Mission-oriented R&I policies: In-depth case studies

Case Study Report

e-Estonia

Virginia Castaños
March 2018

Research and Innovation

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A Study coordinated by the Joint Institute for Innovation Policy (JIIP)

February 2018 Directorate-General for Research and Innovation

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1 Summary of the case study

Summary fiche	
Title:	e-Estonia
Country:	Estonia
Thematic area:	e-Society, e-Government
Objective(s):	e-Estonia aims to make the government more efficient and transparent as well as boosting economic growth and increasing the overall wellbeing of the people of Estonia.
Main governing body:	Ministry of Economic Affairs and Communication
Timeline:	1996-2020
Budget:	The e-Estonia policy has been running for more than 20 years and it has been implemented through various types of policy instruments in a distributed form. Hence there is not any official estimation of the overall budget used for it.
Brief description of the case (250 words)	Estonia has been named 'the most advanced digital society in the world', Estonians have built an efficient, secure and transparent ecosystem that saves time and money. "e-Estonia" is a formidable success story that grew out of the partnership between a forward-thinking government, a proactive ICT sector, and a switched-on, tech-savvy population. When Estonia started building its information society about two decades ago, there was no digital data being collected about their citizens. The general population did not have internet access or even devices with which to use it. It took great courage to invest in IT solutions and take the information technology route. As a result, e-services have become routine for citizens of Estonia: i-voting, e-taxes, e-police, e-health care, e-notary, e-banking, e-census, e-school and much more. e-Estonia's success relies on a clever infrastructure that has made it possible to build a safe e-services ecosystem. Estonia sees the natural next step in the evolution becoming a safe e-state with automatic e-services available 24/7. Essential e-solutions in Estonia that enable the e-society to function smoothly were all built by local Estonian companies. Estonia IT sector has over 20 years of expertise and experience in automating public and private sector services. Today, Estonia has shared its e-governance journey with 60 governments and exported its solutions to over 130 countries around the world.
Implementation and organisation (a brief description of the governance and policy instruments used)	The Ministry of Economic Affairs and Communication developed the principles of information policies and the supportive legislation, also took responsibility for the supervision of relevant state organisations starting from 1993. e-Government developments have been done mainly by responsible ministries and state agencies. Every government department, ministry or business, gets to choose its own technology, based on commonly agreed principles. Estonia has established the role of a government chief information officer (CIO), who reports to the minister of economic affairs and communication (and effectively also to the prime minister, through the e-Estonia Council), to help oversee the coordination of digital projects, including IoT across government while maintaining the independence and uniqueness of each department's digital needs.[1]
Observed / expected outputs, outcomes, and impacts	Nowadays in Estonia, every person can provide digital signatures using their ID-card, Mobile-ID or Smart-ID, so they can safely identify themselves and use e-services. (98% of Estonians have ID-card).

[1] World Bank Group (2017). Internet of Things Report. http://documents.worldbank.org/curated/en/610081509689089303/pdf/120876-REVISED-WP-PUBLIC-Internet-of-Things-Report.pdf

	Estonia's solution for maintaining a modern State is X-Road, it allows the nation's various public and private sector e-Service databases to link up and function in harmony or in other words able to work together so that **data only needs to be requested from the citizen once**. (over 900 organizations and enterprises in Estonia use X-Road). After Estonia's experience with the 2007 cyber-attacks, scalable blockchain technology was developed to **ensure integrity of data stored** in government repositories, and to protect its data against insider threats. Estonia became host to the NATO Cooperative Cyber Defence Centre of Excellence and the European IT agency. Thanks to a safe, convenient and flexible digital ecosystem, Estonia has reached an unprecedented level of transparency in governance and built broad trust in its digital society (30% of Estonians use i-voting and 99% of public services are online 24/7). As a result, the Estonian Information Society Authority[2] claims savings of over 800 years of working time annually and that Estonia has become a hassle-free environment for business and entrepreneurship. Each person in Estonia that has visited a doctor has an online e-Health record that can be tracked and where data privacy is guaranteed. (95% of health data digitized and 99% of prescriptions are digital)[3] The educational digital revolution in Estonia aims to implement modern digital technology more efficiently and effectively in learning and teaching, and to improve the digital skills of the entire nation. For example, it includes ensuring that every student receives the necessary knowledge and skills to access modern digital infrastructure for future use. Estonia's success in the digital revolution can be seen in the educational landscape since twice as many students pursue IT careers in Estonia than the average in other OECD countries. Modern e-solutions make setting up and running a business in Estonia quick and easy. Estonia is one of the countries with most start-ups launched per capita in Europe, (98% of companies are established online, 99%of banking transactions are online, and 95% of tax declarations are filed online).
Assessment of the main elements of mission-oriented R&I initiative[4]	
Directionality (links to societal challenges, industry transformation):	**Yes**: Following regain of its independence in 1991, Estonia tremendously advanced in guaranteeing a societal challenge of the democratic society. The Estonian government turned to ICT solutions to enhance dialogue between the governors and the governed. The earliest and most notable actions were the introduction of the TOM (Today I Decide) system in 2001 (a system for citizens to submit ideas and proposals in the policymaking process), the introduction of e-voting in 2005 (an ID-car based system allowing citizens to vote online in local, national and European consultations) and the OSALE.EE platform in 2007 (a platform for public consultations and getting inputs on draft policy documents from individuals and interest groups)[5] The initiative can be also connected to the UN Goal 9 related to industry, innovation and infrastructure. e-Estonia is also key to finding lasting solutions to economic challenges, such as providing new jobs and promoting the ICT sector and significantly increase access to

[2] Information Society Authority (2018). https://www.ria.ee/x-tee/fact/#eng
[3] e-estonia (2018). https://e-estonia.com/solutions/healthcare/

[5] Joachim Astrom, Hille Hinsberg, Magnus E.Jonsson, Martin Karlsoon. Praxis Center for Policy Studies, Örebro University (2013) Citizen centric e-participation Sweeden. Estonia and Iceland.pdf. ISBN 978-9949-507-20-7

	information and communications technology and strive to provide universal and free access to the Internet. Additionally, like many developed nations, Estonia has introduced a number of Intelligent Transport Systems (ITS) solutions designed to make travel safer and logistics more convenient. For example, in March 2017, Estonia made it legal to test self-driven vehicles on all national and local roads in the country. Work is underway to create a full legal and cyber-risk management framework for using fully autonomous vehicles in regular road and traffic conditions.
Intentionality (specific, well-articulated goals):	**Yes**: The goals of e-Estonia have been quite clearly articulated and quantified. Estonian politicians recognised that investing money in internet and ICT, would be the most efficient way to reduce government costs while simultaneously improving the quality of life for citizens.
Clearly set timeline and milestones:	**To certain degree**: The e-Estonia is further developed with every legislation period. There have been the overall goals and targets for the information society policy. Every adjustment builds on the effort undertaken in the previous period. On the basis of the available material, it is difficult to assess whether the milestones have been clearly set on the outset. Some of those fundamental legislation milestones are the following:[6] • Databases Act (1997/ 2006) • Public Information Act (2001) • Digital Signatures Act (2000) • Act on Intellectual Property (applicable also for state databases) • Principles of Estonian Information Policy (1998, 2004) • Action Plan of Estonian Information Policy – (e-Estonia) (1998, 1999, 2000, 2001,2002, 2003, 2004, 2005, 2006...) • Personal Data Protection Act (1996) • Creation of the necessary e-government infrastructures to support the services: - Digitalized information: information systems and databases in all levels of government. - Formalized exchange: X-road, the connection of public and private sector e-Service databases by a data exchange service layer (2001- ..) - Electronic Identity: Authentication of a user by digital certificate embedded in the ID card or SIM card. • Establishment of services: - e-banking, e-cabinet, M-parking, e-tax (2000) - e-Geoportal (2001) - Digital Signature (2002) - e-School (2003) - e-ticket (2004) - i-Voting (2005) - e-Notary (2006) - e-Police, e-business (2007) - e-Health system (2008) - e-Prescription (2010) - e-Residence (2014)
Mobilises public and private investments:	**To certain degree**: Public investments in e-Estonia have been significant in particular those made by the central government but also by the banking and telecom sectors.

