ACSH Partnership for Excellence
Ministry of the Interior and Safety Republic of Korea
NIA NATIONAL INFORMATION SOCIETY AGENCY
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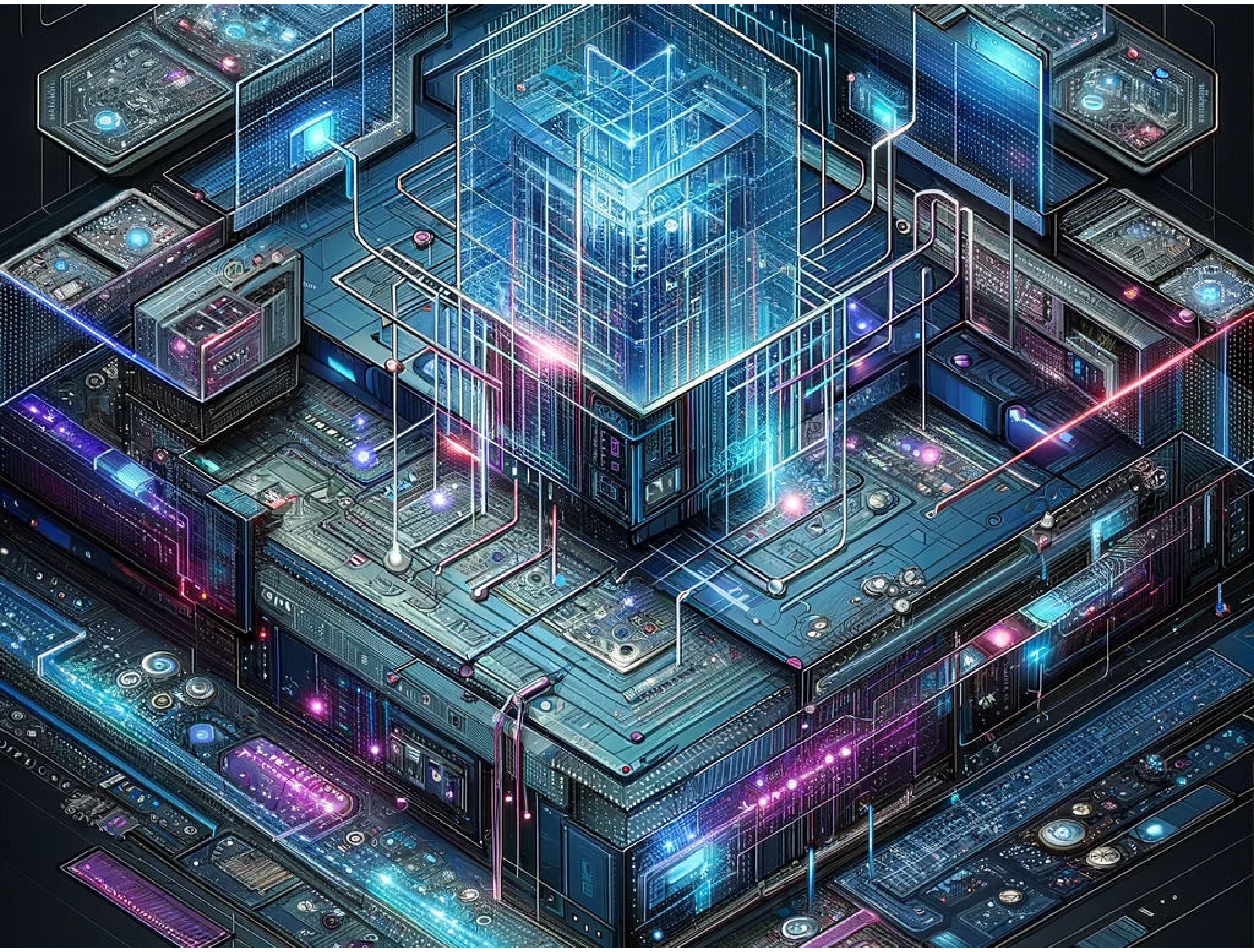
Standards Frameworks for **digital** transformation



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This publication is an output of the “Capacity Building for Innovation in Governance and Digitalisation of Public Services” project, funded by the Government of the Republic of Korea, and jointly implemented by the United Nations Development Programme (UNDP) in Kazakhstan, and the Astana Civil Service Hub (ACSH) in close cooperation with the Ministry of the Interior and Safety (MOIS) and the National Information Society Agency (NIA) of the Republic of Korea.

The knowledge product is intended for policy makers, practitioners, experts, scholars, students, and all those interested in digital transformation related issues and the utilisation of various standards in the constantly expanding digital landscape.

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Prologue

The rapid and extensive adoption of digital technologies and their far-reaching and pervasive impact on people's lives dictates the necessity for a set of standards for digital transformation governance. A set of minimum common principles and guidelines to define and standardise such aspects as safety, security, reliability, efficiency, interoperability, and trust of digital systems and environments are definitely required (UNIDO, 2021).

Standards play a crucial role in shaping the digital transformation process, as they provide a common framework for digital technology applications. They also complement regulations and laws, contributing to digital transformation governance. Adoption of standards fosters compatibility and interoperability among services, products, and processes, while guaranteeing minimum levels of quality and safety. Furthermore, standards can serve as accelerators of change as they promote innovation, and they can ensure the successful scale-up of digital solutions to confront common problems.

This publication was developed in the framework of the joint project implemented through collaborative efforts of the Ministry of the Interior and Safety and the National Information Society Agency of the Republic of Korea, the United Nations Development Programme in Kazakhstan and the Astana Civil Service Hub. It provides an extensive presentation of several standards frameworks utilised across the world. This knowledge product covers areas such as effective utilisation of information technologies, cybersecurity, data privacy protection, cloud computing, infrastructure, etc that can contribute to the digital transformation of the participating countries' public sectors.

We hope that this knowledge product will be useful in the process of digitalisation of government operations and instrumental to improving public service delivery. By sharing valuable information and promoting the highest standards for digital transformation, it makes a substantial contribution to the ongoing progress and success of the participating countries in the constantly evolving digital landscape.

We sincerely hope that you will find the content of this publication informative and useful. Its ultimate aim is to contribute to acquisition of knowledge and expertise for enhancing the participating countries' efforts and actions to establish robust digital systems.

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The Project aims at increasing the capacity of civil servants and practitioners involved in the implementation of innovations in the system of public administration and the digitalisation of public services in seven countries of Central Asia (Kazakhstan, the Kyrgyz Republic, Tajikistan, and Uzbekistan) and the Caucasus (Armenia, Azerbaijan, and Georgia). The Project runs for three years (2021-2023) and it involves capacity building workshops and seminars, and the development of knowledge products.

Special thanks are extended to the ACSH Research and Knowledge Management Team, who devoted considerable time and effort to produce this publication.

We are also grateful to the Government of the Republic of Korea for its generous financial and substantive contribution for accomplishing this piece of work.

About the Ministry of the Interior and Safety (MOIS)

The Ministry of the Interior and Safety (MOIS) is responsible for general affairs of the State Council, promulgation of Acts and subordinate statutes and treaties, government organisation and prescribed number of public officials, awards and decorations, government innovation, administrative efficiency, digital government, personal information protection, management of government buildings and support for elections and referendums. Furthermore, MOIS actively promotes local autonomy and decentralisation by supporting business, finance and taxation of local governments and mediating disputes among local governments. In addition, MOIS takes charge of establishing, supervising, and adjusting policies related to safety and disaster management such as emergency countermeasures, civil defence, and disaster prevention.

With the mission of leading government innovation for a sustainable future by providing more integrated and customised services for the citizens, promoting ethical and efficient use of digital technology, and strengthening private-public partnerships, MOIS has been leading the digital transformation of the public sector and collaborating with its partner countries to build a better digital society for all around the globe.

More information at www.mois.go.kr/eng/sub/a02/aboutMinistry/screen.do

About the National Information Society Agency (NIA)

The National Information Society Agency is a public institution founded by the Framework Act on Intelligent Informatization (Article 12), under the Ministry of Science and ICT and the Ministry of the Interior and Safety of Korea. Since its establishment in 1987, it has played a leading role in promoting national informatisation and the digital government of Korea. It has administered important ICT policies and infrastructure projects, including the Master Plan for the National Basic Information System (1987), the establishment of the Super High Speed Information Network (1995). 11 Initiatives and 31 Tasks for e-Government (2001 and 2003 respectively), the enactment of the Act on Promotion of the Provision and Use of Public Data (2013), and the establishment and promotion of the 5G+ Strategy and the National AI Strategy (2019).

With the emergence of the digital transformation era, NIA is working to develop and use key ICT technologies for introducing the DNA+ Strategy to successfully turn Korea into an integrated data-based society - DNA+ stands for Data, Network, AI, and the plus sign symbolises the pre-emptive response measures to various issues such as the digital divide among different social classes and overt-reliance on various ICT devices. Its ultimate goal is to resolve social issues and open the future for the nation with ICT.

More information at eng.nia.or.kr/site/nia_eng/04/10401000000002016093002.jsp

About the United Nations Development Programme (UNDP)

The United Nations Development Programme (UNDP) is the leading United Nations organisation fighting to end the injustice of poverty, inequality, and climate change. Working with a broad network of experts and partners in 170 countries, it help nations to build integrated, lasting solutions for people and the planet.

More information at www.undp.org

About the Astana Civil Service Hub (ACSH)

The Astana Civil Service Hub is a flagship initiative of the Government of Kazakhstan and the United Nations Development Programme. It was created in 2013 by 5 international organisations and 25 countries: now comprising 43 participating countries. The geographical range of its participants stretches from the Americas and Europe through the CIS, the Caucasus, and Central Asia to ASEAN countries, demonstrating that partnerships for civil service excellence is a constant and universal need for all nations.

Its mandate is to assist in the promotion of public service effectiveness by supporting the efforts of governments of the participating countries in building institutional and human capacity; and thus, contributing to the improvement of civil service systems in the countries of the region and beyond.

The Astana Civil Service Hub is a multilateral institutional platform for the continuous exchange of knowledge and experience in the field of public service development, aiming at supporting government in the region and beyond through fostering partnerships, capacity building and peer-to-peer learning activities, and evidence-based research.

More information at www.astanacivilservicehub.org

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Introduction

In an era marked by the relentless advance of digital technologies, the need for standard frameworks in the realm of digital transformation governance becomes increasingly apparent. The profound and widespread impact of these technologies on individuals, organisations, and societies underscores the urgency of establishing a common set of principles and guidelines to ensure that the digital landscape operates smoothly and securely. These standards are essential for shaping the way we navigate the digital frontier, defining parameters such as safety, security, reliability, efficiency, interoperability, and trust in digital systems and environments. By setting common minimum standards, we create a foundation upon which the digital world can evolve, flourish, and ultimately benefit humanity.

The importance of these standards cannot be overstated. They provide a shared framework that enhances the compatibility and interoperability of digital services, products, and processes. This, in turn, guarantees minimum levels of quality and safety, thus fostering a sense of uniformity in the digital realm. Moreover, standards are instrumental in facilitating innovation, acting as catalysts for positive change in the technology landscape. By adhering to these standards, digital solutions can be scaled up to address common problems effectively, ensuring that the benefits of digital transformation are accessible to all.

The implications of establishing such standards reverberate far beyond the confines of the digital realm. With access ensured, these standards have the potential to break down spatial and social barriers, bringing about a more inclusive and connected world. They open doors to new forms of employment and entrepreneurship, empowering individuals to tap into the vast opportunities presented by the digital age. However, in this transformation, there also lurks the threat of automation and robotics displacing traditional jobs, underscoring the need for careful and considerate governance of digital transformation. In this complex interplay between technology and society, standardisation becomes the guiding compass, helping us navigate toward a future where the benefits of digital innovation are realised, while minimising potential disruptions and ensuring the well-being of all.

Digital technologies, with their transformative potential, offer a unique pathway to address and advance the United Nations Sustainable Development Goals (SDGs), particularly SDG 16 and SDG 17. SDG 16 seeks to foster peaceful, just, and inclusive societies by equally distributing the benefits of digital technologies. Standard frameworks for digital transformation governance are instrumental in achieving this goal. By ensuring that digital systems and environments adhere to principles of fairness, safety, and trust, these standards can help bridge the digital divide, ensuring that the advantages of technological progress are accessible to all. Through the establishment of common minimum standards, marginalised communities can participate more fully in the digital age, thus promoting social inclusion and justice.

Furthermore, the transnational nature of many disruptive digital technologies necessitates a coordinated international effort to build effective regulations and policies, aligning with the principles of SDG 17. Standardisation in digital transformation governance plays a pivotal role in fostering global collaboration and partnerships. As different nations and regions embrace digital transformation, standard frameworks provide a common language and set of expectations that facilitate international consensus on regulatory matters. These standards create a foundation for harmonising policies and regulations across borders, enabling smoother cross-border data flows, trade, and cooperation. In the pursuit of sustainable development, especially in areas like climate change, healthcare, and poverty reduction, international cooperation underpinned by digital technology standards becomes a linchpin for success, allowing nations to work together effectively towards achieving the shared objectives of the SDGs.

In essence, the establishment of digital technology standards not only serves as a bridge to ensure the equitable distribution of benefits, aligning with SDG 16, but also promotes international collaboration and consensus-building, essential elements in advancing the transformative agenda of the SDGs, particularly SDG 17. These standards provide the necessary scaffolding upon which a more peaceful, just, inclusive, and sustainable world can be built in the digital age, ultimately propelling us towards a more prosperous and harmonious future for all.

The relationship between standards, regulations, and policies forms a circular and interdependent ecosystem that underpins the concept of good governance in the digital age. Standards provide the foundational framework upon which sound regulations and policies are built. Good governance ensures that digital transformation advances societal well-being while mitigating risks and imbalances.

Standards offer common principles and guidelines, serving as the basis for creating effective regulations. Regulatory bodies and policymakers use these standards to develop laws that align with the digital landscape, promoting consistency and predictability.

In return, well-crafted regulations and policies strengthen standards by enshrining them in law, enhancing compliance and incentivizing innovation. They also promote transparency, accountability, and fairness; vital components of good governance. This circular relationship fosters an environment where digital transformation occurs within an ethical, secure framework, contributing to a just, inclusive, and prosperous future for all.

In the realm of digital transformation, several key principles guide the development and implementation of standards, each contributing to the overarching goal of good governance. These principles are the cornerstones upon which the digital landscape can be built to benefit all.

- ***Trustworthiness:*** Trust is at the core of digital interactions. Standards should ensure the trustworthiness of digital systems, assuring users that their data and transactions are secure, reliable, and transparent.
- ***Inclusiveness:*** Digital transformation should leave no one behind. Standards should be designed to foster inclusivity, making technology accessible and beneficial for all individuals and communities, regardless of their circumstances.
- ***Sustainability:*** As the digital world expands, its impact on the environment becomes more evident. Standards must prioritize sustainability, encouraging eco-friendly practices, responsible resource usage, and energy efficiency.
- ***Interoperability:*** In a world of diverse digital systems, interoperability is key. Standards should enable different technologies to work seamlessly together, enhancing the user experience and promoting innovation.
- ***Safety and Security:*** Cyber threats are ever-present. Standards should prioritize safety and security, providing a robust framework to protect systems and data, and mitigate risks and vulnerabilities.
- ***Data Privacy:*** Personal data is a valuable asset. Standards must ensure data privacy, safeguarding individuals' rights and fostering trust in digital interactions.
- ***International Collaboration:*** Digital transformation transcends borders. International collaboration is essential, and standards should promote global cooperation, harmonizing practices, and regulations to enable cross-border innovation and trade.

These principles are the compass guiding the development and implementation of digital transformation standards. They not only contribute to good governance but also serve as a roadmap for creating a digital future that benefits everyone while addressing the complex challenges of our interconnected world.

In the pursuit of these fundamental principles, various established frameworks and standards play a pivotal role in shaping the digital transformation landscape. These standards, by virtue of their comprehensiveness and effectiveness, have earned their place as guiding beacons in the ever-evolving digital age.

This comprehensive publication covers a range of vital frameworks and standards, providing in-depth insights into their features, specifications, and regulations. The opening standard highlighted in this publication is the Information Technology Infrastructure Library (ITIL), renowned for its effectiveness in efficiently managing and delivering IT services. ITIL plays a pivotal role in advocating best practices in service management, making it an invaluable resource for organisations striving to optimize their IT service delivery.

After ITIL, the e-Government Interoperability Framework is presented. This framework is designed to bolster interoperability and data exchange within the public sector, ensuring that government services are not only accessible but also highly efficient. Its focus on enhancing accessibility and efficiency is instrumental for effective public administration.

The publication proceeds to delve into the Open Group Architecture Framework (TOGAF) and the Control Objectives for Information and Related Technologies (COBIT). TOGAF provides a comprehensive methodology for enterprise architecture, streamlining the design, planning, implementation, and management of an organisation's IT infrastructure. COBIT, on the other hand, delivers a holistic framework for the governance and management of enterprise IT, with a strong emphasis on risk management, value delivery, and resource optimisation.

It continues with the e-Government Interoperability Framework (e-GIF) whose main thrust is to adopt the Internet and World Wide Web specifications for all government systems. Then, with the Cloud Computing Reference Architecture Framework, which offers organisations a well-defined reference architecture for implementing cloud computing solutions. This framework serves as a valuable guide, ensuring that cloud services are adopted securely and effectively, helping organisations harness the benefits of cloud technology while mitigating potential risks.

The General Data Protection Regulation (GDPR) is another pivotal standard outlined in the publication. GDPR has emerged as a global benchmark for data protection and privacy regulations. It sets stringent standards for safeguarding individuals' personal data and imposes obligations on organisations responsible for handling such data. Compliance with GDPR is essential for organisations operating in the European Union and handling the personal data of EU citizens.

Continuing with the publication, the ISO/IEC 27001:2022 standard is introduced. This international standard focuses on information security management systems, offering a systematic approach to protecting sensitive information. ISO/IEC 27001:2022 serves as a valuable resource for organisations aiming to establish robust information security practices and safeguard their data assets effectively.

The Cybersecurity Framework, developed by the National Institute of Standards and Technology (NIST), is another noteworthy framework discussed. It provides comprehensive guidelines for organisations to manage and reduce cybersecurity risks. In an increasingly digital and interconnected world, this framework plays a vital role in helping organisations bolster their cybersecurity posture and protect against a wide range of threats.

These standards collectively represent the essential building blocks for a well-structured and secure digital environment, setting the stage for the effective governance of digital transformation while aligning with the principles of trustworthiness, inclusiveness, sustainability, interoperability, safety and security, data privacy, and international collaboration. Through their implementation, we can navigate the complex challenges of the digital age, ensuring that the benefits of technology are harnessed responsibly and equitably.

I. Information Technology Infrastructure Library Framework (ITIL)

I.1. Introduction

I.1.1 ITIL and its evolution over time

The ITIL framework stands as a widely embraced framework for effective ICT service management. It extends its guidance to diverse service providers, irrespective of industry, aiming to enhance the efficiency and quality of ICT services. This framework holds direct sway over an organisation's processes, services, and functions. It aids in managing ICT services for both internal and external customers, offering essential skills to achieve digital business goals. Aligning ICT with a company's business objectives is a complex endeavour demanding adept technological capabilities. The primary objective of the technology sector is to facilitate the organisation in attaining its overarching aims.

Initially conceived as the acronym "Information Technology Infrastructure Library," ITIL has evolved into a brand, boasting a three-decade existence. While it is no longer an acronym, it remains a trusted guide encompassing adaptable best practices. It acknowledges the distinct professional contexts of organisations, encouraging flexible implementation that conforms to unique requirements. This prompts the question: Why manage ICT services?

Information management holds a strategic role in shaping an organisation's business strategies. Effective ICT service management optimises business processes, elevating their efficiency and effectiveness in handling critical information. Moreover, it fosters the feasibility of diverse business models. Consider the scenario of businesses like banks, airlines, e-commerce platforms, and supermarkets, as well as government organisations operating devoid of ICT. It becomes evident that such entities would struggle to function without digital technologies. These businesses depend extensively on ICT, a concern continuously echoed across organisations.

Presently, a substantial share of business processes relies on ICT resources, underscoring its paramount importance in operations. Simultaneously, service interruptions can yield severe consequences. With mounting demands for ICT services across organisations and business entities, the preparation of technology departments often lags, engendering a juxtaposition between demand and supply. Hence, a meticulous analysis of an organisation's ICT services becomes indispensable, coupled with continuous vigilance. Within this context, this paper aims to showcase how the ITIL framework can bolster ICT processes and services, thereby augmenting organisational management.

Originating in the 1980s under the guidance of the British Government's Central Computer and Telecommunications Agency (CCTA), the ITIL framework began as an assemblage of over 30 books that gradually evolved. These volumes systematically encapsulated IT best practices sourced globally, including contributions from vendors.

In April 2001, the CCTA underwent integration into the Office of Government Commerce (OGC), now known as the Cabinet Office. The OGC adopted the ITIL project, aligning with its mission to collaborate with the UK public sector in catalysing efficiency, optimising fiscal value, and enhancing success in programme and project deliveries.

Contrary to creating a marketable proprietary product, the impetus was to collect best practices addressing the government's growing reliance on IT, compounded by an absence of standardised procedures that inflated costs and propagated errors. It became evident that disseminating these practices would be advantageous for both public and private sectors.

Over time, ITIL's credibility was cemented. By 2005, its practices harmonised with the ISO/IEC

20000 Service Management Standard, the inaugural international benchmark for IT service management, grounded in the British Standard BS 15000.

Since 2013, ITIL has been owned by Axelos, a collaborative entity between the Cabinet Office and Capita. Axelos grants business licenses for ITIL framework utilisation, overseeing updates and process adaptations. However, internal ITIL use within organisations does not require a license. In 2011, ITIL v3 was released, bringing revisions to the 2007 OGC version.

A transformative juncture arrived in 2018 when Axelos introduced ITIL 4, a significant framework overhaul since ITIL v3's inception. Rolled out at the beginning of 2019, ITIL 4 embodies agility, adaptability, and customisation tailored for contemporary enterprises. This version champions interconnectivity, collaboration, and integration of agile and DevOps into IT service management strategies.

I.1.2 Explanation of the need for standardised IT service management practices

The need for standardised IT service management practices arises from the intricate nature of modern businesses and the critical role that information technology (IT) plays in their operations. Standardised IT service management practices offer a structured and systematic approach to managing IT services. They enhance efficiency, quality, risk management, and collaboration while enabling organisations to meet regulatory requirements and adapt to changing business needs.

