even if it requires a fundamental shift in culture and grounds significant third-parties involvement.

The Research Challenge RC3.3: Digital Public Services Value Proposition for All brings a wind of change in the definition and the assessment of value for all stakeholders in a complex public services ecosystem, that brings together citizens, enterprises and industries, non-profit organisations and public administrations at all levels in order to reshape digital public services objectives, scope and means. New modes of operation that go beyond the narrow financial and legal concerns, and appropriately balance the public realm, the market needs, the civic / non-profit philosophy and the public administration interests are envisioned and put into practice. Wider inclusion and consideration issues for all citizens and enterprises irrespectively of their background also constitute a key parameter towards added-value public services for all, on equal terms and with even offerings.

In a Web-based Public Service Economy landscape, value proposition derives from the generation of new economic and societal value chains, increased transparency and trust, ample satisfaction and efficient use of resources devoted by all stakeholders, new governance models for dynamic public-public and public-private partnerships, collaboration and accountability. Such value innovation around public services is eventually converted into a commodity that brings closer the researchers and the stakeholders in defining new directions to be taken for public services.

More targeted issues that should be addressed by the research community in the years to come include:

- Models for quantifiable value proposition for all stakeholders
- Change management and culture change in collective value definition
- Social-economic model for public service co-provision in Future Internet
- New business models embracing public-public and public-private partnerships
- Qualities and innovations that the successful public sector of the future will exhibit
- Value creation at research and business level exploiting thriving opportunities around public services
- Means for sustaining growth and value innovation in public services ecosystems
- Public service quality agreements embracing real value

The research challenge RC3: Digital Public Services Value Proposition for All is associated with the Research Theme 5 RT.5: Future Internet for Collaborative Governance and in particular with the Research Area 5.3 Internet of Services, as well as with the Research Themes RT.3 Policy-making for

the Evaluation and Impact Assessment aspects and RT.4 Identity Management and Trust in Governance with regard to establishing trust with the stakeholders.

Type of research

The present Research Challenge requires more socio-economic research than technological research. Examples of socio-economic research include (without being limited to): Economic studies of the Value Distribution across Stakeholders, New business models studied at micro-level, Potential Inclusion issues in the new Public Service Economy, Stakeholders satisfaction and acceptance especially regarding adaptability, security, privacy, quality, legitimacy.

Relation with other research in parallel fields

From a business perspective, value proposition concerns are also noticed in the Seventh Framework Programme (FP7) - ICT Programme for Research and Development Workprogramme 2009/2010, Objective 1.3 "Internet of Things and Enterprise Environments" and in particular in the Future Internet Enterprise Systems Cluster. eInclusion issues are also promoted in the context of social sciences and ICT research under Objective 7.2 "Accessible and Assistive ICT". However, the research undertaken in an enterprise or social context varies significantly from the research for value innovation brought by public services as required in the public sector. Such research should thus be addressed under the umbrella of ICT for Governance and Policy Modelling.

Timeline

Addressing the specific research challenge «Digital Public Services Value Proposition for All» requires 3 to 5 years of core research towards the concepts and business models that create value for all stakeholders. Applying the research results may then require 5-7 years, mainly in order to radically eliminate the remnants of the past decades in the public sector.

In more detail, the timeline for implementing the specific research challenges is depicted in the following figure.

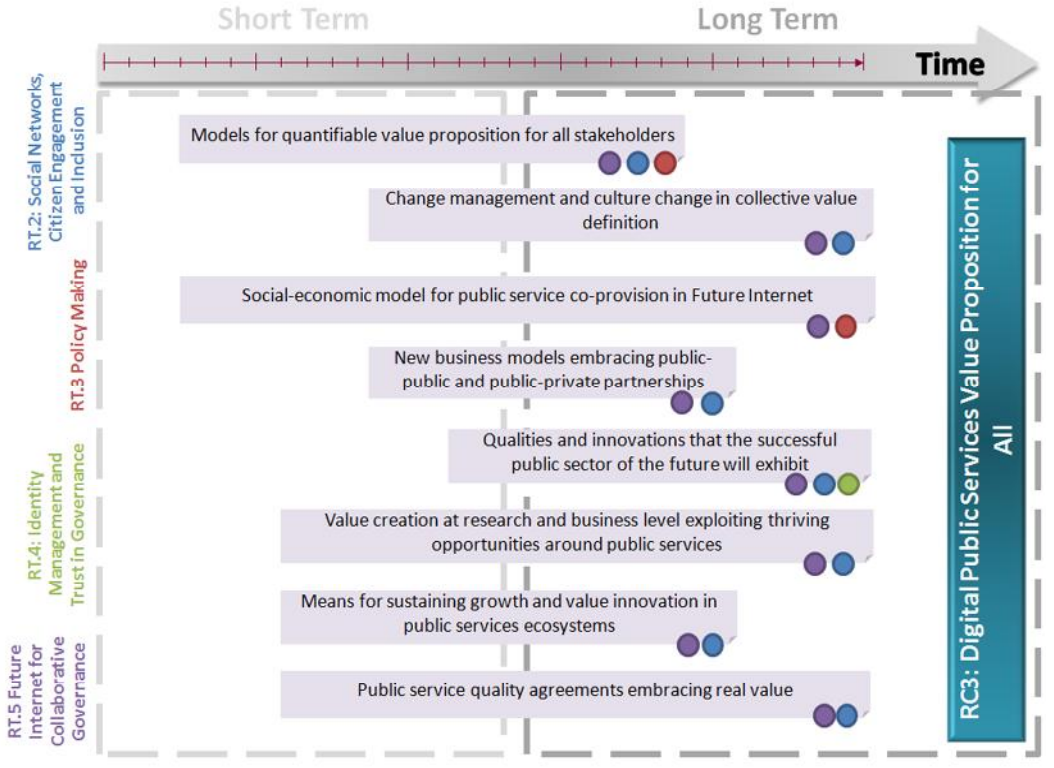

Figure 7-3: Timeline for RC3.3 Digital Public Services Value Proposition for All

Possible research instruments

- Strengthening current EU R&D efforts within the EU Framework Programme and in particular with Specific Targeted Research Projects (STREPs) and Coordination and Support Actions (CSAs) that directly target Governance needs.
- Investing in national medium-term research and innovation that will drive policy and strategy implementation.

7.4.4 RC3.4: Massive Public Information as a Service

Description and link with the state of the art

With the Co-mmunication, Co-llaboration, Co-expressiveness, Co-thinking and Co-creation paradigms constantly expanding, novel technologies towards the Future Internet endow anyone with the ability to access, create, (re-)use, customize, compose, promote and deliver anytime and anywhere user-generated content as new resources or services over the Web.

In this context, the Research Challenge RC4: Massive Public Information as a Service aims at signifying a new attitude towards the public sector information (PSI) as offerings to any interested stakeholder for public, private and civic use, since nothing is too niche or too obscure to attract attention online. PSI that is available for anyone on-the-fly, located on the cloud, adaptive, ubiquitous, participatory, legitimate, linked and visualized evolves into the driving force behind added-value public and third-party services. Information gets morphed with the stakeholders' situation and context to become a unique offering, tailoring the service that exploits it to their exact desires and inclination.

With this research challenge, networked citizens, things and data have the potential to be incorporated into public services by design and at run-time facilitating their digital convergence. Access to public information as a service when associated to an object or a person appears as a seamless and rewarding experience which is further enhanced by intuitively gaining collective insight. Although such information can be considered as 'new gold', innovative ways and clear understanding on how to effectively exploit it and how to transform it into snippets, that are self-tracking and overcome human language barriers, need to be investigated.

More targeted issues that should be addressed by the research community in the years to come include:

- Business perspectives and models on how to leverage data (preserving all ownership rights including non-disclosure)
- Associating value with public content that moves towards the bandwidth of human perception
- Linking public and personal content in a 'fit-for-purpose' service provision
- Collaborative and collective tacit knowledge on public data with the help of visual and geovisual analytics
- Public services proactive behavior exploiting a seamless fabric of networked stakeholders, things and data
- Massive and disperse public content interoperability
- Privacy-respecting data tracking
- Context-aware data quality agreements negotiated on the fly by multiple devices and things

The research challenge RC4: Massive Public Information as a Service is associated with the Research Theme RT.1 Open Government Information & Intelligence for Transparency and in particular with the research areas 1.1 Open Data and Transparent Information Management, 1.2 Linked Data and 1.3 Visual Analytics. It also brings together the RT.5: Future Internet for Collaborative Governance and in particular with the Research Areas 5.2 Internet of Things, 5.3 Internet of Services and 5.4 Human-

Computer Interaction, as well as with the Research Theme RT.4 Identity Management and Trust in Governance with regard to the privacy issues.

It needs to be noted that this Research Challenge is closely related to the GC2: Data-powered collective intelligence and action and in particular to the RC2.2 Real-time, high-quality reusable open government data.

Type of research

The Research Challenge RC4 - Massive Public Information as a Service mainly requires technological research in combination with legal research, mainly for ensuring the personal data legality and privacy preservation.

Relation with other research in parallel fields - what is specific about governance

In the Seventh Framework Programme (FP7) - ICT Programme for Research and Development Workprogramme 2009/2010, Objective 1.5 "Networked Media and 3D Internet" and 4.3 "Intelligent Information Management" are associated with research on various content aspects. However, this research needs to be complemented by research on PSI management, open data quality agreements and tracking in conjunction with public services and participatory sensing under the umbrella of Governance and Policy Modelling.

Timeline

Addressing the specific research challenge «Massive Public Information as a Service» requires 5 to 10 years of core research in Governance, as well as of application research for embracing the research results achieved by other communities.

In more detail, the timeline for implementing the specific research challenges is depicted in the following figure.

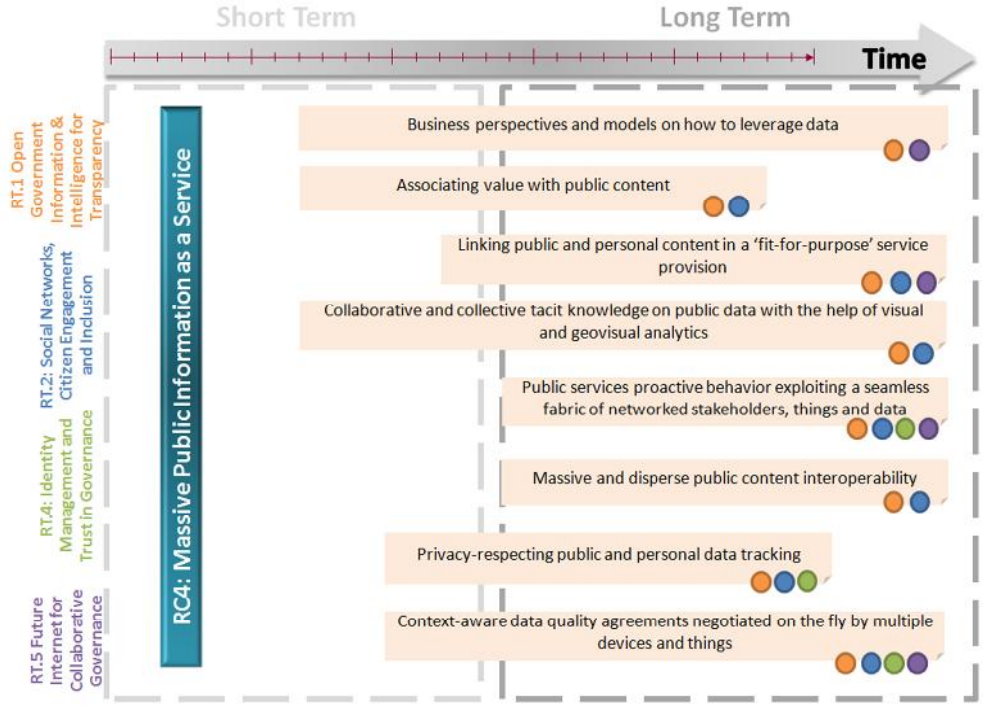

Figure 7-4: Timeline for RC3.4 Massive Public and Personal Information as a Service

Possible research instruments

- Strengthening current EU R&D efforts within the EU Framework Programme and in particular with Integrated Projects (IPs) and Specific Targeted Research Projects (STREPs) that directly target Governance needs.
- Investing in national long-term research and innovation necessary to release data as a service.
- Investigating supporting regulatory environments and resolving legal implications in order to fully reflect the new reality of opening up data.
- Coordination and liaison activities among the portfolio of EU research projects focusing on issues related to Governance, the Web of Data / Content and Future Internet in general.
- Establishing public-private partnerships with strong application focus on Governance and aiming at proactively exposing all stakeholders to novel technologies and services on top of linked data.
- Implementing large scale repositories where various stakeholders may massively share and retrieve data.

7.5 Other Challenges

Realising the vision of the Government Service Utility, would meet further practical and implementation challenges that require focused action, such as:

- *Training*. Even though government service provision as a utility should be a simple and adaptable process, there is a strong need for a smooth transition from the traditional public services philosophy especially for non-IT savvy and elderly citizens, as well as for public servants. A training program should be foreseen that supports modularisation according to the trainees' needs and profile.
- *Financial Sustainability*. Adopting a government service utility philosophy will be economical in the long-term for both the citizens and the government. Nevertheless, during the transformation period major obstacles such as cloud infrastructures, legal barriers or disinclined for change public officers could bring major additional economic burden. A thorough funding scheme for the government service utility should be developed that guarantees the sufficient resources, takes into consideration these risks and examines the role of the funding sources throughout the government service utility's lifecycle.
- *Awareness*. For the successful transition towards facing public services as a utility, a number of dissemination activities should be carried out to increase the awareness of citizens and businesses to this direction. The dissemination strategy should consist of several dissemination policies intended for the wide publication of the new capabilities of public services, realistic use case scenarios, known limitations and frequent misconceptions. Dissemination activities should be based on online and electronic delivery channels as well as non-electronic channels. This type of activities will guarantee a high degree of public services promotion within all targeted stakeholders (including "non-digital literate people").