[6] Arvo Ott PhD (2012) eGovernment Academy. Estonia2.Arvo Ott_interoperability.pdf

	Due to the diversity of the sectors the digital solutions have been implemented in (education, health, tax, government, bank, security, business, etc) it is difficult to estimate the total budget for the e-Estonia initiative.
Focused on new knowledge creation (basic research, TRLs 1-4):	**To certain degree: KSI Blockchain technology** developed by the Estonians is also being used by NATO, U.S. Department of Defence, as well as European Union information systems to ensure cyber security. Although blockchain has only become hot technology in recent years, Estonia is leading the way in the blockchain revolution. Estonian government has been testing the technology already since 2008. Since 2012, blockchain has been in operational use in Estonia's registries, such as national health, judicial, legislative, security and commercial code systems, with plans to extend its use to other spheres such as personal medicine, cyber security and data embassies.
Focused on knowledge application (applied research, TRLs 5-9):	**Yes**: Applied research and application of knowledge have had an important role in this initiative. **X-Road is the secure backbone** of e-Estonia, the Estonian "protected territory" in the cyberspace. It is the environment that allows the nation's various databases, both in the public and private sector, to link up and operate in harmony. Estonians have an official **ID-card and Mobile ID**, which allow them to identify themselves in an online environment and provide legally binding digital signatures worldwide. Estonians have maximized the potential of an already existing technology, the Voice Over Internet Protocol (VOIP), to help people from all parts of the world to be connected in a faster and cheaper way via **Skype**.
Demand articulation (involves instruments for inducing demand):	**Yes**: Demand articulation has been carried out mainly through digital education plus accessibility. The following demand-side instruments have been used: • Tiger Leap Foundation to support ICT in schools (1996) • Look@World project, establishment of 500 Public Internet Access Points all over Estonia (2001) • Computer usage courses for 10% of adult population under Look@World project (2002. 2009-2010) • Free WIFI "movement"- the entire country of Estonia has managed virtually universal wireless Internet access through community participation[7]. • Come Along, computer usage courses for 100,000 citizens (2009/2011) • SmartLabs to support and promote IT-related after school activities among the youth in order to improve IT awareness and increase the number of youth choosing to study science or IT (2012-..) • Estonian smart device security project "NutiKaitse 2017". By using Nutikaitse 2017, at least 300,000 people in Estonia will use secure Mobile- ID for electronic authentication and digital signatures.
Multi-disciplinary (inter-disciplinary and/or trans-disciplinary):	**Yes**: e-Estonia is a collection of different project initiatives spreading through a number of sectors (education, banking, health, security, business, tax administration, etc.) All of them need access to infrastructures, security layers, identification and interfaces.
Joint coordination (multi-level and/or horizontal	**Yes**: e-Estonia can be seen as a continuous national policy. The Ministry of Economic Affairs and Communications is responsible for the

[7] Indrajit Basu (2008) Estonia Becomes E-stonia. http://www.govtech.com/e-government/Estonia-Becomes-E-stonia.html?topic=117673

governance of policies/finance):	development of the State Information Policy.[8] The central government is responsible for setting strategic direction, priorities and providing finance but at the same time the Estonian government is quite decentralised, leaving a lot of the implementation responsibilities to IT managers in ministries, county governors, boards and inspectorates.[9] Cyber Security is one of the most important topic in Estonia. Estonia has developed its information society highly dependent on its ICT infrastructure and electronic services. Therefore, Estonia has ensured that electronic solutions are not the Achilles heal for the society but vice versa the enabler of digital innovation and smart solutions.[10]
Reflexivity (flexible policy design, timely monitoring):	**Yes**: e-Estonia's success relies on a clever infrastructure that has made it possible to build a safe e-services ecosystem. An important part of this ecosystem is flexibility, and the ability to integrate its different parts, while improving the e-services and allowing government systems to grow.
Openness (connected to international agendas and networks):	**To certain degree**: The Ministry of Economic Affairs and Communications received a permit from the government to create a joint non-profit foundation between Estonia and Finland to develop the X-road. This NGO was called Nordic Institute for Interoperability Solutions (NIIS). In the future, the cross-border cooperation will make the development of X-Road more promising for Estonia, as NIIS is financed out of the budgets of both countries. By 2017, a membership fee of EUR 920,500 has been agreed upon.[11] A series of Russian cyber-attacks began 27 April 2007 that swamped websites of Estonian organisations. The direct result of the cyberattacks was the creation of the NATO Cooperative Cyber Defence Centre of Excellence in Tallinn, Estonia: its mission to enhance the capability, cooperation and information sharing among NATO, its member nations and partners in cyber defence by means of education, research and development, lessons learned and consultation. Due to the attacks, the Tallinn Manual on the International Law Applicable to Cyber Warfare was also developed.
Involvement of citizens:	**To certain degree**: e-Estonia's success relies on an open-minded citizenship, who are eager to use e-solutions, and a strong infrastructure that has made it possible to build a safe and user-friendly e-services ecosystem. The successor to citizen participation portal TOM «« Today I decide » (2001) was launched in 2007 (osale.ee), and is now the central consultation-participation portal for the Estonian Government. The portal, managed by the State Chancellery, is connected to the inter-ministerial electronic documentary system EIS. It aims to facilitate wider participation of citizens and civic organisations in politics, and also to draft legislation through discussions and consultation in accordance with relevant development plans. The portal is still operational, although several studies have been critical and consider osale.ee a failed e-democracy tool.

[8]Joinup (2016) eGovernment in Estonia. https://joinup.ec.europa.eu/sites/default/files/inline-files/eGovernment%20in%20Estonia%20-%20February%202016%20-%2018_00_v4_00.pdf

[9] World Bank (2006), "EU-8. Public Sector Capacity in the EU 8. E-Government in Estonia: Development and Best Practice. Background Paper", Report Number: 36930-GLB, available at siteresources.worldbank.org/INTSLOVAKIA/Resources/eGovernmentEstonia.doc

[10] Sandra Roosna, Raul Rikk (2015) eGovernance Acad emy Foundation, e-Estonia-e-Governance-in-Practice.pdf

[11] Ministry of Economic Affairs and Communications. https://www.mkm.ee/en/news/estonia-and-finland-set-non-profit-organisation-development-x-road

	Number of sustainable services co-designed by the public and the private/third sector was 0 in 2013 and the target level is 15 for 2020 [12] The X-Road Community was created in 2013, and meets twice a year. They discuss issues related to the X-Road, and seek solutions to these issues. The community is made up by developers, administrators and business process managers who are interested in being involved in the development of X-Road.

2 Context and objectives of the initiative

Estonia has a population of nearly 1.3 million inhabitants. Not long after its independence from the Soviet Union in 1991, the country decided that the online economy and massive technological innovation was the way forward for a tiny country with no natural resources to fall back on. IT solutions developed within the construction of the e-State constitute a part of the Estonian state administration. Estonia uses information technology as an instrument for increasing administrative capacity and ensuring an innovative and convenient living environment for citizens. That means a lifestyle that values simplicity, speed, comfort and economic savings. Therefore, the keywords behind the development of the e-State in Estonia are sustainable development and high-quality environment.

Since the 1990s Estonia has had a remarkable success in the development of the information society. The major factors that have influenced the evolution of the information society include economic factors, the active role of the public sector, the technological competency, and socio-cultural factors.

2.1 Contextual factors and origins of initiative

In 1996 a cooperative project named Tiger Leap[13] was launched between the government, the business sector, and the citizenship. Tiger Leap helped prioritise the development of an information technology infrastructure and initially provided educational institutes and public agencies access to computers and the Internet. Five years later, ten private and public companies formed a strong public-private partnership, creating the Look@World Foundation[14]. Supported by telecom and banking interests, the project raised digital awareness and popularized the use of the internet and Information and Communication Technologies (ICT), particularly in education, science and culture. The initiative's first project aimed to bridge the country's "digital divide" by providing free computer training to 102.697 participants (10% of the adult population[15]). Estonian children are taught computer programming starting at the age of seven. There's been no looking back. In July 2016, 91.4% of Estonians used the internet; a big jump from 2000, when only 28.6% of the population was connected. Around the same time, Estonia passed legislation that allowed the creation of infrastructures such as the national digital identity program[16] (ID Card) and the data exchange platform X-Road[17], both critical for developing the digital society systems that were to come. In the private sector, the nation's banking sector and the telecommunication sector introduced new online services and innovations like Mobile Parking[18], which signalled the growing digital capacity in the country. With a fully established and functional digital infrastructure in terms of technology, capacity, and regulatory frameworks, Estonia prepared to move into its next phase of digital revolution

[12] Ministry of Economic Affairs and Communications. https://www.mkm.ee/sites/default/files/digital_agenda_2020_estonia_engf.pdf
[13] e-estonia (2018). We Have Built a Digital Society and So Can You. http://www.e-estonia.com
[14] Look@World Foundation (2018). http://www.vaatamaailma.ee/about-us
[15] UNESCO, Mari Roonemaa (2017) Global lessons from Estonia´s tech-savvy government. https://en.unesco.org/courier/2017-april-june/global-lessons-estonia-s-tech-savvy-government
[16] e-estonia (2018). https://e-estonia.com/solutions/e-identity/id-card/.
[17] e-estonia(2108). https://e-estonia.com/solutions/interoperability-services/x-road/
[18] E-estonia (2018) https://e-estonia.com/solutions/location-based-services/mobile-parking/

in the form of Industry 4.0 and real-time economy, with an emphasis on Internet of Things (IoT).[19]

In its Digital 2020[20] agenda, Estonia anticipates the need to monitor current technology trends and carry out pilot projects to keep its information systems and services up to date and constantly evolving. These include technologies such as IoT, advanced analytics, big data, linked open data, augmented reality and privacy enhancing technologies. Highlighted in the Digital 2020 agenda is the belief that IoT can enable priority areas, such as the remote diagnostics of its infrastructure, energy consumption, and safer traffic and transport management.