I.2. Overview

I.2.1 Key Concepts, Principles, and Processes

At the core of the ITIL framework lie several key concepts that form its philosophical underpinnings. The concept of ***"Service"*** embodies the essence of delivering value to customers, underscoring ITIL's customer-centric approach. ***"Service management"*** encompasses the specialised organisational capabilities required to create, deliver, and manage these services effectively. The notions of ***"Service provider"*** and ***"Customer"*** establish distinct roles and responsibilities, ensuring a clear delineation in service interactions. The ***"Service lifecycle"*** concept orchestrates the sequential stages of ITIL, guiding organisations through the holistic journey of service management.

Embracing a set of guiding principles, ITIL directs organisations towards excellence in service management. The principle ***"Focus on value"*** places customer satisfaction and value delivery at the forefront. The principle ***"Start where you are"*** encourages incremental improvement, recognising the existing capabilities within an organisation. ***"Design for experience"*** highlights the importance of user satisfaction and usability. ***"Work holistically"*** urges collaboration across IT functions for seamless service delivery. The principle ***"Progress iteratively"*** advocates for continuous enhancement, while the tenets of ***"Observe directly"*** and "be transparent" emphasise informed decision-making and open communication. Similarly, the principle ***"Keep it simple"*** underscores the significance of simplicity in design and operation.
Woven into the fabric of these concepts and principles are the fundamental processes of ITIL. ***"Incident management"*** ensures swift resolution of disruptions, minimising downtime, and service impact. ***"Problem management"*** delves into root cause analysis to prevent recurring incidents, enhancing service stability. ***"Change management"*** oversees the introduction of changes to services, reducing risks and service disruptions. ***"Service level management"*** focuses on defining and monitoring service levels to meet customer expectations. ***"Capacity management"*** optimises resource utilisation for efficient service delivery. ***"Availability management"*** guarantees service availability by proactively addressing potential disruptions. ***"IT service continuity management"*** ensures service resilience in the face of disasters. ***"Financial management for IT services"*** manages IT finances for cost optimisation.

"Configuration management" maintains accurate records of IT assets. ***"Release and deployment management"*** ensures smooth introduction of changes. ***"Knowledge management"*** captures and shares organisational knowledge.

Table 1: Key reasons for standardised IT service management practices

Dimension	**Concepts and Principles**
Consistency and Predictability	Standardised IT service management practices establish a uniform approach to delivering services. This consistency ensures that services are provided in a predictable manner, leading to better customer experiences and reduced disruptions.
Efficiency and Productivity	Standardised processes eliminate redundancies, optimise workflows, and reduce the chances of errors. This streamlined approach enhances the efficiency and productivity of IT operations.
Quality Assurance	Standardised practices are based on proven methodologies and best practices. Following these practices ensures higher service quality, minimising the risks of errors and service failures.
Risk Management	Standardised practices include procedures for identifying, assessing, and mitigating risks. This proactive approach helps in identifying potential issues before they escalate into major problems.
Scalability	Standardised practices can be scaled up or down to accommodate the changing needs of an organisation. As the business grows or evolves, standardised processes ensure that the quality of services remains consistent.
Interdepartmental Collaboration	Standardised practices facilitate better communication and collaboration between different IT teams and departments. This alignment minimises conflicts and ensures that everyone is on the same page.
Regulatory Compliance	Many industries are subject to regulations and standards related to data security, privacy, and IT governance. Standardised practices help organisations meet these compliance requirements, avoiding legal and financial repercussions.
Continuous Improvement	Standardised practices often include mechanisms for regular review and improvement. This ensures that processes remain up-to-date, aligned with industry trends, and continuously optimised.
Reduced Training Time	New employees can quickly adapt to standardised processes as they follow established guidelines. This reduces the time and resources required for training and onboarding.
Enhanced Customer Satisfaction	Consistent service delivery and faster issue resolution lead to higher levels of customer satisfaction. Meeting customer expectations becomes easier with standardised practices in place.
Benchmarking and Best Practices	Standardised practices allow organisations to benchmark their performance against industry standards and best practices. This helps identify areas for improvement and innovation.
Change Management	Standardised practices provide a structured framework for implementing changes. This minimises the impact of changes on ongoing operations and ensures proper testing and validation.

I.2.2 Significance of Concepts and Processes: Elevating IT Service Delivery and Management

Each concept and process within ITIL contributes significantly to the improvement of IT service delivery and management. The ***"Service"*** concept directs attention to customer value, emphasising that services must align with business objectives and customer needs. ***"Service management"*** provides a structured approach to delivering value, incorporating processes, people, technology, and resources. The ***"Service provider and customer"*** distinction foster clear roles and accountability, enhancing communication and collaboration. The ***"Service lifecycle"*** offers a holistic framework for creating, delivering, managing, and improving services, ensuring strategic alignment and continuous enhancement.

ITIL processes bear profound significance in service management. ***"Incident management"*** minimises disruptions, ensuring timely service restoration. ***"Problem management"*** addresses root causes, preventing repeated incidents. ***"Change management"*** minimises risks during changes, maintaining service stability. ***"Service level management"*** aligns IT services with business objectives, enhancing customer satisfaction. ***"Capacity management"*** optimises resource usage, preventing under or over-provisioning. ***"Availability management"*** ensures uninterrupted service availability. ***"IT service continuity management"*** safeguards services during disasters, maintaining business continuity. ***"Financial management for IT services"*** optimises resource allocation, achieving cost efficiency. ***"Configuration management"*** ensures accurate records of IT assets, facilitating change management. ***"Release and deployment management"*** introduces changes seamlessly, reducing service disruptions. ***"Knowledge management"*** enhances decision-making and problem-solving, empowering organisations.

I.2.3 ITIL Framework and Lifecycle Approach

Central to ITIL's efficacy is its lifecycle approach. The ITIL framework comprises five stages, each representing a critical phase of the service lifecycle:

- ***Service Strategy:*** This phase encompasses understanding business goals, analysing market demands, and creating a service strategy that aligns IT services with business objectives. Key deliverables include a service portfolio, financial management plans, and a comprehensive understanding of customer needs.
- ***Service Design:*** Following the strategy phase, services are designed to meet established objectives. This involves crafting architectural plans, documentation, and processes that ensure services deliver the intended value. Deliverables encompass comprehensive service designs, service level agreements (SLAs), and technology considerations.
- ***Service Transition:*** Transitioning from design to operational status, this phase ensures that services are introduced seamlessly. Activities include change management, testing, training, and validation. Key deliverables include tested services, documented changes, and training materials.
- ***Service Operation:*** Once in operation, services must be maintained and managed effectively. This phase encompasses incident management, problem resolution, and continuous monitoring to maintain service performance. Deliverables include incident reports, resolved problems, and performance metrics.
- ***Continual Service Improvement (CSI):*** The final phase emphasises a cyclical process of evaluation and enhancement. Data analysis, customer feedback assessment, and process refinement activities lead to updated processes and plans. Deliverables involve improvement initiatives, updated documentation, and a culture of ongoing improvement.

I.2.4 Benefits of ITIL Implementation

The implementation of ITIL brings forth a host of benefits that reverberate throughout an organisation's IT service landscape:

- ***Enhanced Service Quality:*** ITIL's customer-focused approach ensures that services meet customer needs and expectations, resulting in higher service quality and satisfaction.
- ***Alignment with Business Goals:*** The lifecycle approach of ITIL integrates IT strategies with overarching business goals, forging a direct link between IT services and organisational success.
- ***Risk Mitigation:*** Through meticulous change management and risk assessment, ITIL minimises disruptions caused by poorly managed changes, leading to increased stability and reliability in service delivery.
- ***Operational Efficiency:*** The structured processes and practices advocated by ITIL streamline operations, reduce redundancies, and optimise resource allocation, culminating in heightened operational efficiency.
- ***Collaboration and Communication:*** ITIL promotes collaboration among various IT teams and departments, fostering seamless communication and the sharing of knowledge.
- ***Continuous Improvement:*** The CSI phase encourages organisations to adapt and refine their services based on data-driven insights, enabling them to remain relevant in an ever-evolving landscape.
- ***Clear Documentation:*** ITIL mandates clear documentation of processes, procedures, and service designs, fostering greater understanding and facilitating smoother transitions.
- ***Adaptability:*** The iterative nature of the ITIL framework enables organisations to adapt to changing circumstances, ensuring that services remain pertinent and effective over time.
- ***Cost Optimisation:*** By aligning services with business needs and improving resource utilisation, ITIL helps organisations optimise costs and achieve a more favourable return on investment.
- ***Organisational Alignment:*** Implementing ITIL nurtures a culture of collaboration and accountability, aligning various stakeholders towards shared service delivery goals.

I.3. ITIL Roles and Responsibilities

Within the ITIL (Information Technology Infrastructure Library) framework, roles and responsibilities are defined meticulously to ensure effective IT service management (ITSM). These roles form the backbone of ITIL implementation, offering a structured approach to managing services and processes. This discussion delves into the various roles and responsibilities outlined within ITIL, highlighting key positions like Service Owner, Process Owner, and Service Desk. The analysis emphasises the importance of role clarity and accountability in maintaining streamlined IT service management.

I.3.1 Exploring Various Roles and Responsibilities within ITIL:

- ***Service Owner:*** The Service Owner is a critical role responsible for the overall management and accountability of a specific IT service throughout its lifecycle. They bridge the gap between IT and the business, ensuring that the service aligns with business needs, goals, and customer expectations. The Service Owner oversees service strategy, design, transition, operation, and continual improvement. They collaborate with various stakeholders to define service requirements, SLAs, and KPIs.

- ***Process Owner:*** Process Owners are accountable for the design, efficiency, and effectiveness of a specific ITIL process. They ensure that processes are well-documented, followed, and continuously improved. Process Owners work to eliminate bottlenecks, enhance efficiency, and address any challenges within their respective processes. Their role encompasses maintaining process documentation, setting performance metrics, and driving process improvements.
- ***Service Desk:*** The Service Desk, often referred to as the "Single Point of Contact," is the frontline team responsible for receiving, logging, and managing incidents and service requests from users. They provide timely and accurate responses, troubleshoot issues, and escalate more complex problems to appropriate teams. The Service Desk acts as the face of IT support, ensuring effective communication and resolution for end-users.
- ***Change Manager:*** The Change Manager is accountable for overseeing the Change Management process. They evaluate and authorise changes to IT services, ensuring that changes are thoroughly assessed for risks, impacts, and alignment with business needs. Change Managers help maintain service stability by preventing unauthorised or poorly managed changes that could disrupt operations.
- ***Problem Manager:*** The Problem Manager focuses on preventing recurring incidents by identifying and addressing the root causes and analyses incident data, perform trend analysis, and works to implement permanent fixes to prevent similar issues from occurring in the future. The Problem Manager's role contributes to improving service quality and reducing disruptions.
- ***Incident Manager:*** The Incident Manager is responsible for the efficient handling and resolution of incidents to minimise service disruptions and prioritises incidents based on their impact and urgency, coordinates incident resolution efforts, and communicates updates to stakeholders. Incident Managers ensure that incidents are resolved in a timely manner and that end-users are informed throughout the process.

I.3.2 Importance of Role Clarity and Accountability in IT Service Management

The foundation of successful IT Service Management lies in the clarity of roles and the accountability of individuals within an organisation. This clarity and accountability not only enhance the efficiency and effectiveness of IT operations but also foster a culture of collaboration and continual improvement. Let us delve into the significance of role clarity and accountability in IT Service Management across various dimensions.

- ***Effective Communication:*** Clearly defined roles ensure that responsibilities are well-understood across the organisation. This clarity fosters effective communication between teams, minimising misunderstandings and streamlining collaborative efforts.
- ***Efficient Operations:*** Role clarity prevents duplication of efforts and ensures that tasks are assigned to the appropriate individuals or teams. This leads to smoother operations, reduced delays, and optimised resource utilisation.
- ***Accountability:*** Clear roles establish accountability, making it evident who is responsible for specific tasks and outcomes. This promotes ownership and ensures that tasks are completed to a high standard.
- ***Timely Issue Resolution:*** With designated roles and responsibilities, issues are addressed promptly by the right individuals. This accelerates incident resolution, reduces downtime, and enhances end-user satisfaction.
- ***Process Adherence:*** Roles like Process Owners ensure that processes are well-maintained and followed consistently. This adherence leads to greater process efficiency, adherence to best practices, and improved service quality.
- ***Holistic Service Management:*** Roles like Service Owner ensure that services are managed holistically, from inception to retirement. This approach aligns services with business needs, resulting in higher customer satisfaction and value delivery.
- ***Continual Improvement:*** Clearly defined roles foster accountability for improvement initiatives. Process Owners and other roles actively seek opportunities to enhance processes, driving a culture of continual improvement.

ITIL roles and responsibilities form the pillars of effective IT service management. These roles, such as Service Owner, Process Owner, and Service Desk, ensure that services and processes are managed cohesively, resulting in streamlined operations, efficient incident resolution, and a culture of continuous improvement. Role clarity fosters accountability, effective communication, and efficient resource utilisation, all of which are paramount for delivering high-quality IT services that align with business objectives. As organisations embrace ITIL, the implementation of well-defined roles becomes essential for navigating the complexities of modern IT landscapes and ensuring sustained excellence in service delivery and management.

I.4. Implementation Process

The implementation of ITIL (Information Technology Infrastructure Library) within an organisation is a strategic endeavour that fosters efficient and effective IT service management. This process involves a series of steps, from initial assessment to full integration, each contributing to the alignment of IT services with business objectives. This overview outlines the key stages of adopting and implementing ITIL, encompassing assessment, planning, training, and execution. Additionally, it delves into the challenges organisations might face during implementation and provides strategies for successful adoption.

I.4.1 Steps in Adopting and Implementing ITIL

In adopting and implementing ITIL, it is imperative to recognise that each step in the implementation process plays a crucial role in achieving the desired outcomes. These steps encompass initial assessment, detailed planning, comprehensive training, process design, pilot implementation, full-scale execution, and an ongoing commitment to continuous improvement. This systematic approach not only ensures a smoother transition but also increases the likelihood of successful integration of ITIL principles into an organisation's IT service management practices.

- ***Assessment:*** The journey begins with assessing the organisation's current IT service management practices. This includes evaluating existing processes, identifying pain points, and gauging the organisation's readiness for change. Gathering insights from stakeholders and understanding business needs are pivotal in shaping the ITIL adoption strategy.
- ***Planning:*** Once the assessment phase is complete, organisations delve into comprehensive planning. This stage involves determining the scope of implementation, defining clear goals, and outlining the strategy for integrating ITIL practices. Establishing a project team, assigning roles, and setting a timeline are vital components of the planning phase.
- ***Training and Awareness:*** Organisations must invest in training and raising awareness among their staff. ITIL is based on a shared understanding of roles, processes, and concepts, and proper training ensures that everyone involved is equipped to effectively embrace ITIL practices. Training programmes can vary from basic awareness sessions to in-depth certification courses.
- ***Process Design and Customisation:*** During this phase, existing processes are redesigned to align with ITIL principles. Organisations customise ITIL processes to match their unique business needs and existing workflows. This phase often requires collaborative efforts to ensure that processes are well-defined, streamlined, and effective.
- ***Pilot Implementation:*** Before full-scale implementation, a pilot phase is recommended. This involves implementing ITIL practices on a smaller scale within a specific department or service. The pilot phase allows for testing and validation of the processes in a controlled environment, enabling necessary adjustments before broader implementation.

- ***Continuous Improvement:*** The final stage involves embracing the ITIL principle of continual service improvement. Organisations gather data, analyse performance, and identify areas for enhancement. This cyclical process ensures that ITIL practices evolve to meet changing business needs and technological advancements.

I.4.2 Challenges and Considerations in Implementing ITIL

Navigating the path toward successful implementation comes with its own set of challenges and considerations that organisations must be prepared to address. These challenges span various aspects, from cultural resistance within the workforce to resource allocation, change management, and the complexity of customising ITIL practices. Overcoming these hurdles is essential to realise the full benefits of ITIL adoption.

- ***Cultural Resistance:*** Changing established processes can be met with resistance from employees. Overcoming resistance requires effective communication, involvement of key stakeholders, and showcasing the benefits of ITIL adoption.
- ***Resource Allocation:*** Implementing ITIL demands time, effort, and resources. Ensuring adequate resources are allocated for training, process redesign, and ongoing monitoring is critical.
- ***Change Management:*** ITIL adoption is a significant organisational change. Implementing robust change management practices helps address challenges, mitigate risks, and ensure a smooth transition.
- ***Complexity Management:*** Customising ITIL processes to fit the organisation's needs while maintaining simplicity can be challenging. Balancing complexity with ease of use is vital for successful implementation.

I.4.3 Strategies for Successful Adoption

To ensure a smooth and successful adoption of ITIL principles within an organisation, several strategic approaches can be employed. These strategies, ranging from top-down leadership support to effective training and gradual implementation, are essential in facilitating a seamless transition to ITIL practices.

- ***Top-Down Support:*** Leadership commitment and sponsorship play a pivotal role in ensuring successful ITIL adoption. Leadership support demonstrates the importance of the initiative and encourages others to embrace the change.
- ***Effective Training:*** Comprehensive training programmes, tailored to different roles, enhance understanding and acceptance of ITIL practices. Well-trained staff are more likely to adopt new processes seamlessly.
- ***Gradual Implementation:*** Implementing ITIL in phases or starting with a pilot helps mitigate risks and allows for iterative improvements based on real-world experiences.
- ***Communication and Awareness:*** Transparent communication about the benefits of ITIL adoption and how it aligns with business goals fosters buy-in from employees and stakeholders.
- ***Continuous Monitoring and Feedback:*** Regularly monitor the progress of ITIL implementation and gather feedback from users. This ensures that adjustments can be made in response to real-time insights.

The adoption and implementation of ITIL within an organisation is a transformative journey that requires careful planning, training, and execution. The steps outlined, from assessment to continuous improvement, pave the way for streamlined IT service management aligned with business goals. While challenges may arise, strategies like top-down support, effective training, gradual implementation, and continuous monitoring can steer organisations towards successful ITIL adoption. By embracing ITIL's principles and customising them to fit unique organisational needs, businesses can unlock the potential for improved service quality, enhanced efficiency, and continued growth in the dynamic realm of IT service management.

I.5. Case studies

This paper examined the widespread adoption and impact of the Information Technology Infrastructure Library (ITIL) framework on IT service management in governmental organisations and across diverse industries globally.

UK Government Leading the Way:

The British government came up with the idea for ITIL and now it is an official policy run by the UK Government's Office of Government Commerce (OGC). The UK Government started using ITIL in 2005, and it helped them do a lot better with their technology services. They saved money, made customers happier, followed rules better, and focused more on what customers needed.

Government Support and Rules:

Governments have been a big reason why ITIL has become popular. In the USA, some government groups make companies get ITIL certificates. In Australia, the government tells its groups to use ITIL to make technology better. ITIL started with the government, but now lots of private companies use it too.

Benefits Seen Worldwide:

Many countries like Australia, New Zealand, Singapore, and the UAE have used ITIL too. They found that it helped them spend less money on technology, make their customers happier, work faster and better, reduce risks, and follow rules. These benefits have made ITIL a well-known way to make technology services better.

Worldwide Impact:

Big companies like Procter & Gamble and General Motors use ITIL to get technology services from other countries, especially places like India. They want the companies they work with to have ITIL certification too. In summary, ITIL's journey from a government initiative to a global phenomenon exemplifies its enduring value in optimising IT service management. Its principles continue to guide organisations toward more efficient, customer-centric, and compliant technology service delivery, making ITIL an indispensable tool in the modern digital landscape.

I.6. Conclusions

In conclusion, the Information Technology Infrastructure Library (ITIL) stands as a pivotal framework for IT service management, offering a structured and comprehensive approach to aligning technology services with organisational goals. This framework, which has evolved over three decades, has become a global standard adopted by governments, public and private organisations, and businesses of all sizes. ITIL's success can be attributed to its customer-centric approach, emphasis on process excellence, and adaptability to various industry contexts.

The core concepts and principles within ITIL, such as the focus on value, continual improvement, and clear role definitions, provide a strong foundation for enhancing IT service delivery and management. The framework's fundamental processes, including incident management, problem management, and change management, offer practical solutions to common IT service challenges.

ITIL's lifecycle approach, comprising Service Strategy, Service Design, Service Transition, Service Operation, and Continual Service Improvement, guides organisations through a holistic journey of service management. Each phase plays a crucial role in ensuring that IT services are not only efficient but also strategically aligned with business objectives.

Implementing ITIL is a strategic endeavour that requires careful planning, training, and gradual integration. While challenges such as cultural resistance and resource allocation may arise, strategies such as top-down support, effective training, and continuous monitoring can facilitate successful adoption.

Real-world case studies demonstrate the widespread impact of ITIL on IT service management, with governments leading the way in its adoption. From the UK government's pioneering use of ITIL to multinational corporations seeking ITIL certification for their service providers, the framework has proven its effectiveness in improving service quality, efficiency, and alignment with customer needs.

In summary, ITIL has evolved into a cornerstone of IT service management, offering a roadmap for organisations to deliver high-quality services, reduce risks, and foster a culture of continual improvement. As technology continues to advance, ITIL remains a valuable tool for organisations striving to navigate the complexities of modern IT landscapes while ensuring excellence in service delivery and management.

I.7. Summary of Key Points

Evolution of ITIL: ITIL, initially conceived as the "Information Technology Infrastructure Library," has evolved over three decades into a globally recognised framework for IT service management. It has transitioned from an acronym to a brand, offering adaptable best practices.

Importance of IT Service Management: Effective IT service management is crucial for organisations as information technology plays a strategic role in shaping business strategies, optimising processes, and ensuring efficiency and effectiveness.

Key Concepts and Principles: ITIL is guided by key concepts such as "service," "service management," "service provider," and "customer," as well as principles like "focus on value" and "continual improvement."

Fundamental Processes: ITIL outlines fundamental processes including incident management, problem management, change management, service level management, and more, each contributing to efficient service delivery and management.

ITIL Lifecycle: The ITIL framework follows a lifecycle approach, comprising Service Strategy, Service Design, Service Transition, Service Operation, and Continual Service Improvement, ensuring strategic alignment and ongoing enhancement of IT services.

Benefits of ITIL Implementation: Organisations implementing ITIL benefit from enhanced service quality, alignment with business goals, risk mitigation, operational efficiency, improved collaboration, and a culture of continuous improvement.

Roles and Responsibilities: ITIL defines key roles such as Service Owner, Process Owner, Service Desk, Change Manager, Problem Manager, and Incident Manager, each contributing to effective IT service management through role clarity and accountability.

Implementation Process: The adoption of ITIL involves stages such as assessment, planning, training, process design, pilot implementation, execution, and continuous improvement, with considerations for addressing challenges and ensuring successful adoption.

Global Impact: Governments worldwide have played a significant role in driving the adoption of ITIL, with organisations in various countries experiencing benefits such as cost savings, improved customer satisfaction, and better risk management.