7.6 Actors to be involved

The Grand Challenge GC.3 Government Service Utility brings together in a collaboration mode the following actors:

- *Government administrations* at all levels that would play a key role as providers of the new service utility to all stakeholders in collaboration with other public and private institutions.
- *Policy-makers* who would participate actively in order to establish the legal and regulatory framework that surrounds offering public services as a utility.
- *Industry* with cloud and software-as-a-service vendors and service providers laying the foundations for a Government Service Utility.
- *Academia and Researchers* would bring the state-of-the-art methodologies and technologies that enable the fast, reliable and adaptable provision of public services on top of Cloud infrastructures and in collaboration with the Internet of Things, Internet for People and Web of Data. Moreover, such researchers would have a technological (computer science, services) background, as well as a social and legal research profile.

- *Citizens and enterprises* as public service prosumers that would be the main enablers and beneficiaries of the government service utility.

7.7 Benefits

Considering public services as a commodity in the context of a Government Service Utility can be is recognized as a sound investment for research and practice, extremely beneficial to all key stakeholders in terms of:

- High-quality public services (instant, secure, reliable, available, cost-containment and resources preserving benefits, context-aware, adaptable)
- Flexibility and adaptability to real citizens needs at their own ends
- Inclusiveness and ubiquitous access
- Active participation and engagement
- Strong collaboration ties in the form of vibrant ecosystems built around public services
- Added-value and innovation for all stakeholders

7.8 Summary

The dawn of a new era which highlights service creation and delivery as its principal ingredient has started to influence the public sector that now needs to drive public services towards Future Internet advancements. The Grand Challenge GC3-Government Service Utility has adopted the key concepts of a utility, such as Ubiquitous nature, Usability, Federation, Co-generation, and De-regulation, and is aligned to the philosophy of collaboration, openness and innovation. It aims to cultivate a vision of the Internet of the Future, where public organisations, citizens, enterprises and non-profit organisations can collaboratively shape public services at design-time and runtime, in order to be delivered as a utility-like offering at their own ends, to the channels they prefer and in the context and situation they are.

In this context, the research challenges that should be addressed with a long-term perspective include:

- RC3.1: User-driven innovation shaping Public Services during their whole lifecycle in order to be delivered to their beneficiaries at their own ends, in ways and means they prefer.
- RC3.2: Change the DNA of Public Services in the direction of the 1-1-1 concept that supposes that «Every public service can be provided in one-stop, within one second, with one euro cost, to any device and by anything».
- RC3.3: Digital Public Services Value Proposition for All which defines and assesses the impact for all stakeholders within a complex public services ecosystem.
- RC3.4: Massive Public Information as a Service promoting a service-oriented attitude to the public sector information (PSI).

8 GC4: Science Base of "ICT for Governance and Policy Modelling"

8.1 Description

ICT for governance and policy modelling appear as key enabler towards unlocking the full potential of participative decision-making, which is expected to drive society to a new era of citizens and decision makers working together for facilitating our lives.

This fact has motivated researchers, practitioners and decision makers to launch various initiatives, projects, research studies and working platforms that aim to deal in a successful manner with the various issues that lay within this domain. As a result, in recent years, many projects, which are able to enable better decision-making, raise the level of the discussion, and bring additional insight, by opening up the discussion to a wider constituency, and by blurring the boundaries between experts and citizens insights.

As described in CROSSROAD Deliverable D1.2 - State of the Art Analysis, in recent years we witnessed the bloom of tools and ICT-based initiatives. Yet, this domain is still very unstructured and unchartered, still at the margin of policy-making, on any stage of the decision-making procedure. For example, the lack of fully-automated information transformation still forces the citizens' contribution into policy-making to be read and analysed by civil servants, as filtering mechanisms are still embryonic, and rely very much on manual ratings by users, which in many cases are also subjective. Only seldom, sophisticated data-mining tools are used in conjunction with collaborative tools. User-generated content has never been directly used as a determinant factor in strategic decisions. Advanced modelling techniques are deployed as an exception rather than as a rule, and agent-based modelling has been applied mainly at micro level.

The great opportunities that lie ahead in this field and the need for dedicated research effort has been recognised by the EC, which launched back in the 2008 a call for proposals for research projects in the field of ICT for governance and policy modelling. Yet, as projects funded under this action are still developing and delivering their first set of results, it is more obvious than ever that this domain is far from consolidated and recognized, as well as very diverse. The key elements of diversity appear to be:

- The high multi-disciplinarity, which involves disciplines such as information systems, engineering, mathematics, statistics, economics, sociology, design and user interface, political science.
- The attempt to merge different cultural approaches to research and development: innovation in the field of policy modelling, forecasting and simulation is theory-led and academic; in the fields of mass collaboration, participation and visualisation it is more practice-based and user-driven.

As a result, we witness that the domain in its current state attempts to compound and include aspects of various scientific and applications domains; however, this attempt is quite fragmented (mainly due to the wide landscape of the domains ingredients) and significant results will come only

by mobilising huge resources. The reason behind this statement is the need of simultaneous horizontal and vertical research, which reveals the lack of strictly defined concepts and axioms in this domain that could be reused and could facilitate building on them.

Therefore, in order to shift from a fragmented research field to a scientific domain, ICT for governance and policy modelling has to be studied and developed, following scientific practices similar to neighbouring domains – such as those of Social sciences, Political sciences, Systems/Complexity science, Services science as well as Economic sciences. Moreover, as the models that should be used in this domain may be complex and more data driven than, e.g. in physics or (often incorrect and non-predictive) traditional economics, it is essential to thoroughly study and design correct and up to the point modelling methodologies and techniques, for the correct implementation of models that will act as the cornerstones for the scientific grounding of it.

8.2 Vision

In order to fully analyse Governance and Policy Modelling as a scientific domain, one should go further in defining the interfering elements and concepts. Such concepts will allow for a broader definition of the boundaries of this new principle, touching upon the following categorizations:

- The methods, still being sought after in most of the cases: formal description means for the problem and solution spaces, models and tools for designing processes, data structures or information systems, guidelines and standards for concurrent development of systems that can facilitate policy modelling "by design" are just a few examples.
- The subjects, by means of different instantiations of real-life systems, where the scientific means of policy modelling are to be applied.
- The application domains, referring to the real-life administration or service sub-sectors that the subjects belong to. It is obvious that one should expect diverse standards or scientific methods across different sectors of the everyday life.

Among the scientific domains recognised by the international community the following subjects have been identified to be within those that might contribute for the Governance and Policy Modelling scientific foundations:

- Social sciences
- Political sciences
- Information science
- Systems complexity

All these domains possess strong theoretical background, based on domains tagged as "neighbours" of Governance and Policy Modelling, which are formal sciences (like mathematics, computers and systems), applied sciences and social sciences.

In order to proceed towards the formulation of a scientific base for this domain, research activities should target a new set of concepts, theories, and principles derived from established and emerging sciences, as well as associated methods, techniques, and practices for solving the aforementioned problems. A similar approach has been presented for the software engineering science [110].

In this context, the vision of this Grand Challenge is the domain of ICT for governance and policy modelling to become a scientific field in its own right, which will contain all the required elements that will support and result in constructive research activities and will eventually lead to better, more concrete and all inclusive solutions for both policy makers and citizens. To become a new domain as describes, it needs to be formulated as a defined domain, with its own axioms, rules and concepts.

Moreover, in order to come up with such a new domain, ICT for governance and policy modelling should be conceived under a new perspective, other than the one it is perceived today, which is just about mixing policy issues, decision making processes and various ICT tools. Evidence of the past reveals that applying new tools to old concepts is not enough to make a domain wide and deep enough to be transformed into a new science. Therefore, new concepts and ideas should arise in order to not only justify the need of such a domain, but to dictate its establishment between Politics and Informatics.

8.3 List of relevant gaps

The Grand Challenge analysed in this section does not directly derive from a specific gap of those described in CROSSROAD Deliverable D3.2 - Updated Gap Analysis Report however it seems to be closest to those of Research Theme 3.

Research Theme 1: Open Government Information & Intelligence for Transparency	**Assessment of relevance for GC4[7]**
→ *Systematic management and monitoring of transparency*	x
→ *On-the fly Open Data Quality Agreements*	x
→ *Public, real-time linked data*	x
→ *Citizen-oriented linked data querying and reasoning*	x
→ *Seamless collaboration and cooperation in data layer*	x
→ *Large-scale public information Visualisation*	x
Research Theme 2: Social Computing, Citizen Engagement and Inclusion	
→ *Open and cross-language collaborative filtering / attention economy tools*	x
→ *High-quality expertise identification through reputation management*	x
→ *Distributed Early Warning Systems for risk prevention*	x
→ *Affordable large-scale collaboration*	x
→ *Leveraging casual participation*	x
→ *Robust and large-scale argument support systems*	x
→ *Robust Natural Language Interfaces*	x
→ *Higher levels of acceptability*	x

[7] X – low relevance, xx – medium relevance, xxx – high relevance

→ *Participation*	x
Research Theme 3: Policy Making	
→ *ICT for state-of-the-art policy-making*	xxx
→ *Large-scale quantitative data for formal policy models*	xxx
→ *Argumentation analysis and encoding*	xxx
→ *Scalability of modules*	xxx
→ *Large-scale transformation and aggregation of modules*	xxx
→ *Collaborative Intelligence in policy-making*	xxx
→ *Usability in modelling and simulation*	xxx
→ *Identification of application fields for modelling and simulation modelling*	xxx
→ *Reliability of modelling techniques*	xxx
→ *Integration of tangible and intangible aspects into formal models*	xxx
→ *New models of "democracy"*	xxx
Research Theme 4: Identity, Privacy and Trust in Governance	
→ *Interoperability and integration issues of identity management in large-scale systems*	x
→ *Means for authentication and Identity Management*	x
→ *Legitimate data protection in high flexible business processes*	x
→ *Digital identity for governance and policy modelling*	x
→ *Flexible and dynamic disclosure management tools and technologies*	x
→ *Trust in Social Networks*	x
→ *Intellectual Property Rights*	x
Research Theme 5: Future Internet for Collaborative Governance	
→ *Massive Government Clouds*	x
→ *Business models for public-private clouds governance*	x
→ *Mobility and Participatory Sensing*	x
→ *Real-time context-aware services*	x
→ *Human-computer interaction*	x

However, this Grand Challenge also addresses other gaps of all the other Research Themes, as it aims to build upon the existing gaps in an effort to formulate a scientific base for the domain of ICT for governance and policy modelling, which will be used to tackle all present and emerging issues.

8.4 Research Challenges

8.4.1 RC4.1: Multidisciplinary issues and relations with neighbouring domains

Description and link with the state of the art

In order to promote the current Grand Challenge, it is essential to tackle the multidisciplinary issues of the domain and investigate all relations with the neighbouring domains. As presented in the State of the Art deliverable, ICT for governance and policy modelling is a quite multidisciplinary field, that embraces issues that extend from social sciences, modelling and simulation, to social networks, compute human interaction and security. In this context, one should seek into sorting out the various dimensions of the domain and should identify links to other domains and/or formal sciences that could support the evolution of the domain and the transfer of knowledge and expertise. In doing so, domain experts will be able to conceptualise and formulate a specific domain structure and all the necessary components of it. Those elements and the corresponding domain structure will be set as targets in an action plan of ICT for governance and policy modelling, which will be placed in line in order to de-fragment the domain and construct a solid structure, embracing all the relevant resources and elements that are required for the domain to appear in the scientific map as a self-containing one. This Research Challenge is related to all the state of the art areas and subareas, which is the most resounding evidence of the multidisciplinary character of the domain.

Current status

Until recently, although the multidisciplinary character of the domain was quite evident, there were no synchronised efforts to build this domain. Research concentrated in small sub-areas and researches tried to identify and apply up to a low scale methodologies and tools that were used in other domains which looked as "neighbouring" to that of policy modelling.

Future research will thus have to focus on issues like:

- Identification of all research areas and sub-areas of the domain (extend the CROSSROAD taxonomy) in order to completely map the domain and reveal all its dimensions.
- Liaisons with the neighbouring sciences as multi-disciplinarity is a reality in this research field.
- Examination of links with neighbouring domains and formal sciences.
- Knowledge transfer from already established domains and sciences for facilitating the support of the domain via existing tools and methodologies.

Type of research

The present Research Challenge requires mainly research towards all possible dimensions of the field in terms of identifying issues, methodologies, tools and frameworks that could be included in this domain. In this context, the research to be conducted should focus on areas and issues, which are closely, related with the use of ICT in other neighbouring domains, such as political sciences, social sciences, computer sciences in conjunction with policy-making, etc. In more detail, the type of needed research in the context of this Research Challenge is concerned with the following aspects:

- Extensive Mapping of domain's areas and subareas

- Multidisciplinary exploration of the various sub-areas
- Desk based research for identifying links to neighbouring domains and sciences
- Requirements analysis and transformation of ported methodologies and tools into policy modelling related elements

Relation with other research in parallel fields - what is specific about governance

Due to the "horizontal" character of this research challenge, it is not strongly related to any parallel field. However, when talking about new scientific domain one can identify efforts that are focused at similar challenges, in order to sort out multidisciplinary issues and to establish links with other domains towards a more inclusive approach of formulating the domain through the support of elements from neighbouring domains that can also be applied in policy modelling.