In Estonia, the development of the information society is based on the Principles of the Estonian Information Policy, adopted by the Estonian Parliament in 1998. These principles were reviewed and updated in 2006 in the course of preparing the Estonian Information Society Strategy 2013 (Digital Agenda 2020).

Most of these principles remain relevant today[21]:

- The development of the **information society** in Estonia is a strategic choice to improve the competitiveness of the state and to increase the overall wellbeing of people.
- The public sector leads the way in pursuing the principles for the development of the information society.
- The **protection of fundamental freedoms and rights**, personal data and identity will be ensured. Individuals are the owners of their personal data and will have an opportunity to control how their personal data are used.
- The public sector will organise its processes so as to ensure that citizens, entrepreneurs and public bodies provide **any information only once**.
- The information society will be developed in **cooperation between the public, private and third sector** as well as all with other partners, including users of ICT solutions.
- When developing the information society, the continuity of the **Estonian language and culture will be ensured**.
- The information society will be created for all residents of Estonia, while particular attention will be paid to the integration of social groups with special needs, to regional development and to the strengthening of local initiatives. **Everybody should have access to the internet**.

Since 2000 Estonian R&D and innovation policy is financed from three main sources: targeted and baseline financing (national financing), foreign funds (mainly Structural Funds) and private funding. National funding has grown 7.5 times since the year 2000 in line with the R&D share in GDP from 0.61% in 2000 up to 1.63% in 2010 (MER, 2011)[22]. At the beginning of 2000, innovations alongside with overall economic growth emanate to a large extent from Foreign Direct Investments (FDI) made into Estonian economy together with inward technology transfer (technology imports). The positive factor derived by relatively high FDI inflow is the fast learning opportunities, which are necessary basis for

[19] 120876-REVISED-WP-PUBLIC-Internet-of-Things-Report.pdf , World Bank
[20] Estonia, Ministry of Economic Affairs and Communication. Digital Agenda 2020 for Estonia.
[21] E_estonia-E_government.pdf, E_Governance Academy Foundation, 2016
[22] Joint Research Centre (2013), Erawatch country report 2011: Estonia https://rio.jrc.ec.europa.eu/sites/default/files/riowatch_country_report/ERAWATCH%20Country%20Report%20Estonia%202011.pdf

generating own technological solutions. High level of FDI inflows to Estonia in turn has generated much optimism about the future perspectives of the Estonian industry[23].

Besides, societal inclination towards a fast acquisition of modern technologies, willingness to experiment with new solutions and internationally successful promotional campaigns have introduced Estonia in the international arena as a rapidly evolving information society. The keys to the success of Estonia's e-revolution have been cooperation and reciprocity. Successive governments have backed e-Estonia since it was launched in the early 1990s. The private sector, academic institutions and citizens have all cooperated to make the initiative a winner. Reciprocity, because the state has gained the confidence of its citizens, who in turn have given the state full access to their personal data. Estonians have a digital identification programme that is the envy of much larger countries – they can complete just about every municipal or state service online in a matter of minutes.

	Drivers	Barriers
Political	• Small new country • Active role of the public sector • Cooperation and reciprocity	
Economic	• Pro-active ICT sector and banking sector (Look@Word Foundation)	• Few resources
Societal	• Tech-savvy population • The confidence of its citizens	• Continuous learning of new interfaces and technologies
Technological	• Foreign Direct Investments(FDI) and technology imports • Interoperability Infrastructure and Enablers (X-Road framework, Internet network, Electronic Identty, Secure Data Exchange) • Pioneered state security standards.[24]	• Keep personal privacy
Legal	• The protection of fundamental freedoms and rights, personal data and identity is ensured	• Regulation changes required

The **X-Road framework** is one of the drivers that has catapulted Estonia to the top of various e-government rankings. This framework has been developed following the following principles of Estonian e-governance:

- **Decentralisation:** There's no central database and every stakeholder, whether a government department, ministry, or business, gets to choose its own system.
- **Interconnectivity**: All system elements exchange data securely and work smoothly together.
- **Integrity**: All data exchanges, M2M communications, data at rest, and log files are, thanks to the blockchain technology[25], independent and fully accountable.
- **Open platform**: Any institution may use the infrastructure and it works as an open source.
- **No legacy**: Continuous legal change and organic improvement of the technology and law. Once-only Principle[26]: data is collected only once by an institution, eliminating duplicated data and bureaucracy.

[23] Tarmo Kalvet (2001) ICT, Innovations and Innovation policy. http://ev2.ioc.ee/useful/evikings-ict-innov-policy.pdf
[24] e-estonia (2018). https://e-estonia.com/wp-content/uploads/eestonia-raamat-presentatsioon-2.pdf
[25] e-estonia (2018). https://e-estonia.com/solutions/security-and-safety/ksi-blockchain/
[26] SCOOP4C (2017) Serge Novaretti, Luukas KristjanIIvess. http://2017.tallinnconference.ee/app/uploads/2016/06/Once_Only_Principle_1.pdf

- **Transparency**: Citizens have the right to see their personal information and check how it is used by the government via log files.

2.2 Strategic and operative objectives and milestones of the initiative

Since 1998 the e-Estonia initiative has provided the creation and management of the information society, implementing cyber security measures, setting up electronic identity and secured data exchange, developing a new generation of broadband networks, formulating necessary regulations and educating citizens. All of them are important aspects for establishing an e-society.

In November 2013, the Government approved the Estonian Digital Agenda 2020 which will be used to establish a well-working state information and communication technology environment [27].

Four goals have been established to support the development of the Estonian information society:

- An ICT infrastructure that supports economic growth, the development of the state and the welfare of the population.
- Larger number of jobs with higher added value, improved international competitiveness and higher quality of life.
- Smarter governance.
- Enhanced awareness of Estonia as an e-state all over the world.

The development plan is supposed to help Estonia to achieve the strategic goals laid out in the competitiveness agenda, Estonia 2020, and the sustainable development strategy, Sustainable Estonia [28]:

- Improving the competitiveness of the economy
- Improving the welfare of people
- Contributing to more effective governance

Below is a list of priority initiatives and projects that are being developed:

- Completion of the next generation broadband network.
- The creation of a Nordic Digital Infrastructure Institute (NDII) — an international development centre for the joint development of X-Road, e-identity, digital signature and other components of the basic service infrastructure.
- 20% of the active population of the European Union (EU) should be using digital signature by 2020 to expedite business operations and facilitate management of personal matters. The take-up of digital signatures in the EU will be one of the primary goals of Estonia's foreign policy in the field of ICT and one of the priorities of Estonia's EU presidency in 2018.
- In the context of growing data volumes and widespread cross-usage of data, greater control over the use of their personal data will help people cope with certain loss of privacy.

[27] https://www.mkm.ee/en/objectives-activities/information-society
[28] Ministry of Economic Affairs and Communications.
https://www.mkm.ee/sites/default/files/digital_agenda_2020_estonia_engf.pdf

- Technology, user habits and legislation are in a constant state of change. Therefore, the public sector should not have any important ICT solutions that are older than 13 years.

- The public sector's capacity to apply data analytics solutions will be increased significantly over the coming years.

- The aspiration for Estonia is to become as recognised for its e-services as Switzerland is in the field of banking.

Some of the principal milestones:

- **Creation of "virtual embassis"**: to ensure the continuity of the state 'in the cloud', information systems critical for the functioning of the state will be securely preserved in 'virtual embassies' located in other countries, making Estonia more resilient in times of natural or man-made crisis.

- **Establishment of a Global information society Think Tank**: Estonia's reputation as a hub for innovation and development on information society will be promoted. This will be done by sharing the experience in e-governance and by promoting the underpinning concepts of information society, such as internet freedom, protection of privacy, etc.

- **By 2020, the number of people employed in the Estonian ICT sector will have doubled**. Activities set out in the Estonian Lifelong Learning Strategy 2020 will mainly contribute to this. However, these actions will be complemented by the current Digital Agenda by promoting ICT careers and studies, plus raising the quality of higher education in the field.