Continual Relevance: ITIL remains relevant and adaptable to evolving technological landscapes, making it a valuable resource for organisations seeking to navigate the complexities of IT service management.

ITIL's evolution, core concepts, principles, processes, and lifecycle approach offer organisations a structured path to achieving excellence in IT service delivery and management, with real-world case studies demonstrating its global impact and continued relevance.

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II. E-Government Interoperability Framework (e-GIF)

II.1. Introduction

As e-government develops, it is becoming more and more important to ensure interoperability among various services and information systems, as better public services tailored to the needs of the citizen and business, require the seamless flow of information across government. According to the European Interoperability Framework (EIF), the term “interoperability” denotes the ability of organisations to interact towards mutually beneficial goals, involving the sharing of information and knowledge among them, through the business processes they support, by means of the exchange of data among their Information and Communication Technology (ICT) systems.

Many governments are constantly working to improve the interoperability of e-government, with e-GIF in the UK being a representative example. The e-Government Interoperability Framework (e-GIF) sets out the government’s technical policies and specifications for achieving interoperability and ICT systems coherence across the public sector. The e-GIF defines the essential prerequisites for joined-up and web-enabled government. The e-GIF is the technical cornerstone of the e-government policy for joining up the public sector electronically and providing modern, improved public services. It is a pragmatic, Internet-based approach for reducing cost and risk. It frees up public sector organisations to concentrate on serving the customer through value added information and services.

Adherence to the e-GIF policies and specifications is mandatory. The main thrust of the e-GIF is to adopt the Internet and World Wide Web (WWW) specifications for all government systems. The e-GIF also sets out policies for establishing and implementing metadata across the public sector. However, stipulating policies and specifications are not sufficient by themselves. Successful implementation will mean the provision of support, best-practice guidance, toolkits, and centrally agreed schemas. The GovTalk site (Schemas and Standards) provides best-practice guidance, Frequently Asked Questions (FAQs), and advice on training and toolkits, and outlines the management processes.[1]

The e-GIF first came into force when Version 1 was announced in the House of Commons (U.K.) in 2000, with the last version – Version 6.1 – released in March 2005.[2] Currently, many countries are applying e-GIF to suit each country's circumstances or developing and operating other types of interoperability frameworks. In this report, the e-GIF (Ver. 6.1) is described first, followed by other types of interoperability frameworks.

II.2. Overview of the e-Government Interoperability Framework(e-GIF)

II.2.1 Definition of e-GIF

The e-Government Interoperability Framework (e-GIF) was developed by the UK Cabinet Office that recognised the need for seamless information flow across government to better serve the

[1] Cabinet Office UK GovTalk. Schemas and Standards; https://webarchive.nationalarchives.gov.uk/ukgwa/20111205165431/http://interim.cabinetoffice.gov.uk/govtalk/schemasstandards.aspx
National Archives. (2010). Cabinet Office. e-GIF. https://webarchive.nationalarchives.gov.uk/ukgwa/20111205171933/http://interim.cabinetoffice.gov.uk/govtalk/schemasstandards/e-gif.aspx
[2] National Archives. (2005). Cabinet Office. Archived e-GIF Published Documents - Title: e-Government Interoperability Framework Version 6.1. https://webarchive.nationalarchives.gov.uk/ukgwa/20111205214947/http://interim.cabinetoffice.gov.uk/govtalk/archive/policy_documents_1_of_1/e-gif/e-gif_published_documents/e-government_interoperability_framework_version_61.aspx
National Archives (2010). Cabinet Office. e-GIF. https://webarchive.nationalarchives.gov.uk/ukgwa/20111205171930/http://interim.cabinetoffice.gov.uk/govtalk/faqs/egif.aspx

needs of citizens and businesses. The e-GIF establishes governmental technical policies and specifications to achieve interoperability and ICT system coherence in the public sector.

The e-GIF is a set of policies and standards to enable information to flow seamlessly across the public sector and provide citizens and businesses with better access to public services. The e-GIF document consists of six sections:

- (Sec 1) Policy and scope.
- (Sec 2) Technical policies.
- (Sec 3) Implementation support.
- (Sec 4) Management processes.
- (Sec 5) Change management; and
- (Sec 6) Complying with the e-GIF.

The policy and scope of e-GIFs are as follows:

- Modern joined-up government demands joined-up (interoperable) ICT systems.
- Provides clearly defined policies and specifications for interoperability and information management.
- Readily located and passed for government information resources between the public and private sectors, taking account of privacy and security obligations.

The e-GIF defines the minimum set of technical policies and specifications governing information flows across government and the public sector. These cover interconnectivity, data integration, content management metadata and e-services access. The government is committed to ensuring that these policies and specifications are constantly aligned to the changing requirements of the public sector and to the evolution of the market and technology.

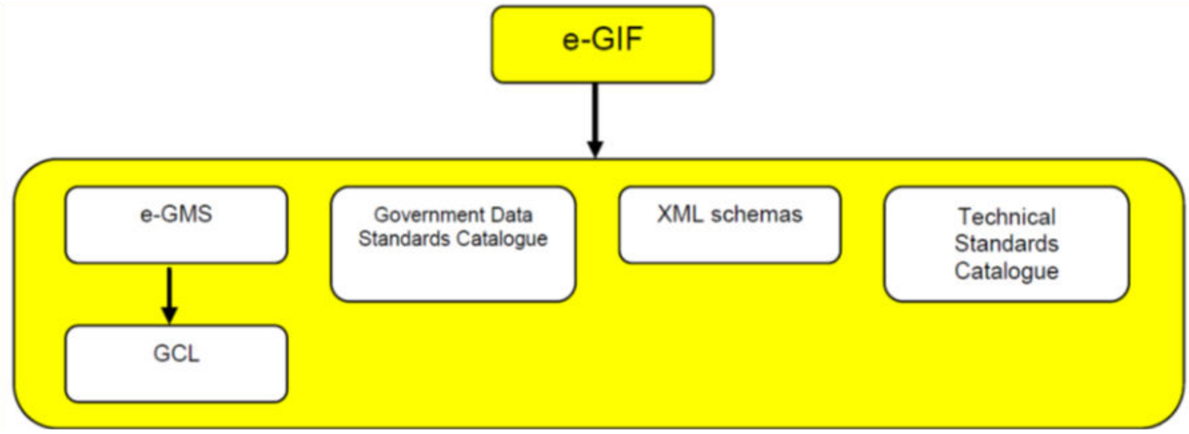
II.2.2. Structure of e-GIF

II.2.2.1 e-GIF Architecture

The e-GIF architecture contains:

- The Framework, which covers high-level policy statements, technical policies and management, implementation, and compliance regimes;
- The e-GIF registry, which covers the e-Government Metadata Standard (e-GMS) and Government Category List (GCL), the Government Data Standards Catalogue (GDSC), XML schemas and the Technical Standards Catalogue (TSC).

Figure 1: e-GIF Architecture


e-GIF
e-GMS
GCL
Government Data Standards Catalogue
XML schemas
Technical Standards Catalogue

The key policy decisions that have shaped the e-GIF are:

- Alignment with the Internet.
- Adoption of XML (eXtensible Markup Language).
- Adoption of the browser as the key interface.
- Addition of metadata to government information resources.
- Development and adoption of the e-GMS (UK e-Government Metadata Standard), based on the international Dublin Core model (ISO 15836).
- Development and maintenance of the GCL (Government Category List).
- Adherence to the e-GIF is mandated throughout the public sector.
- Interfaces between government information systems and intermediaries providing e-Government services shall conform to the standards in the e-GIF.

The selection of e-GIF specifications has been driven by interoperability, market support, scalability, openness, and international standards. The e-GIF covers the exchange of information between government systems and the interactions between the UK Government and citizens, intermediaries, businesses (worldwide), organisations in UK Government, other governments, e.g., UK/EC, UK/US, etc.

Mandatory compliance with e-GIF only applies to the public sector within the UK. However, e-GIF standards also affect the UK's public sector information systems and those of private and other countries. Therefore, while it is recognised that e-GIF compliance obligations cannot be imposed on citizens, businesses and foreign governments, the UK Government makes it clear to everyone that this is its preferred method of interface.

II.2.2.2 e-GMS

Because joined-up government needs joined-up information systems, the e-Government Metadata Standard (e-GMS), as part of the e-GIF, is required to ensure maximum consistency of metadata across public sector organisations. The Standard (e-GMS) lays down the elements, refinements and encoding schemes to be used by government officers when creating metadata for their information resources or when designing search systems for information systems.

Box 1: Key Documents relating to e-GMS.

1. e-GMS 3.1
2. e-GMS Version 3.1 for Websites
3. e-GMS Encoding Scheme - Type 1.0
4. e-GMS Encoding Scheme - Audience (draft)

II..2.2.3 Government Data Standards (GDS) Catalogue

The e-Government Interoperability Framework (e-GIF) mandated the adoption of XML and the development of XML schemas as the cornerstone of the government interoperability and integration strategy. A key element in the development of XML schemas is an agreed set of data standards. The agreed set of Government Data Standards (GDS) to be used in the schemas and other interchange processes is contained in the Data Standards Catalogue. These standards are also recommended for data storage at the business level.

Box 2: GDS Data Menu

- Address.
- Contact information.
- Financial.
- Identifiers.
- Organisation information.
- Person information.
- Other.
- Relationships.
- Temporal.

II.2.2.4 XML Schemas

Many government processes involve interchange of data. Hence, schemas are applied to understand data exchanged [transactions] among information systems. Underpinning these transactions, XML schemas are common data definitions which GovTalk defined for use throughout the public sector.[3]

II.2.2.5 Technical Standards Catalogue

The Technical Standards Catalogue defines the minimum set of specifications that conform to the technical policies as defined in e-GIF.[4]

II.2.2.6 Technical policies

This section outlines the detailed technical policies for interconnection, data integration, content management metadata and e-services access. Technical policies for business areas are also included.[5] The last specification for the TSC is given in Appendix 1 of this report, and it covers the areas of interconnection, data integration, content management metadata and e-services access, specifications for business areas and appendices. Each area comprises tables containing specifications and includes version numbers and notes. Each area comprises tables containing specifications and includes version numbers and notes. The UK Government has been committed to ensuring that these technical policies and specifications are kept aligned to the changing requirements of the public sector and to the evolution of the market and technology.

Box 3: Interconnection (Example of Technology policies)

Technical policies for interconnection cover the following:
2.3 Within government, the norm will be to use the intrinsic security provided by the Government Secure Intranet (GSI) to ensure email confidentiality. Unless security requirements dictate otherwise, outside the GSI and other secure government networks one of the following shall be used: S/MIME or secure mail transport and secure mail access standards protected using at least 128-bit TLS/SSL connections.

Table 2: Example of TSC Table (Specifications for interconnectivity)

Component	Specification	Status[6]
Hypertext transfer protocols	RFC 2616, Upgrade mechanism in HTTP/1.1 to initiate Transport Layer Security (TLS) over an existing TCP connection	A
E-mail Transport	E-mail products that support interfaces that conform to the SMTP/MIME for message transfer. This includes RFC 2821, RFC 2822, RFC 2045, RFC 2046, RFC 2646, RFC 2047, RFC 2231, RFC 2048, RFC 3023, RFC 2049. Note: e-mail attachments may conform to the file types for browsers and viewers as defined for the specific delivery channel, see Section 7 – e-Services access and Channels	A
Transport security	SSL v3/TLS (RFC 2246)	A

[3] Schemas are split into four areas: (1) Schema Library; (2) Schema Search; (3) Guidance for Developers; and (4) Schema RFP Form. Access to additional core schemas is available in the UK Government Data Standards Catalogue, more documents concerning schemas can be found under Guidance for Developers. Further information can be found under Change Control Procedures for e-Government Resources.

[4] National Archives. (2010). Cabinet Office. Technical Standards Catalogues (TSC)-TSC Contents. https://webarchive.nationalarchives.gov.uk/ukgwa/20111205171942/http://interim.cabinetoffice.gov.uk/govtalk/schemasstandards/e-gif/technical_standards_catalogue.aspx

[5] For the latest technical specifications for these policies, see the Technical Standards Catalogue (TSC, Ver 6.2), which also contains a glossary of abbreviations and acronyms used in the e-GIF. National Archives. (2009). Cabinet Office. E-GIF Published Documents - Technical Standards Catalogue version 6.2. https://webarchive.nationalarchives.gov.uk/ukgwa/20111205175001/http://interim.cabinetoffice.gov.uk/govtalk/schemasstandards/e-gif/tsc_rtf_and_pdf_versions.aspx

[6] A = Adopted; R = Recommended; U = Under review; F = For future consideration.

II.2.2.7 Implementation support, etc.

Sections 3 to 6 of e-gif are necessary for implementing, managing, changing, and complying with e-gif. The contents outline and structure are shown in Table 2.

Table 3: Summary of e-GIF Section 3 ~ Section 6

Section	Content	Items
3. Implementation support	The processes by which the e-GIF and the tools needed to implement it will be developed, applied, and maintained	• Priorities. • XML schema production. • e-Government Metadata Standard. • www.govtalk.gov.uk. • Membership of working groups.
4. Management processes	The roles and responsibilities of central government and other public sector and industry organisations are outlined below. Whilst this is not meant to be exhaustive, it does indicate the main functions.	• e-Government Unit. • Public sector organisations. • Industry. • The citizen. • Senior IT Forum. • Interoperability Working Group. • Government Schema Group. • Metadata Working Group. • Smart Cards Working Group. • Other working groups.
5. Change management	The e-GIF specifications will inevitably change and will have the capability to change quickly when required. The change management process must ensure that the e-GIF remains up to date and is aligned to the requirements of all stakeholders and to the potential of new technology and market developments. *The following paragraphs describe an inclusive Internet-based consultation process that will encourage participation and innovation. They also describe how changes to e-Government resources specifications will be managed.*	• e-Government resource owner. • Lifetime of an e-Government resource. • Consultation and innovation. • Request for Comments. • Request for Proposals. • Updates to the e-GIF.
6. Complying with the e-GIF	The e-GIF policies mandate adherence to the TSC and the e-GMS and this section provides general guidance on what compliance means in that context and how it will be enforced. Also includes those functions within private/commercial organisations that develop and/or deliver licensed government services.	• What does comply with the e-GIF mean? • Use of XML schemas and data standards. • Timetable. • Stakeholders. • Compliance responsibilities. • Public sector communities. • Maintaining compliance with new versions of the e-GIF. • Failure to comply. • Additional guidance.

II.2.3 Status of various interoperability frameworks

This part introduces policies to ensure interoperability of government information systems in various countries. Each country's interoperability policy takes various forms depending on the progress of each country's e-government or the level of application of the policy (more details are provided in the case studies section).

First, the policy of securing interoperability from an architectural perspective first began in the United States, and other countries such as Korea also applied it. The United States and Korea have established policies to secure interoperability based on Enterprise Architecture (EA). These countries have appointed a Chief Information Officer (CIO), whose responsibilities include establishing an EA and ensuring interoperability.

Table 4: Current data policies and laws in leading countries[7]

Category	US	China	EU	UK	Japan	Australia
Major policies	Federal Data Strategy (FDS)	14th 5-Year Big Data Industry Development Plan	European Data Strategy	National Data Strategy (NDS)	Comprehensive Data Strategy	Australian Data Strategy
Data Industry Promotion Agency	CDO Council, Chief Data Officers Council	Ministry of Industry and Information Technology	EC, European Commission	Department for Digital, Culture, Media & Sport	Digital Agency	Digital Transformation Agency
Detailed policy	Federal Data Strategy Action Plan; Data Center Optimisation Initiative	Pilot project for fostering big data industry	European Open Science Cloud	Data First Programme	My Number Card	Research Data Infrastructure Initiative
Major regulations and legislations	State data/ privacy protection laws (e.g., CCPA)	Data Security Law	General Data Protection Regulation (GDPR), Data Governance Act (DGA) Data Act	General Data Protection Regulations	Amended Personal Information Protection Act; Basic Act on Formation of Digital Society; Basic Act on Advancement of Public and Private Sector Data Utilisation	Australian Privacy Act
Features	Helping federal agencies advance their data capabilities	Government-oriented top-down industry development	Building an integrated data ecosystem	Active support for cross-border data flow	Promotion of public-private cooperation based on administrative data	Establishment of policies that combine existing policies and legal systems

** In the case of the United States, there is no government-wide privacy law.*

[7] Korea Data Agency. 2022 Data Industry White Paper Summary. https://www.kdata.or.kr/fileDownload.do;jsessionid=86AAB35B8638019723892FCBB87C1BF9?srvFile=20230221153233563680.pdf&usrFile=2022_Data%2bIndustry%2bWhite%2bPaper_Summary.pdf&folder=whitepaper

Other cases, Estonia's X-Road and Korea's e-Gov Framework are examples of countries that have established a common, government-wide information and communications infrastructure to ensure interoperability rather than simply policies or recommendations. Estonia (X-tee) and Korea (public information sharing system) are building a common infrastructure to connect data and services and securing interoperability through this. In particular, Korea is improving interoperability at the software and application level by developing a common framework – the e-Gov Standard Framework - related to system development.

Recently, as the importance of data has been further highlighted, governments in each country are establishing national data strategies and policies to secure interoperability for data. Since the scope of each country's data policy is wide and diverse, here we only briefly summarize each policy in Table 4.

II.2.3.1 European Interoperability Framework

In November 2022, the European Commission (EC) proposed the Interoperable Europe Act to strengthen interoperability in the public sector. Interoperability allows administrations to cooperate and make public services function across territorial, sectoral, and organisational boundaries, while those administrations remain sovereign actors at all levels of government.[8] The European Union’s (EU) digital ambition for 2030 and the remaining gaps in the actual uptake and implementation of interoperability have shown the necessity of creating a reinforced and more strategic interoperability policy with strengthened cooperation between the Member States and the EU Institutions on public sector interoperability.

The ”European Interoperability Framework (EIF)” is part of the “Communication – COM (2017) 134” - from the European Commission adopted on 23 March 2017.[9] The framework gives specific guidance on how to set up interoperable digital public services. It offers public administrations concrete recommendations on how to improve governance of their interoperability activities, establish cross-organisational relationships, streamline processes supporting end-to-end digital services, and ensure that both existing and new legislation do not compromise interoperability efforts. The successful implementation of the EIF will improve the quality of European public services and will create an environment where public administrations can collaborate digitally.

The EIF is accompanied by the Interoperability Action Plan, which outlined priorities that should support the implementation of the EIF from 2016 to 2020. The Interoperability Action Plan is comprised of five focus areas, addressing issues related to the identification of mechanisms to govern interoperability, collaboration between organisations, engagement of stakeholders, and raising awareness of the benefits of interoperability. It also covers the development, improvement, and promotion of key interoperability enablers, while considering the needs and priorities of end users.

II.2.3.2 X-Road (X-tee)

X-Road, an open-source software and ecosystem solution that provides unified and secure data exchange between private and public sector organisations, is the backbone of e-Estonia. Invisible yet crucial, it allows the nation’s various public and private sector e-service information systems to link up and function in harmony. Estonia’s X-Road environment “X-tee” – where the name of X-Road derives from – includes a full range of services for the general

[8] European Commission. Join up – interoperable Europe – policy. The Interoperable Europe Policy. https://joinup.ec.europa.eu/interoperable-europe/policy

[9] European Commission. New European Interoperability Framework; https://ec.europa.eu/isa2/sites/default/files/eif_brochure_final.pdf; https://ec.europa.eu/isa2/sites/default/files/eif_leaflet_final.pdf
European Commission. ISA2 – The New European Interoperability Framework. https://ec.europa.eu/isa2/eif_en/

public, and since each service has its own information system, they all rely on X-Road. To ensure secure transfers, all outgoing data is digitally signed and encrypted, and all incoming data is authenticated and logged.[10]

X-Road connects different information systems that may include a variety of services. It has developed into a tool that can also write to multiple information systems, transmit large data sets, and perform searches across several information systems simultaneously. X-Road was designed with growth in mind, so it can be scaled up as new e-services and platforms come online. X-Road provides a robust and secure solution to exchange data and establish a collaborative ecosystem. It streamlines data exchange processes, enhances security, and facilitates interoperability, enabling organisations to derive greater value from their data assets.

II.2.3.3 Enterprise Architecture (EA)

According to the UNDP "e-Government Interoperability Guide",[11] achieving interoperability through GIFs and their standards, architectures have an important role in ensuring e-government interoperability successes. An Enterprise Architecture is a strategic planning framework that relates and aligns ICT with the business functions that it supports. The establishment of EA at the national level began with the U.S. Federal Government, and many countries are currently establishing and operating National EAs (Christiansen and Gotze, 2007). For instance, the Danish government describes its EA as a: "common framework that ensures general coherence between public sector IT systems, at the same time as the systems are optimised in terms of local needs. It is a common framework with a view to quality improvement, resource optimisation and cost reduction."

The Federal Enterprise Architecture (FEA) is the U.S. Federal Government's EA. FEAF Ver 2.0 is the most recent version and includes CPM and 6 reference models. Based on this, managing the agency's EA is included in the responsibilities of the agency CIO. Korea is also operating a government-wide EA by referring to the FEA of the United States. Since EA covers the entire organisation's business processes, data, services, and technologies, there are many countries that establish IF policies to ensure their interoperability. Korea has a Technology Reference Model (TRM) of the government-wide EA, an interoperability management framework.

II.2.3.4 E-Government Standard Framework

The e-Government Standard Framework is an infrastructure environment for implementing application software (SW) and provides basic functions in the application SW runtime. The e-Government Standard Framework has an objective to increase the quality of e-Government services, the efficiency of IT investment and the standardisation and the reusability of application SWs through establishing and applying the development framework standard.

II.2.4. International surveys (UN, WB, OECD) and interoperability frameworks

Many international organisations are publishing analysis reports on the current status of e-government in each country. International organisations send questionnaires to capture the status of digitalisation – including interoperability policies and status - in the participating

[10] After independence, Estonia built its national administrative system on a digital basis and established a foundation for sharing data online. Because it was difficult to physically build an administrative system (e.g., building a new government office, etc), it was more realistic to opt for digital technology. Recognising that data sharing is a factor that enables safe and efficient national administration, we have introduced innovative services based on this and established a virtuous cycle of digital service development.
e-Estonia. Interoperability services - X-ROAD. https://e-estonia.com/solutions/interoperability-services/x-road/.
[11] UNDP. 2007. e-Government Interoperability Guide. https://www.unapcict.org/sites/default/files/2019-01/e-Government%20Interoperability%20-%20Guide.pdf

countries and analyse their responses which are presented in the form of an [annual] report. This section briefly presents the Indices results with respect to interoperability dimension.