Timeline

2 to 3 years in order to have meaningful results for the items listed under Future Research, which basically are:

1. Identification and mapping of domains sub-areas and relevant tools and methodologies (1 yr)
2. Liaisons with the neighbouring sciences (1/2 yrs)
3. Identification of links to other research domains (1/2yrs)
4. Knowledge transfer from other domains and application/transformation of tools and methodologies (4/6 yrs)

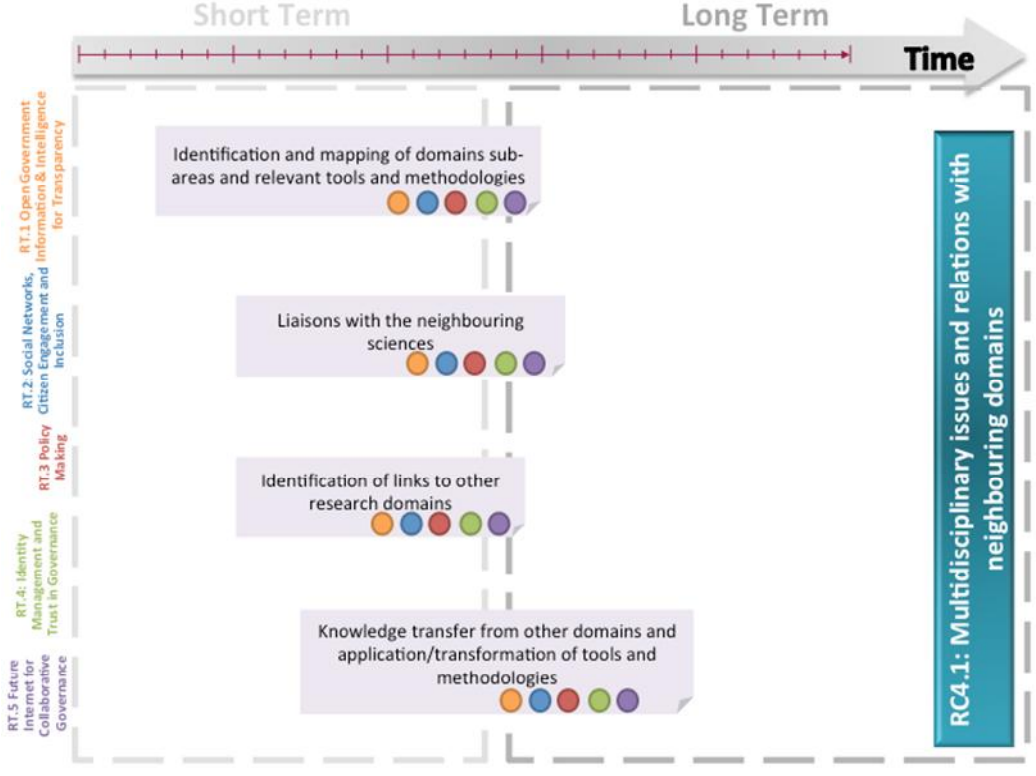

Figure 8-1: Timeline for RC4.1 Multidisciplinary issues and relations with neighbouring domains

Possible research instruments

- Strengthening current EU R&D efforts within the EU Framework Programme and in particular with Coordination and Support Actions (CSAs) that directly target Governance needs.
- Coordination and liaison activities among the portfolio of EU research projects of the neighbourging domains.

8.4.2 RC4.2: Metrics and Assessment Models, Decision Support, Modelling & Simulation Tools

Description and link with the state of the art

This research challenge refers to the need for investigating and selecting the major tools and methodologies which can help the domain of ICT for governance and policy modelling to advance even further and to construct a wealthy inventory of tools and models that can be utilised to support arguments and hypotheses towards more evidence based and tool supported procedures. Tools and models like those derive mostly out of Research Area 3 "Policy Making" as it covers most aspects that have to do with modelling, simulation, decision support, metrics and assessment models as well as other issues that deal with the analysis of complex systems and policy formation.

The reference Research Areas in the SoA regarding this research challenge are: RA3.1 - Policy Context Analysis, RA3.2 – Policy Modelling, RA3.3 Policy Simulation, and RA3.4 – Policy Evaluation.

However, the references do not only limit themselves to the Research Theme 3, but span also over all the other Research Themes, as tools, methodologies and other elements present in other areas can also contribute towards the realisation of this challenge.

Current status

As it has been documented in most of the gaps coming out of CROSSROAD deliverable "D3.2 – Updated Gap Analysis report", it is evident that there is a vast lack of tools and methodologies dedicated to satisfy the domain needs. In fact, most of the gaps described in the above mentioned report could be minimized (if not eliminated) have there been available tools and methods specifically tailored or designed from scratch to satisfy to the needs of the domain.

As a separate domain, ICT for governance and policy modelling should possess various metrics and assessment models in order to be able to accurately measure different facts and figures of importance and to be able to evaluate the actions taken and the degree of their impact on the current landscape. Moreover, and as an extension to these, decision support tools and methodologies, as well as modelling and simulation tools and methodologies are also essential. In this context, the domain's stakeholders will be able, via the support of tools like these, which will be specifically designed based on the domains requirements and tailored to the domains' issues, to tackle all phases and dimensions of a policy issue, from its conceptualisation phase (utilising decision support tools and ex-ante evaluation for further advancing an idea to an implementation proposal, modelling tools for the

representation of an issue) to its testing (utilising simulation tools), application (using decision support tools for applying the policy) and evaluation phase (where metrics and assessment models will be used for ex-post evaluation).

As a result, systems implemented at present or systems of the past do suffer heavily on trustworthy and evidence based models that can be utilised to acquire real data and perform realistic operations, which result to uncertainty of the decisions that they produce as their outputs.

Current research, as well as previous research, has only recently started to focus on several issues:

- Social computing and analysis of social behaviour of public in computer generated environments
- Modelling of complex policy issues in various bits of the complete policy formation lifecycle
- Modelling and utilization of linked data, for fetching publicly available data that could interpret social behaviour at certain points and could lead to social behavioural models
- Methodological frameworks of systems evaluation based on users' opinions
- Collection and analysis of public opinions from various web sources and social networks
- Engagement of citizens in decision makers through online deliberation platforms and electronic voting mechanisms
- ICT-enabled analysis and simulation of policies
- Analysis and information mining in huge data sources

Future research will thus have to focus on following issues:

- Design of methodologies and tools for modelling policies end-to-end, consisting of both procedures, technologies and actors
- Definition of integrated policy models that describe fully systems, processes and user interactions
- Definition and implementation of model repositories for the foundations of policy modelling procedures
- Definition of assurance metrics, instruments to measure them and of general assessment frameworks, which will highlight the importance of ICT for governance and policy modelling (Value Proposition of the domain) by identifying the impacts in the various levels that are affected by it
- Integration of qualitative and quantitative data and data quality filtering mechanisms into decision support tools
- Implementation of open test beds infrastructures for simulation and evaluation of human behaviour and reaction to policy changes

Type of research

The present Research Challenge requires mainly research on modelling, simulation and evaluation methodologies and tools in order to construct a complete framework which can support decision makers and practitioners to construct, test and implement policies in a way, characterised as a structured one and in alignment with the scientific disciplines that will be established in the domain.

In more detail, the type of needed research in the context of this Challenge is concerned with the following aspects:

- Implementation of modelling tools and construction of domain specific models
- Application and implementation of innovative modelling methodologies to policy modelling
- Simulation environments and structures
- Definition of evaluation frameworks, tools, metrics and instruments for revealing the value of the domain

Relation with other research in parallel fields - what is specific about governance

This challenge is in close relation with modelling and simulation, as it consists mainly of modelling and simulation methodologies, tools and techniques, which have to be invented. Moreover, there is also very close relation with social sciences as it aims at researching behaviour and attitudes of citizens towards policies, both as individuals and as parts of wider society.

As far as it regards governance, there are some aspects, which may justify this Research Challenge:

- The implementation of policy models are based solely on general socioeconomic data, and thus do not actually represent the current conditions, as in most cases, the most important and unpredictable actor (e.g. the citizen) is left outside
- Ex-ante evaluation of policies are of outmost importance for decision makers, but they fail to provide a holistic image of the possible future situation, as not only are data used for simulation and modelling of low quality and quantity, but most importantly the methodologies and models used are not able to present an integrated screenshot of the society, which is mixing procedures and human behaviours

Timeline

5 to 10 years in order to have meaningful results for the items listed under Future Research, which basically are:

1. Design of methodologies and tools for modelling policies end-to-end (3/5 yrs)
2. Definition of integrated policy models (5/8 yrs)
3. Definition and implementation of model repositories (3/5 yrs)
4. Definition of assurance metrics and assessment frameworks (3/5 yrs)
5. Integration of qualitative and quantitative data into decision support tools (3/5 yrs)
6. Implementation of open test beds infrastructures for simulation and evaluation (3/8 yrs)

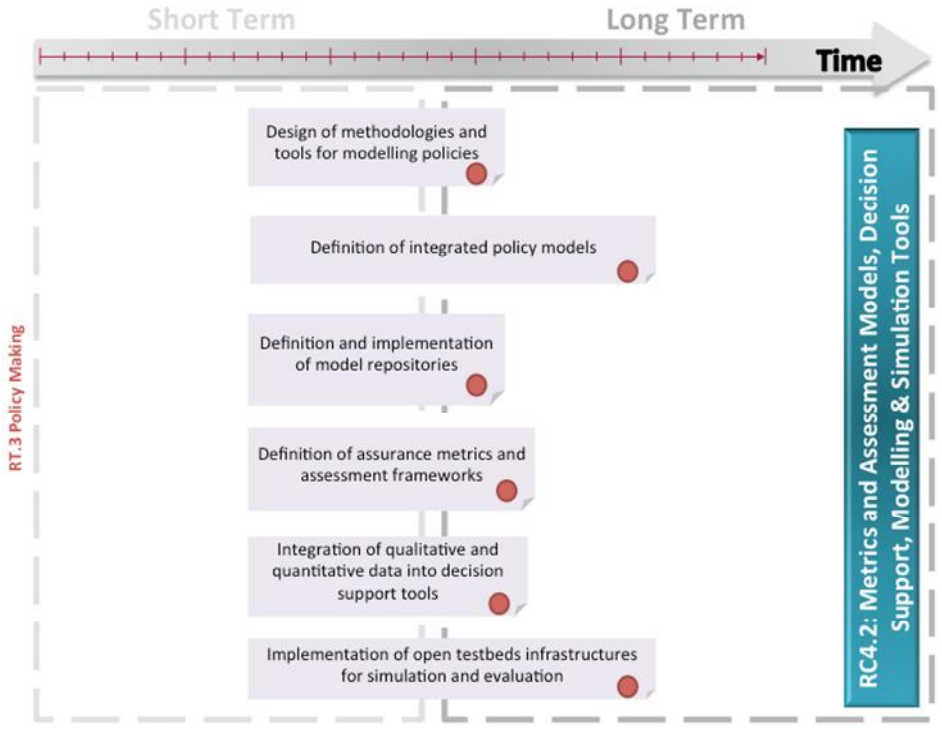

Figure 8-2: Timeline for RC4.2 Metrics and Assessment Models, Decision Support, Modelling & Simulation Tools

Possible research instruments

Strengthening current EU R&D efforts within the EU Framework Programme and in particular with Integrated Projects (IPs) and Specific Targeted Research Projects (STREPs) that directly target the domains needs needs.

8.4.3 RC4.3: Formal methods and tools

Description and link with the state of the art

This research challenge focuses on setting the foundation on Governance and Policy Modelling in order to create a general consensus about the domain and not only clarify various open issues, but also introduce the basic elements that could be used by next generation scientist to build upon.

The main issue targeted by this research challenge is the definition of Governance and Policy Modelling as a well-structured science domain, with a globally accepted syllabus, vocabulary, axioms, concepts, tools and methodologies. As we have witnessed in the state of the art, although the domain of Governance and Policy Modelling is quite fragmented, there are numerous links between the different research themes, areas and sub-areas, to an extent that a large-size but quite difficult to navigate graph can be constructed. This complexity results in repetition of work in the various sub-areas, in the implementation of incompatible applications and systems and ultimately in various interpretations of same concepts and issues, which causes great frustration between the research and

decision-making community. In this context, the establishment of the main foundation principles, alongside with a knowledge base, for Governance and Policy Modelling looks like a prerequisite for advancing research and development in the domain, as it will set the basic elements that will transform this set of isolated and self-containing research areas to particles of a greater science.

Current status

At present, there seems to be an absolute lack of initiatives and projects that are working towards the foundations of the domain or towards the harmonisation of the domain. The fragmentation of the domain implies that there has been limited work carried out to homogenise the various areas that exist today and to create efficient liaisons with neighbouring areas for knowledge transportation and possible collaboration.

Moreover, we witness totally different perspectives on the same issues depending of the background of each scientist or practitioners; those with background in ICT focus more on technology, Decision Makers are more concerned with processes and societal issues. As a result, state of the art technological systems, which are being built, are unable to offer any real added-value to decision makers, while at the same time systems that are useful for decision makers are not possible to be transported to ICT platform due to misinterpretation of functional and not functional requirements.

This vast gap that exists today in the field of Governance and Policy Modelling is the obvious result of not having defined the field as a new scientific field, with common rules, models and processes that should be understandable and manageable by everyone that is actively participating in it.

In this context, future research should focus on issues like:

- Design of methodologies and tools for the formal representation and modelling of end solutions, compromising of both procedures, technologies and actors
- Agreement on fundamental concepts
- Definition of the goals and the values of the domain, alongside with the definition of the major problems and solutions that should be implemented
- Definition of a common dictionary, which will highlight the common concepts of the domain and will create a taxonomy of the various elements
- Review of the past and current landscape of the domain
- Publication of a "user manual" for researchers and decision makers to make the introduction to the domain less cumbersome

Type of research

The type of needed research in the context of this Challenge encompasses:

- Formal definitions of the domains concepts, goals and issues
- Review of current and past evolutions of the domain and statistical analysis

Relation with other research in parallel fields - what is specific about governance

This challenge although not directly related with any other research in parallel fields is seen as the

outmost requirement for all other researches. Having set the main principles for the domain together with a repository of knowledge will elevate all research activities that are ongoing in the parallel fields, as it will offer them direct links to more concrete and generally agreed concepts, which will be more clear and understandable.