3 Resources and management

3.1 Governance and management model

The main steering body for the implementation of the strategy (Digital Agenda 2020) is the Information Society Council led by the Prime Minister. The members of the Council are the Minister of Economic Affairs and Communications, other ministers responsible for the development of information society and key nongovernmental experts, including representatives of the ICT sector.

The tasks of the **Information Society Council** are:

- to discuss and approve draft action plans and reports on their execution before submission to the Government of the Republic;
- to discuss and approve amendments to the strategy (including information society vision 2020) before submission to the Government of the Republic;
- to discuss and approve terms of reference for evaluations on the implementation of the strategy and to discuss the results of evaluations;
- to guide the co-operation between sectors and institutions in order to achieve the objectives of the strategy;
- to form opinion on matters of strategic importance for the development of information society in Estonia;
- to make proposals for drafting new policy documents for the development of information society in Estonia, reviewing and forming opinions on their drafts – including especially other national sectoral strategies and their action plans, legislative acts, Estonian positions in the EU and other international organisations;
- to fulfil the role of sectoral monitoring committee for EU Structural Funds in the areas of ICT policy (monitoring execution of programmes, discussing amendments to strategic documents, etc).

The day-to-day co-ordination of the implementation of the Digital Agenda (i.e. its action plans) is done through thematic or task-based working groups and networks (e.g. records management council, expert group on interoperability, etc.). The launch of working groups and networks will be decided either by the Information Society Council, the Minister for Economic Affairs and Communications or the Government of the Republic on the proposal of the Council or the Minister – depending on the topic or task at hand.

In addition, the network of CIOs of government agencies has an important role in organising everyday cooperation for executing the activities laid down in the action plans. The network is led by the Department of State Information Systems of the Ministry of Economic Affairs and Communications. The members of the network are the officials responsible for the ICT development in all ministerial areas, as well as the representatives of local authorities and the ICT sector.

MEAC centralises e-Estonia policy development but e-Government developments are decentralised and mainly done by responsible ministries and state agencies. Every government department, ministry or business, gets to choose its own technology, based on commonly agreed principles.

Cyber Security is one of the most important topics in Estonia. Estonia has developed its information society highly dependent on its ICT infrastructure and electronic services.

Therefore, Estonia has ensured that electronic solutions are not the Achilles heal for the society but vice versa the enabler of digital innovation and smart solutions.29

In Estonia, the most important cyber security roles and responsibilities are shared between the Ministry of Economic Affairs and Communications, the Ministry of Internal Affairs, and the Ministry of Defence.

Ministry of the Interior is responsible for developing identity management policies (including electronic identity), and coordinating national crisis management activities, including cyber crisis.

The **Ministry of Defence** is responsible for organising national defence by deterring attacks against Estonia and ensuring that Estonia is capable of defending itself against external threats. The Ministry has established the NATO Cooperative Cyber Defence Centre of Excellence with the mission to enhance the capability, cooperation and information sharing among NATO, its member nations and partners in cyber defence.

3.2 Financing model

The e-Estonia initiative has been running for nearly 20 years and it has been implemented through many different types of policy instruments over the time. Hence there is not, and largely cannot be, any official (or even unofficial) estimation of the overall budget used. Funding from the European Union Structural Funds amount to 85% of the financing used for information society development [30].

Estonia prioritized the ICT development and backed it up by real government resources around 1% of budget every year between 1994 and 2004.[31] The following table shows the annual budget from 1997 to 2002 according to the "Information Technology in Public Administration of Estonia" [32] It does not include the salary cost of ICT staff, expenditures on information technology of public sector agencies involved.

Table 1: e-Estonia budget 1997-2002. Source: Ministry of Economic Affairs and Communications (2002)

Year	Budget (MEUR)
1997	9.3
1998	8.6
1999	14.4
2000	11.75*
2001	12.8
2002	16.7

*Since year 2000 IT included direct cost and investment

In **2004–2006**, the sum allocated to support the development of the information society with the structural funds and the Cohesion Fund totalled to EUR 8.3 million.

In **2007–2013**, the development of the information society was supported with EUR 62.6 million and the broadband EUR 24.5 million in total EUR 87.1 million. In the period 2014–2020 a funding of EUR 200 million, coming both from their own and the EU funds, will be mainly allocated to the implementation of the digital agenda[33].

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[29] Sandra Roosna, Raul Rikk (2015) e-Governance Academy Foundation, e-Estonia-e-Governance-in-Practice.pdf.

[30] Ministry of Economic Affairs and Communications. https://www.mkm.ee/en/objectives-activities/information-society

[31] e-Governance Academy, e-Estonia. Strategic decisions for success. https://www.ria.ee/public/publikatsioonid/e-Estonia_plenary_session_demo.pdf

[32] Ministry of Economic Affairs and Communications (2002). "Information Technology in Public Administration of Estonia" Tallinn 2002, ISBN 9985-819-08-X

[33] Ministry of Economic Affair and Communications, https://www.mkm.ee/en/objectives-activities/information-society

The government information system, including maintenance costs, salaries, and investments, costs 50–60 million euros a year[34]. As compared to many other countries where expenditure on information technology is estimated to be 2.5-4% of the state budget, Estonian expenditures have been quite modest.

Unfortunately, there is not a clear public official budget available for the whole initiative *e-Estonia since 1994 until now.*

3.3 Key actors involved in the initiative

Actors involved belong to the quadruple helix: government, university, industry and third sector.

On the political level, two major Estonian ministries are involved in the development of eID:

- **Ministry of the Interior** (MoI) is responsible for the legal framework regulating identity documents. In addition, it is also the authority supervising the Police and Border Guard Board[35] (PBGB), directly responsible for issuance and maintenance of identification documents, and for maintaining electronic identities of residents at large.

- **Ministry of Economic Affairs and Communications** (MEAC) is responsible for the legal framework and implementation of the Digital Signatures Act[36] and eIDAS regulation[37], as well as the supervision of the Information System Authority (RIA), that coordinates the development and administration of the national information system, to help the state provide the best possible electronic services to citizens in a secure environment. [38]

  - **RIHA**[39], responsible for administrating the state information system, guarantees the transparency of the administration of the national information system and helps to plan national information management.
  - **The State Register of Certificates**, functioning under the MEAC, is a supervisory body for certification and time-stamping service providers.
  - **e-Identity Working Group** was originally established under the auspices of MEAC, and comprised different stakeholders from the public and private sector. The group held meetings when necessity addressing topical issues regarding eID maters.

There **are two private companies** that had an essential role in the delivery and management of the Estonian eID:

- TRÜB Baltic AS (owned by Gemalto AG) is the company responsible for manufacturing of plastic ID-cards, and also their personalization.

- Certification Centre (SK ID Solutions AS, SK) functions as a certification authority and maintains the electronic infrastructure necessary for issuing and using ID-cards. In addition, the Certification Centre acts as a Mobile-ID technology provider in close collaboration with major local telecom operators.

Nowadays IDEMIA, a world leader in digital security & identification technologies, is the company involved in the delivery and management of the Estonian eID.

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[34] Interview e-Government Academy of Estonia
[35] Ministry of the Interior, https://www2.politsei.ee/en/organisatsioon/organization/
[36] Ministry of Economic Affair and Communications, https://www.riigiteataja.ee/en/eli/530102013080/consolide
[37] Ministry of Economic Affair and Communications, http://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:32014R0910&from=EN
[38] Information System Authority, https://www.ria.ee/en/about-estonian-information-system-authority.html
[39] Information System Authority. https://www.ria.ee/en/administration-system-of-the-state-information-system.html.

Non-Governmental Organisations

- **E-Governance Academy (eGA)**: establishes and disseminates knowledge and best practices in the fields of e-governance, e-democracy, open information societies and national cybersecurity globally and assists other governments to implement Estonian e-governance model.

- **Look@World Foundation**: promotes the use of Internet and ICT in education, science and culture, e.g. projects on ICT-skills, safe usage of ICT, and ICT-related afterschool activates.

- **Estonian Association of Information Technology and Telecommunications**: voluntary umbrella organisation uniting Estonian IT and telecommunications companies aiming to promote their mutual co-operation in Estonia's development towards the digital society.

Academic Institutions

- **University of Tartu** leading centre of research and training in Estonia.

- **Tallinn University**, its interdisciplinary focus areas are educational innovation, digital and media culture, cultural competencies, healthy and sustainable lifestyle and society and open governance

3.4 Monitoring system and evaluation of the initiative

A vision network will be established under the leadership of the Strategy Unit of the Government Office in collaboration with the Ministry of Economic Affairs and Communications to monitor the progress towards realisation of the Estonian information society vision 2020 and the trends of information society and ICT in the world. The network will not be an official body; it will be a (mostly virtually working) community of cooperation and a platform for exchanging ideas.