II.2.4.1 UN (EGDI)

The E-Government Development Index (EGDI) presents the state of E-Government Development of the United Nations Member States.[12] Along with an assessment of the website development patterns in a country, the E-Government Development index incorporates the access characteristics, such as the infrastructure and educational levels, to reflect how a country is using information technologies to promote access and inclusion of its people. The EGDI is a composite measure of three important dimensions of e-government, namely: provision of online services, telecommunication connectivity and human capacity.

According to the UN Report, leading e-government countries have specialised laws or regulations related to digital procurement, digital identity and digital signatures, and legal frameworks that address access to information such as data sharing, interoperability between public institutions, and government spending.[13]

II.2.4.2 World Bank (GTMI)

The GovTech Maturity Index (GTMI) was developed as part of the GovTech Initiative to introduce a measure of GovTech maturity in four focus areas,[14] and to assist practitioners in the design of new digital transformation projects. The 2022 version of the GTMI is the simple average of the normalised scores of the four components:[15]

- **CGSI:** The Core Government Systems Index (17 indicators) captures the key aspects of a whole-of-government approach, including government cloud, interoperability framework and other platforms.
- **PSDI:** The Public Service Delivery Index (9 indicators) measures the maturity of online public service portals, with a focus on citizen centric design and universal accessibility.
- **DCEI:** The Digital Citizen Engagement Index (6 indicators) measures aspects of public participation platforms, citizen feedback mechanisms, open data, and open government portals.
- **GTEI:** The GovTech Enablers Index (16 indicators) captures strategy, institutions, laws, and regulations, as well as digital skills, and innovation policies and programmes, to foster GovTech.

[12] UN. UN E-Government Knowledgebase - E-Government Development Index (EGDI). https://publicadministration.un.org/egovkb/en-us/About/Overview/-E-Government-Development-Index
UN. E-Government Survey 2022. https://publicadministration.un.org/egovkb/en-us/Reports/UN-E-Government-Survey-2022

[13] The UN Survey includes the following questions related to interoperability: (1) Are there any laws or regulations regarding national data governance, including data sharing / exchange / interoperability between government agencies? (Data Interoperability); (2) Is there a national e-government strategy or equivalent strategy? (May include interoperability strategies); (3) Does the government provide concrete measures to ensure meaningful connectivity / access to e-government services for women and/or other vulnerable groups? (May include interoperability criteria, including accessibility).

[14] (1) Supporting core government systems; (2) Enhancing service delivery; (3) Mainstreaming citizen engagement; and (4) Fostering GovTech enablers.

[15] World Bank (WB). GovTech: Putting People First. https://www.worldbank.org/en/programs/govtech/gtmi

Table 5: WB GTMI Survey: Core Government System, 1_3. GIF

Number	Question
1_3	Is there a government interoperability framework?
1_3.1	I-3.1 Title of the GIF report.
1_3.2	GIF report / draft URL.
1_3.3	GIF was introduced / will be introduced in (year).
1_3.4	GIF operational status.
1_3.5	Scope > Is there a shared GIF?
1_3.6	Is there a data quality framework?
1_3.7	Is there a system to monitor the 'uptime' of government information systems?
1_3.8	Is there guidance for replacing legacy government information systems?
1_3.9	Monitoring & publishing of GIF usage, compliance, benefits?
1_3.9.1	If Yes > Supporting document (report/URL).

According to the survey, a total of 85 economies (43 percent) declared having a government interoperability framework (GIF) in place and 40 economies acknowledged having an extensively used GIF. Although the 2022 GTMI results show the relevance of interoperability as a key GovTech building block, substantial investments are needed to mainstream it in the vast majority of countries surveyed.

II.2.4.3 OECD (DGI)

The OECD Digital Government Index (DGI) benchmarks the comprehensiveness of digital government strategies and initiatives by assessing the presence of a whole-of-government approach to adopting digital technologies and using data in central and federal public sector organisations.[16]

The assessment is based on the six dimensions of the OECD Digital Government Policy Framework: (1) digital by design; (2) data-driven public sector; (3) government as a platform; (4) open by default; (5) user-driven; and 6) proactiveness. The DGI is a composite index that takes values from 0 to 1, where 1 indicates the highest digital government maturity and 0 indicates low and/or fragmented progress across organisations. The latest questionnaire consists of a total of six parts;[17] all parts include questions related to interoperability.

II.3 Comparison of different e-GIF frameworks

Many countries have established frameworks such as e-GIF to ensure interoperability, but various other types of interoperability policies are also being promoted. In this part, e-GIF is compared with four other cases, and details for each case are explained in the “Case Study” section.

- EIF. While e-GIF is intended to secure interoperability within countries, EIF is the EU's interoperability framework to secure interoperability between countries.
- Estonia's X-Road. X-Road is a layer for data exchange in Estonia and is implemented as an actual information system. X-Road is the basis for securing interoperability between connected systems by linking information systems according to the proposed protocols and interfaces.

[16] OECD. Going Digital Toolkit - Digital Government Index (DGI) https://goingdigital.oecd.org/en/indicator/58

[17] Special Section on COVID-19 Post Pandemic Assessment; (1) Governance of Digital Government; (2) Public Sector Capacities for Digital Government; (3) Data-Driven Public Sector; (IV) Open Government Data - from the Survey on Open Government Data 5.0; (5) Service Design and Delivery in the Digital Age.

- Enterprise Architecture. In the United States, the CIO of a government agency organises and manages the agency's EA as a blueprint for the development and operation of the information system. EA presents guidelines for securing interoperability through six sub-architectures and reference models for each architecture.
- Korea's e-government framework. This framework is a standardised development framework developed to solve the problem of not securing compatibility when linking or improving information systems built due to different development frameworks of developers when promoting informatisation projects and developing information systems. It was created to ensure compatibility and interoperability from the development stage of information systems and software.

The main differences between e-GIF and each other framework are:

- EIF and X-Road are being expanded to ensure interoperability between countries.
- The United States is pursuing interoperability from an architectural perspective, and there are also cases of fact standardisation in other countries and the private sector.
- The e-government standard framework secures interoperability by applying common components from the development stage.
- The U.S. government's EA-based policy appears to have been the first to implement a government-wide interoperability policy (Office of Management and Budget, OMB 97-16). However, the U.K.'s e-GIF was applied to many countries at a faster rate than the spread of EA-based interoperability policies.

The characteristics and differences of each interoperability framework policy are summarised in Table 6.

Table 6: Comparison of interoperability framework policy

Framework Policy	Key Components	Strengths	Weaknesses	Best use cases
e-GIF	• e-GMS. • Government Data Standards Catalogue. • XML Schemas. • Technical Standards Catalogue.	• Internet based pragmatic approach for reducing cost and risk. • Used by many countries as a leading example of interoperability policy.	• Revisions stopped after 2005.	• Expanded to over 30 countries and connected to EIF.
EIF	• One conceptual model. • Four interoperability levels. • 12 underlying principles. • 47 recommendations.	• Expanding interoperability across countries.	• Detailed connection and application tailored to each country's characteristics are required.	• Continuous improvement progress by EU expert group.
X-Road (x-tee)	(X-ROAD Architecture) • Central service. • Security service. • Information system. • Time-stamping authority (TSA). • Certification authority (CA).	• (X-ROAD ECOSYSTEM OWNERS) Centralised governance; Scalability; Trust and transparency; Collaboration opportunities; Cost savings. • (X-ROAD ECOSYSTEM MEMBERS) Secure data exchange; Interoperability; Simplified integration; Access to data sources; Improved efficiency. • (BENEFITS TO COMPANIES) Market potential; Competitive advantage; Reusability and scalability; Cost savings and efficiency; Support and community resources; X-Road Technology Partner Programme.	• There are many things to consider when transitioning from a legacy system or development environment.	• Promote inter-country cooperation with Finland and attempt to spread to many countries.
EA (Ref. FEA)	(Enterprise Architecture) • Baseline architecture. • Target architecture. • Transition plan. (Federal Enterprise Architecture framework) • Collaborative Planning Methodology. • Common Approach Reference model.	• To provide a common approach for IT acquisition in the United States federal government. • To ease sharing of information and resources across federal agencies. • Reduce costs and improve citizen services.	• Difficulty achieving desired goals as extensive and ongoing management is required	• Many countries are applying it to suit their own environments, and there are many examples and tools in the private sector (TOGAF, etc).

Framework Policy	Key Components	Strengths	Weaknesses	Best use cases
e-Gov. S/F	(Architecture of e-Gov Framework) • Runtime environment (Lite). • Development environment. • Management environment. • Operation environment. • Common components.	• - Quality improvement effect accompanied by increased development productivity. • - Maximise reusability and interoperability. • Improved information service standardisation rate.	• As the focus is on securing interoperability in specific (development) fields, policies in other fields such as data exchange are also needed. • Requires compatibility with other civil frameworks.	• Presenting an ecosystem model at the building block (common component) development framework level. • Application of e-government standard framework to 6,359 public informatisation projects.

II.4 Various interoperability frameworks explained.

This section elaborates the specific details of the various frameworks briefly presented earlier.

II.4.1 European Interoperability Framework (EIF)

The EU announced a new European Interoperability Framework in 2017 to promote seamless services and data flows for European public administrations. The European interoperability framework is a commonly agreed approach to the delivery of European public services in an interoperable manner. It defines basic interoperability guidelines in the form of common principles, models, and recommendations.

The purposes of EIF are to:

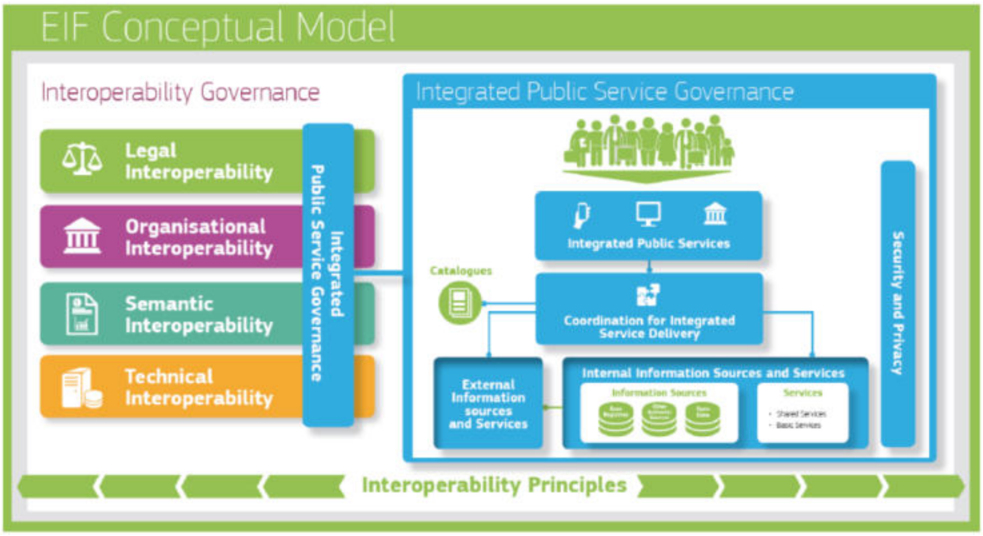
- Inspire European public administrations in their efforts to design and deliver seamless European public services to businesses and citizens which are, to the degree possible, digital-by-default, cross-border-by-default, and open-by-default;
- Provide guidance to public administrations for the design and update of National Interoperability Frameworks (NIFs), or national policies, strategies and guidelines promoting interoperability;
- Contribute to the establishment of the Digital Single Market (DSM) by fostering cross-border and cross-sectoral interoperability for the delivery of European public services.

The EU revised the EIF (1) to align with policy development; (2) to extend and align with emerging trends; and (3) to place more focus on EIF implementation.

The EIF elements are one conceptual model, four interoperability levels, 12 underlying principles, and 47 recommendations. The EIF content and structure is presented below:

- Chapter 2 - Presents a set of principles intended to establish general behaviours on interoperability;
- Chapter 3 - Presents a layered interoperability model which organises in layers the different interoperability aspects to be addressed when designing European public services;
- Chapter 4 - Outlines a conceptual model for interoperable public services. The model is aligned with the interoperability principles and promotes the idea of 'interoperability by design' as a standard approach for the design and operation of European public services;
- Chapter 5 - Providing an overview and the major elements of the EIF.

Figure 2: The revised EIF conceptual model


EIF Conceptual Model
Interoperability Governance
Legal Interoperability
Organisational Interoperability
Semantic Interoperability
Technical Interoperability
Integrated Public Service Governance
Integrated Public Service Governance
Integrated Public Services
Catalogues
Coordination for Integrated Service Delivery
External Information sources and Services
Internal Information Sources and Services
Information Sources
Services
Shared Services
Basic Services
Security and Privacy
Interoperability Principles

Box 4: Example of Recommendation

Recommendation 39
Match each base registry with appropriate metadata including the description of its content, service assurance and responsibilities, the type of master data it keeps, conditions of access and the relevant licenses, terminology, a glossary, and information about any master data it uses from other base registries.

II.4.2 X-Road (X-tee)

X-Road is an open-source data exchange layer solution that enables organisations to exchange information over the Internet. X-Road is a centrally managed distributed data exchange layer between information systems that provides a standardised and secure way to produce and consume services. X-Road is based on distributed architecture and ensures confidentiality, integrity, and interoperability between data exchange parties. X-Road provides a built-in organisational management model that supports building and operating a nationwide X-Road ecosystem. X-Road is the backbone of e-Estonia, Invisible yet crucial, as it allows the nation’s various public and private sector e-service information systems to link up and function in harmony. The first version of X-Road was released in Estonia in 2001. The technical implementation of X-Road has evolved and changed over the years, but the main concept has remained the same since the beginning.

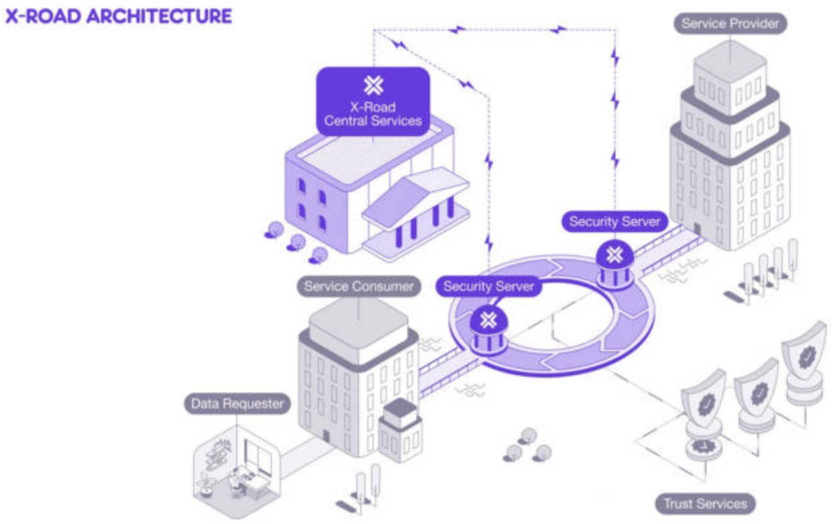
Estonia’s X-Road environment “X-tee” (the Estonian national data exchange layer) – where the name of X-Road derives from – includes a full range of services for the general public, and since each service has its own information system, they all rely on X-Road. To ensure secure transfers, all outgoing data is digitally signed and encrypted, and all incoming data is authenticated and logged.

Box 5: X-Road features

- Address management.
- Message routing.
- Access rights management.
- Organisation level authentication.
- Machine level authentication.
- Transport level encryption.
- Timestamping.
- Digital signature of messages.
- Logging.
- Error handling.

X-Road connects different information systems that may include a variety of services. It has developed into a tool that can also write to multiple information systems, transmit large data sets, and perform searches across several information systems simultaneously. X-Road was designed with growth in mind, so it can be scaled up as new e-services and platforms come online. X-Road is a digital public good verified by the Digital Public Goods Alliance, and it is released under the MIT open-source license and is available free of charge.

Figure 3: X-Road Architecture



Technically the X-Road ecosystem consists of Central Services, Security Servers, Information Systems, TSA(s), and CA(s).

- ***Central Services:*** The Central services consist of Central Server and Configuration Proxy. Central Server contains the registry of X-Road members and their Security Servers. Besides, the Central Server contains the security policy of the X-Road instance that includes a list of trusted certification authorities, a list of trusted time-stamping authorities, and configuration parameters. Both the member registry and the security policy are made available to the Security Servers via HTTP protocol.

- ***Security Servers:*** The Security servers mediate service calls and service responses between Information Systems. The Security Servers encapsulate the security aspects of the X-Road infrastructure: managing keys for signing and authentication, sending messages over a secure channel, creating the proof value for messages with digital signatures, timestamping, and logging.

- ***Information Systems:*** The Information systems produce and/or consume services via X-Road and they are owned by an X-Road member. X-Road supports consuming and producing both REST (Representational state transfer) and SOAP (Simple object access protocol) services. However, X-Road does not provide automatic conversions between different types of messages and services.

- ***Time Stamping Authority (TSA):*** All the messages sent via X-Road are time-stamped and logged by the Security Server. The purpose of the timestamping is to certify the existence of data items at a certain point in time. The TSA provides a time-stamping service that the Security Server uses for time-stamping all the incoming/outgoing requests/responses. Only trusted TSAs that are defined in the Central Server can be used.

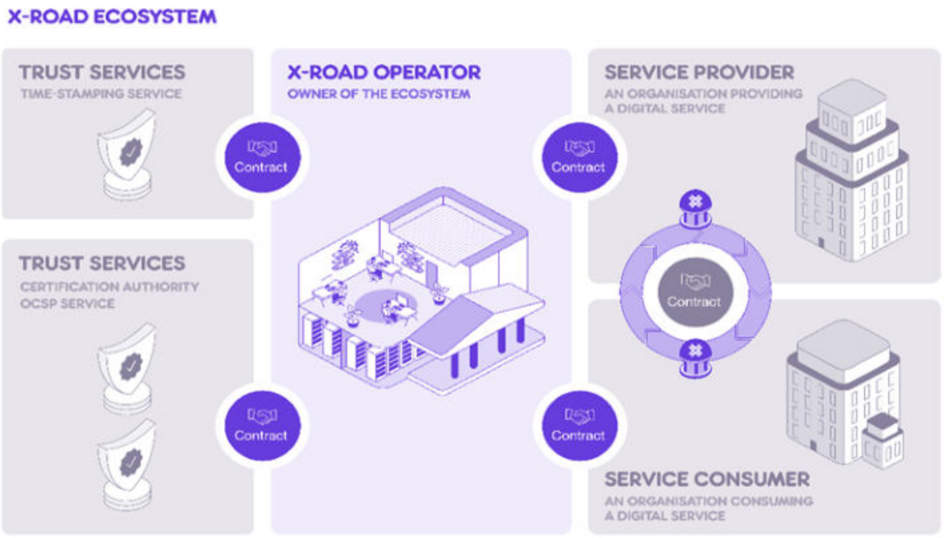
- ***Certification Authority (CA):*** The certification authority (CA) issues certificates to Security Servers (authentication certificates) and X-Road member organisations (signing certificates). Authentication certificates are used for securing the connection between two Security Servers. Signing certificates are used for digitally signing the messages sent by X-Road members. Only certificates issued by trusted certification authorities that are defined in the Central Server can be used.

Today, X-Road is implemented in over 20 countries around the world. X-Road provides built-in support for cross-border data exchange through federation, which means joining two X-Road ecosystems. Members of the federated ecosystems can publish and consume services with each other as if they were members of the same ecosystem.[18]

Estonia and Finland have jointly established the Nordic Institute for Interoperability Solutions (NIIS), a non-profit association that ensures the development and strategic management of X-Road® and other cross-border solutions for digital government infrastructure. Its mission is to develop e-governance solutions, kicking off with X-Road. NIIS is responsible for the development of the X-Road core and providing support to its members.[19] X-Road is used nationwide in the Estonian data exchange layer X-tee and in the Suomi.fi Data Exchange Layer service in Finland. X-Road is released under the MIT open-source license and is available free of charge for any individual or organisation.

[18] Two X-Road ecosystems can be joined together, federated that is a one-to-one relationship between two ecosystems. Federation enables easy and secure cross-border data exchange between member states using X-Road and Members of the federated ecosystems can publish and consume services with each other, as if they were members of the same ecosystem. Technologies such as Linux, Java, SOAP, REST, and PKI are applied to X-Road.
[19] Nordic Institute for Interoperability Solutions. Is X-Road a Data Space Technology? NIIS. https://www.niis.org/blog/2023/6/21/is-x-road-a-data-space-technology; X-Road® Architecture, https://x-road.global/architecture

Figure 4: X-Road Ecosystem



II.4.3 Federal Enterprise Architecture Framework (FEAF)

In the United States, under the E-Government Act, agency administrators oversee the development of enterprise architecture within and across agencies. Legally speaking, Enterprise Architecture means: (1) a strategic information asset base that defines the mission; (2) information necessary to carry out the mission; (3) the skills required to perform the mission; and (4) Transition process for implementing new technologies that respond to changing mission needs. And it includes (1) basic architecture; (2) target architecture; and (3) Sequence planning. The Federal Enterprise Architecture Framework (FEAF) is a guideline to support the development and operation of EA in each public institution in the United States. The FEAF v2 describes a suite of tools to help government planners implement the Common Approach and includes CRM, CPM, and artifacts.[20]

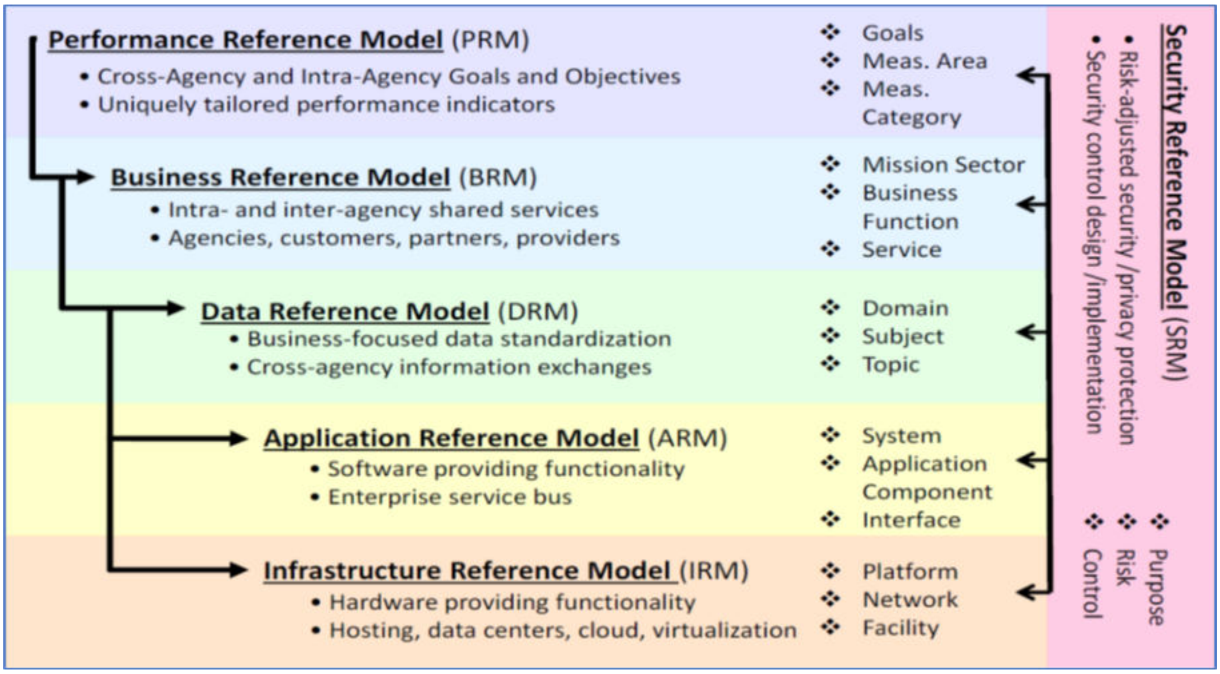
II.4.3.1 Consolidation Reference model

At its core is the Consolidated Reference Model (CRM), which equips OMB and Federal agencies with a common language and framework to describe and analyse investments. It consists of a set of interrelated "reference models" that describe the six sub-architecture domains in the framework; (1) Strategy; (2) Business; (3) Data; (4) Applications; (5) Infrastructure; and (6) Security.