Timeline

3 to 5 years in order to have meaningful results for the items listed under Future Research, which basically are:

1. Documentation of the main concepts, goals, definitions and issues (3/5 yrs)
2. Definition of standard, commonly accepted vocabulary and a "user manual" (2/3 yrs)
3. Review of the domain, discovery of links with to other sciences (2/3 yrs)
4. Definition of metrics and development of an evaluation assessment framework (3/5 yrs)

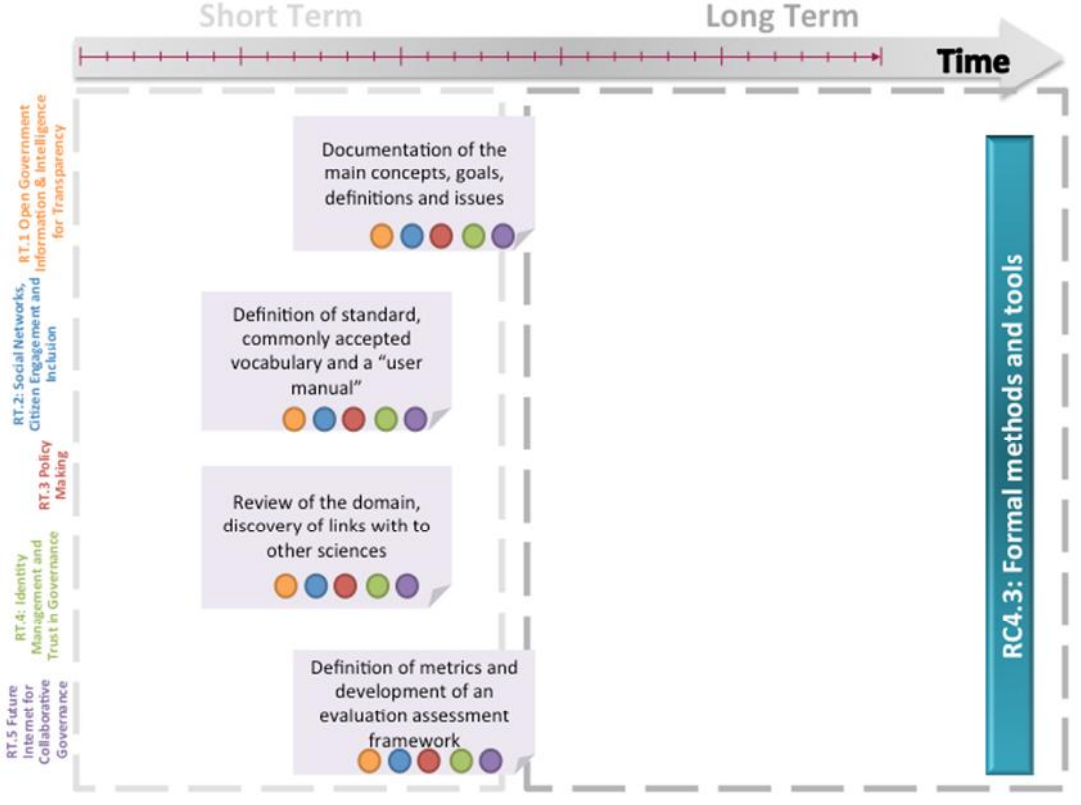

Figure 8-3: Timeline for RC4.3 Formal methods and tools

Possible research instruments

Strengthening current EU R&D efforts within the EU Framework Programme and in particular with Coordination and Support Actions (CSAs) that directly target Governance needs.

8.5 Other Challenges

Community Formation

The evolution of the domain should be based on the establishment of a scientific community, which will undertake the task of paving the way for the establishment of the field as a new science and for constantly supporting the field, in order to sustain it and attract new disciples. Moreover, the community will be able to identify new trends and steer the domain's focus accordingly, in order to meet the new societal challenges, at the moment they arise. In this context, the existence of an "invisible college" (scientists referring to each other as peers, maybe some initiators, charismatic leaders creating followers / pupils / schools) with a critical mass of research clearly assigned to the new area is envisaged, which would act as the cornerstone of the community. This action should be surrounded with many other features, such as team-ups with other relevant communities (semantics, social networks, etc.), organisation of conferences focused specifically in the domain, funding programmes that will support and promote the field, creation of domain specific journals, academic curricula, post or undergraduate academic programmes, etc. The output of this action will be a new generation of scientists that correctly understand political and technological sciences and that would be able to establish ICT for Governance and Policy Modelling as a new science.

8.6 Actors to be involved

The main actors to be involved in this Grand Challenge include:

- Government
    - Decision Makers
    - Policy Modellers
    - Evaluation Experts
    - IT Units
- Academia
    - Computer scientists
    - Political scientists
    - Sociologists
    - Economists
    - Engineers
- Industry
    - Modelling and Simulation firms that will work towards the realisation of the modelling and simulation methodologies and tools of RC2

8.7 Benefits

The main benefits deriving from this Grand Challenge although not directly visible to citizens are of outmost importance for the systems and the applications to be designed and deployed and their success depends heavily on the benefits that this Grand Challenge will offer.

In more detail, the establishment of ICT for governance and policy modelling as new science, will not only empower the domain by attracting more resources, but will also instantly impact the evolutions of the various research themes that it contains, as the absence of foundations will be covered by new elements which will promote the systematic and sequential advancement of every development. In this context, the benefits will be visible for all stakeholder groups. Citizens, as the "consumers" of the final services that derive from the different policies will gain as they will enjoy more trustworthy and transparent services and policies, which have been tested prior to their release and are scientifically grounded. Decision makers will also draw benefits, as they will be able to utilise models and tools that are specifically designed to meet their expectations and serve their needs for objective and evidence-based policy modelling. Last but not least, researchers will have the opportunity not only to establish the foundations of this new domain by bringing on the surface new innovative models and concepts that could facilitate the domain's formation, but to be also the ones that will pave the way towards the domain's maturity by introducing new ideas and exploring new research directions that can drive the domain even further.

8.8 Summary

Summing up, this section presented the Grand Challenge title "GC4: Science Base of "ICT for Governance and Policy Modelling". The general aim of this challenge is to establish the initial foundation of Governance and Policy Modelling as a new science, complementing those of Informatics and Politics, which is envisaged to benefit all developments of the field.

The Grand Challenge encompasses following Research Challenges:

- RC4.1: Multidisciplinary issues and relations with neighbouring domains, that investigates possible links with other scientific areas and attempts to structure the domain according to other successful domains.
- RC4.2: Metrics and Assessment Models, Decision Support, Modelling & Simulation Tools, that aims to bring together the technological and the societal aspects of the domain of ICT for governance and policy modelling towards more concrete, holistic and accurate decision support models.
- RC4.3: Formal methods and tools, which aims at setting the foundations for the new proposed science domain.

Alongside, this challenge includes also the vision of building an active community around it (Challenge titled "Community Formation"), which will be the main motivator that will work towards the establishment and the evolution.

Part C. Annexes

Annex A: References

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Annex B: Summary of the State of the Art

During the last years, ICT for Governance and Policy Modelling has been initiated by the European Commission in order to consolidate and advance research in a new, yet multi-disciplinary and fragmented domain. With the ultimate goal to build constituency and outline a concrete roadmap for future research, the CROSSROAD Project ("A Participative Roadmap for ICT Research in Electronic Governance and Policy Modelling") has extensively investigated the underlying state of play in its deliverable entitled D1.2 State of the Art. Based on this work, CROSSROAD aimed to summarise how a mapping of this domain has been conducted for the first time, which is the current state of play in research, practice and policy, which conclusions can be drawn and what trends are recognised.

In an effort to reach consensus on the diverse domain of ICT for Governance and Policy Modelling, a Research Areas Taxonomy has been created on the basis of a concrete quantitative methodology. The taxonomy, which now consists of 5 Research Themes (RTs) as broad thematic categories that contain and classify a number of research areas at lower levels, has been discussed and validated by the Experts Scientific Committee that closely follows CROSSROAD advancements, as well as by relevant EU-funded projects in this domain.

RT.1: Open Government Information & Intelligence for Transparency appears as the data- and knowledge- oriented research theme. It initially analyses how open data intended for public, private and civic use is published in order to reach out to various communities and investigates its potential contribution to achieving greater transparency in the public sector. Linked Data that has emerged as the new trend in the World Wide Web for machine-readable and interconnected data is further studied due to the enhanced user experience it offers and the network effects it causes. A new research discipline, Visual Analytics, also contributes to gaining insight on complex large sets of data with its interactive Visualisations and analytical reasoning techniques.

RT.2: Social Networks, Citizen Engagement and Inclusion infuses the social dimensions of the Governance and Policy Modelling by investigating the Social Computing phenomenon that has already revolutionized the way people communicate, exchange content and knowledge, raise their opinions and influence each other. More traditional citizen engagement and eParticipation methods that have paved their way during the last decade also fall into the scope of this theme, while emphasis is laid on public opinion mining, extracting people's opinion from the web and exploring how collective wisdom can be reached in order to facilitate decision making in the public sector.

RT.3: Policy Making, clearly positioned towards ICT-enabled policy-making, initially analyses the economical, social and environmental context as a preparatory stage for policy modelling which then actually represents the problem and its proposed solution in models. Policy Simulation testing out the various models in an effort to pre-evaluate the application of a specific policy, in a controlled, artificial environment is also studied, while at the last stage in the policy-making process, Policy Evaluation provides the necessary qualitative and quantitative assessment mechanisms to monitor the actual policy application.

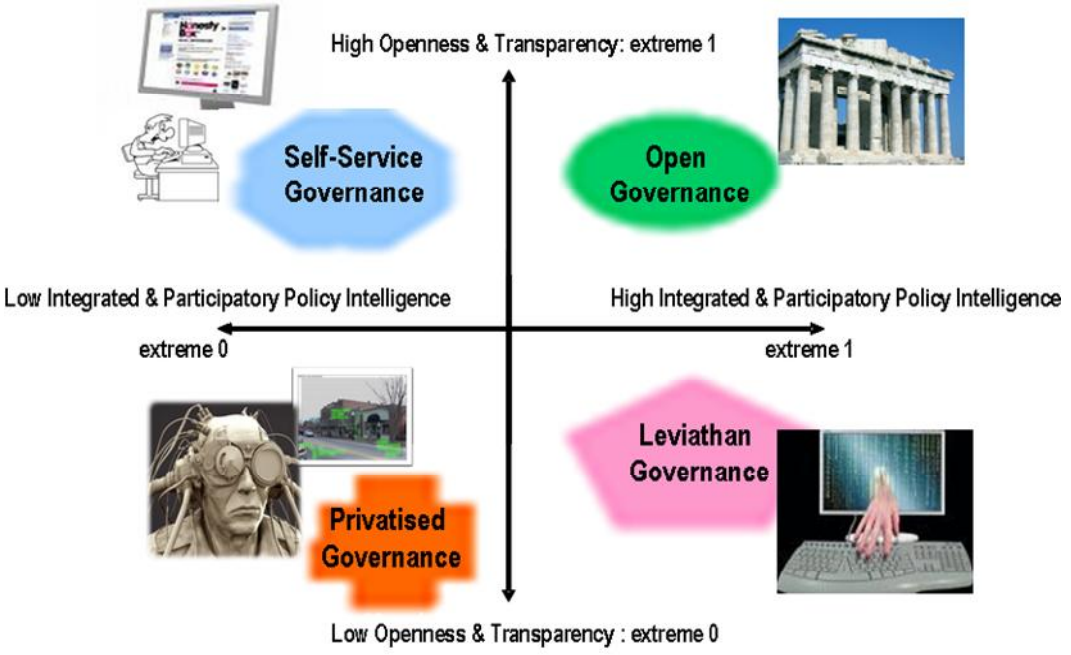
RT.4: Identity Management and Trust in Governance is driven by the need to safeguard citizens' and public authorities' digital presence from misuse. In this context, identity management with federated

identities, access control and authentication mechanisms in ubiquitous environments, as well as privacy and data protection have proved to contribute in building trust among citizens and public authorities.

RT.5: Future Internet for Collaborative Governance embraces the Internet evolution and entails transparent and multichannel service provision via the Internet of Services, low cost cloud infrastructures emerging from Cloud Computing advancements, better human-computer interfaces and seamless interaction with non-conventional web devices that communicate in the Internet of Things.

In particular, the CROSSROAD Research Areas taxonomy brings together 17 Research Areas that contain more than 80 Research Sub-Areas. In each research theme and its research areas, the research-oriented approaches, the practice-driven implementations and the policy positions have been identified in an effort to elaborate on their current uptake and future perspectives in terms of research potential, practice demand and market penetration.

Annex C: Summary of the Scenario exercise



Today's Internet is a remarkable catalyst for creativity, collaboration and innovation providing amazing opportunities impossible to imagine just two decades ago. If one had then predicted that in 2010 a child could freely access satellite images of any place on earth, interact with people from everywhere and search trillions of data with a simple click on her PC, she would have been taken for fool. The ambition of the CROSSROAD Visionary Scenarios Design was to prepare today a similar excursion into the future, target 2030. The scenarios developed for ***Digital Europe 2030*** aim at defining the vision of how governance and policy modelling could develop twenty years from now, so as to identify the research needs that the research community has to address. These efforts may in fact help the fool sound wise, once again, in 2030.

These scenarios have been designed through a foresight exercise conducted by the Information Society Unit of the Institute for Prospective Technological Studies (IPTS) in collaboration with CROSSROAD's partners and interactively with experts. The goal of the Visionary Scenario Design exercise was in fact to explore different possible alternative futures in the context of ICT for governance and policy modelling research (rather than attempting to predict the future), and elaborate on possible impacts that the future mainstream on society of ICT tools in this domain may have. For this purpose, a 5 steps methodology has been followed including: 1) a trend analysis to determine the developments that can be considered key drivers for the future of ICT for governance and policy modelling, 2) the selection of the scenarios by determining key uncertainties and main impact dimensions 3) writing of the scenarios, 4), outlining implications of the scenarios by expert and public consultation and 5) deriving conclusions for policy implications and research challenges with particular respect to their contribution to overall EU policy goals as described in the EU2020 strategy and the European Digital Agenda.

From a methodological perspective, the foresight exercise conducted as part of CROSSROAD was structured in order to be: 1) Evidence-based, as it builds upon the trends emerging from a policy review and trends analysis and the assessment of the State of the Art of Research in ICT for governance and policy modelling; 2) Expertise-based, as it includes the views of experts gathered through the Call for contributions issued by CROSSROAD and further discussion held during a restricted Workshop to validate the scenario design framework; 3) Interactive-based, as it incorporates the inputs provided during the Expert Workshop and collected through online public consultation; and 4) Creative-based, as it is founded upon 'creative-thinking' conducted through a series of brainstorming activities by the IPTS research team and CROSSROAD partners and experts.

Within this framework, the main research question underpinning the Scenarios Design was the following: *Taking into account possible future scenarios, maybe radically different, what are the future needs for ICT tools for governance and policy modelling?*

Following the mapping and analysis of the state of the art in the research themes related to the domain of ICT for governance and policy modelling and the identification of emerging policy and research trends conducted, as well as considering selected normative visions proposed by Experts in their position papers submitted in response to the CROSSROAD's Call for Contributions, and a preliminary assessment of the forthcoming research trends that can be depicted by other projects funded by the FP7 in this domain, the main impact dimensions which are likely to influence future research directions in the area of ICT for governance and policy modelling have been defined. Based also on analysis of existing scenario exercises and the current shaping of policies and strategies for the development of the European Information Society the impact dimensions identified have been refined and guided the developing of the scenarios framework to be used to depict possible state of the future Digital Europe.