Impact evaluations and performing monitoring typically take place at the level of singular instruments. The progress reports on the implantation status of the e-Estonia initiative are published in the e-Estonia web site[40]. The indicators used to evaluate the progress of the e-Estonia initiative are multiple (social indicators, financial indicators, healthcare indicators, e-government, ICT sector, etc.)

The e-Estonia initiative has been evaluated from different organizations and the highest rankings have been reached in different topics: number one - OECD tax competitiveness; World Economic Forum Entrepreneurship- European Commission EU Digital Economy and Society Index- FREEDOM HOUSE Internet Freedom, etc.

Furthermore, an overview about the activities undertaken under the initiative is provided via social media: Facebook, Twitter, LinkedIn, etc.

The e-Estonia initiative is being well communicated at different levels: professionals, citizens, foreign delegations, etc. e-Estonia Showroom offers a full overview of the e-solutions and guests receive an inspirational introduction to the underlying mechanisms involved in digitizing a society, an overview of the main challenges and policies, an understanding of the infrastructure, e-solutions and services, as well as contact with the IT industry.

3.5 Level and type of citizen engagement in the initiative

The e-Estonia initiative has been strongly led by the Estonian government with a top-down driven approach. In the first phase of the initiative, there is no evidence of the level and

[40] e-estonia (2018), https://e-estonia.com/wp-content/uploads/updated-facts-estonia.pdf

type of citizen engagement in the definition, implementation and monitoring of e-Estonia. Citizens are seen and regarded mainly as consumers and potential users of new e-services. This situation is largely a heritage of the former Soviet system, where developments based on customer feedback were not commonly practiced[41].

Nevertheless, this situation has been gradually changing as Estonian tertiary, or "free sector" has played an active role in shaping open governance and e-democracy. To coordinate public inputs for policy debate, three different portals have been created, funded by taxpayers (osale.ee, e-Consultation System, Rahvaalgatus.ee[42]). According to Secretary of State Heiki Loot, "Estonia is known to be the only country where the drafting of legislation and inter-ministerial coordination processes are so transparent."

In 2016, Estonia was recognized as one of countries that has best included NGOs in the process of consulting the open government plan of action. Last year, citizen initiative portal Rahvaalgatus.ee was launched, making it possible to compose and send collective initiatives to the Estonian Parliament.

Estonia has also made some bold moves in experimenting with modern methods of the decision-making process. Rahvakogu or the People's Assembly is a good example. Originally a platform of crowdsourcing ideas to amend electoral laws, three out of fifteen proposals sent to parliament via the online platform have actually become law.[43]

Estonians are proud of their public image as a tech-savvy nation, e-government isn't just a fact of the Estonian way of life, but also an indispensable part of national identity, what has been regarded as the foundation upon which modern Estonia has been built.

It has been also argued that the creation of "the most modern government" in the world has had really nothing to do with modernity or technology, but was instead dependent on something quite archaic, namely the tribal nature of the Estonian society – a point made by RND professor Wolfgang Drechsler. This makes Estonians less paranoid of power, which, in turn, makes it easier for them to entrust personal, and even sensitive information, such as medical records or voting data, to state information systems[44]. This is shown by figures: 98% of Estonians have a national ID-card, over 30% of Estonian voters from 116 countries use i-Voting in Estonian elections, 98% of companies are established online and 99% of banking transactions are online.

On the basis of the available information it seems that overall e-Estonia initiative has been quite widely communicated via different channels and social media. Many of the e-services have received attention in the press and the initiative has been also promoted at European level.

4 Policy instruments and wider policy-mix used for implementing the initiative

4.1 Description of the R&I policy instruments used for implementing the initiative

Estonia has established the foundation necessary to implement the e-Estonia initiative and strategies. The following policy instruments were tackled early on:

- **Policy/regulatory framework**, the government has established regulatory policies and regulatory frameworks that are not technology specific.

- **Institutionalization and governance**. The e-Estonia digital society evolution started reconsidering the state, its services, and its legal framework from scratch. Instead of

[41] European Commission, http://ec.europa.eu/invest-in-research/pdf/download_en/psi_countryprofile_estonia.pdf
[42] Republic of Estonia Government Office. https://riigikantselei.ee/en/engagement-and-participation
[43] UNESCO, Mari Roonemaa (2017) Global lessons from Estonia´s tech-savvy government. https://en.unesco.org/courier/2017-april-june/global-lessons-estonia-s-tech-savvy-government
[44] Kadi Vooglaid (2018). Estonian World. What should be the state´s role in a digital future? http://estonianworld.com/technology/kadi-maria-vooglaid-states-role-digital-future/

developing a single, all-encompassing, central system, Estonia has created an open, decentralised, and distributed system that links different services and databases effectively and securely.

- Technical infrastructure, especially for **interoperability**. Estonia has established the X-Road platform, which provides a shared platform in the form of a uniform protocol for data exchange between government bodies, and also with G2B and B2G.

- **Public-private partnerships**, including promoting businesses and start-ups. Estonia has actively engaged the private sector under the coordination of the government CIO to set goals for the Estonian ICT policy and to prepare the Digital Agenda 2020.

- **Competencies and education**. Estonia has placed significant emphasis on digital literacy at all levels. Within the government, there is strong emphasis on digital leadership and skills as part of competence models.

- **Data** sharing between institution in a safe way.

There are three crucial components that have facilitated Estonia's reliance on the Internet: The Electronic ID card, X-Road, and extensive public Wi-Fi. These three mechanisms have enabled Estonia to develop extensive systems that have enhanced government operations by eliminating useless bureaucracy, improved the quality of life for all Estonians, and have created thousands of jobs in the ICT sector.

- The **Electronic ID card** enable users to securely verify their identity and thus gain access to the online systems. Since e-ID cards are issued to every Estonian over the age of 15, 90% of citizens use this digital identification system on a constant basis.

- The **X-Road project** was launched by the Estonian government in the 1990's to create a secure and standardized environment for interconnection or enabling data exchange between a multitude of different information systems. X-Road is a solid backbone that has enabled creation of various innovative e-solutions[45]:

  - **Citizen portal** acts as a one-stop shop to government e-services starting from various information queries and ending at submitting applications (such as applying for child benefits and municipal day care centres) and exchanging documents with government agencies.
  - **Estonian e-health system** connects hospitals, clinics and other organisations to implement the unified Electronic Health Record[46] (e-health record) that supports health care by supplying medical practitioners with detailed information about patient's health all the while protecting their privacy.
  - **The e-prescription system** allows doctors to create prescriptions and make them immediately available to pharmacies. The patient can call the doctor and receive the medicine directly from pharmacy without having to visit the doctor for a paper-based prescription.
  - The e-File is an information system that manages **court proceedings** of various types. The e-File system uses X-Road to connect business processes of court, police, public prosecutors, prisons, lawyers and ordinary citizens.
  - **The e-police system** provides the police officers access to state registers such as vehicle register and document register. For example, the police can use this system to check whether a suspiciously behaving vehicle is reported as stolen. Due to the ubiquitous access to up-to-date information, Estonian citizens do not need to carry a driver's license or vehicle documents as such information is verified online directly from the source.

[45] Cibernetica, https://cyber.ee/en/e-government/x-road/
[46] e-estonia (2018) https://e-estonia.com/solutions/healthcare/e-health-record/

Figure 1: X-Road Estonia. Source: Ott, 2014[47]

- The existence of **public Wi-Fi** throughout Estonia, even in loosely populated areas, enables all citizens to have constant access to each of the nations' online programs.

- And finally, **the Cyber Security**: the Estonian national cyber security arrangements allow public and private sectors and citizens to interact securely in a common data exchange environment while ensuring confidentiality and privacy. The result is that Estonia has thousands of e-services, which are accessible worldwide

Figure 2: Cyber Security. Source: E-Governance Academy[48]

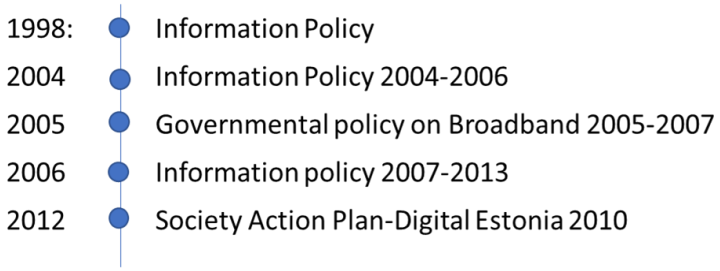
[47] Arvo Ott PhD (2014) e-Governance Academy. Estonia2.Arvo Ott_interoperability.pdf
[48] E-Governance Academy

4.2 Connections with other policies

Different policies and instruments have contributed to e-Estonia initiative. Here is the timeline of the e-Government development in different areas: administration, education, legislation, police and infrastructure.[49] The private sector, academic institutions and citizens all have cooperated to make the initiative a winner.