These are designed to facilitate cross-agency analysis and the identification of duplicative investments, gaps, and opportunities for collaboration within and across agencies. Also, by applying all six reference models, agencies can establish a line of sight from the strategic goals at the highest organisational level to the software and hardware infrastructure that enable achievement of those goals. Collectively, the reference models comprise a framework for describing important elements of federal agency operations in a common and consistent way.

[20] Federal Enterprise Architecture Framework Version 2. https://obamawhitehouse.archives.gov/sites/default/files/omb/assets/egov_docs/fea_v2.pdf

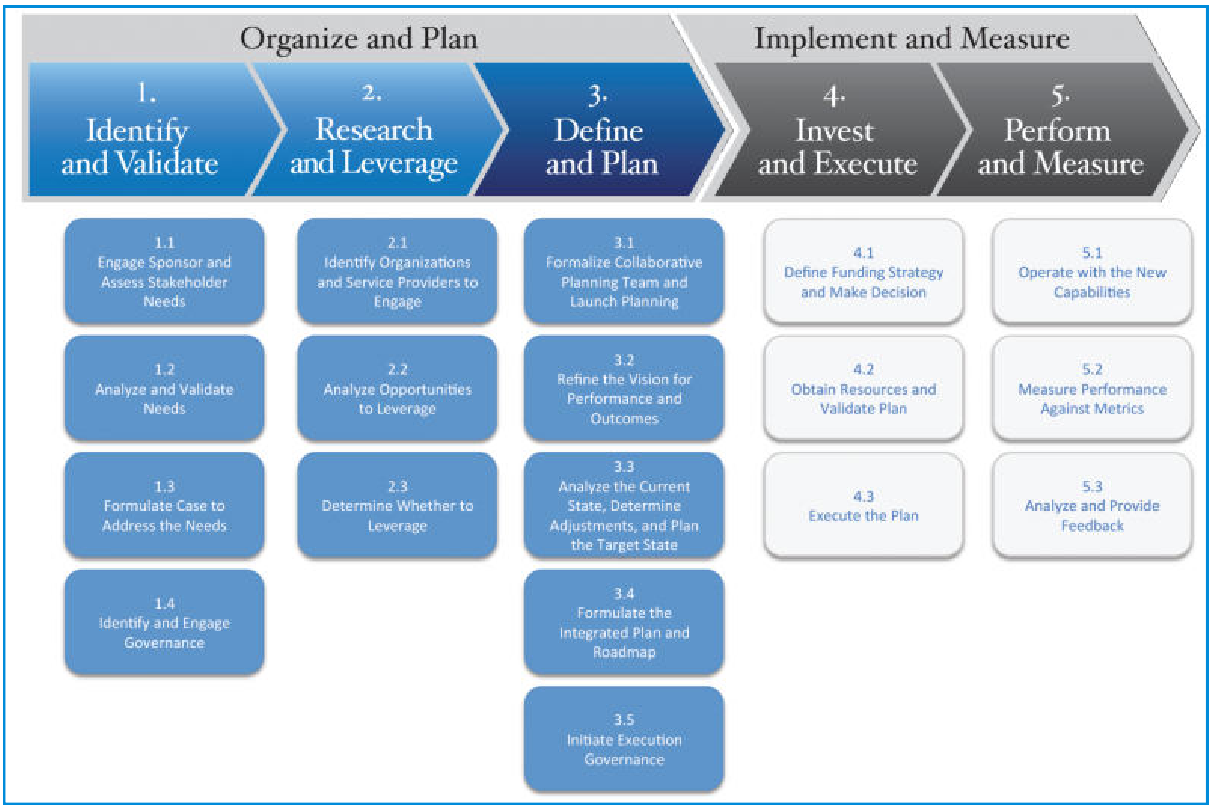
Figure 5: Consolidation Reference model


Performance Reference Model (PRM)
• Cross-Agency and Intra-Agency Goals and Objectives
• Uniquely tailored performance indicators
Business Reference Model (BRM)
• Intra- and inter-agency shared services
• Agencies, customers, partners, providers
Data Reference Model (DRM)
• Business-focused data standardization
• Cross-agency information exchanges
Application Reference Model (ARM)
• Software providing functionality
• Enterprise service bus
Infrastructure Reference Model (IRM)
• Hardware providing functionality
• Hosting, data centers, cloud, virtualization
Goals
Meas. Area
Meas. Category
Mission Sector
Business Function
Service
Domain
Subject
Topic
System
Application Component
Interface
Platform
Network
Facility
Security Reference Model (SRM)
• Risk-adjusted security /privacy protection
• Security control design /implementation
Purpose
Risk
Control

II.4.3.2 Collaborative Planning Methodology

The real value to the agency of developing Enterprise Architecture is to facilitate planning for the future in a way that transforms the government while making it more efficient. The agency can use the EA process to describe the enterprise as it currently is and determine what the enterprise should look like in the future, so that it can make plans to transition from the current state to the future state. The Collaborative Planning Methodology provides steps for planners to use throughout the planning process to flesh out a transition strategy that will enable the future state to become reality. It is a simple, repeatable process that consists of integrated, multi-disciplinary analysis that involves sponsors, stakeholders, planners, and implementers.

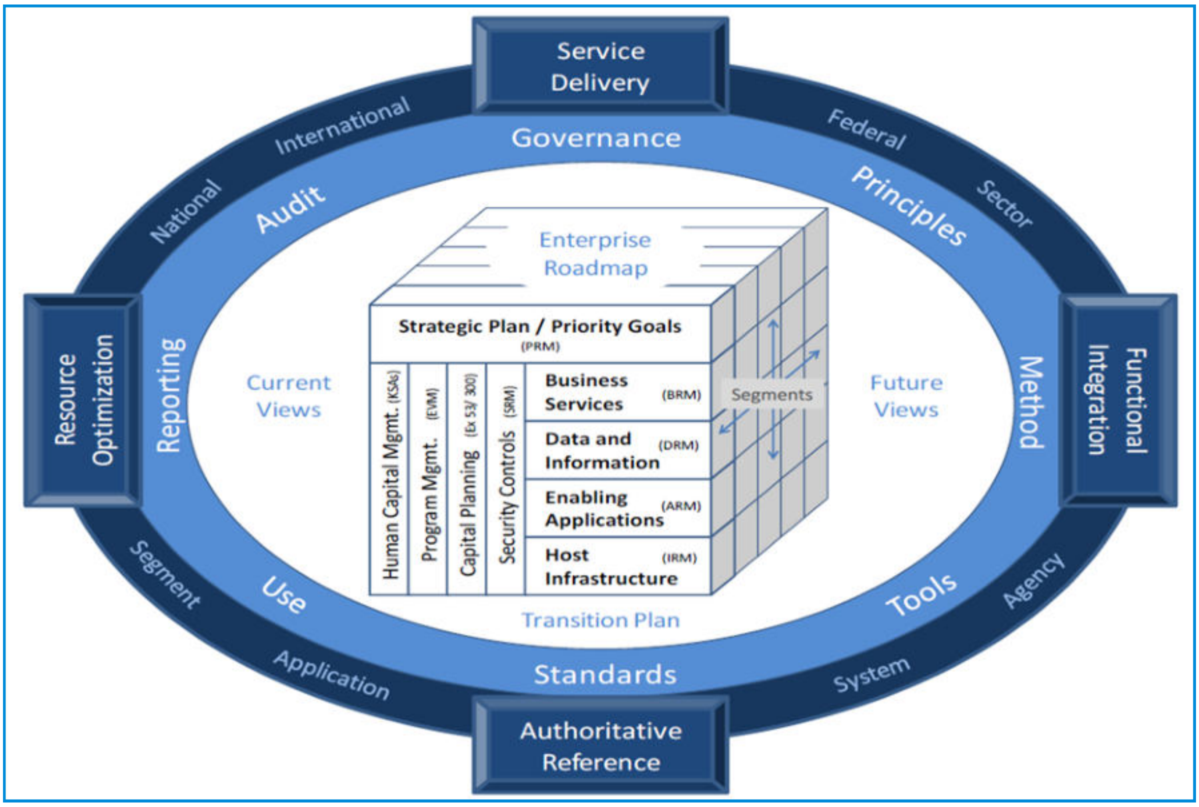
Figure 6: Collaborative Planning Methodology


Organize and Plan
Implement and Measure
1. Identify and Validate
2. Research and Leverage
3. Define and Plan
4. Invest and Execute
5. Perform and Measure
1.1 Engage Sponsor and Assess Stakeholder Needs
1.2 Analyze and Validate Needs
1.3 Formulate Case to Address the Needs
1.4 Identify and Engage Governance
2.1 Identify Organizations and Service Providers to Engage
2.2 Analyze Opportunities to Leverage
2.3 Determine Whether to Leverage
3.1 Formalize Collaborative Planning Team and Launch Planning
3.2 Refine the Vision for Performance and Outcomes
3.3 Analyze the Current State, Determine Adjustments, and Plan the Target State
3.4 Formulate the Integrated Plan and Roadmap
3.5 Initiate Execution Governance
4.1 Define Funding Strategy and Make Decision
4.2 Obtain Resources and Validate Plan
4.3 Execute the Plan
5.1 Operate with the New Capabilities
5.2 Measure Performance Against Metrics
5.3 Analyze and Provide Feedback

II.4.3.3 Artifacts

The agency will create an Enterprise Roadmap to document the current and future architecture states at a high level and presents the transition plan for how the agency will move from the present to the future in an efficient, effective manner. The agency's Enterprise Roadmap combines the artifacts developed for the EA, both current and future state versions, with a plan developed through the Collaborative Planning Methodology. This creates awareness, visibility, and transparency within an organisation to facilitate cross-organisation planning and collaboration. It maps strategy to projects and budget and helps identify gaps between investment and execution, as well as dependencies and risks between projects.

Figure 7: EA Artifacts



There are six sub-architecture domains in the Common Approach to Federal Enterprise Architecture: (1) Strategic; (2) Business Services; (3) Data and Information; (4) Enabling Applications; (5) Host Infrastructure; and (6) Security. These six sub-architecture domains delineate the types of analysis and modelling that are necessary to meet stakeholder requirements.

Based on EA best practices, the Common Approach to Federal EA lists one required core documentation artifact for each of the six sub architecture views.

Table 7: Core Document

Sub-Architecture Domain	Required Core Artifact
Strategy	Concept Overview Diagram
Business	High-Level Process Diagram
Data	High-Level Logical Data Model
Applications	Application Interface Diagram
Infrastructure	High-Level Network Diagram
Security	Control List

All in all, the Federal Enterprise Architecture Framework v2 helps to accelerate agency business transformation and new technology enablement by providing standardisation, analysis and reporting tools, an enterprise roadmap, and a repeatable architecture project method that is more agile and useful and will produce more authoritative information for intra- and inter-agency planning, decision-making, and management.

II.4.4.5 e-Government Standard Framework (e-GOV Frame)

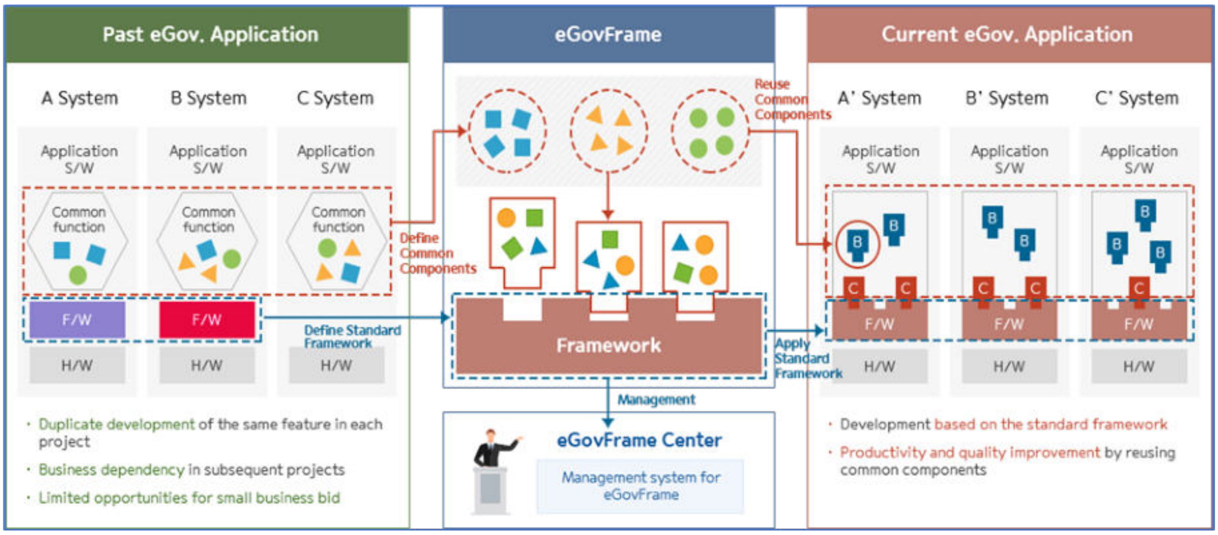
The e-Government Standard Framework is a platform-specific standardised development framework for public sector IT projects in Korea.

There are many problems in the existing e-Government system because each individual application system uses various kinds and versions of frameworks. The development frameworks used in the existing e-Government system are hard to maintain without vendors' technical support because they are provided as Black Box modules, and so have specific vendor dependency.

The standardisation of e-Government Framework eliminates the technical dependency on vendors' proprietary development frameworks, promotes the standardisation, and so increases the quality and reusability, of application SWs. It also increases the investment efficiency through the unification of development framework maintenance.

The e-Government Standard Framework is an infrastructure environment for implementing application SWs and provides basic functions in the application SW runtime. The e-Government Standard Framework has an objective to increase the quality of e-Government services, the efficiency of IT investment and the standardisation and the reusability of application SWs through establishing and applying the development framework standard. The e-Government Standard Framework adopts Apache License, Version 2.0. But other open-source SWs used in the Standard Framework retain each pertinent licensing policy.

Figure 8: Standardisation of e-Gov Frame



- Duplicate development of the same feature in each project
- Business dependency in subsequent projects
- Limited opportunities for small business bid

- Development based on the standard framework
- Productivity and quality improvement by reusing common components

Features

The e-Government Standard Framework has the following features to accomplish its objective to increase the interoperability and the reusability of National Information Systems.

- Complies with open standards.
- Integrates with commercial solutions.
- Is oriented towards standardisation on the national scale.
- Is flexible to cope with the newest technologies.
- Provides easy to use and function-rich environments.

Benefits

The e-Government Standard Framework increases development productivity and component reusability among application systems by providing a standardised infrastructure, increases the interoperability and promotes the standardisation of application SWs through the interface standards.

- Increase in development productivity.
- Increase in the reusability of e-Government application systems.
- Increase in the interoperability of the eGovernment systems.
- Standardisation of e-Government application systems.
- Promotion of open-source SW use.
- Improvements in the competitiveness of SM-sized SW vendors.

Box 6: e-GOV Frame Vision, Objective and Strategies

Vision

Improve service quality of e-Government and efficiency of ICT investment.

Objectives

- Reuse common features.
- Increase Interoperability.
- Reflect latest ICT trends.
- Resolve vendor dependency.
- Enhance SMEs competitiveness.

Strategies

- Standardisation.
- Openness.
- Community.

Structure

The e-Government Standard Framework is composed of 8 Service Layers, Common Components (templates), Runtime Environment, Operation Environment, Development Environment and Administration Environment. The Standard Framework, composed of the Runtime Environment, the Development Environment, the Management Environment, the Operation Environment. and the Common Components, presents an application architecture for the development of web application systems.

Figure 9: Structure of the e-Government Standard Framework

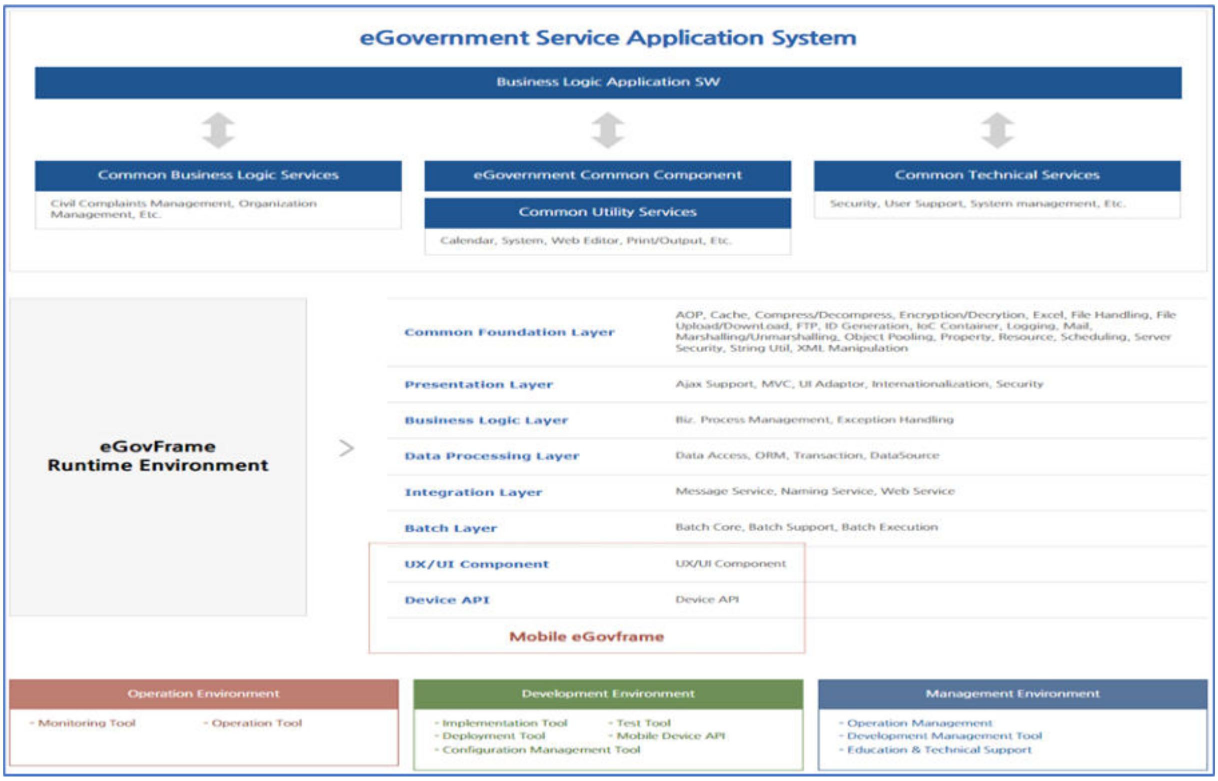

eGovernment Service Application System
Business Logic Application SW
Common Business Logic Services
Civil Complaints Management, Organization Management, Etc.
eGovernment Common Component
Common Utility Services
Calendar, System, Web Editor, Print/Output, Etc.
Common Technical Services
Security, User Support, System management, Etc.
eGovFrame Runtime Environment
Common Foundation Layer
AOP, Cache, Compress/Decompress, Encryption/Decrytion, Excel, File Handling, File Upload/DownLoad, FTP, ID Generation, IoC Container, Logging, Mail, Marshalling/Unmarshalling, Object Pooling, Property, Resource, Scheduling, Server Security, String Util, XML Manipulation
Presentation Layer
Ajax Support, MVC, UI Adaptor, Internationalization, Security
Business Logic Layer
Biz. Process Management, Exception Handling
Data Processing Layer
Data Access, ORM, Transaction, DataSource
Integration Layer
Message Service, Naming Service, Web Service
Batch Layer
Batch Core, Batch Support, Batch Execution
UX/UI Component
UX/UI Component
Device API
Device API
Mobile eGovframe
Operation Environment
- Monitoring Tool
- Operation Tool
Development Environment
- Implementation Tool
- Test Tool
- Deployment Tool
- Mobile Device API
- Configuration Management Tool
Management Environment
- Operation Management
- Development Management Tool
- Education & Technical Support

Table 8: Architecture of the e-Government Standard Framework

Component	Functions & Roles
Runtime Environment	Runtime Environment is the foundation of software applications and provides the basic functionality required to run an enterprise application. The Runtime Environment of the e-Government Standard Framework is composed of 8 service layers and provides 39 services.
Development Environment	As a base module on which the web-based application programmes run, composed of 5 layers such as the screen processing, the business logic processing, the data processing, the integration processing, and the common foundation. As a collection of tools for the easy development of application programmes based on the Screen Development Tool, the Component Development Tool, the Data Development Tool, the Test Automize Tool, the Code Inspection Tool, the Template Project Generation Tool, the Common Component Tool, the Customize Development Composition Tool, the Server Environment Management Tool, the Mobile Standard Source Code Generation Tool, the Mobile Template Project Generation Toolset, the Mobile Common Component Toolset, the Mobile Customize Development Composition Toolset, the Server's Development Environment (Windows, Unix, etc), and the Install Toolset.
Operation Environment	A system for various operations of the Standard Framework such as monitoring application programmes running on the Runtime Environment, managing various system faults, and so on.
Management Environment	A system for various operations of the Standard Framework such as monitoring application programmes running on the Runtime Environment, managing various system faults, and so on.
Common Component	A system for various operations of the Standard Framework such as monitoring application programmes running on the Runtime Environment, managing various system faults, and so on.