The visionary scenario design developed as part of the research was intended to provide a structured framework for analysis of current and future challenges related to the research domain of ICT for governance and policy modelling. It takes the "real world" (of today) and constructs images of potential worlds (of tomorrow) highlighting ways in which key uncertainties could develop. The aim is to present clues and key impact dimensions for building alternative visions of future worlds to be explored, hence increasing our ability to perceive possible path of development of ICT applications for governance and policy modelling in the years to come, thus outlining key elements to be taken into consideration for the roadmapping of research in this domain.

In practice, the key technology and societal trends we are witnessing nowadays can be distilled in two basic uncertainties related to the way the European society and individual Member States will shape their policies and research agendas in the future. In general terms, these uncertainties regard 1) the societal value system we will be living in (more inclusive, open and transparent or exclusive fractured and restrictive), and 2) the response (partial or complete, proactive or reactive) to the acquisition and integration of participatory policy intelligence techniques in support of data processing, Visualisation and simulation for evidence-based policy modelling.

The key impact dimensions identified in relation to the scenarios framework developed were classified into two axes: **Openness and Transparency** and **Integrated and Participatory Policy Intelligence**. The two axes have been chosen to represent the way in which different future societal and policy directions could develop.

According to the position of the different scenarios in the framework, the scenarios depicted for the future of ICT for governance and policy modelling of Digital Europe at the horizon 2030, are the following:

- **Open Governance:** characterised by High Openness and Transparency and High Integration in Policy Intelligence;
- **Leviathan Governance:** characterised by Low Openness and Transparency and High Integration in Policy Intelligence;
- **Privatised Governance:** characterised by Low Openness and Transparency and Low Integration in Policy Intelligence;
- **Self-Service Governance:** characterised by High Openness and Transparency and Low Integration in Policy Intelligence.

The visionary scenarios design exercise resulted into four distinctly different and radical views of what the governance and policy-making system of the European society could be in the future and which could be the consequent implications for citizens, business and public services. The scenarios were developed by means of narration (i.e. storytelling), as description of possible outcomes on selected key domains of the European society where emerging research trends related to the development of ICT tools for governance and policy modelling are likely to have a major (positive or negative) impact. The timeframe in which the elements of the visions will occur are however influenced by the 'speed of change', which the overall technological landscape and societal context will take. However, considering the unprecedented and fast growth and speed of uptake experienced in several research themes under investigation (e.g. Social Computing, Mobile technologies, Pervasive Computing, etc.) and the related enabling applications of ICT for governance and policy modelling, it is argued that the world in 2030 will be radically different from the world we are living in today.

In an **Open Governance scenario**, it is expected that by 2030, people's use of the Internet will have enhanced collective intelligence (both human and ICT-enabled) and users will actually be allowed to unprecedented access to information and knowledge, and the possibility to use policy modelling techniques to solve global challenges and perform in an efficient and effective manner daily business and leisure related activities, as well as opening up for the provision of personalized and real-time public services. Governance processes and policy-making mechanisms will be based on powerful ICT-enabled tools allowing simulation and Visualisation that will also enhance the development of intelligent systems capable of finding meaning in confusion and solve new problems, independent of human acquired knowledge. In brief, the resources of the Internet and the collective policy modelling capabilities will shift cognitive capacities, letting to machines the work of memorizing and processing data and information, while humans will be able to focus on critical thinking and develop new analytical skills.

New literacies will therefore be required to function in a world where the future Internet might change the very notion of information and knowledge management, where users are their own content creators, and this increases the need for 'filtering' data and information flows and assessing quality, dealing with information overload and risks of 'mass-distraction'. This will influence also the learning system of the future, characterised by a mix of formal and informal education processes, thus eventually affecting increase of working productivity and economic growth. The focus will be on

the capacity to build and use social networks to help solve problems, as ICTs will more and more become and extension of individual and collective human intelligence.

In general terms, governance processes and politics will be based more on visual representation and simulated storytelling than old fashioned written texts. A sort of 'screen literacy' will therefore emerge and ICT-enabled mechanisms for real-time representation of information and knowledge reasoning and rendering will be pivotal for communicating to citizens and integrating their feedback and argumentations, including exploring and analysing inputs and opinions provided through different medias and especially Social Computing and micro-blogging mobile systems that are expected to be widespread in society. The online engagement of citizens and various governance stakeholders will increase and new ways of producing and share knowledge in an open manner will mainstream, thus changing radically the traditional governance processes and decision making mechanisms. This will also lead to the development of an era of open innovation, thus opening up unimagined opportunities for research and technological development. In this regard, it is expected that all institutions, public, private and third sector alike, will start listening more intently to their stakeholders, thus giving birth to a sort of 'molecular democracy'.

Online cooperation and collaborative governance will increase becoming more functional, thus avoiding the possible 'Chaos Scenario' evoked by Garfield in relation to the digital age. Online active participation in political, educational and social activities will increase as more people are connected and it will allow people to access relevant information to make informed choices and governments to take better and transparent decisions. This will facilitate the interaction between various stakeholders and the authority and governing structure of large organisations will witness profound changes in power relationships making more horizontal and participatory the decision-making processes, as ICT tools will allow collaborative and integrated management of data and information and a shift from experts to non experts knowledge creation, thus increasing the demand for accountability and permitting the close evaluation of performance and to take into considerations the needs of multiple constituencies.

In this context, one major driver of change is expected to be the release of public data and the development of local-based activities to exploit the reuse and link of data and information, rendering knowledge available and visual-user friendly to the vast majority of users. Citizens, businesses and researchers will have direct access to the data and information they need and this will create new opportunities for people to interact with and influence governance and policy-making processes, as well as advances in solving societal problems. The risk however will be that only the 'time wealthy' will have the possibility to engage and thus the degree of digital divide and digital inclusion will especially matter in this realm.

The **Leviathan Governance Scenario** assumes the emergence of an 'enlightened oligarchy' using high-tech tools and systems to collect and manage information that is only shared within the government. Judgment and decision-making is based on analytical processing of factual information. This makes possible the emergence of 'real-time governance', meaning that all aspects of government/citizen relationship (Finance, Health, Education, etc.) are controlled, to the benefit of the public, (e.g. tax/salaries are not needed). All services are pre-offered, in a personalized way, without prior asking thus leading to great savings in time. In this context, citizens trust the government, and are in favour of giving away their rights (voting, privacy, etc.) and are generally (persuaded to be)

happy with the situation, as no human-caused problems exists (but only external problems caused by nature).

This situation could lead to a number of prospective opportunities for society, where the 'real-time governance' system is proactively demand-driven offering directions and services before being asked. Education, Health and Security are therefore radically improved; decision-making is based on analytical processing of factual information, thus no misleading decisions as objective information is diffused as everything is effectively controlled at central level. At the same time, emotions and thoughts are controlled and directed towards the public good and humans are generally (persuaded to be) satisfied with their lives. As a matter of fact, in this scenario, potential terrorist attacks and pandemic diseases are eliminated; emergency situations are managed in an optimum way, and in general terms humans have more quality time to devote to their real interests without wasting time in schools, training or even visits/acquaintances without purpose; industries effectively co-operate (instead of unfairly competing) as they are regulated by the state and integration and social cohesion are ensured by default. Complete documentation and processing of everything that happens in the real or virtual world is available for subsequent scientific research under the auspice of government.

On the other side, several risks are linked to this possible state of the future. Citizens are passive recipients of the decisions reached by information systems with the consent of an oligarchy. They don't sense any excessive passion and sentiment, but only controlled and often inertia feelings. Freedom of will is restricted as almost everything from birth to death is predefined and pre-calculated to optimize performance. Information overload at some point of time or potential failure of the information systems to respond to a critical, unforeseen situation would result in a chaos with human beings and devices not knowing how to respond. Safeguarding everything from human senses and brains to the social networks friends could lead to a kind of revolution, no matter how well the intelligent systems predict human behaviour.

In this scenario, Europe becomes an autonomous world that abolishes freedom of circulation and travel beyond its borders. With a limited oligarchy setting and implementing the strategic policy priorities and controlling governance processes in full, with the support of special national secret police forces, no citizens' active participation in everyday decision-making will be required or sought for. This means that governors model priorities in the objective function of the simulation and decision-making systems while citizen engagement tools are disappearing as social networks only serve the purpose of communicating and exchanging content. Full-scale 3D simulations and policy intelligence tools facilitate decision-making which is automatically running with the oligarchs typically simply approving its recommendations of the best policy option for the majority of citizens; services are provided proactively in a personalized way to the human beings and autonomous ICT-enabled systems, thus, ensuring the elimination of corruption and an efficient resource planning and allocation.

In the **Privatised Governance Scenario**, it is imagined that society is shaped through decisions, which are taken by a group of business representatives and thus private companies are in control of governance, not governments. Discussion on societal aspects or about the role and behaviour of citizens is neglected as they are only chess pieces under the control of large corporations, thus eliminating any interaction and participatory mechanism with citizens and de facto eliminating democracy, as we know it today. This will have a number of consequences, such as for example the

emergence of new global pandemic disease, which may appear easily because of the nomadic life style of many business people. Thus, companies will reach some agreement on health protection of their employees but this will not guarantee all the population.

ICT-enabled modelling, monitoring, simulation and decision support systems would be highly developed in this scenario by individual companies, but not necessarily integrated. Running billions of simulations to find best possible alternative for decision-making will require the establishment of co-opetition mechanisms, but this will not automatically allow avoiding risks. Simulations based on data gathered by sensors and collected from continuous monitoring and analysing networks, businesses, and customers, as well as the whole environment include information at global level, but still parcelled and owned by corporations. For example, integrated Environmental Assessment using environmental models and impact assessment tools will permit to develop systems that will facilitate the estimation of possible risks and optimal business strategy planning for the individual companies, but this will require the development of sophisticated co-opetition mechanisms in order to gather as much information as possible (monitoring, sensing and spy systems) to protect their own databases and to maintain their performance in an highly competing and hostile environment.

In this scenario, in fact, decision making is strongly dependent on the capacity of the ICT systems that facilitate decision making and are threatened by frequent terroristic attacks from independent groups and/or communities that can however be prevented by the deployment of ICT systems able to forecast cyber attacks through running social simulations. On the other hand, since media will be owned by large corporations and will generally support them, false and uninformative campaigns will take place and this will make emerge the need to verify all information and data made available. More importantly, and despite this scenario may also open up opportunities for high innovation due to the pressure given by competition on a free market also for basic research, several risks should also be considered especially with regard to the use of ICT for health and education for example, or for energy efficiency and to guarantee environmental protection and prevent possible natural disasters.

In general terms, while ICT advances driven by private companies is expected to reach high levels of development in areas such as teleworking and telemedicine, or to deploy early warning systems to avoid global pandemic disease and disasters, assisted by real time decision support systems, these will imply an high cost for ordinary citizens and there are high risks of exclusion that could lead to a fragmented society where social welfare services are not guaranteed to all, thus exacerbating possible social tensions and conflicts.

The **Self-Service Governance scenario** embodies the vision of society with empowered citizens who take the roles of policy makers. Citizens put forward (within communities) their own policies in accordance with the do-it-yourself principle and choose from the variety of public services those they need and they consent to. This is also a society where freedom of expression is perceived as the supreme value and where the agency of the individual (the capacity of individuals to act independently and to make their own free choices) reigns over the structure (choices and opportunities are embedded in the system). This scenario introduces a vision of a self-organised society (with phasing out institutions) that is able to address emerging problems in a faster way than the classically defined government does. What is more, it may provide disparate solutions that could prove more robust and resilient in the face of crisis. Those who are not interested in the increased autonomy and empowerment would rather adopt a passive 'follow-the-group' attitude.

Nevertheless, this diversity of opinion stemmed from the existence of closed communities may result in deepening of existing divides and lack of societal cohesion. This implies further exclusion of those who lack e-Skills. High insularity of the society would afflict most severely migrants deprived of local social networks, running into communication problems due to the language and culture differences. However, thanks to the deployment of efficient translation tools, the dissipative communities may in the end create a vivacious cross-cultural and multi-language society. These closed communities may flourish thanks to the group thinking benefits but also decay due to the 'crowd stupidity' effect and lack of knowledge transfers. As this scenario implies existence of multiple divergent groups, there is a need of tools and functionalities that allows for a bridge linking these communities and allow for divergent thinking (e.g. 'people who like this usually totally overlook that'). The process of gradual disappearance of institutions and lack of trust in government results in the need of new trust providers. It means that reputation management, applied to both content and people, plays a significant role in the service provision. Reputation tools may be delivered either by different systems depending on community or trough social pattern recognition. Moreover, one's identity would comprise of different privacy layers that are shared with different groups and individuals on a case-by-case basis. Authentication would be granted by communities themselves, which may result in the complete lack of intra-communication and hinder the transferability of trust across people and groups. The abundance of information produced and available online by citizens will exacerbate the problem of information overload. People would be unable to navigate through the different opinions expressed by thousands of citizens, thereby restricting their focus on local networks only, which may increase the 'crowd stupidity' effect. What is more, the multiplication of communities based on particular interests conducts to the impossibility of aggregating opinions of users from the EU Member States and the global virtual communities and therefore inability to address collective issues. The fragmentation of communities is likely to hinder the capacity to tackle systemic challenges such as scarcity of natural resources. At the same time, there is still a possibility that the majority of citizens are not interested in participating in governance due to the lack of engagement culture. For that reason, new leaders could emerge who may unify disparate groups but also damage the subtle equilibrium of the self-service and collaborative-based culture.

This scenario entails also the end of centralised, government-controlled education. The predominance of open knowledge paradigm paves the way to the creation of self-managed communities of learners that share information, co-build curricula and co-deliver training. Even though this new system allows for the existence of the open, lifelong process of acquiring skills, it generates a set of different competing and not harmonized training schemes and accreditation systems. Concurrently, it may incur the disintegration of common civic values, as the education system nowadays is still an important tool to build shared values.

In conclusion, the trends analysis and the visionary scenarios exercise argue that the influences and drivers of innovation and new organisation of the public sector, combined with the increased pressure that most welfare states are under, not only could result in new changes, but they also change the pace with which the welfare state would adapt to the new environment, giving birth to new engagement rules with stakeholders and citizens. These areas of change have impact on and pave the way for increased openness of the public sector, greater participation, involvement of the users, new roles, as well as the need for more integrated and intelligent policy-making mechanisms.