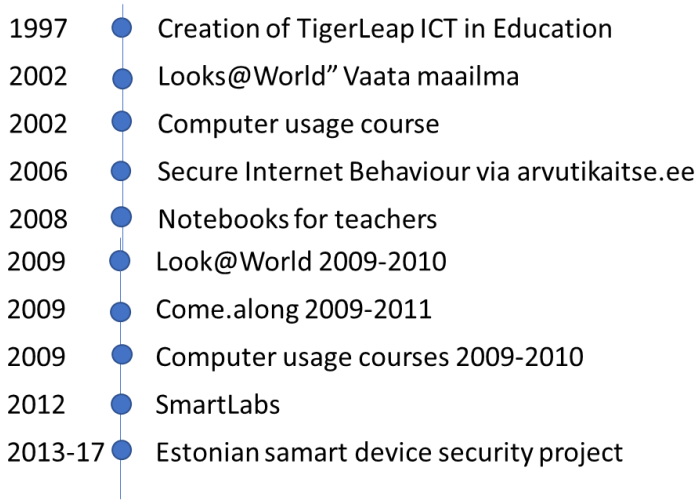
Policy:

Successive governments have backed e-Estonia since it was launched in 1998. Several policies and action plans have contributed looking forward to the best way of digitalizing society and the state. The Government approves the Cyber Security Strategy for 2014–2017 with the objective of increasing the capacity of the state in the area of cyber security and raising the awareness of the population of cyber risks.



Education:

In Estonia, a variety of ICT education programmes have played an essential role in the success and widespread utilisation of the country's electronic identity system for various transactional processes, as well as in the overall growth in the number of people using different e-services. The main partner organisations participating in ICT knowledge transfer projects have been Look@ World and Tiger Leap Foundation. Various campaigns and training courses aimed at improving digital literacy, such as the computer and internet training programme "Come Along!", have been organised on the initiative of the private sector and with the participation of the public sector.

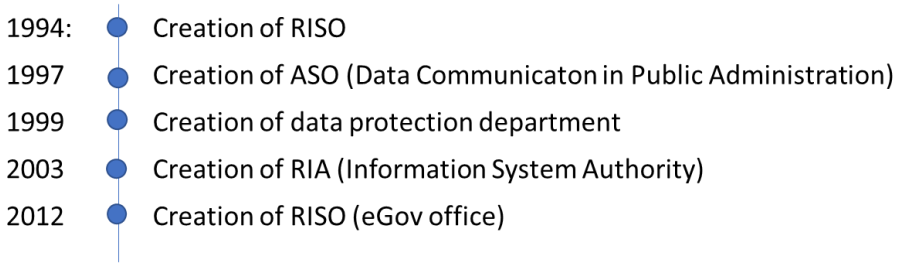


Administration:

Moving towards e-Governance in daily public administration, however, requires extensive organisational and administrative changes, without which the expected benefits will remain

[49] e-Governance Academy (2017) Welcome to Estonia. http://ega.ee/wp-content/uploads/2016/09/eGA-esitlus-eEstonia_2016_PDF.pdf

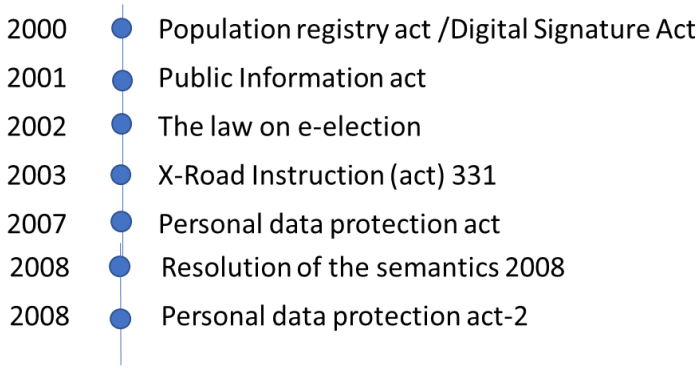
just a dream. Formation of the Estonian information society was full of challenges and the creation of new agencies and offices has been required for manage it:



Legislation:

Acts are adopted to develop the e-services. Estonia has been often reported as a country with favourable legislative environment towards ICT and the most important legislative acts have been approved without external pressure. Indeed, in some instances, the regulatory framework has been crucial. For example, the Public Information Act took effect in January 2001. This Act included significant provisions on electronic access and disclosure (e.g., the duty to maintain websites, obligation to ensure that the information is not 'outdated, inaccurate or misleading', e-mail requests must be treated as official requests for information, etc.). Information disclosed via a website is very extensive and has changes routines how information is handled within public sphere contributing to the emergence of 'good governance' in Estonia[50].

Approved on 8 March 2000, the Digital Signatures Act, provides the necessary conditions for using digital signatures and the procedure for exercising supervision over the provision of certification services and timestamping services. Digital signature has the same legal consequences as a hand-written signature.



Infrastructure:

e-Estonia's success relies on a clever infrastructure that has made it possible to build a safe e-services ecosystem. An important part of this ecosystem is flexibility and the ability to integrate its different parts, while improving e-services and allowing government systems to grow.

The "EstWin" project aims to bring ultra-fast internet to the rural areas of Estonia. The Estonian Association of Information Technology and Telecommunications deployed a middle mile passive network mainly to the rural areas of the country. A big part of the project funding came from the European Agricultural Fund for Rural Development (EAFRD) and the European Regional Development Fund (ERDF).[51]

[50] Tarmo Kalvet (2007), PRAXIS working paper nº 29. The Estonian Information Society Developments since the 1990's.
[51] https://www.youtube.com/watch?v=a_W9G6a38ZE

In addition to the implementation of the Digital Agenda, coordination must be ensured between the ICT policy and other policies that are key to the development of information society (including the Estonian information society vision 2020). For this purpose, bilateral or multilateral meetings of ministries are held under the leadership of the Ministry of Economic Affairs and Communications and/or the Government Office, e.g. to harmonise the execution of different sectoral strategies and to agree or report on actions laid down in the work programme of the Government of the Republic.[52]

4.3 Key turning points of the initiative and policy adaptation measures.

Estonia passed legislation that allowed the creation of infrastructure that has been key turning point of the iniciative:

- The national **digital identity** (ID Card) program and the data exchange ***platform X-Road***, both critical for developing the digital society systems that were to come.
- In the private sector, the nation's banks and telecoms introduced online services, which signaled the growing digital capacity in the country.

With a fully established and functional digital infrastructure in terms of technology, capacity, and regulatory frameworks, Estonia prepared to move into its next phase of digital revolution in the form of Industry 4.0 and real-time economy, with an emphasis on IoT. In its Digital Agenda 2020, Estonia foresees the need to prioritise areas, such as the remote diagnostics of its infrastructure, energy consumption, and safer traffic and transport management[53].

Major changes / turning points of the initiative	Description of the flexibility mechanism / policy adaptation measures
The Tiger Leap program in Estonian schools, 1996	The program fully equipped schools with computers and Internet access and other ICT services. Computer science classes were provided in 84% of schools in the following eight years. Besides, Estonia has become one of the developed start-up ecosystems where young ICT companies are booming. ICT is one of the key technologies that are currently leading the paradigm that started in the beginning of the 1990s. The successful combination of education and enterprise shows the role of ICT as the engine of the innovation-driven development in a small society.
The Principles of the Estonian Information Policy, adopted by the Estonian Parliament, 1998	These principles were reviewed and updated in 2006 in the course of preparing the Estonian Information Society Strategy 2013 (Digital Agenda 2020). The current principles serve as a basis for an action plan for establishing an information society. An important link between policies and action plans was also

[52] Ministry of Economic Affairs and Communications. https://www.mkm.ee/sites/default/files/digital_agenda_2020_estonia_engf.pdf.