II.5 Conclusion

This report introduces various e-GIF related cases in the U.K., E.U., U.S., and Korea. In this section, their implications are summarised across some important overarching elements.

II.5.1 Governance

As can be seen from the surveys conducted by international organisations, securing interoperability requires extensive policies from various perspectives in addition to technical standards and specifications. For instance, linkage with national policy, establishment of basic plan, consideration of public convenience such as accessibility, creation of environment for application of interoperability, etc.

According to this need, there are cases of using multiple policies together rather than a single policy or adjusting the scope of the interoperability policy. For example, most e-GIFs or architectures are provided in the form of standards or guidelines. Therefore, in order to ensure compliance, these policies must be linked to procedures such as design, testing, and auditing. In the case of Korea, compliance with e-GIF is specified in the request for proposal for an information system project, and compliance with this is checked at the end of project execution. In the case of the United States, establishing EA and following standards is designated as the role of the CIO. Therefore, in order to improve interoperability across the country, it is necessary to establish a legal and institutional governance system to efficiently operate interoperability policies.

II.5.2 Selection of appropriate e-GIF model.

The level and direction of interoperability policies are different depending on the environment and characteristics of each country. Therefore, efforts are expanding to improve interoperability to suit the realities of each country by referring to other countries' policies and

.

systems. These changes are occurring in various ways, such as beyond the scope of the country or due to restrictions in more specific standards. Therefore, when selecting an interoperability framework, it is necessary to consider the level of development of e-government, the status of infrastructure construction, and the scope of targets requiring interoperability.

II.5.3 Selection of appropriate technology

In e-GIF, a technology suitable for the government's information system environment must be selected and principles for this must be presented. In recent years, with the spread of the Internet, data-centric interoperability policies are expanding rather than improving interoperability in connection with physical environments such as networks and servers. In addition, the speed of change in IT technology is very fast, so a system for monitoring and selection of technology and standards must be established.

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II.7 Appendix : Technical Standards Catalogue (TSC, Ver 6.2) contents

Introduction	Changes from previous version
	Issues under consideration
Interconnection	Table 1: Specifications for interconnectivity
	Table 2: Specifications for Web Services
Data integration	Table 3: Specifications for data integration
	Figure 1: Direct XML Model
	Figure 2: Interchanges via middleware
Content management metadata	Table 4: Specifications for content management metadata
	Table 5: Specifications for identifiers
e-Services access	Table 6: Specifications for computer workstations
	Table 7: Specifications for other channels
	Table 8: Specifications for mobile phones
	Table 9: Specifications for conferencing systems over IP
	Table 10: Specifications for VoIP (Voice over IP) systems
	Table 11a: Specifications for smart cards - data definition
	Table 11b: Specifications for smart cards - applications including multi-applications
	Table 11c: Specifications for smart cards - electrical
	Table 11d: Specifications for smart cards - communication protocols
	Table 11e: Specifications for smart cards - physical
	Table 11f: Specifications for smart cards - security
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	Table 12: Specifications for biometrics data interchange
	Table 13: Specifications for smart travel documents
	Table 14: Specifications for accessibility and usability
Specifications for business areas	Table 15: Specifications for business areas - miscellaneous
	Table 16: Specifications for business areas - e-Learning
	Table 17: Specifications for business areas - e-Health & social care
	Table 18: Specifications for business areas - finance
	Table 19: Specifications for business areas - commerce, purchasing & logistics
	Table 20: Specifications of business areas - workflow & web services
Appendices	Appendix A: Abbreviations and Acronyms used in e-GIF
	Appendix B: Glossary of Metadata Terms

III. Open Group Architecture Framework (TOGAF) and Control Objectives for Information Related Technology Framework (COBIT)

III.1. Introduction

The dynamic digital landscape has accelerated the need for streamlined data architecture and seamless data exchange between enterprise systems. Two predominant standards frameworks, The Open Group Architecture Framework (TOGAF) and Control Objectives for Information and Related Technology (COBIT), offer important insights. These frameworks are especially beneficial to the public sector, which seeks to adapt and implement advanced digital solutions. Enterprise Architecture aids in the assembly of isolated processes into a cohesive environment conducive to change and aligned with the integrating business strategy. Key factors for successful IT strategy include efficient information management and Digital Transformation. Enterprise Architecture offers a strategic roadmap to enhance digital capabilities, enabling swift adaptability to the business landscape.

Both COBIT and TOGAF stand as renown methodologies suitable for steering IT governance and shaping enterprise architecture. They have been proven to be particularly effective in diverse real-world applications, aiding organisations in achieving their strategic objectives. In the process of selecting between the COBIT and TOGAF frameworks for IT governance and enterprise architecture, the needs and objectives of the implementing body must be clearly defined. South Korea serves as an instructive example for this. The National Information Society Agency (NIA) in South Korea has employed COBIT in its IT auditing initiatives. On the other hand, the Korea's Government-wide Enterprise Architecture Plan (GEAP) relies heavily on TOGAF. These specific applications underscore the importance for organisations — especially government bodies — of selecting a framework that aligns with their strategic goals. This report will delve into the merits of both COBIT and TOGAF while highlighting how South Korea's practical application of these frameworks can offer valuable insights to other nations.

In the context of data storage and exchange, TOGAF and COBIT serve as valuable standards frameworks, each contributing unique perspectives to digital operationalisation within the public sector. TOGAF emphasises data standards in detail for data interoperability and definition sharing. In both the United States and Canada commented in TOGAF, they put efforts to harmonise their databases with Common Standard Terminology. COBIT, in contrast, adopts a broader lens, focusing on IT governance at an enterprise level. This distinction highlights the critical lesson that the choice of framework will influence not just data governance but also how to establish linkages for data integration across various databases. Korea provides a noteworthy example in this context; its 'Public Data Provision Standard,' 'Database Standardisation Guidelines for Public Agencies,' and 'Common Standard Terminology' policies offer crucial insights into the establishment of data standards. Regardless of the chosen framework, the ability to share and easily use data remains an essential factor, emphasising the need for comprehensive data standardisation and management policies.

III.2. Overview of data storage and exchange frameworks

III.2.1 TOGAF

III.2.1.1 Introduction to TOGAF

TOGAF (The Open Group Architecture Framework) is a framework for Enterprise Architecture, used to develop architecture within organisations. It was developed by The Open Group Architecture Forum, with its origins in the US Department of Defence's TAFIM. TOGAF is a freely available standard that can be customised and adopted based on an organisation's unique requirements. Adopting an effective Enterprise Architecture, particularly one established through the TOGAF standard, delivers extensive benefits, directly contributing to enhanced governance, digital innovation, and economic advancement in multiple dimensions. The TOGAF standard offers a structured approach to streamline business operations and increase organisational agility, providing a competitive edge. It fosters a unified digital environment across the enterprise, enhancing interoperability, simplifying system management, and reducing software development and maintenance costs. TOGAF significantly reduces business and IT complexity, optimising return on investment in existing infrastructure. It also increases strategic flexibility, minimising risk associated with new investments and lowering their cost of ownership. Moreover, TOGAF simplifies procurement processes, accelerating decisions without compromising architectural coherence. This leads to economical procurement of multi-vendor open systems. Especially, The TOGAF Architecture Development Method (ADM) offers a comprehensive, step-by-step approach to designing and implementing enterprise architectures.

Box 7: The TOGAF Standard Document

- ***Architecture Development Method (ADM):*** The ADM provides organisations with a structured, step-by-step process for Enterprise Architecture development, covering stages of design, planning, implementation, and governance. Notably for government bodies, the ADM can be instrumental in digitalising public services and enhancing interoperability across departments.
- ***ADM Guidelines & Techniques:*** This part of the TOGAF standard offers a comprehensive collection of guidelines and techniques to apply the TOGAF approach and ADM. It can bolster an organisation's adaptability to changes and efficiency in managing complex architectural projects.
- ***Architecture Content Framework:*** This aspect of TOGAF presents a structured metamodel for creating architectural artifacts. It aids in crafting clear, consistent architectural documentation, understandable and usable by all stakeholders within an organisation, inclusive of non-technical decision-makers.
- ***Enterprise Continuum & Tools:*** This section provides information on pertinent taxonomies and tools for categorising and storing the outcomes of architectural activities. It aids organisations in managing architectural resources efficiently and reusing them across various projects.
- ***Architecture Capability Framework:*** This framework defines the organisation, processes, skills, roles, and responsibilities needed to establish and operate an architecture function. It can contribute to the development of an efficient architecture team and the management of the architecture capability in an organisation.

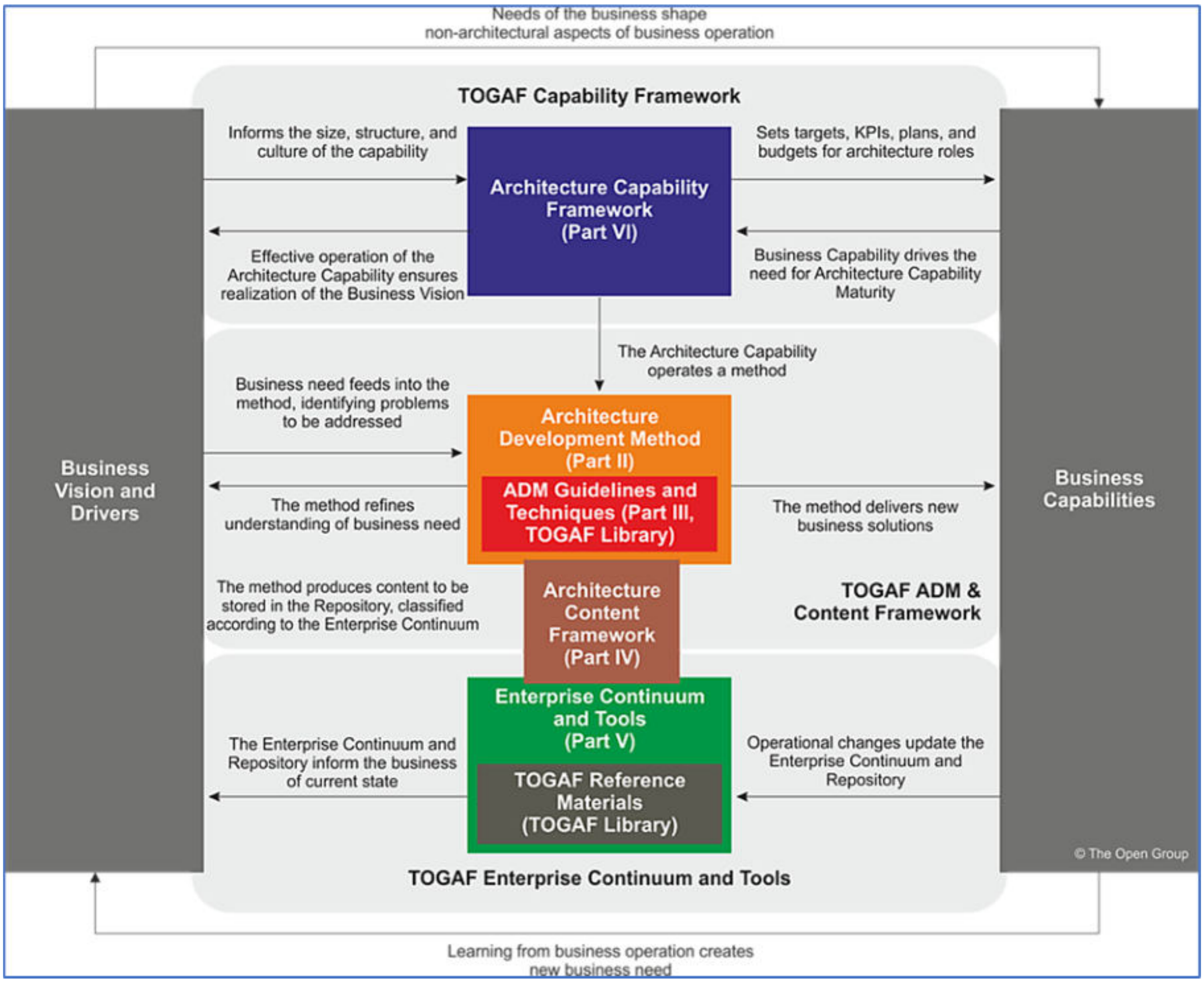
Source https://www.opengroup.org/togaf-licensed-downloads.

All activities repeatedly refine and implement the architecture, enabling organisations to adapt steadily and purposefully to their business objectives and opportunities. Phases within the ADM are as follows:

- ***Preliminary Phase*** describes the preparation and initiation activities required to create an Architecture Capability including customisation of the TOGAF framework and definition of Architecture Principles
- ***Phase A: Architecture Vision*** describes the initial phase of an architecture development cycle. It includes information about defining the scope of the architecture development initiative, identifying the stakeholders, creating the Architecture Vision, and obtaining approval to proceed with the architecture development.
- ***Phase B: Business Architecture*** describes the development of a Business Architecture to support the agreed Architecture Vision.
- ***Phase C: Information Systems Architecture*** describes the development of Information Systems Architectures to support the agreed Architecture Vision.
- ***Phase D: Technology Architecture*** describes the development of Technology Architecture to support the agreed Architecture Vision.
- ***Phase E: Opportunities & Solutions*** conducts initial implementation planning and the identification of delivery vehicles for the architecture defined in the previous phases.

- ***Phase F: Migration Planning*** addresses how to move from the Baseline to the Target Architectures by finalising a detailed Implementation and Migration Plan.
- ***Phase G: Implementation Governance*** provides an architectural oversight of the implementation.
- ***Phase H: Architecture Change Management*** establishes procedures for managing change to the new architecture.
- ***Requirements Management*** examines the process of managing architecture requirements throughout the ADM.

Figure 10: Structure of TOGAF



Needs of the business shape non-architectural aspects of business operation
TOGAF Capability Framework
Informs the size, structure, and culture of the capability
Architecture Capability Framework (Part VI)
Sets targets, KPIs, plans, and budgets for architecture roles
Effective operation of the Architecture Capability ensures realization of the Business Vision
Business Capability drives the need for Architecture Capability Maturity
The Architecture Capability operates a method
Business need feeds into the method, identifying problems to be addressed
Architecture Development Method (Part II)
ADM Guidelines and Techniques (Part III, TOGAF Library)
Business Vision and Drivers
Business Capabilities
The method refines understanding of business need
The method delivers new business solutions
The method produces content to be stored in the Repository, classified according to the Enterprise Continuum
Architecture Content Framework (Part IV)
TOGAF ADM & Content Framework
Enterprise Continuum and Tools (Part V)
The Enterprise Continuum and Repository inform the business of current state
Operational changes update the Enterprise Continuum and Repository
TOGAF Reference Materials (TOGAF Library)
© The Open Group
TOGAF Enterprise Continuum and Tools
Learning from business operation creates new business need

Source https://pubs.opengroup.org/architecture/togaf9-doc/arch/

III.2.1.2 Key components of TOGAF

We can find solutions in TOGAF about how to maintain and guarantee interoperability in data exchange and storage in Phase C: Information Systems Architectures - Data Architecture. It describes the development of Data and Application Architectures. The objectives are to develop the Target Information Systems Architectures, describing how the enterprise's Information Systems Architecture will enable the Business Architecture and the Architecture Vision, in a way that addresses the Statement of Architecture Work and stakeholder concerns and identify candidate Architecture Roadmap.

Major Architectural Inputs for Data Architecture include:

- Data Principles.

- Architecture Repository: Re-usable building blocks (Especially the definitions of current data), Publicly available reference models, Organisation-specific reference models, Organisation standards.
- Draft Architecture Definition Document: Baseline Data Architecture, Target Data Architecture.
- Draft Architecture Requirements Specification: Gap analysis results (from Business Architecture).

It is important to highlight the foundational role of publicly available reference models, organisation-specific reference models, and organisation standards in constructing Data Architecture. Relying on sector-specific data models, such as those for agriculture, emergency management, and other areas, is essential. Such models enhance nationwide interoperability within their respective sectors. Moreover, when organisations adopt consistent data models, they ensure uniformity in the storage and exchange of data, facilitating better understanding and cooperation across systems. These standard models, along with reference models and organisation standards, collectively establish a robust baseline, promoting seamless sharing and interpretation of data across diverse systems. One of the major outputs of the Data Architecture include is data interoperability requirements.

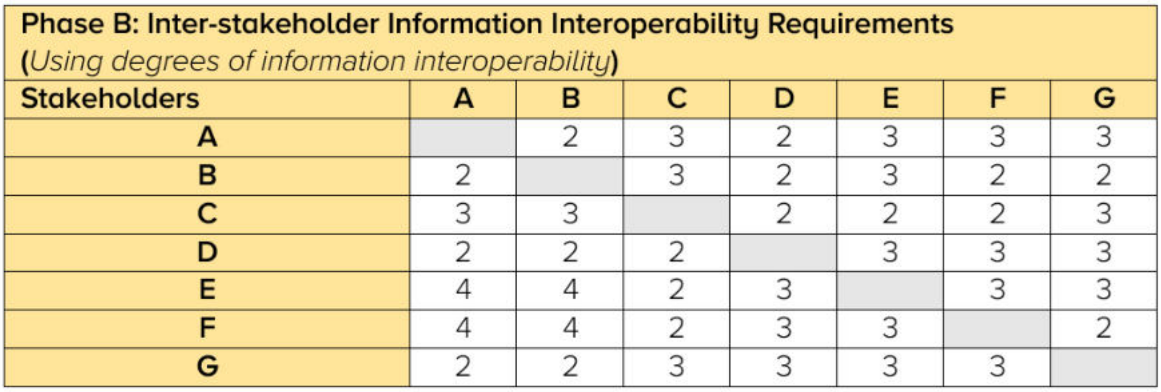
III.2.1.3 Implementation Process of TOGAF

To implement Data Architecture, it is required to select applied standards for each of datasets and prepare the documents such as Business data model, Logical data model, Data management process model, Data Entity/Business Function matrix, Data interoperability requirements (e.g., XML schema, security policies).

TOGAF provides Interoperability requirements guidelines as well. A definition of interoperability in TOGAF is "the ability to share information and services". Defining the degree to which the information and services are to be shared is a very useful architectural requirement, especially in a complex organisation and/or extended enterprise. In the Data Architecture, it is described to use the corporate data and/or information exchange model. In TOGAF, implementing interoperability requires the creation, management, acceptance, and enforcement of realistic standards that are SMART (Specific, Measurable, Actionable, Realistic, and Time-bound). In the example of The Canadian Department of National Defence and NATO specifying interoperability is four degrees:

- ***Degree 1:*** Unstructured Data Exchange involves the exchange of human-interpretable unstructured data, such as the free text found in operational estimates, analysis, and papers.
- ***Degree 2:*** Structured Data Exchange involves the exchange of human-interpretable structured data intended for manual and/or automated handling, but requires manual compilation, receipt, and/or message dispatch.
- ***Degree 3:*** Seamless Sharing of Data involves the automated sharing of data amongst systems based on a common exchange model.
- ***Degree 4:*** Seamless Sharing of Information is an extension of Degree 3 to the universal interpretation of information through data processing based on co-operating applications.

Figure 11: Interoperability Matrix in TOGAF



Phase B: Inter-stakeholder Information Interoperability Requirements
(Using degrees of information interoperability)

Stakeholders	A	B	C	D	E	F	G
A		2	3	2	3	3	3
B	2		3	2	3	2	2
C	3	3		2	2	2	3
D	2	2	2		3	3	3
E	4	4	2	3		3	3
F	4	4	2	3	3		2
G	2	2	3	3	3	3	

Source:The Open Group

The Business Information Interoperability Matrix in TOGAF is useful to measure how much level inner-stakeholders need to exchange to each other based on four degrees.

Operating a mature Architecture Capability within a large enterprise produces a vast array of architectural outputs. To effectively manage and leverage these outputs, there's a need for a formal taxonomy for various types of architectural assets. This must be coupled with dedicated processes and tools designed for storing architectural content. In this context, the Architecture Repository within the Enterprise Continuum and Tools offers a structured framework for the Standards Information Base. Furthermore, the Reference Library provides guidelines, templates, patterns, and other forms of reference material. These resources can be utilised to expedite the creation of new architectures for the enterprise. Types of standards are Legal and Regulatory Obligations, Industry Standards and Organisational Standards which is also specified in Data Architecture. The classification of standards in the Standards Information Base is as follows:

Business Standards:

1. Standard shared business functions
2. Standard role and actor definitions
3. Security and governance standards for business activity

Data Standards:

1. Standard coding and values for data
2. Standard structures and formats for data
3. Standards for origin and ownership of data
4. Restrictions on replication and access

Applications Standards:

1. Standard/shared applications supporting specific business functions
2. Standards for application communication and interoperation
3. Standards for access, presentation, and style

Technology Standards:

1. Standard hardware products
2. Standard software products
3. Standards for software development

In the context of data storage and data exchange standards, it is significant to highlight how TOGAF differentiates Data standards from Application standards. Lately, many organisations have recognised the need for data standards not just within the scope of application standards. This is because data standards focus on data exchange specifically for AI-based data analysis, rather than merely for application-driven services.

III.2.2 COBIT

III.2.2.1 Introduction to COBIT

COBIT (Control Objectives for Information Technologies) is a framework developed by ISACA (Information Systems Audit and Control Association). ISACA is a global professional membership association catering to individuals employed in or interested in IT audit, IT risk, and IT governance fields. COBIT 2019 is the latest edition of ISACA's globally recognised framework for governing and managing enterprise information and technology (EGIT). The COBIT 2019 Framework is designed to provide a comprehensive guide to stakeholders on the advancements and driving principles of the COBIT framework. It introduces new concepts and terminology while explaining the COBIT Core Model and its 40 governance/management objectives. Several specialised focus areas and guidance documents are available to complement the core framework:

- *COBIT for DevOps Audit Programme:* This programme aims to apply the COBIT framework principles to DevOps, helping enterprises evaluate and improve their governance system over DevOps.
- *IT Control Objectives for Sarbanes-Oxley, 4th Edition:* A guide that provides instructions on how to assess the effectiveness of internal controls over financial reporting to comply with the Sarbanes-Oxley Act.
- *COBIT 2019 for Small and Medium Enterprises:* A tailored guidance for small and medium enterprises seeking to apply the COBIT 2019 model in their organisations.
- *COBIT Focus Areas:* These publications delve into specific topics, providing guidance on how to apply COBIT principles to areas like DevOps, Information and Technology Risk, and Information Security.
- *COBIT 2019 Design Guide:* A how-to guide for putting COBIT into practical use, advising users on tailoring a governance system to their enterprise's unique context.
- *COBIT 2019 Implementation Guide:* An updated guide that follows a similar approach to the previous COBIT 5 Implementation Guide but incorporates the new concepts of COBIT 2019.
- *Implementing the NIST Cybersecurity Framework Using COBIT 2019:* This guide illustrates the use of COBIT 2019 to implement the NIST Cybersecurity Framework, providing a method to improve cybersecurity goals.