Future Research challenges in the emerging domain of ICT for governance and policy modelling are huge and complex and cannot be dealt in isolation. A strict relationship also exists with the broader task of envisioning and developing the Future Internet. As a matter of fact, the Internet was never designed to serve massive scale applications with guaranteed quality of service and security. Emerging technologies like streaming high quality video and running 3D applications, or applications to enable mass collaboration, data processing, simulation and Visualisation through complex modelling, face severe constraints to run seamlessly anytime, everywhere, with good quality of services.

European scientists proved to be at the forefront of ICT research since the invention of the web and the rapid technological developments of the last 20 years. It is now time to bring together different research disciplines that could contribute to take advantage of the opportunities of ICT for better governance and policy modelling, and at the same time overcome the possible risks linked to the mainstream in society of large-scale applications in this domain. In addition to this, and from a ICT infrastructure perspective, we should also consider that the current Internet, as an ubiquitous and universal means for communication and computation, has a series of inherent unresolved problems, and it is expected to reach soon both its architectural capability limits and its capacity limits. The future development of the Internet infrastructure will have also to deal with the complementary advancements in technological applications and groundwork that has been in place for years now and that should yield innovation in the future. More-powerful devices, even-cheaper netbooks, virtualization and cloud computing (including portable solutions), reputation systems for social networking and mass collaboration tools, as well as the proliferation of sensors, reporting and decision support systems, do-it yourself embedded systems, robots, sophisticated algorithms for processing data and performing statistical simulation and analysis, Visualisation tools to report results of these analysis, affective technologies, personalized and location-aware services, facial and voice recognition systems, electronic paper, anomaly-based security monitoring, self-heating systems and other, are expected to mainstream in the next 20 years.

But more important than network requirements and technological applications, the consideration of socio-economic aspects in the development of future ICT tools for governance and policy modelling appears of crucial importance. Socio-economics as a multi-disciplinary field, which cuts across all research areas of the ICT for governance and policy modelling domain, entails research challenges that in this context are manifold. Suitable governance and policy-making mechanisms need to be designed which will provide appropriate incentives for participation, but at the same time ensuring security as well as avoiding risks of enlarging digital exclusion for example. Legal and regulatory issues such as digital rights, privacy and data protection, have also to be taken into consideration, as the demand for trust establishment in the governance realm may increase (or shift) as its usage scenarios change. For example, an ever increased openness of ICT-enabled governance and policy modelling mechanisms, and the criticality and value of the transactions conducted over the open platform that may be used for this purpose may create incentives for malicious use of data and information. While security technologies will be developed to address the technological challenges linked to this, additional risks on trust are imposed by the specific domain under investigation, mainly due to the potential pervasiveness, large-scale and involvement of users. The challenges include, for instance, the design of identity management systems capable of dealing with billions of entities, and

their different roles in the governance sphere, the trustworthiness and control of distributed applications based on services offered through open service delivery platforms, and the secure and trusted interaction with real-world objects and entities through sensors and actuator network infrastructures.

The opportunities the future ICT tools for governance and policy modelling opens for individuals, businesses and governments are huge but will only become possible if appropriate conditions and 'governance models' are developed. The expectations in fact are that ICT tools for governance and policy modelling will force change in institutions, no matter how resistant they are. And whether it could be predicted that governments that redefine their relationship with their stakeholders will be the ones to succeed, the market will still drive that process in the commercial domain. Tensions may emerge, as stakeholders know more and more about the organisations that are trying to serve them. In the longer term it can also be expected that governments will embrace more 'networked-governance' structures, but a struggle will still unfold between traditional bureaucratic systems and network-based mechanisms as to which is the best way to organize people, knowledge and service delivery. As a matter of fact, changes in governance structures and processes may well occur in phases in response to pressures wrought up by new ICT tools and emerging societal behaviours.

At the same time it seems that an increasing demand from the scientific and business community, as well as from civil society organisations and citizens groups themselves will drive the emergence of 'experimentally-driven research', to address broad governance and policy-making challenges, developing and applying ICT tools and applications to exploit the full value of the mass collaboration and open and participatory paradigm underpinning the future technological developments and governance directions in Europe. This would eventually allow for testing new ICT-based solutions and models for collaborative governance and participatory policy modelling, permitting socio-economic impact assessment of future societal changes. This last issue entails the need of building upon the momentum that the domain of ICT for governance and policy modelling has been recently gaining, through the CROSSROAD community. In order to further bridge the gap between various stakeholders and between long-term research and large-scale experimentation, so to enable cross-fertilization across different scientific disciplines and integration of resources, special emphasis should be put on fostering common research results, creating value for the EU research community concerned, avoiding fragmentation of research efforts and implementing a joint strategic research agenda for the future of ICT for governance and policy modelling in support of the building of Digital Europe 2030.

Annex D: Summary of the Gap Analysis

The overall aim of the Gap Analysis was to identify and assess the differences between today's and possible future outlooks for ICT research in the domain of ICT for governance and policy modelling.

The gap analysis collaborative process resulted in 42 gaps: 6 gaps within RT1, 9 gaps within RT2, 11 gaps - RT3, 7 gaps - RT4, 5 gaps - RT5 and 4 gaps stemming from visionary scenarios):

Research Theme 1: Open Government Information & Intelligence for Transparency

- *Systematic management and monitoring of transparency* refers to lack of studies on organisations and organisational structures involved in enforcing and monitoring the public data release.
- *On-the fly Open Data Quality Agreements* refers to the need for a framework for management and resolution of legal issues of publishing open data.
- *Public, real-time linked data* is still at an early research stage and counts a few empirical implementations, therefore, the development and the application of practical mechanisms and frameworks that allow real-time public sector data interconnection and system reuse is needed.
- *Citizen-oriented linked data querying and reasoning* aims to empower citizens to participate effectively in policy-making with development of citizen-oriented linked data querying and analysis tools.
- *Seamless collaboration and cooperation in data layer* refers to the need for further study on visualisation web systems that support asynchronous or synchronous collaborative .
- *Large-scale public information Visualisation* may turn the public information overload into an opportunity by enabling decision-makers to visually navigate through information streams, as well as to gain insight into the opinions expressed and to take effective actions in real-time situations.

Research Theme 2: Social Computing, Citizen Engagement and Inclusion

- *Open and cross-language collaborative filtering / attention economy tools* refers to the need for enhanced recommendations systems, tools facilitating feedback mechanisms to augment human attention and make most of the limited attention available as well as prevent extensive group thinking effects.
- *High-quality expertise identification through reputation management* refers to integration of multiple reputation management systems with advanced detection of unfair rating.
- *Distributed Early Warning Systems for risk prevention* entails both better modelling techniques as well as tools that capture the complexity of interrelated variables, and the capacity to better use human judgement to spot risks and anomalies in appearing patterns.
- *Affordable large-scale collaboration* refers to the lack of efficient rating and filtering tools and the need for advanced tools for easy and reliable aggregation of preference
- *Leveraging casual participation* refers to the need for tools and methods that ensure natural user interface for large-scale participation, enable to embed participation into the policy cycle (on all

levels) and allow for engagement without a formal invitation to participation and in the environment chosen by citizens.

- *Robust and large-scale argument support systems* refers to the need for tools which identify various user groups and recognise their specific requirements as well as offer user-friendly, intuitive interfaces.
- *Robust Natural Language Interfaces*, ie. development of natural user interface, available for non-experts may bridge the digital divide and increase the take-up of eParticipation services.
- *Higher levels of acceptability* present the need to investigate current political systems and the role of different stakeholders to the weaknesses of today's systems and investigate whether the approaches adopted are likely to achieve higher levels of acceptability and/or reduced levels of disaffection.
- *Participation* focus on investigating the different facets of the term and reflection on changes in the current political systems that would enable mass participation.

Research Theme 3: Policy Making

- *ICT for state-of-the-art policy-making* shows there is a lack of appropriate tools and technologies to support existing and well established methodologies for policy context analysis and strategic planning. Moreover, scalability of current tools and technologies in the field is very low.
- *Large-scale quantitative data for formal policy models* refer to the need for further research on approaches to identify patterns in data, which can be relevant for policy context analysis practice.
- *Argumentation analysis and encoding* reports on problems to derive formal models from narrative data and vice versa, transforming intrinsic knowledge to explicit knowledge. This process should be supported by graphical visualisation and data mining tools.
- *Scalability of modules refers to th*e issue that current simulation models are customised to a specific problem scope, i.e. these models meet the exact problem scope of a specific issue but they are not applicable without adoption. Therefore research on possibilities of multi-scale simulation, i.e. across different e.g. dimensions of size, geography, time, and detail is needed.
- *Large-scale transformation and aggregation of modules* refers to a lack of interoperability of models and the need for simplification of models in order to allow their aggregation.
- *Collaborative Intelligence in policy-making* describes the need for engagement of users both policy makers and citizens in modelling and simulation in order to achieve consensus through shared understanding..
- *Usability in modelling and simulation* refers to the need for further research and technology development to make certain methods usable for wider public and not only, as it is today, for the users with programming skills.
- *Identification of application fields for modelling and simulation (policy execution – monitoring and enforcement)* refers to the lack of research on the most useful and efficient application fields for policy-making as well as general frameworks and criteria to assess the usefulness of applying modelling and simulation for policy modelling.

- *Reliability of modelling techniques* refers to the lack of a realistic and affordable test that provides enough evidence that the model and the simulation meets its requirements.
- *Integration of tangible and intangible aspects into formal models* refers to integration of tangible (objective) and intangible (subjective) aspects into formal models, i.e. how to prioritise alternatives taking into account tangible and intangible aspects and of how to aggregate individual priorities to obtain a social priority.
- *New models of "governance"* that use tools supporting the global policy-making process (formulation, modelling of the problem, modelling of preferences, prioritisation, exploitation of the model, learning and education, effectiveness evaluation).

Research Theme 4: Identity Management and Trust in Governance

- *Interoperability and integration issues of identity management in large-scale systems* refer to lack of IT compliance for integrated, process supportive identity management.
- *Means for authentication and Identity Management* encompasses integration in the same device of hard (eID) and soft (password) authentication for specific problems, as well as tools for identification and authentication of citizens with different degrees of security.
- *Legitimate data protection in high flexible business processes* implies integral technological security of all the stages of the policy-making process (e.g. identification, prioritisation, discussion, decision making).
- *Digital identity for governance and policy modelling* calls for further research on reliable identification and data protection systems for governmental communication as well as on privacy issues and any-place and any-time information availability for anyone.
- *Flexible and dynamic disclosure management tools and technologies* focus on disclosure management technologies along with tools and technologies for rapid collaboration.
- *Trust in Social Networks* refers to the need for globally secured infrastructures and data exchange and data usage keeping control over information and transparent for the end-user.
- *Intellectual Property Rights* refers to the lack of knowledge-based technology that could be used to provide expert advice on intellectual property in the digital era as well as the need for national, European and International legislation (EU directives, international agreement etc.).

Research Theme 5: Future Internet for Collaborative Governance

- *Massive Government Clouds* points out the need for identification and learning from best practices and policies to facilitate effective incident handling.This calls for advanced guiding principles and standards to allow evaluation and certification of cloud-based services.
- *Business models for public-private clouds governance* are needed to establish whether clouds are really a cost-effective platform for services. It entails also a choice between possible deployment models – private, community, public or hybrid.
- *Mobility and Participatory Sensing* refers to interoperability of devices and likewise automated data synchronization across different devices as well as the need to bridge the gap between

Internet of Things and Governance and Policy Modelling in order to fully available exploit sensor data.

- *Real-time context-aware services* shows that need for small, ubiquitous and wireless technologies in the field of Governance and Policy Modelling enabling mobile service provision and multi-channel access, especially for those who are not able to use existing ICT solutions.
- *Human-computer interaction* calls for further research on computer linguistics and other formats of data delivery in order to identify, develop and establish new services in the field of Governance and Policy Modelling.

Gaps resulting from needs in visionary scenarios

- *A new political participative model* refers to new models of interest articulation, new processes of interest generation and new ICT-enabled governance models.
- *Governance of and through Public Good data and tools* show that tools and methods for full automation of data collection and processing for Governance and Policy Modelling as well as the solutions for some legal, social and ethical problems (e.g. privacy, security, etc.) are needed.
- *Governance of and through Club Good data and tools* refer to effective and real-time cooperation of public agencies in the field of crisis management
- *Governance of and through Private Good data and tools* asks in which means could ICT support self-governance and how can it prevent misuse and allow for smooth functioning of the system.

Annex E: Summary of the Deliberation Results report

The Deliberation Results report presents the results of the deliberation process launched to review the Draft version of the CROSSROAD Roadmap on ICT for Governance and Policy Modelling. The report is part of the Roadmap Composition Work Package and aims at documenting feedback on the Roadmap content from the ICT for Governance and Policy Modelling community.

The CROSSROAD Networking Session was organised in the conjunction with the ICT 2010 Conference in Brussels and took place on September 27th, 2010. More than 100 participants attended the session, which aimed at creating feedback and reaching community consensus on the research roadmap on ICT for governance and policy modelling. After the introduction to the CROSSROAD aims and the presentation of the Grand Challenges, the participants were asked to rank the research ideas within the challenges according to their importance for future advancements in the domain. The ranking results confirmed the preference of the community for a user-centred and collaborative approach in the ICT for Governance and Policy Modelling domain as well as the importance of the Policy Modelling and Simulation research.

An online deliberation was also opened and announced at the CROSSROAD Networking Session. The platform was available for a month (until October 29th, 2010) at http://CROSSROAD.uservoice.com. All the Grand Challenges received considerable amount of votes with the GC2 *Data-powered collective intelligence and action* receiving the highest score, which repeated the results of the workshop ranking results. Each of the research ideas within the four grand challenges received also a high number of votes. To sum up, the online deliberation process resulted in the validation of the research ideas by the large community of experts who took part in this exercise.

The Deliberation Results from the ICT 2010 Networking Session and the online deliberation were, in general, similar. Closer analysis of the ranking outcome suggests that the *Federated dynamic identity management* may be replaced or merged with the new question of *How we restore control over personal data to the individual and help people to acquire trust online* as it was suggested the former is non-specific to the ICT for Governance and Policy Modelling field and would be addressed anyway by neighbouring domains. The research challenges in the GC4 should be also revisited to check their interdependence. Moreover, there is a need to stress the importance of the inclusion of all citizens in the Grand Challenge Data-powered collective intelligence and action. Also, a new research idea on *how to acquire consensus when confronted with open questions* shall be integrated into the final version of the roadmap.