[53] World Bank Group (2017). Internet of Things Report. http://documents.worldbank.org/curated/en/610081509689089303/pdf/120876-REVISED-WP-PUBLIC-Internet-of-Things-Report.pdf.

	established since then. On the basis of the Principles, an Information Policy Action Plan that is updated annually was developed where all Government agencies made specific proposals with schedules, sources of finance, and responsibilities for implementation of information policy.
X Road	The service infrastructure (X-Road, public key infrastructure and eID, the document exchange centre, state portal eesti.ee) has allowed Estonia to improve public services with ICT solutions fast and flexibly. The distributed and interoperable state information system has created a good potential for Estonia to seize and benefit from the trend towards more and more devices and machines being connected to the computer network.
Cyberattack	Estonian computer networks were subject to a cyberattack in April and May 2007 following the tensions with Russia over the removal of a Soviet-era war memorial. Avoidance of cybercrime has been an important field in Estonia and has been promoted by all major information society stakeholders. This was the idea behind Estonian Public Key Infrastructure and ID cards and later eServices Interoperability Architecture; banks have been also very active in increasing awareness regarding cybercrimes. The most recent step in this respect is an initiative 'Computer Protection 2009 with the objective of becoming the country with the most secure information society.
Digital Agenda 2020 for Estonia	This plan has been effective since 2013. The focus for this period is creating an environment that facilitates the use of ICT and the development of smart solutions in Estonia in general. The goal is to increase the economic competitiveness, the well-being of people and the efficiency of public administration

5 Realised or expected outputs, outcomes and impacts

5.1 Outputs and new instruments

Today, **almost everything is done digitally**, from filing taxes to paying for parking. In school, child's attendance, homework and grades are all available online. Residents can pay for parking through their mobile phones, or reserve time slots for passing border checkpoints. 95% of citizens file their taxes online through the E-Tax electronic tax filing system, which only takes an average of three to five minutes to complete. Health records are digitized, while residents can also sign legally binding contracts online, or register a business. Business owners can also check their property and legal records online. You can even apply for e-residency digitally.

Estonia also has one of the **fastest connection speeds** in the world, the result of fiber-optic cabling established throughout the country by 2012. Wi-Fi is available free of charge throughout the country.

Estonia has a Public Key Infrastructure (PKI), a binary key code that has a public and private key. The PKI ties a person's public key with their identity, so that **the digital identity of a person can be verified**. That means that any misuse of information can be immediately identified. In addition, citizens or e-residents can view a log of who has their information, and also who has actually accessed their information. Through a Data Protection Inspectorate, e-residents can file a complaint if they believe their information is being misused.

5.2 Outcomes

The indicators below show how IT-solutions have improved everyday life in Estonia. [54]

Outcomes Areas	Indicators
Savings and efficiency	• At least 2% of state GDP is saved due to collective use of digital signatures • 800 years of working time are saved annually thanks to data exchange. • Time to establish a business reduced from 5 days to 18 minutes
Financial indicators	• 98% of companies are established online • 99% of banking transactions are online • 95% of tax declarations are filed online – it takes only 3 minutes!
e-Government indicators:	• 98% of Estonians have a national ID-card. • Over 25,000 people have applied for e-Residency. • Over 30% of Estonian voters from 116 countries use i-Voting in Estonian elections.
Healthcare:	• 97% of patients have countrywide-accessible digital records. • 97% of prescriptions are digital. • 500,000 queries by doctors and 300,000 queries by patients every year.
X-Road data exchange platform:	• 99% of public services online with 24/7 access. • 500 million queries annually via X-Road. • No system downtime since 2001.
Public safety:	• Police work has become 50 times more effective thanks to IT solutions. • e-Police system available in police cars unites over 15 databases, including those of Schengen and Interpol. • Estonia was the first country in the EU to legalise testing self-driving vehicles on public roads.
Cyber security:	• Locked Shields is the world's largest and most advanced international technical live-fire cyber defence exercise. • it takes place annually in Estonia concurrent with the CYCON conference. • Estonian government started live tests with KSI Blockchain technology in 2008. Today, KSI Blockchain service is available globally in more than 180 countries. • Estonia hosts the NATO Cooperative Cyber Defence Centre of Excellence and European IT agency.
Education:	• First in Europe in the OECD PISA test. • Two times more students in ICT. • Related courses on the average than in developed countries. • 85% of schools use e-School where one million grades are entered every day.

[54] e-Governance Academy (2017) Welcome to Estonia. http://ega.ee/wp-content/uploads/2016/09/eGA-esitlus-eEstonia_2016_PDF.pdf

5.3 Impacts

So far, e-Estonia initiative has led to major social and cultural impact for Estonians. Estonians are proud of its **public image as a tech-savvy nation**, e-government isn't just a fact of the Estonian way of life, it is also an indispensable part of national identity.

Besides, this initiative has been an **international success** as testified by the large and increasing number of consultations by researchers, experts and foreign delegations that looking for solution and lesson learned in his way to Estonia´s digitalizing.

Estonia's digitization began with the rejection of Finland's old analog telephone exchange. Now, the roles have been reversed. In 2015, Finland introduced a partial version of X-Road with the aim of moving towards a more digitized society, with support from Estonia. The Estonian and Finnish governments are also embarking on cross-border data exchange.

Any country today can set up their own **X-Road system**. The X-Road technology is now open-sourced and readily available for any country to employ. Central components of its source codes were published openly under a MIT license on October 2016. In fact, Azerbaijan and Namibia are deployed it into their own digital systems. Azerbaijan, for instance, has enlisted the help of the company that developed X-Road to create an "updated version of Estonia's X-Road." Namibia is similarly deploying the same technology, with the help of Estonian companies like Cybernetica and e-Governance Academy[55]. Ukraine started in 2017 deployment of the x-road based secure data exchange system[56]

Today, Estonia is **a model of digitization**. It points to the road forward, and with its open-source technology, it has now paved the road for those who want to follow.

Through private and public cooperation, Estonia's information society and e-government have become one of the most advanced in the world – due to the ICT solutions that have become part of Estonians lives, Estonia is now known as e-Estonia. Private and public-sector cooperation will create even more opportunities, which in turn, will increase economic growth resulting in the **Estonian ICT sector becoming increasingly stronger with each passing year**.

e-Governance has had significant **social impacts** in Estonia.

- The introduction of IT has helped to strengthen public order in Estonia and assist in the case of accidents. The use of IT tools in the security services (e-Police, rescue board, emergency centre) has halved the number of deaths by accident in Estonia over the last 20 years.

- Citizens can select e-solutions from among a range of public services at a time and place convenient to them. In most cases there is no need to physically attend the agency providing the service.

- The efficiency of e-Government is most clearly expressed in terms of the working time ordinary people and officials save, which would otherwise be spent on bureaucracy and document handling.

- Modern e-solutions have made setting up and running a business in Estonia quick and easy.

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[55] Wen Hoe (2017) John F.Kennedy School of Government, Harvard university. https://www.innovations.harvard.edu/blog/estonia-one-small-country-digital-government-having-big-impact-x-road

[56] Mari Pedak e-Governance Academy. Estonia, Sweeden and the EU to help Ukraine implement a secure data exchange solution. http://www.ega.ee/news/estonia-sweden-eu-to-help-ukraine-implement-a-secure-data-exchange-solution/

- Employees of the security services are now able to remotely determine 35% of the locations of accident victims to within a 5-metre radius, and 93% of emergency calls are answered within 10 seconds.

- Today, over 95% of the data generated by hospitals and doctors has been digitized, and blockchain technology is used for assuring the integrity of stored electronic medical records as well as system access logs.[57]

5.4 Summary of the key indicators

<table>
<tr><th>Key indicators</th><th></th></tr>
<tr><td>Timeline:</td><td>1998-/2013-20</td></tr>
<tr><td>Objective and targets:</td><td>The general objective of the strategy is to contribute to achieving higher growth, more jobs and increased welfare by creating an environment supporting the use and development of ICT solutions. General objective is divided in five sub-objectives:
1. ICT infrastructure for economic growth, smarter governance and the well-being of individuals;
Target: Everybody has access to fast and free internet
Target: Basic (service) infrastructure supports the management of personal and business matters both nationally and cross-border
2. Better ICT skills for more jobs with higher added value, increased international competitiveness
Target: People know how to use the internet to improve their quality of life and have the necessary skills
Target: More higher value-adding jobs through higher ICT skills and higher quality of life;
3.Smarter governance and public administration;
Target: Public services are easy to use and cost-effective
Target: Services are developed and policies are formulated in co-operation between the public sector and the citizens
4.Greater awareness of e-Estonia in the world.
Target: The development of information society in Estonia is knowledge-based and takes into account worldwide trends
Target: Estonia is a world-renowned e-state</td></tr>
<tr><td>Total budget:</td><td>Unfortunately, there is not a clear public official budget available for the whole indicative e-Estonia since 1997 until now.</td></tr>
<tr><td>Annual budget:</td><td>
<table>
<tr><th>Year</th><th>Budget (Mll EUR)</th></tr>
<tr><td>1997</td><td>9,3</td></tr>
<tr><td>1998</td><td>8,6</td></tr>
<tr><td>1999</td><td>14,4</td></tr>
<tr><td>2000</td><td>11,75</td></tr>
<tr><td>2001</td><td>12,8</td></tr>
<tr><td>2002</td><td>16,7</td></tr>
<tr><td>2004-2006</td><td>8,3 (Structural Funds)</td></tr>
<tr><td>2007-2013</td><td>87,1</td></tr>
<tr><td>2014-2020</td><td>200</td></tr>
</table>
</td></tr>
<tr><td>Share of budget, public funding:</td><td>NA</td></tr>
<tr><td>Share of budget, private investment:</td><td>NA</td></tr>
<tr><td>Leverage effect (additional public/private investments the initiative has triggered):</td><td>NA</td></tr>
<tr><td>Key (official/public) indicators applied for monitoring the progress towards the targets:</td><td>The indicators for monitoring the current Digital Agenda 2020: Progress will be measured with the following indicators:
• Take-up of 100Mbit/s or faster internet connections</td></tr>
</table>