COBIT aims to facilitate a flexible and tailored Enterprise Governance of IT (EGIT) design and implementation. COBIT emphasises the Importance of Enterprise Governance of Information and Technology (EGIT). EGIT is complex and multifaceted. There is no one-size-fits-all approach to design, implement and maintain effective EGIT within an organisation. It requires a tailored approach that aligns with the specific context and needs of an organisation. Governing board members and senior management are required to bear greater accountability for IT, thereby fostering a culture intent on maximising its value. EGIT focuses on value delivery from digital transformation and mitigating business risk that arises from it. The three main outcomes of successful EGIT adoption include benefits realisation, risk optimisation, and resource optimisation.

- ***Benefits realisation:*** It focuses on generating value for the enterprise through I&T and maintaining/increasing value from existing IT investments. IT value should be aligned with the business's values and be measured in a way that showcases its contribution to the enterprise's value creation process.
- ***Risk optimisation:*** This involves addressing business risk associated with the use, operation, and adoption of IT within an enterprise. Risk management focuses on preserving value, with the management of I&T-related risk being integrated within the enterprise risk management approach.

- ***Resource optimisation:*** This ensures that the required capabilities and resources are provided to execute the strategic plan, including updating or replacing outdated systems, providing training for IT personnel, and exploiting data and information for optimal value.

III.2.2.2 Key components of COBIT

The COBIT principles of a governance system and a governance framework form the bedrock of effective enterprise IT governance. They guide the design, implementation, and management of the governance systems and frameworks in a way that aligns with the unique needs of an enterprise, while remaining adaptable to changes. Governance System Principles dictate that an enterprise requires a tailored system to balance benefits, risks, and resources while generating value from IT. This system should be dynamic, adaptable, distinguish governance from management, and provide comprehensive coverage of all IT-related aspects of the enterprise. On the other hand, Governance Framework Principles stipulate that the framework should be rooted in a conceptual model for consistency and automation potential. The framework should remain open and flexible, enabling the addition of new content and dealing with emergent issues without compromising integrity. Importantly, it should align with relevant standards, frameworks, and regulations to ensure compliance and leverage established best practices.

The Governance and Management Objectives form an integral part of the COBIT framework, ensuring that information and technology align with and contribute to enterprise goals. These objectives, always linked to one process and a series of related components, fall under two categories - governance objectives and management objectives, each under the purview of different levels of leadership within an organisation. Governance Objectives are typically overseen by boards and executive management. Grouped within the Evaluate, Direct, and Monitor (EDM) domain, these objectives involve evaluating strategic options, providing direction to senior management on selected strategies, and monitoring the strategy's execution and achievement. Management Objectives, held by senior and middle management, are organised into four domains: Align, Plan, and Organise (APO); Build, Acquire, and Implement (BAI); Deliver, Service, and Support (DSS); and Monitor, Evaluate, and Assess (MEA). These domains handle strategic IT alignment, IT solution acquisition and integration, IT service delivery including security, and performance monitoring against internal and external standards. Together, they enable efficient and effective enterprise IT management, assuring continuous improvement and strategic alignment. Through these governance and management objectives, the COBIT framework ensures a comprehensive approach to the governance of enterprise IT, offering strategic alignment, effective delivery of IT services, and constant evaluation and improvement of IT performance and conformance.

III.2.2.3 Implementation Process of COBIT

There are seven phases that comprise the COBIT implementation approach:

- What are the drivers?
- Where are we now?
- Where do we want to be?
- What needs to be done?
- How do we get there?
- Did we get there?
- How do we keep the momentum going?

The COBIT implementation approach does not specifically address data storage and data standards for interoperability. It is noteworthy that in COBIT, the term ***'Interoperability'*** is not directly used; instead, the focus is on ***'Interrelationships'***. However, one of three principles for a governance framework is “A governance framework should align to relevant major related standards, frameworks and regulations”. COBIT provides list of referenced standards and is aligned to several related standards and frameworks including CMMI Data Management Maturity model. Also, in some objectives, data management is included for efficient data exchange both within and outside the enterprise.

- ***APO02 (Managed strategy):*** Requires the digital transformation strategy of the organisation and deliver the desired value through a road map of incremental changes. It handles changes in all different aspects of the organisation, from channels and processes to data, culture, skills, operating model, and incentives.
- ***APO14 (Managed data):*** Ensure effective utilisation of the critical data assets to achieve enterprise goals and objectives.
- ***EG11 (Compliance with internal policies):*** Number of incidents related to noncompliance with policy. Percent of stakeholders who understand policies. Percent of policies supported by effective standards and
- ***APO03 (Managed enterprise architecture):*** Represent the different building blocks that make up the enterprise and its interrelationships, as well as the principles guiding their design and evolution over time, to enable a standard, responsive and efficient delivery of operational and strategic objectives.

In EG11, there is an emphasis on establishing internal data standards policies across the enterprise. If the data standards is formalised officially and enforced within the organisation, it indicates that the data standardisation policy is being effectively implemented at the enterprise level. APO03 presents objectives to achieve interrelationships within the institution's data.

III.2.3 Introduction of the EA framework in South Korea

The role of information technology is becoming increasingly important in enabling organisations to respond agilely to various environmental changes in their value-creating activities. Business complexity is increasing, and the separation of business and IT functions is no longer relevant. And when organisations want to change their systems to respond to changes in the environment, the systems are so complex that they do not know where or how to make changes. They need something that makes it easy to see the entire system, like a blueprint for a building.

In this respect, EA (Government-wide Enterprise Architecture - GEAP) in South Korea was introduced to organise these complex systems in an easy-to-understand manner. It makes it easier to transform complex enterprise systems into the required form. GEAP integrates the components of the entire organisation, such as business, application, data, technology, and security, according to certain standards and procedures, and then it organises structurally the relationships for efficiently organising information systems.

South Korea has institutionalised the management of Enterprise Architecture through the Ministry of the Interior and Safety (MOIS).[21] Within this legislation, EA is defined as a "system that comprehensively analyses organisational components such as business, applications, data, technology, and security according to certain standards and procedures, subsequently organising their interrelationships structurally."

When developing GEAP, South Korea referred to ZEAF, FEAF, TEAF, DODAF, and TOGAF. The characteristics, advantages, and disadvantages of other EAs and GEAP are as shown in Table 9.

[21] Electronic Government Act, Articles 45-47, on the introduction and utilisation of Information Technology Architecture.

III.2.3.1 Key components of the EA framework

To establish an Enterprise Architecture (EA), it is essential to first lay down a solid Enterprise Architecture Framework (EAF). While numerous advanced frameworks exist and the government even offers guidelines, enterprises can use these as references. However, it is crucial to tailor the framework according to the unique characteristics of the enterprise, rather than applying it blindly. Typically, an EAF takes shape during the planning phase of an EA project. Among the various components of the EAF, the architecture matrix is distinctly defined in the phase of organizing EA information. Thus, the process of defining the EAF can be viewed as a consensus-building exercise, ensuring alignment with any specific change requirements of the enterprise.

Table 9: Key components of Enterprise Architecture Framework

Category	Component	Description
Direction / Guidance	IT Policy	Provides consistent objectives and directions independent of systems, architecture, tools, and products to introduce and apply IT in accordance with the organisation's fundamental policies.
	Enterprise Architecture Strategy	Reflects alignment of the enterprise's existing and newly derived IT strategies with the organisation-wide vision and purpose. The strategy includes the architectural vision and purpose.
	Architecture Principles	Offers objective criteria for investments and decision-making to achieve the enterprise architecture objectives.
	Requirements	Refers to the organisation-wide requirements to fulfil the enterprise architecture strategy. Requirements should be written from an organisation-wide perspective.
Enterprise Architecture Activities	Architecture Model	Defines an architecture model that categorises all of the organisation's resources by perspective and viewpoint. It is represented as a matrix that categorises all resources of the enterprise.
	Lifecycle	Comprises a series of processes to plan, develop, apply, maintain, control, and supervise the enterprise architecture. Each phase - planning, development, application, maintenance, control, and supervision - has its specific focus and activities.
	Support Tools	Tools to systematically and efficiently support the activities of the lifecycle. It includes reference models, investment-related procedures, maturity models, and EA management systems.
Deliverables	Architecture Deliverables	Resulting products developed according to EA activities. They are defined with reference to the purpose and use of EA and can be used according to different viewpoints. Some mandatory deliverables are defined in the Government-wide EA Deliverable Meta Model Document.

Source https://dataonair.or.kr/db-tech-reference/d-guide/da-guide/?mod=document&uid=247

III.2.3.2 Implementation Process of EA

Enterprise Architecture (EA) management is an essential process that encompasses a set of activities aimed at the systematic organisation and utilisation of EA. These activities ensure coherence and consistency across the entirety of the information management system. The EA management process not only classifies and defines detailed tasks required for EA management but also establishes standardised procedures, documentation formats, and regulations that must be adhered to.

After building the EA, it is utilised and controlled. The EA is then evaluated based on changes in the business or technological environment and its usage state. Necessary modifications are identified, which then become part of the EA information applied throughout the enterprise.

It is crucial for the definition of the EA management process to centralise all activities around EA. If only the change and management process of EA is newly added to the existing IT process, there are chances that the process might not be carried out correctly. If the EA-related processes are not conducted properly, up-to-date of EA information cannot be maintained, and there might be issues in retaining the integrity of EA information.

Thus, it is essential to identify the flow of IT processes – establishment, utilisation/control, evaluation, change – from an EA perspective. Designing centred on EA information ensures the integrity of EA information. Recognising changes to EA information in the development and operation processes ensures the contemporaneity of EA information.

Table 10: Key Components of the EA Management Process

EA Component	Objective	Activities
Planning	Strategize the direction of EA management and to create plans for the effective application and utilisation of EA.	Establish plans for the achievement of EA, which include the direction of EA management and effectively applying and utilising EA.
Change Management	Ensure the up-to-date quality and relevance of sector-specific EA information.	Review, approve, and implement changes to EA information.
Compliance Control	Enhance the compliance level of EA across various information management sectors and relevant operational departments.	Inspect and support the reference and adherence to EA information.
Utilisation Support	Elevate the degree of EA utilisation.	Promote, educate, and disseminate EA information and best practices to ensure its effective use.
Utilisation Support	Elevate the degree of EA utilisation.	Promote, educate, and disseminate EA information and best practices to ensure its effective use.
Management System	Increase the efficiency of EA management and utilisation.	Construct and operate an information management system for EA.
Evaluation	Identify opportunities for improvement by periodically assessing the state of EA management and utilisation.	Define the EA evaluation model and perform regular evaluations to identify areas for improvement.

Table 11: Features, advantages, and disadvantages of different frameworks

	ZEAF	FEAF	TEAF	DoDAF	TOGAF	EA (GEAP)
Features	• Introduced the architecture concept in the late 1980s to understand business activities from an engineering perspective. • Offers a modelling perspective from a 5W1H viewpoint.	• Latest version released in 2003, provides U.S. federal government framework guidelines. • Based on reference model EAF.	• U.S. Treasury's EAF (along with FEAF, DoDAF is a representative EAF).	• Ensure interoperability among weapon systems for effective operational performance.	• Private standard alliance, Open Group.	• Driven with the objective to serve as a standard and guide for introducing enterprise architecture in government and public institutions.
Advantages	• Provides a detailed modelling perspective according to 5W1H. • Defines areas of business activity concern from Planner, Owner, Designer, Builder, Sub-contractor perspectives.	• Not just modelling, the framework includes specific implementation plans. • Utilises various reference models like BRM, DRM, SCRM, TRM, PRM.	• Emphasises functional perspectives that express How-Where-When, information perspectives for What-How Much-How Freq, organisational ones for Who-Why, and infrastructure ones for Enable.	• Defines templates for outputs in detail, allowing modelling in a uniform and verified manner. • Provides detailed definitions and formats for operational models.	• Proposes specific architecture development processes - well-defined utilisation relationships among various reference models.	• Includes almost all items related to enterprise architecture in the framework, making it convenient as a basic framework.
Disadvantages	• Defines even those areas with low utilisation from an informatisation perspective. • Overly focused on modelling expression, lacking in defining actual architectural activities and foundation.	• Well-defined concerning understanding and evolution of the architecture model but lacks an evolutionary perspective on the organisation and related regulations.	• Framework is centred around enterprise architecture outputs, lacking in approachability for utilisation. • Lacks perspective on continuous corporate activities.	• In a general corporate environment, there is a possibility of over-investment as it demands excessive outputs and accuracy.	• Introducing the continuum concept based on a meta-model makes it hard to reflect organisational uniqueness in the framework.	• Only presents a standard framework, recommending specific contents to be written by the referring institution.

Source https://dataonair.or.kr/db-tech-reference/d-guide/da-guide/?mod=document&uid=247

III.3 Comparison of TOGAF, COBIT, GEAP

While TOGAF and COBIT overlap in governance and management of IT resources, they were designed with different primary objectives. COBIT goes into detail for specific processes, but it might not be as specific as TOGAF when discussing architecture details. This does not mean COBIT is lacking but rather that it focuses on systems and applications. TOGAF does not just focus on a singular domain but encompasses applications, data, business, and technology architectures, ensuring a comprehensive perspective. Conversely, COBIT's merit lies in its process capability assessment model. This model stands out as it facilitates the evaluation of the maturity levels of IT processes, providing a clear roadmap for improvement and advancement in enterprise-wise.

The Government Enterprise Architecture Process (GEAP) of South Korea provides direction and guidance for IT policy, enterprise architecture strategy, architecture principles, and requirements. One of the remarkable aspects of GEAP is the Information System Act established in 2005. With this Act, all IT-related projects are mandated to be registered on the government-wide GEAP site. This ensures transparency, as all public agencies in Korea can access and search every system established in the Korean public sector. This not only prevents redundant constructions, leading to budget savings, but also boosts efficiency across the board. Moreover, while GEAP provides a robust framework that touches upon almost all items related to enterprise architecture, it also has the flexibility to allow institutions to draft detailed contents tailored to their needs.

The major features and advantages of each standard are summarised here, and in Table 12:

- ***TOGAF:*** Its comprehensive view on architecture – spanning applications, data, business, and technology – ensures that all domains are adequately addressed. This wide coverage provides businesses with a general view, which is essential for strategic decision-making and alignment with business goals.
- ***COBIT:*** The process capability assessment model is its strength. Organisations can benchmark their IT processes against industry standards, understand where they stand, and get guidance on areas of improvement. This structured approach ensures that IT processes evolve in alignment with business requirements, ensuring optimal use of IT resources.
- ***GEAP:*** Its mandatory registration of IT projects under the Information System Act ensures transparency and accountability. The centralised repository acts as a knowledge base, ensuring that mistakes are not repeated, and best practices are propagated across all institutions. The flexibility of the GEAP framework also ensures that institutions are not straitjacketed into a one-size-fits-all approach but can adapt the guidelines to their specific context.

Recently, it has become evident that placing a detailed emphasis on data standards would enhance their effectiveness in data exchange. In this regard, the governments of the USA and Canada have made efforts to establish a common data standard across government bodies. Notably, in the USA, the National Information Exchange Model (NIEM). NIEM is comprised of a common data standard (NIEM Core) and specialised data standards (NIEM domains) adopted by governance groups for specific domains.

Consequently, from the viewpoint of data storage and exchange, there is a pressing need for a more detailed approach and methodology for practical data management. The goal of data exchange and integration extends beyond mere IT services. It is also pivotal for AI and data analysis. A lack of standardised data storage and management can incur significant costs. In this context, organisational and sector-wide data models and standards across nations become imperative to maximise data potential.

Table 12: Comparison of TOGAF, COBIT, GEAP

Framework	Key Components	Strengths	Weaknesses	Best use cases
Features	• Phase A: Architecture Vision • Phase B: Business Architecture • Phase C: Information Systems Architectures • Phase D: Technology Architecture • Phase E: Opportunities & Solutions • Phase F: Migration Planning • Phase G: Implementation Governance • Phase H: Architecture Change Management	• Specific architecture development process proposal • Well-defined utilisation relationships of various reference models • From interoperability in data perspective, it consistently presents organisational-level data standard management. • It presents various tools and matrices that can be used from a data linkage perspective, making it easy to apply in practice.	• A lack of management methodology for data standards and linkage, such as the DRM (Data Reference Model). • A lack of crucial data domains and codes from the perspectives of data exchange. • While TOGAF provides measurement methodologies, it does not offer specific templates for institutions to manage standards.	• Dairy Farm Group (Hong Kong): Referred to the TOGAF Standards Information Base (SIB). • Department of Social Security (UK): Included a Standards Information Base (SIB) in their approach.
COBIT	• Processes • Organisational structures and frameworks • Principles, policies, and procedures • Information • Culture, ethics, and behaviour • People, skills, and competencies • Services, infrastructure, and applications	• Providing tailored approach that aligns with the specific context and needs of an organisation. • Focus on IT alignment in enterprise with constant evaluation and improvement of IT performance and conformance.	• As a framework viewed from the perspective of IT audit, its content is primarily structured around enterprise-level system management. • It focuses more on system-to-system connections rather than data standards. • Instead of addressing data exchange and standards separately, COBIT approaches them from a perspective of system integration for the achievement of institutional objectives.	• Dubai Customs: Implemented a unified governance framework and system based on COBIT. • Saudi Arabian Municipality: Adopted COBIT for their enterprise governance and service management framework.

Framework	Key Components	Strengths	Weaknesses	Best use cases
GEAP (South Korea)	• Direction/Guidance (IT Policy, Enterprise Architecture Strategy, Architecture Principles, Requirements) • Enterprise Architecture(Architecture Model, Support Tools) • Deliverables (Architecture Deliverables)	• Effective Introduction and Operation of the Information System Act has been established by the law announced on December 30, 2005. All systems, databases, software, and hardware information built from every IT project are mandated to be registered on the government wide GEAP site (www.geap.go.kr) • All public agencies in Korea can search every system established in the Korean public sector. This enables them to prevent redundant constructions, leading to budget savings and enhanced efficiency. • Easily utilized as a basic framework as it includes almost all items related to enterprise architecture in the framework.	• Only provides a standard framework, recommending institutions to draft detailed contents themselves. • The shift has been made towards a government-wide system (GEAP) of managing IT projects, and the construction of EA (Enterprise Architecture) is individually managed based on the specific needs of each institution.	• Ministry of Land, Infrastructure and Transport: Integrated EA into planning and budgeting with executive support. • Statistics Korea: Evaluated all IT projects by the CIO • Busan Metropolitan City: Aligning EA with their Balanced Scorecard • Seoul Metropolitan City: Achieved significant savings through diligent annual EA project reviews. • Ulsan Metropolitan City: Streamlined IT planning • KEPCO: Substantial budget savings in 2010-2011. • Korea Institute of Nuclear Medicine: Oversaw tasks from inception to execution.

III.4. Presentation of use cases and good practices (Korean cases)

Drawing on frameworks such as TOGAF and COBIT, GEAP in South Korea serves its role as a comprehensive schematic that systematically organises key system attributes, including processing tasks, product hardware/software, data, and applied technologies.

In Enterprise Architecture utilisation and management, GEAP in South Korea exhibits numerous exemplary instances of integration in both the public and private sectors. Such integration not only reflects the commitment to information-driven governance but also the optimisation of resources.

- ***Ministry of Land, Infrastructure and Transport:*** Recognised as a pioneer in the construction, management, and utilisation of EA, the Ministry leverages it intensively for information planning and budget formulation. The firm commitment from the CEO, CIO, and the department overseeing IT signifies its unwavering focus. Additionally, it has developed a system to integrate and manage EA information from affiliated and sub-organisations.
- ***Statistics Korea:*** Institutionalisation marks every stage of their EA-based information planning, project execution, and performance management. Through an established review committee for IT initiatives, even ordinary tasks and general accounting budgets are scrutinised. The CIO is dedicated to monitoring EA information continuously.
- ***Busan Metropolitan City:*** The achievements of EA are intertwined with the institution's Balanced Scorecard (BSC). Relying on the "Information Technology Architecture Operation Regulation", a Planning and Finance Officer has been designated as the chief responsible officer. They have segregated teams for EA promotion and utilisation, and the BSC evaluation incorporates EA performance metrics.
- ***Seoul Metropolitan City:*** Being one of the first public entities to adopt EA, Seoul City has successfully ingrained a management and utilisation system. Through an annual review of EA-based projects and information management, tangible benefits have been derived. For instance, a budget feasibility review in 2011 resulted in savings of KRW 54.4 billion across 20 projects and a further KRW 3.99 billion through the integration of four projects.
- ***Ulsan Metropolitan City:*** The city capitalises on the National EA to avert redundant investments during IT project planning and resource management.
- ***KEPCO:*** Their commitment to EA is evident through a dedicated organisation under the direct supervision of the CEO. The ICT planning team oversees all IT projects, data standardisation, and systematic EA performance management. Notably, between 2010 and 2011, a preliminary review of IT projects resulted in a budget saving of KRW 600 million.
- ***Korea Institute of Nuclear Medicine:*** They have embarked on building an IT management system from the EA perspective. Through EAMS, they manage computer tasks, impact analysis, development, and operation.

The Reference Model in EA is a standardisation of architectural components identified for abstraction. It serves as an abstracted model that institutions or enterprises refer to when establishing their enterprise architecture. Reference Model abstracts are a conceptual model of the system, ensuring that it meets various perspectives. Additionally, it provides components in a reusable manner, facilitating its applicability across multiple enterprises.

It is also recommended to leverage defined reference models for industries with similar characteristics. Every enterprise can draw inspiration from a generic reference model to its sector, allowing them to devise a unique architecture.

There are various reference models, including the Business Reference Model (BRM), Data Reference Model (DRM), Service Reference Model (SRM), Technical Reference Model (TRM), and Performance Reference Model (PRM).

- ***Performance Reference Model (PRM):*** Presents items, indicators, and methods for measuring IT performance outcomes.
- ***Business Reference Model (BRM):*** Serves as the benchmark for business architecture, classifying and defining the business or tasks of the targeted architectural institution.
- ***Service Reference Model (SRM):*** Acts as the standard for application architecture, categorising and defining the functionalities of application services.
- ***Data Reference Model (DRM):*** Sets the guideline for data architecture, analysing major data elements exchanged between institutions, and further defining and standardising them.
- ***Technical Reference Model (TRM):*** Establishes the criterion for technical architecture, classifying and identifying information technology.