The ICT Networking Session further brought an important suggestion to complement the research challenges' description with the information on the added value of this research for citizens in order to enable the wider public to embrace the roadmap results.

To conclude, the workshop and online deliberation results showed that that the Grand Challenges, validated already during the Samos and Lausanne workshops, answer well the research community needs and expectations for further research. Furthermore, there were no research ideas (within the Grand Challenges) that were rejected or ranked as unimportant albeit the votes' distribution was not equal. Finally, the new ideas and comments showed the interest of the community in this exercise and enriched the final version of the roadmap.

Annex F: Roadmapping activities related to CROSSROAD – Full Review

1. VisMaster

Project description and rationale

VisMaster is a European Coordination Action Project focused on the research discipline of Visual Analytics. The goal of this Coordination Action is to join European academic and industrial R&D excellence from several individual disciplines, forming a strong Visual Analytics research community.

Visual Analytics - description

Visual Analytics is the combination of related research areas including visualisation, data mining, and statistics. *Visual analytics combines automated analysis techniques with interactive visualisations for an effective understanding, reasoning and decision making on the basis of very large and complex datasets*[8].

Visual analytics tools and techniques are used to synthesise information, analyse massive and dynamic data and detect trends. This field provides technology that combines the strengths of human and electronic data processing. The user gives the direction of analysis, whereas the system has to provide effective means of interaction. Visual representation helps to navigate through different data layers and tasks.

It comprises visualisation with core adjacent disciplines such as data management, spatio-temporal data analysis, data mining as well as human perception and cognition.

Current research and implementations

Development of principles, methods and tools for design of perception-driven, multimodal interaction techniques for Visualisation and exploration of large information spaces, as well as usability evaluation of such systems.

- The availability of improved display resources (hardware)
- Development of novel interaction algorithms incorporating machine recognition of the actual user intent and appropriate adaptation of main display parameters such as the level of detail, data selection, etc. by which the data is presented.
- Perceptual, cognitive and graphical principles, which in combination lead to improved visual communication of data and analysis results.
- Efficiency of the Visualisation techniques to enable interactive exploration interaction techniques such as focus & context.

Physics and astronomy with applications such as flow Visualisation, fluid dynamics, molecular

[8] Vismaster, Mastering the Information Age Solving Problems with Visual Analytics, September 2010.

dynamics, nuclear science and astrophysics, etc. (simulation of a supernova in the SciDAC programme).
Business applications, including simulations on the financial markets (Smartmoney).
Amongst relevant policies the most important ones include: Public Safety & Security, Environment and Climate Change, Monitoring Financial Markets.

Four challenges – data, users, design and technology

- **Scalability, uncertainty of the data and real time analysis**
  - Integration of heterogeneous and dynamic data such as numeric data, graphs, text, audio and video signals, semi-structured data, semantic representations trough clustering or classification before Visualisation.
  - Storage, retrieval, transmission and streaming of the large datasets
  - Support for multiple levels of data and information abstraction
  - Cleaning and harmonisation of uncertain and missing data in near real-time
  - Analysis of data with references both in space and in time (spatio-temporal data are often incomplete, interpolated, collected at different times, based upon different assumptions etc.)
  - Indexing, aggregation and analysis in real-time, identifying trends and detecting unexpected behaviour when the dataset is changing dynamically
  - Scalability of visualisations
  - Semantic management
- **Meeting the users needs – simplifying the interfaces and enabling collaboration**
  - Confidence in data and transparency of information on its origin
  - Intuitive and interactive user interfaces
  - Assisting methods for non-advanced users in understanding the outcomes of visualisation
  - Collaboration methods
- **Designing the visual analytics systems using the state-of-the-art knowledge**
  - Transfer of theoretical and practical knowledge to designers of visual analytics systems, possibly in the form of design guidelines
  - Need of unified architectural model
- **Technology – providing the infrastructure needed**
  - Progressive analysis functionality – partial results overview
  - Multi-scale analysis in relation to the geo-spatial data
  - Next generation of lightweight web-based visualisation tools with methodology for basic visualisation functions, such as linking and brushing

Conclusions and relation to the CROSSROAD roadmap

VISMaster	Relevance to CROSSROAD	Relation to CROSSROAD taxonomy				
Roadmap recommendations		**Open Government Information & Intelligence for Transparency**	**Social Networks, Citizen Engagement and Inclusion**	**Policy Modelling**	**Identity Management and Trust in Governance**	**Future Internet for Collaborative Governance**
Scalability, uncertainty of the data and real time analysis	HIGH	X	X	X		X
Meeting the users needs	HIGH		X			X
Designing the visual analytics systems using the state-of-the-art knowledge	HIGH			X		
Technology – providing the infrastructure needed				X		

2. PHS2020: Roadmapping Personal Health Systems: Scenarios and Research Themes for Framework Programme 7th and beyond, 2009

Project description

PHS2020 was Framework Programme 7 Support Action. It aimed at producing a roadmap for future research in the field of ICT supported Personal Health System (PHS).

Definition

Personal Health Systems (PHS) assist in the provision of continuous and personalised health services to individuals regardless of location for various purposes including lifestyle management and prevention, early diagnosis, treatment, and disease management. They include both solutions aimed at fully empowering individuals' "respons-ability" of self-caring and solutions supporting collaboration between individuals and healthcare professionals and organisations.

They consist of:

a) Ambient and/or body (wearable, portable or implantable) connected devices, which acquire, monitor and communicate physiological parameters and other health related information of an individual (related to e.g., vital body signs and biochemical markers);

b) Intelligent processing of the acquired information and coupling of it with environmental information expert biomedical knowledge to derive important new insights about individual's health status.

c) Active feedback based on such new insights, either from health professionals or directly from the devices to the individuals, assisting in diagnosis, treatment and rehabilitation as well as in disease prevention and lifestyle management.

Results

In view of future evolution of PHS, the roadmap called for:

1. Infusion of clinical evidence and of molecular and genetic data (**Bio (medicine) infused PHS**)
2. Advancement in the development of sensors (**Third generation PHS sensors**)
3. More sophisticated algorithms and data processing solution capable of turning inert data and information into knowledge and knowledge into wisdom (which knowledge for which action) (**Intelligent PHS data processing**)
4. All of which need to rest upon interfaces and channels of interaction maximising inclusiveness and users friendliness (**Users inclusive PHS interfaces, Advancing Lab on Chip**).

In sum, five research domains were identified during the scenarios building and gap analysis exercises.

1. PHS will become truly personalised and fully accepted by healthcare professionals only when they will be infused with (Bio)medicine

The researchers suggested continuation of research on development of shared patient-doctor and new research on classification of genetic info, integration of genome data, studies of connection between diseases and genetics and incorporating co-morbid guidelines into PHS.

Furthermore, on the implementation side it called for developing standards and consensus about knowledge, including patients with co-morbidities into on-going pilots and strong need for multi-level and multi-application inter-operability: across different PHS applications, between PHS and PHRs, between PHS and applications; between BMI applications and PHRs, in particular inclusion of molecular and genetic data into PHRs.

2. Make PHS data processing more intelligent

Roadmap indicated scoping of the following problems PHS integrated with high-risk jobs, PHS as a tool for lifestyle management and convergence of PHS, domotics, and surrounding data. It has urged to continue and improve research **pre-processing of data; multi-modal data integration** and development of patient aid. Moreover, it suggested supporting new research on **data fusion, implementation of data mining, patterns assessment and knowledge extraction**, **predictive methods and algorithms.** On the implementation side it stressed the **need for interoperability, privacy preserving algorithms and development and supplement of legal framework**.

3. Develop Third Generation PHS sensors

Sensors are the building blocks of PHS and the foundation upon which intelligent data processing rests. The roadmap urged to scope the problem of Integration of MEMS and NEMS and bio-power generation. It has also suggested continuing and improving research on **improving efficiency, effectiveness and comfort of wearable sensors; deploying all-encompassing sensors/actuators; improving on-board processing of data**.

What is more in this area, it has shown the need for support **new research on integrating bio-sensors; contactless sensors; contextual sensing; bio-imaging; and Integrating and testing modular sensors networks (Plug & Play**).

Whereas on the implementation side, it suggested defining **common standards for allowing full interoperability of sensors.**

4. Design more inclusive PHS interfaces

Gaps related to inclusion of all users and users acceptance of PHS were the most numerous among those mentioned by experts. The roadmap pointed out the need of scoping the problem of integration of tailored ergonomics and developing guidelines for quality stamps and certifications. It has also called for continuing and improving research on **convergence of multi-modal interaction, integration of force feedback applications and alternative sensing**.

Further to that, it pointed out to supporting new research on **alternative recognition and activation; affective computing, virtual interacting & interfacing; motivational support tools**.

As a final point, it showed the advantages of involvement of end users assessment and evaluation for the implementation aspect.

5. Push advances in Lab on Chip

Lab on chip is the building block of Point-of-Care (PoC), whose aim is to integrate multiple laboratory functions on a single unit capable of handling small fluids volumes.

In this particular area, the roadmap indicated the need for scoping the problem of integrating bio-degradable materials. Moreover, it urged to continue and improve research on optimisation of time-to-result; improving multi-markers in one chip; fully integrating sampling, mixing, reaction, separation and detection functions in one chip. What is more, it called for support for new research on personal-enabled LoC for in/on body analysis. Finally, it indicated the need of cost/benefit analysis of implementation processes.

Conclusions and relation to the CROSSROAD roadmap

PHS2020		**Relation to CROSSROAD taxonomy**				
Roadmap recommendations	**Relevance to CROSSROAD**	**Open Government Information & Intelligence for Transparency**	**Social Networks, Citizen Engagement and Inclusion**	**Policy Modelling**	**Identity Management and Trust in Governance**	**Future Internet for Collaborative Governance**
Bio (medicine) infused PHS	LOW					
Third generation PHS sensors	HIGH					X
Intelligent PHS data processing	HIGH	X	X		X	X
Interfaces and channels of interaction maximising inclusiveness and users friendliness	HIGH		X			

3. eGovRTD2020: Roadmapping eGovernment Research. Visions and Measures towards Innovative Governments in 2020, 2007

Project description and rationale

eGovRTD2020 was co-funded as a specific support action within the 6th framework programme of ICT of the European Commission. Its main aims were to identify and characterise the key research challenges, required constituencies, and possible implementation models for holistic and dynamic governments in Europe and around the world in 2020 and beyond.

Project conclusions and recommendations

i. **Trust in eGovernment**. Research is needed to understand what conditions are necessary and what mechanisms are needed to build and maintain trust in eGovernment processes and services. In this respect there is also a need to identify the different kinds of trust related to eGovernment, e.g. trust in government or trust in ICT, and its special characteristics.

ii. **Semantic and cultural interoperability of public services**. In principle, increased Internet access and the potential of the web for communication and education should bridge cultural boundaries. Yet, cultural and language differences continue to block effective communication and action across different countries, lobbies, and governmental functions. To facilitate cross-organisational collaboration among the various users, semantic and cultural interoperability are preconditions.

iii. **Information quality**. In the future, guaranteeing information quality will become both more important and more difficult as the number and variety information sources (including informal sources such as wikis and weblogs) continues to grow.

iv. **Assessing the value of government ICT investments**. Proper frameworks, methods, tools and metrics to monitor and evaluate the efficiency as well as benefits of eGovernment investments are lacking. Above all, a clear under- standing of the value of eGovernment, and value for whom is needed.

v. **eParticipation, citizen engagement and democratic processes**. In using ICT, elected officials and civil servants must remain open and ac- countable in their activities, behaviour, and decision-making. At the same time, government must ensure that those individuals and groups that wish to participate in democratic processes have the opportunity and means to do so.

vi. **Mission-oriented goals and performance management**. Many eGovernment projects do not start with the primary missions of government in mind. Instead, they are often dominated by a technology-driven approach. This is similar to the situation in which a budget is structured and evaluated by the nature of expenses rather than by the public service goals that expenditures support. In both cases management attention is diverted away from the core mission.

vii. **Cyber infrastructures for eGovernment**. Future eGovernment technology platforms might consist of a reliable, ubiquitous infrastructure that supports systems and applications assembled out of readily-available, re-usable components. However, realisation of this

possibility requires research in various domains including whether and how a building block-oriented ICT-industry could develop, and what types of architectures, building blocks, and standards are needed.

viii. **Ontologies and intelligent information and knowledge management**. Governments are currently struggling with huge information overloads, with new and emerging ICT capabilities, and with a shortage of information management skills and human expertise. Ontologies and knowledge management facilities (such as search, retrieval, visualisation, text mining, and intelligent reasoning) seem promising be exploited to achieve information quality and economy, and to support knowledge management processes in eGovernment settings.

ix. **Governance of public-private-civic sector relationships**. Increasingly, governmental functions and public services incorporate significant roles for private sector or civic organisations. These roles play out in a variety of relationships from advisory, to collaborative, to contractual, to full partnerships. Adequate principles and frameworks are lacking, which facilitate and set the ground of collaboration in advancing and deploying eGovernment in regards to sharing responsibilities and exchanging information among networks of diverse organisations in ways that generate public value and satisfy public requirements for fairness, accountability, and competence.

x. **Government's role in the virtual world**. Global electronic markets, virtual organisations, virtual identities, virtual products and services, and Internet-related crime are growing in prominence and importance. In a world that is increasingly non-physical and borderless, government's roles, responsibilities and limitations are subject to change and are blurring.

xi. **Crossing borders and the need for governance capabilities**. Social networks, gender issues, environmental concerns, political movements, etc. reach beyond local, regional or national borders. It is unclear, how these phenomena can be steered and governed properly across organisational boundaries, especially through exploiting capabilities available in neighbourhood regions and contexts.

xii. **eGovernment in the context of socio-demographic change**. Demographic trends with global consequences (such as age distribution, wealth distribution, immigration, and mobility and distribution of workers) are generating pressing issues in both developed and developing countries. Within the European Union, facilitating mobility of citizens and trade across the whole internal European market are strategic aims to foster. These strategic goals as well as the demographic movements and changes require the public sector at the various administrative and political levels to act and react with according public service offers.

xiii. **Data privacy and personal identity**. Data privacy and personal identity have become important aspects in the Information Society. On the one hand, the potential of modern ICT could be exploited to take advantage of personal information to improve the performance and quality of government services. On the other hand, privacy and personal data need to be secured and protected in order to prevent misuse and fraud.