[57] e-estonia (2018). https://e-estonia.com/

- Share of internet non-users among 16 to 74 years olds in Estonia
- Satisfaction with the quality of public services among adult population ages in Estonia
- Satisfaction with the quality of public services among entrepreneurs
- Share of ICT professionals in total employment

The fulfilment of all targets under the four sub-objectives will be measured with the following indicators

1.ICT infrastructure for economic growth, smarter governance and the well-being of individuals;

- Fixed internet access for all households
- Access to mobile internet throughout Estonia
- Take-up of 100 Mbit/s or faster internet subscriptions
- Estonia is among the top five countries in terms of internet freedom
- Share of people using the secure electronic identity among all the people holding any eID
- Number of valid eIDs issued to non-residents
- Share of economically active population in the EU using digital signatures
- Number of Nordic (or other) countries with whom Estonia has jointly developed basic infrastructure components
- Number of countries with whom Estonia has developed cross-border public services based on the Estonian basic infrastructure (e.g. X-Road or eID)
- Number of enterprises having joined the X-Road

2. Better ICT skills for more jobs with higher added value, increased international competitiveness

- Share of internet non-users among 16 to 74-year olds in Estonia*
- Share of people considering their computer skills sufficient to protect their personal data on the internet
- Share of people having used e-commerce (% of all people aged 16 to 74)
- Share of people having used cross-border e-commerce (% of all users of e-commerce)
- Share of 16 to 74-year-old residents considering their computer skills sufficient for looking for or changing jobs over the following year
- Employers' satisfaction with the ICT skills of employees available in the labour market
- Share of ICT professionals in total employment*
- Share of ICT products and services in total export
- Share of ICT professionals in total employment

3.Smarter governance and public administration;

- Share of public services corresponding to common quality requirements, % of all public services
- Awareness of public e-services among adult population aged 16 to 74
- Awareness of public e-services among entrepreneurs
- Satisfaction with public services* among adult population aged 16 to 74
- Satisfaction with public services* among entrepreneurs
- Share of paperless interaction in total official communication
- Share of machine-processable e-invoices exchanged between the public and private sector
- Services life-cycle cost index
- Share of internet users having used the possibilities of e-inclusion

	• Share of ministries publishing feedback on their websites about the results of public consultations • Number of sustainable services co-designed by the public and the private/third sector • Number of training and pilot projects designed to improve the quality of policy-making • by using ICT 4.Greater awareness of e-Estonia in the world. • Number of public and private sector key figures having participated in information society events • Availability of national information society statistics and its relevance to policy-making needs • Coverage of e-Estonia in international media
Other key indicators (e.g. outputs/outcomes/impacts):	-

6 Conclusions and lessons learned

6.1 Identification and assessment of key strengths and weaknesses of the initiative

Strengths	Weaknesses
• General consensus among main forces in Estonian society. • Commitment of political elites. • Right mix of private and public initiative. • Active role of government. • Project based development. • Little baggage of previous practices. • It has managed to spread in many directions, covering different sectors. • It has so far also gained public acceptance and the e-tools offered are widely used.	• The rate of ICT deployment differs from on institutions to another, it's necessary training leaders for improving digitizing deployment.[58] • Despite its progressive use of IT technologies, Estonia is still ranked 9th in the DESI index, with the main point for improvement being digitizing companies.59

The Estonian experience has shown that the main criticism of an information society –loss of privacy or privacy violations – can be overcome. A successful information society based on e-solutions can be built safely without compromising privacy. A comprehensive and consistent explanation shows users how their rights are protected so that trust in e-solutions can grow as each individual perceives how they benefit from them.[60]

In addition, a change of mentality is needed, institutional leaders are required to take on new challenges as it is necessary to provide them inspiring training on the benefits and advantages of digitization.

6.2 Lessons learned and key messages for European R&I policy

Estonia, located in the Northern part of Europe and surrounded by the Baltic Sea in the west, was considered as one of the most liberal economies in the world. After gaining freedom from the Soviet rule in 1991, Estonia was left with minimum resources and infrastructure. But, the vision of its leaders helped the country to mark its presence among the world countries in a short period of time. The leaders understood that 'Internet' was

[58] Interview e-Governance Academy of Estonia
[59] European Commission. https://ec.europa.eu/digital-single-market/en/scoreboard/estonia
[60] e-estonia. https://e-estonia.com/wp-content/uploads/stories-a4-v02-lessons-learned.pdf

the key ingredient for the development of the country and strived towards building an e-society combining together government, people and technology. The result was 'e-Estonia', one of the most advanced e-societies in the world – a success story that grew out of a partnership between an innovative government, participative ICT sector and switched-on-tech-savvy citizens. The success of e-governance has helped Estonians and the Estonian nation to enjoy a wide range of e-solutions. In addition to this, the model has become a paradigm for others who wish to follow the same path.

e-Estonia's success relies on and a strong infrastructure that has made it possible to build a safe and user-friendly e-services ecosystem. Thanks to a safe, convenient, and flexible infrastructure, Estonia has reached an unprecedented level of e-services which may be invisible for the user, that means that the government can provide automatically e-service to the user reducing bureaucracy and time.

The main critical factor that a state should take into account to digitize its society and provide invisible services are[61]:

- Once-only – Data is collected only once by any institution, eliminating duplicated data and bureaucracy.
- Interoperability – All system elements exchange data securely and work smoothly together.
- Digital Identity- It is provided to authenticate people without physical contact.
- Cross border services- As businesses and citizens become more mobile, the need for truly international e-services becomes more pressing to provide cross border data exchange. This has enormous potential for facilitating access to entrepreneurship, tax payment, e-commerce etc.

Besides trust, another crucial feature of the Estonian digital infrastructure is its transparency—as an Estonian citizen (or an e-Resident) you can always log in to your personal government side interface and see who has enquired information about you a police officer, a doctor you visited earlier, or a tax official.

The lesson of Estonian digital transformation success is a lesson on trust and transparency. Any company or organisation, which looks into digital transformation and innovation, has to rely on its customers', members' or employees' trust for the initiative. If there is a lack of trust, then look into ways on how new technology could improve it (as blockchain does). Blockchain technology solves many of the problems that data governance professionals have been trying to solve for years. The technology developed by the Estonians is also being used by NATO, US Department of Defence, as well as European Union information systems to ensure cyber security.

As a summary recommendations from e-Estonia experience, the following messages can be drawn for other governments in their aims towards digitalisation[62]:

Lessons learnt from government perspective:

- Strong cooperation with private sector in implementation and awareness raising.
- Promotion of all aspects of information society in a holistic manner.
- Creation and maintaining the legislative framework.

[61] Interview with e-Governance Academy of Estonia

[62] Interview with e-Governance Academy of Estonia, see also Laying the foundations of e-Estonia. https://www.ria.ee/public/publikatsioonid/Laying_the_Foundations_demo.pdf

- View IT developments together with public administrative reform.
- Promotion of a project based development (more chance for self-correction, if something doesn't work).
- As government: take care of your culture and language (nobody else will do it for you).

Lessons for better digital government:

- Create digital resources.
- Connect all government offices.
- Train your people to use the technology.
- Create the rules for public information.
- Consider your IT advisor as part of the management team.
- Use administrative compulsion for businesses but not for citizens.

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Estonia has been named 'the most advanced digital society in the world' as a result of their long-term policy e-Estonia. The initiative grew out of the partnership between a forward-thinking government, a proactive ICT sector, and a switched-on, tech-savvy population, and have built an efficient, secure and transparent ecosystem that saves time and money. Different types of e-services have become routine for citizens of Estonia: i-voting, e-taxes, e-police, e-health care, e-notary, e-banking, e-census, e-school and much more. The success of the initiative relies on a clever infrastructure that has made it possible to build a safe e-services ecosystem. Essential solutions that enable the e-society to function smoothly were all built by local Estonian companies. Estonia has shared its e-governance journey with 60 governments globally, and exported its solutions to over 130 countries around the world.

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