Conclusions and relation to the CROSSROAD roadmap

eGovRTD2020	Relevance to CROSSROAD	Relation to CROSSROAD taxonomy				
Roadmap recommendations		**Open Government Information & Intelligence for Transparency**	**Social Networks, Citizen Engagement and Inclusion**	**Policy Modelling**	**Identity Management and Trust in Governance**	**Future Internet for Collaborative Governance**
Trust in eGovernment	HIGH	X			X	X
Semantic and cultural interoperability of public services	HIGH					X
Information quality	HIGH					
Assessing the value of government ICT investments	LOW					
eParticipation, citizen engagement and democratic processes	HIGH		X			
Mission-oriented goals and performance management	HIGH	X				X
Cyber infrastructures for eGovernment	MEDIUM					X

Ontologies and intelligent information and knowledge management	HIGH		X			
Governance of public-private-civic sector relationships	LOW					
Government's role in the virtual world	LOW					
Crossing borders and the need for governance capabilities	HIGH	X				X
eGovernment in the context of socio-demographic change	LOW					
Data privacy and personal identity	HIGH				X	

4. The Future of Cloud Computing, Opportunities for European Cloud Computing Beyond 2010. Expert Group Report, 2009

Project description and rationale

This report was initiated by the European Commission in 2009 to capture the development in cloud computing and its relevance and meaning for the European market and research communities. It bases on a series of meetings between invited experts that discussed the current technological and economic situation, its development in the near and far future, as well as future requirements towards cloud technologies to enable and maximize a European economic opportunity.

Project conclusions and recommendations

I. Suggested research topics:

Scale and elastic scalability of the cloud - Current solutions are not only restricted to horizontal scale out, but also inefficient as it tends to resource over usage due to limited scale down capabilities and full replication of instances rather than only of essential segments.
Cloud (systems) development and management - These systems are still executed mostly manually, thus contributing to substantial efficiency and bottleneck issues.
Data management - In particular as data size and diversity grows, pure replication is no viable approach, leading to consistency and efficiency issues. Also, the lacking control over data location and missing provenance poses security and legalistic issues.
Programming models and resource control - Current models are not aligned to highly scalable applications and thus do not exploit the capabilities of clouds, whilst they should also simplify development. Along the same line, developers, providers and users should be able to control and restrict distribution and scaling behaviour.
Trust, security and privacy - Apart from the issues inherent to any Internet provided service, additional aspects related e.g. to multi- tenancy and control over data location arise. What is more, clouds simplify malicious use of resources, e.g. for hacking purposes, but also for sensitive calculations (such as weapon design) etc.

II. Setting up the regulatory framework related to economical aspects (when, why, how to use which cloud system and how this impacts on the original infrastructure) legalistic issues (especially related to intellectual property rights and data protection) and Green IT (reducing power consumption).

III. The experts recommended as well:

- Setting up of large-scale research and experimentation test beds
- Development of joint programmes that encourage expert collaboration groups
- Encouraging the development and production of (a) CLOUD interoperation standards (b) an open source reference implementation
- Promoting the European leadership position in software through commercially relevant open source approaches

Conclusions and relation to the CROSSROAD roadmap

The Future of Cloud Computing	Relevance to CROSSROAD	Relation to CROSSROAD taxonomy				
Roadmap recommendations		**Open Government Information & Intelligence for Transparency**	**Social Networks, Citizen Engagement and Inclusion**	**Policy Modelling**	**Identity Management and Trust in Governance**	**Future Internet for Collaborative Governance**
Scale and elastic scalability	HIGH				X	X
Regulatory framework	HIGH					X
Large-scale research and experimentation test beds	HIGH					X
Joint programmes	HIGH					X
Open source reference implementation	HIGH	X				
Promoting the European leadership position through commercially relevant open source approaches	LOW					X

5. White Paper: "World Society Modeller"(S Gaia), FET Flagship Proposal within the Future IcT stream

Project description and rationale

S GAIA is a Flagship Proposal submitted to FET as part of the FuturIcT socio technical work stream. The project propose a creation of a ubiquitous toolset to be available to everyone, everywhere, every day, to handle social engagement meaningfully within the overall context of society, its individuals, groups, businesses, enterprises, professional and governmental institutions (including the Future Internet(s) of People, Things and Services (IoPTS) etc. The paradigm of S GAIA is that the above social context is a complex system of interacting entities. The processing of these is an essential requirement of the future Internet. The project comprises complexity science, computational socio-geonomics, and meta modelling. The applied ICT social complexity platform is called Metaloger.

S Gaia is a computer-human confluent modelling environment used to model society including its relationship to the world ecology. It will be pervasive across society's systems in use processing their dynamics and thus giving the capacity to model and build a joined up GAIA view of the world from a society perspective. It aims at discover the social genome, i.e. a meta model of society, i.e. 'the properties of society, that in some way determine human social existence. In its vision, it foresees building a new synthesis of Society and ICT that leverages society itself and will be a key component of the Information Society.

S GAIA will be a platform that can be considered as a kind of dynamic engine for human development, experiment, innovation and complex problem resolution constituted of:

- an interdisciplinary ecological framework for the progress of science and engineering,
- a global virtual world modelling and simulation environment (alias global/cloud computing), and an ubiquitous event based processing infrastructure, that handles complex emergent phenomena in socio-technic systems
- a vast and pervasive deployment infrastructure that supports people in matching the power of the toolset to the dynamics of life. This is the dimension of *computational purpose* engineering, plus *people* enablement, empowerment and engagement.

Project aims

Embedding the new science of computational socio-geonomics into the mainstream of systems practice; normative models enable integration of systems at any desired level of abstraction across micro, meso, and macro levels

Developing new forms of computational science, technologies and infrastructures, to support the new practice globally. The two salient features are "species" representation and a radically extended applied science of Meta modelling

Developing new paradigms of social engagement that can be termed "computer human confluence" in which the chief component that elucidates complex dynamics is that of *socially enacted information*

Conclusions and relation to the CROSSROAD roadmap

S-Gaia	Relevance to CROSSROAD	Relation to CROSSROAD taxonomy				
Roadmap recommendations		**Open Government Information & Intelligence for Transparency**	**Social Networks, Citizen Engagement and Inclusion**	**Policy Modelling**	**Identity Management and Trust in Governance**	**Future Internet for Collaborative Governance**
New science of computational socio-geonomics	HIGH			X		X
Meta-model of society	HIGH			X		
New paradigms of social engagement that can be termed "computer human confluence	HIGH		X			X

6. Internet of Things. Strategic Research Roadmap, 2009

Project description and rationale

The Internet of Things is an integrated part of Future Internet and could be defined as a dynamic global network infrastructure with self configuring capabilities based on standard and interoperable communication protocols where physical and virtual "things" have identities, physical attributes, and virtual personalities and use intelligent interfaces, and are seamlessly integrated into the information network. The vision of Future Internet based on standard communication protocols considers the merging of computer networks, Internet of Media (IoM), Internet of Services (IoS), and Internet of Things (IoT) into a common global IT platform of seamless networks and networked "things".

This future network of networks will be laid out as public/private infrastructures and dynamically extended and improved by terminals created by the "things" connecting to one another. We envisage that the Internet of Things will allow people and things to be connected Anytime, Anyplace, with Anything and Anyone, ideally using Any path/network and Any service.

The concept of Internet of Things can be regarded as an extension of the existing interaction between humans and applications through the new dimension of "Things" communication and integration. The main IoT technologies presented allow identifying the research and development challenges and outlining a roadmap for future research activities to provide practical and reliable

solutions.

Research needs

Identification Technology,
IoT Architecture
SOA Software Services for IoT
Internet of Things Architecture Technology,
Communication Technology,
Network Technology,
Software and algorithms,
Hardware Devices
Hardware Systems, Circuits and Architectures
Data and Signal Processing Technology, ·
Discovery and Search Engine Technologies
Power and Energy Storage Technologies, ·
Security and Privacy Technologies,
Material Technology
Standardisation

Conclusions and relation to the CROSSROAD roadmap

Internet of Things	**Relevance to CROSSROAD**	**Relation to CROSSROAD taxonomy**				
Roadmap recommendations		**Open Government Information & Intelligence for Transparency**	**Social Networks, Citizen Engagement and Inclusion**	**Policy Modelling**	**Identity Management and Trust in Governance**	**Future Internet for Collaborative Governance**
IoT architecture and technology	HIGH				X	X

7. The Living Roadmap of Complex Systems

The Living Roadmap of Complex Systems is an initiative of the Réseau National Des Systèmes Complexes (RNSC) is a consortium of scientific institutes (CNRS, CEMAGREF, CIRAD, IFREMER, INRA, INRIA, INSERM, IRD) and representatives of universities and colleges (CPU, CGE). It is aimed is to assemble all the actors that would like to contribute to the development of complex systems. The roadmap is built collaboratively on the complex systems roadmaps platform hosting several collaborative roadmaps from this domain.

The science of complex systems— (CS) *embraces irreducibility of system behaviour and emphasises adaptive self-organisation of components, without central design - often inspired by self-organisation in biological and social systems. It seeks to develop theoretical foundations that allow characterising the nature of transitions in behaviour - emergence - that occur when systems massively scale-up. The vision is to explore based on these foundations - radically new ways of monitoring, modelling and designing of such massive scale systems*[9].

The aim of living roadmap of complex systems is to identify in an on-going process a set of wide thematic domains for complex systems research over the next years.

Formal epistemology, experimentation, machine learning

The data collected on complex systems, typically on enormous scales, poses challenges for efforts to reconstruct their multiscale dynamics and their multiple downward and upward influences. The task requires the help of a formal epistemology and massive computation, and a generalization of the kind of "open science" originally inspired by the high-energy physics community. The challenges encompass computer tools for exploration and formalization and computer-assisted human interactions.

Stochastic and multiscale dynamics, instabilities and robustness

Hierarchical structures extending over a wide range of space-time scales are ubiquitous in the geosciences, the environment, physics, biology and socio-economic networks. They are the fundamental structures building up our four-dimensional world's complexity. Scale invariance, or "scaling" for short, is a powerful mathematical tool for characterising these structures and inferring properties across scales, instead of dealing with scale-dependent properties. Four-dimensional scaling analysis and modelling are still relatively little used and under-developed. Random dynamical system theory is also a powerful approach for grasping multiscale dynamics. Other important domains of investigation are phase transitions, emerging patterns and behaviours, which result when we move up in scale in the complex four-dimensional fields.

[9] FET Proactive Workshop on Objective IST-2007.8.4.The Science of Complex Systems for Socially Intelligent IC. Complexity Research Projects Forum, ECCS'07 Dresden, 6th October 2007

Collective behaviour in homogeneous and heterogeneous systems

From genetic and social networks to the ecosphere, we face systems composed of many distinct units, which display collective behaviour on space and time scales clearly separated from those of individual units. Among many others, we can mention cellular movements in tissue formation, flock dynamics, social and economic behaviour in human societies, or speciation in evolution. From a methodological point of view, successful modelling of such influences requires, at least: the quantification of environmental heterogeneities at different scales; the improvement of the formalization of heterogeneity; the identification of the heterogeneity features that are relevant at the population level and the study of population responses to changes in these heterogeneities.

From optimal control to multiscale governance

In order to compromise and to decide on policy actions to match the objectives, it is necessary to build an appropriate understanding of the phenomena, often through modelling which includes the effect of the potential actions. Unfortunately, current methods (reinforcement learning, viability, etc.) for assessing policy actions only work practically for models in state spaces of low dimensionality. Progress can be sought in two directions: either by extending these methods to multiscale and higher dimensionality dynamics and multi-level actions (e.g. central and decentralised), or by projecting multiscale dynamics into smaller spaces.

Reconstruction of multiscale dynamics, emergence and immergence processes

The data collected from complex systems are often incomplete and difficult to exploit because they are limited to a single level, i.e. refer to observations made on particular scales of space and time. Gathering data effectively first requires the definition of common concepts and pertinent variables for models at each level. Another important problem is obtaining unified and coherent representations useful for integrating different levels of organisation and for predicting the dynamics of the complete system.

Designing artificial complex systems

Modelling and simulation are crucial complementary tools in the exploration of complex systems. Artificial complex systems can be created to analyse, model and regulate natural complex systems. Conversely, new and emergent technologies can find inspiration from natural complex systems, whether physical, biological or social.

Emergence in physics: collective behaviour and fluctuations out-of-equilibrium

Away from equilibrium, in contrast, when external constraints are applied or during extremely slow relaxation toward equilibrium (glassy dynamics), one observes the emergence of collective behaviour at all scales, giving rise to complex patterns and dynamics as well as "anomalous" transport properties. Understanding the underlying mechanisms to these phenomena and identifying the universal features of these non-equilibrium situations is one of the major goals of physics in the 21st century.

Theory and Measure of Networks

The complex network approach is a way to work on the multiscale structure characterizing most complex systems. The challenges are liked to structure, hierarchy of nodes, classification of networks, measure and data formalisation as well as study of networks dynamics.

Perturbations and robustness of complex systems

An important characteristic of complex systems is their sensitivity and robustness to different kinds of perturbations. Understanding the evolution is a very important task, crucial for understanding the possibilities for system control. A second challenge relates to the importance of being able to identify the sensitivity to perturbations both for systems and associated models. The last challenge tackles the question of the appearance of collective forms or patterns as complex systems evolve.

"Prediction" versus "Understanding".

Data analysis can lead to a phenomenological model (which potentially allows prediction of the behaviour of a complex system at different scales) whereas to understand a complex system one needs a theoretical model (a set of laws).

Conclusions and relation to the CROSSROAD roadmap

Complex Systems		**Relation to CROSSROAD taxonomy**				
Roadmap recommendations	**Relevance to CROSSROAD**	**Open Government Information & Intelligence for Transparency**	**Social Networks, Citizen Engagement and Inclusion**	**Policy Modelling**	**Identity Management and Trust in Governance**	**Future Internet for Collaborative Governance**
Collective behaviour in homogeneous and heterogeneous systems	HIGH		X	X		
From optimal control to multiscale governance	HIGH			X		
Reconstruction of multiscale dynamics, emergence and	HIGH			X		

immergence processes						
Designing artificial complex systems	HIGH			X		
Emergence in physics: collective behaviour and fluctuations out-of-equilibrium	HIGH			X		
Theory and Measure of Networks	HIGH		X			
"Prediction" versus "Understanding"	HIGH			X		