From the perspective of data storage and exchange standards, let us examine the Business Reference Model (BRM), the Service Reference Model (SRM), and the Data Reference Model (DRM). The Business Reference Model (BRM) is a reference model that defines functions based on the independent business operations of an institution. As of 2020 in South Korea, it is categorised into a total of 17 policy fields, 71 policy areas, 523 primary functions, 1,833 secondary functions, and 9,558 tertiary functions. The units of operations defined in the BRM do not necessarily correspond to tasks performed by a specific institution. Instead, they signify that regardless of the purpose and nature of tasks an institution undertakes, those tasks can be described using the units of operations outlined in the BRM. This provides a common benchmark for business analysis. It enables institutions to identify if different entities are performing similar tasks, facilitating collaborative system development to support similar functions. The BRM can also assist in searching for projects in other institutions that share similar content, offering a point of reference.

The Service Reference Model (SRM) serves as a function-centric, evaluative reference model designed to categorise service elements that support the execution of tasks and the achievement of objectives. Primarily, it is intended to promote the identification of applications in the public sector, fostering connections between tasks and services, encouraging reuse, and preventing redundant development. This represents a standard classification system for services, independent of tasks and organisational structures. Through this model, institutions can discover governmental-level tasks and application service elements. The goal of constructing the SRM is to provide a classification system to encourage the reuse of application services and offer a unified and integrated classification system for government agency task support components. It also promotes the development, accumulation, and distribution of components between the industry and government, simplifying the identification of complex and diverse governmental department application services.

As of 2012, the Service Reference Model comprises three service fields: Public Services, Internal Government Support Services, and Common Technical Services.

- ***Public Services*** focuses on supporting unique institutional tasks and the execution of projects. It aligns with government department tasks and objectives and encompasses task rules and procedures. It consists of various sectors like residents' lives, environment, national infrastructure, intellectual activities, social welfare, public health, economic activities, cultural life, public safety, and international and inter-Korean exchanges. This sector is organised into 1st level (10 categories), 2nd level (36 categories), and 3rd level (107 categories).
- ***Internal Government Support Services*** refer to services that multiple institutions commonly use and are provided in an integrated environment. They consist of commonly utilised services across various institutions, including audit, legal, finance, general administration, task management, public relations, human resource management, and informatisation. This sector is organised into 1st level (8 categories) and 2nd level (38 categories).

- ***Common Technical Services*** encapsulate the technical components needed to implement both Public Services and Internal Government Support Services. These are technology service components that can be commonly utilised across multiple systems regardless of specific tasks. If the components in the Common Technical Services field are refined and reused/shared, it can reduce the development and management costs for basic functions in information system construction and ensure interoperability among application functions. This sector is organised into the 1st level (9 categories) and the 2nd level (50 categories).

The Data Reference Model (DRM) is an architectural framework tailored to facilitate information comprehension and utilisation across various organisations. It defines standards and structures to encourage inter-institutional data exchange, data standardisation, reuse, and management. The five key elements that make up the DRM framework are:

- ***Data Model:*** This represents a schematic of all data being utilised and built upon across the government. It helps identify existing data and the relationships between various data domains. By referring to this model, individual institutions can gain clarity on what kind of data is currently being built, operated, and used throughout the government.
- ***Data Classification:*** This defines the criteria for classifying data. The data in the government-wide data model are grouped based on this classification. Furthermore, elements of the data structure are mapped to this classification system. Using this classification system facilitates more accessible data management and search capabilities.
- ***Data Structure:*** All data elements within the scope, their owners, standardised item definitions, and relationships between these elements are documented. This offers standardisation guidelines and pointers for the data elements being built and utilised. Ultimately, significant standardised data elements are registered to encourage sharing and reuse.
- ***Data Exchange:*** This is all about setting standards and mechanisms for data exchange. It provides definitions for exchange targets, the structure of messages, and messaging methods. The aim is to manage the history of data exchanges effectively. Through the data exchange packages defined here, data elements can be referred to and reused.
- ***Data Management:*** This section defines policies, rules, processes, and organisational structures related to maintaining data quality, standardisation, and security. It is an essential part of ensuring that the data is trustworthy, secure, and adheres to set standards.

Building upon established frameworks like TOGAF, COBIT, and EA, South Korea has introduced a practical methodology for managing public data from a perspective of data standard and data exchange. According to the Data-Based Administration Law in Korea, public bodies are required to manage the metadata of databases they generate, acquire, and oversee. Metadata refers to the representation of data's structure, attributes, characteristics, and history. This is clearly outlined in the "Database Standardisation Guidelines for Public Agencies" issued by the Ministry of the Interior and Safety, which prescribes 43 standard elements. Through this system, all metadata of databases from tables to columns of every public agency is managed in an integrated metadata management system. This ensures a foundational setup for efficient data search and exchange across different public entities.

To foster the integration and shared utilisation of public data, the Ministry of the Interior and Safety have established a set of Common Standard Terminology. This initiative seeks to ensure consistency and uniformity in data models by standardising terms or column names that are frequently used across different agencies. An often-encountered issue is the varied use of terms which mean the same thing, such as 'mobile phone number' and 'cell phone.' The introduction of the Common Standard Terminology is a strategic effort to provide a unified label for such terms. Discrepancies in terminology and format invariably necessitate extra processing, resulting in added costs and expended time.

However, by implementing the Common Standard Terminology in the databases of public agencies, data integration becomes notably more efficient. When public institutions apply standards in their operations, they must adhere to the superior standards in place. In the event of a database construction or database rebuilding project, the creation of database standards is necessary. At this stage, the database must conform to both the higher-level "Institutional Standards" and the broader government standard, "Common Standard Terminology" as well.

Additionally, when formulating standards at the organisational level, the use of the Common Standard Terminology is compulsory. These principles are also considered primary inspection criteria during the evaluation and oversight of database construction projects. There are 1,686 terms that have been standardised under the Common Standard Terminology. South Korea's Common Standard Terminology was established for the same reasons as the U.S.'s National Information Exchange Model (NIEM) Core. The NIEM serves as a reference model, catering to a wide array of communities such as Justice, Maritime, MilOps, Screening, Surface Transportation, Biometrics, CBRN, Agriculture, Emergency Management, Human Services, Immigration, Infrastructure Protection, Intelligence, and International Trade.

This widespread involvement ensures representation from federal, state, local, tribal, private sector, and even international entities. It offers a consensus on terms, definitions, relationships, and formats without dictating how information must be stored in individual systems. The NIEM model encompasses specific elements tailored to each community's needs. Moreover, it contains core elements (NIEM Core) that have gained universal agreement across all the communities employing NIEM. Some of these universally acknowledged core elements are "person," "location," "item," "organisation," and "activity." Beyond just being a reference model, NIEM is the foundational layer upon which data exchanges are constructed. It not only presents the model but also provides a clear set of rules and methodologies concerning its use. There is an established Information Exchange Development Lifecycle that adheres to standardised protocols, ensuring consistency and reusability for everyone.

The Ministry of Interior and Safety have established the "Public Data Provision Standard". They refer to the standards that should be applied when offering sets and collections of data (datasets) that need to be provided in a consistent format and with identical items, considering the demands of private sector utilisation. Numerous institutions have provided public data in diverse formats. With the increasing volume of public data and rising demand for its usage, as of 2021, an average of 64 institutions have been delivering similar data in varied forms. Considering the demands from the private sector and the requirement to provide data in a uniform format and items, as of 2023, there are 169 types of Public Data Provision Standards established.

IV. Cloud Computing Reference Architecture Framework

IV.1. Introduction

This part presents a reference architecture for cloud computing. The cloud reference architecture refers to an architectural model that assists in designing and constructing services in a cloud computing environment. It serves as a guide to develop stable and scalable applications by efficiently utilising services and technologies provided by various cloud providers.

IV.2. Key Principles of Cloud Reference Architecture

The cloud reference architecture must adhere to several key principles to enable cloud users to build and use stable and efficient applications in the cloud environment. Clouds built upon these principles help users optimise cloud resources, meet business requirements, and enhance security, reliability, performance efficiency, cost optimisation, and operational efficiency.

- ***Operational Excellence:*** This principle improves operational processes to enhance system availability and reduce costs. It emphasises elements like change management, monitoring, issue response, and automation.
- ***Reliability:*** The reliability principle aids in designing and operating systems to withstand unexpected failures. It includes topics such as resilience, elasticity, and data integrity.
- ***Security:*** Security principles pertain to safeguarding data, systems, and networks. They encompass access control, data protection, identity authentication, and authorisation.
- ***Performance Efficiency:*** Performance efficiency focuses on efficient resource utilisation, covering topics like scalability, performance optimisation, and resource management.
- ***Cost Optimisation:*** The cost optimisation principle assists in effectively utilising cloud resources to reduce costs. It includes efficient cost management, resource resizing, usage analysis, and more.

IV.3. Principles for Creating Cloud Reference Architecture

Numerous standards organisations and associations have presented cloud reference architectures, and major cloud companies also share their cloud computing architectures for reference. In this document, reference architectures provided by institutions or companies were utilised, following these principles:

- The reference architecture draws upon cloud architectures formulated by international standards organisations as well as those put forth by major players in the cloud industry.
- The emphasis of the reference architecture provided is on the perspective of cloud service providers rather than that of users.
- The reference architecture was designed to be independent of specific companies' cloud technologies.
- The referenced architecture seeks to incorporate the latest advancements in cloud computing technology whenever possible.
- Given the existence of various cloud types, reference architectures are provided based on representative types.
- As cloud service technologies encompass a vast array of features and incorporate numerous recent technologies like AI and big data, the reference architecture primarily focuses on presenting architectures centred around core cloud technologies.

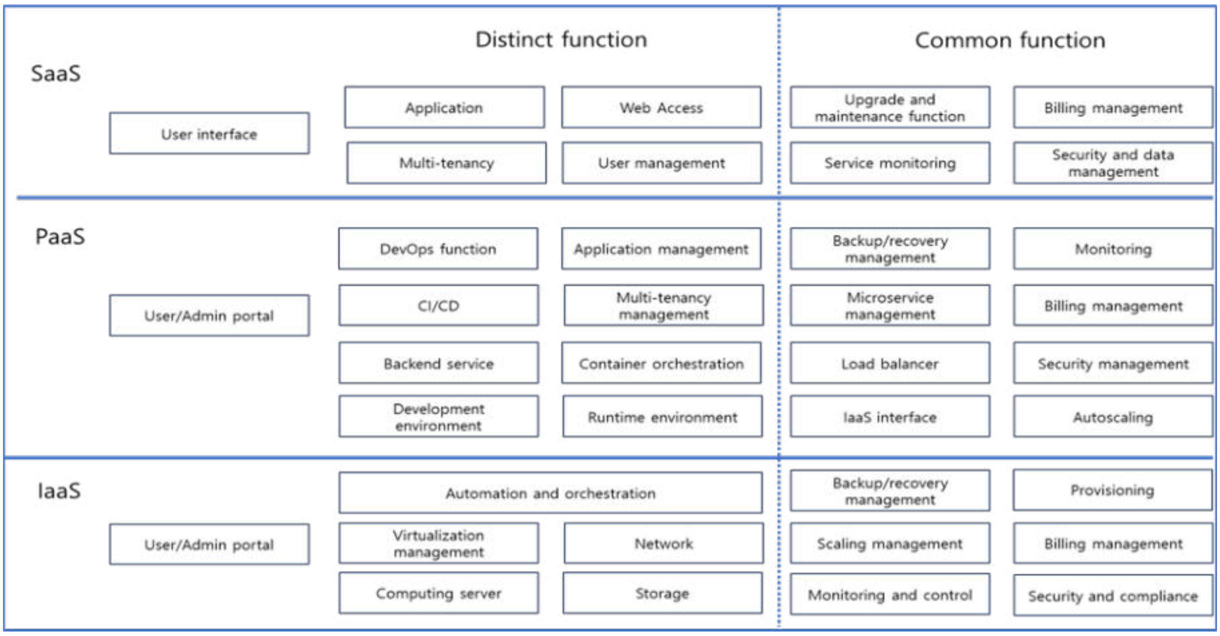
IV.4. Architecture Components Based on Cloud Service Types

Cloud services are fundamentally categorised into three main types based on the nature of the services they offer:

- ***IaaS (Infrastructure as a Service)*** entails cloud service providers lending hardware required for computing in the form of services.
- ***PaaS (Platform as a Service)*** involves cloud service providers offering platforms necessary for application development and execution.
- ***SaaS (Software as a Service)*** refers to software applications being leased in service form by SaaS providers.

These three service types constitute the foundational aspects of cloud computing, and in addition, a plethora of other "as a service" models exist to cater to diverse needs.

Figure 12: Overall architecture for Cloud



IV.4.1 IaaS (Infrastructure as a Service)

IaaS is one of the cloud computing service models, providing virtualised computing resources to deliver infrastructure on-demand. It innovatively reduces the burdens of purchasing and managing hardware by virtualising existing on-premises infrastructure and delivering it over the internet. IaaS offers flexibility to scale resources such as virtual servers, storage, and networking up or down as needed.

Key components of IaaS include:

- ***Computer Servers:*** Refers to server resources used in a cloud computing environment, employing virtualisation to logically partition and manage hardware resources.
- ***Storage:*** Enables data storage and management through cloud storage. Various types like block storage, file storage, and object storage are available.
- ***Networking:*** Manages communication between virtual servers and external connections through virtual networking. It involves IP address allocation, firewall configuration, load balancing, etc.
- ***Virtualisation Management:*** IaaS platforms provide virtualisation management tools supporting tasks such as creation, management, monitoring, and scaling of virtual machines.

- ***Automation and Orchestration:*** Automates and manages tasks like resource deployment, provisioning, and scaling using automation tools to increase operational efficiency.
- ***Security and Compliance:*** Provides features and tools for data security and compliance, safeguarding data integrity and privacy.
- ***Scaling Management:*** Allows resources to be scaled up or down according to demand, catering to fluctuating business needs.
- ***Billing System:*** Most IaaS providers charge fees based on resource usage, which can dynamically change according to actual usage.
- ***User/Admin Portal:*** The user and admin portal for IaaS is a web-based interface used for utilising and managing IaaS services. It aids users in managing and controlling IaaS resources and utilising the services provided by the IaaS provider.
- ***Provisioning:*** Refers to the process of dynamically creating, configuring, and deploying computing resources in a cloud environment. This process is crucial for efficiently acquiring necessary computing resources and configuring the environment to meet the requirements of applications.

IaaS empowers developers and businesses to develop, deploy, and operate applications without the complexities of managing hardware infrastructure, offering a robust cloud computing model.

IV.4.2 PaaS (Platform as a Service)

PaaS is a cloud computing service model that provides a platform for developing, deploying, and managing applications. It abstracts infrastructure and runtime environments to allow developers to focus on application code. This simplifies and accelerates tasks throughout the application development lifecycle.

Key concepts and components of PaaS include:

- ***Development Environment:*** PaaS offers developers the necessary environment to write and test application code. It can include integrated development environments (IDEs), development tools, debugging tools, etc.
- ***Runtime Environment:*** PaaS provides the runtime environment in which applications run. This includes web servers, databases, middleware, runtime libraries, etc.
- ***Application Management:*** Encompasses features to manage the entire lifecycle of applications, ensuring easy operations and management.
- ***DevOps Functionality:*** Enhances collaboration between development and operations, automating software development and deployment processes, fostering communication and collaboration between teams.
- ***Container Orchestration:*** Automates deployment, management, scaling, and adjustment of multiple containers. It simplifies the deployment and management of large-scale distributed applications and efficiently operates containerised applications.
- ***Microservices Management:*** In a microservices architecture, management features include tasks related to developing, deploying, monitoring, scaling, and managing independent microservices. It ensures stability, availability, performance, and security of the entire system.
- ***Backend Service Provisioning:*** Offers various services for developers to easily add required functionalities. This includes database management, messaging services, security services, etc.
- ***Scaling and Load Balancing:*** Automatically scales resources and performs load balancing based on application demand to optimise performance.
- ***Deployment and Management:*** Simplifies application deployment and management. Supports version control, automated deployment, monitoring, logging, etc.

- ***Multi-Tenancy:*** Supports multi-user or multi-tenant environments, allowing multiple developers or teams to use the same application instance while separating data and configurations.
- ***Billing System:*** PaaS providers often use subscription-based fee models. Users pay monthly or annually for service usage.
- ***User/Administration Portal:*** The user and administration portal for PaaS is a web-based interface used to manage and utilise PaaS services. It helps users manage and control PaaS resources and utilise the services provided by the PaaS provider.

PaaS allows developers to focus on application development while reducing infrastructure management burdens, enabling faster development and deployment of innovative solutions. This model simplifies and accelerates the software development lifecycle, aiding businesses in responding more quickly to their needs.

IV.4.3 SaaS (Software as a Service)

SaaS is a cloud computing service model that provides software over the internet, accessible through web browsers or mobile apps. Users can access and utilise software applications without purchasing or installing them. SaaS offers a convenient way for both businesses and individuals to access various types of software applications.

Key concepts and components of SaaS include:

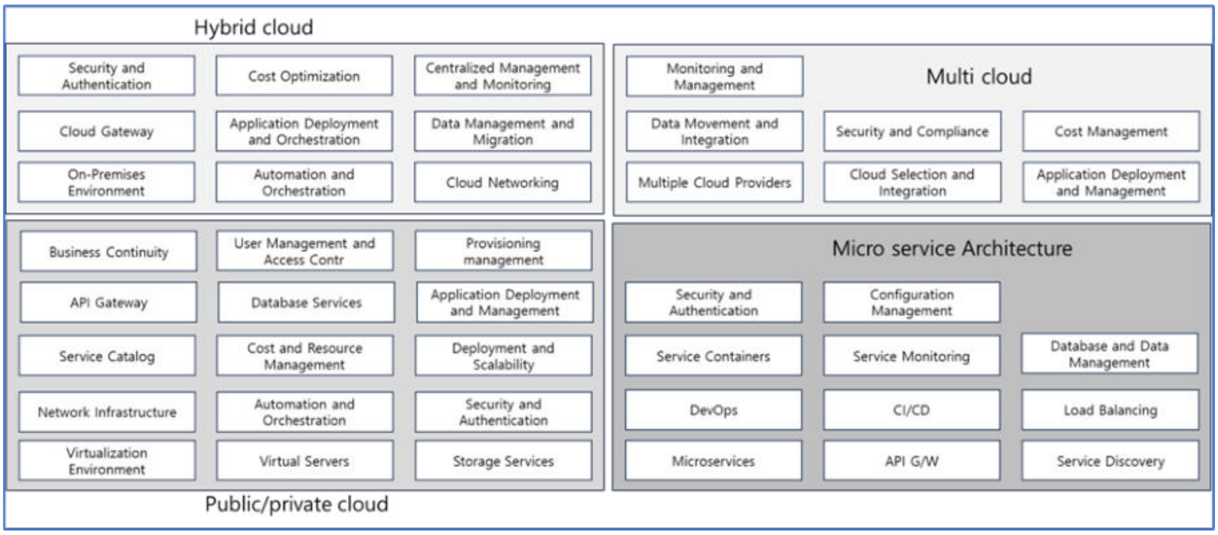
- ***Application:*** SaaS providers offer various types of software applications, ranging from email, word processing, spreadsheets, project management, customer relationship management (CRM), human resources (HR), and more.
- ***Web-Based Access:*** Users can access SaaS applications from any internet-connected device using a web browser or mobile app, providing flexibility and convenience.
- ***Multi-Tenancy:*** SaaS uses a multi-tenant model, allowing multiple users or organisations to share the same application instance while separating data and configurations.
- ***Upgrades and Maintenance:*** SaaS providers handle software upgrades and maintenance. Users automatically have access to the latest version, while tasks like system management and security patches are managed by the provider.
- ***Security and Data Management:*** SaaS provides various features for data security, including data backup and recovery, data sharing, and access control.
- ***User Interface:*** SaaS applications provide a user interface (UI) for users to interact with and utilise the application easily.
- ***User Management Features:*** Includes features necessary to manage user accounts and permissions within the software application provided by the SaaS provider.
- ***Service Monitoring:*** In a SaaS (Software as a Service) environment, service monitoring involves monitoring and analysing the status, performance, availability, and usage patterns of provided software applications to ensure operational status and optimisation.
- ***Billing System:*** SaaS providers primarily use a subscription-based fee model. Users pay monthly or annually to access and use the service.

SaaS offers users rapid and convenient access to software and reduces the burdens of software purchase and management. This model enhances efficiency in both individual and business operations and can facilitate innovation.

IV.5. Architecture Models Based on Cloud Deployment Types

Cloud computing architecture can be classified in various ways based on different perspectives, offering several types that can be chosen to meet application and business requirements. Below is an introduction to the key cloud computing architectures.

Figure 13: Architecture Models Based on Cloud Deployment Types


Hybrid cloud
Security and Authentication
Cost Optimization
Centralized Management and Monitoring
Cloud Gateway
Application Deployment and Orchestration
Data Management and Migration
On-Premises Environment
Automation and Orchestration
Cloud Networking
Monitoring and Management
Multi cloud
Data Movement and Integration
Security and Compliance
Cost Management
Multiple Cloud Providers
Cloud Selection and Integration
Application Deployment and Management
Business Continuity
User Management and Access Contr
Provisioning management
API Gateway
Database Services
Application Deployment and Management
Service Catalog
Cost and Resource Management
Deployment and Scalability
Network Infrastructure
Automation and Orchestration
Security and Authentication
Virtualization Environment
Virtual Servers
Storage Services
Micro service Architecture
Security and Authentication
Configuration Management
Service Containers
Service Monitoring
Database and Data Management
DevOps
CI/CD
Load Balancing
Microservices
API G/W
Service Discovery
Public/private cloud

IV.5.1 Public/Private Cloud

The public cloud architecture is based on the infrastructure provided by cloud service providers. It enables the development, deployment, and management of applications using various services and resources. The private cloud architecture involves building a dedicated cloud environment within an organisation. It balances security and compliance requirements with the agility and efficiency of cloud computing.

The major components of the public and private cloud architecture are as follows:

- ***Virtualisation Environment:*** Utilises virtualisation technology to separate computing resources into virtual machines (VMs) and containers.
- ***Virtual Servers:*** Instances of virtual machines (VMs) that run applications and are managed within the virtualised environment.
- ***Storage Services:*** Provides storage services for data storage and management, including block storage, file storage, and object storage.
- ***Network Infrastructure:*** Manages network communication between applications using virtual networks, load balancing, and firewalls.
- ***Automation and Orchestration:*** Automates resource provisioning, management, scaling, and orchestration of tasks.
- ***Security and Authentication:*** Implements security mechanisms such as data protection, access control, and encryption.
- ***Service Catalogue:*** Defines and provides a list of available cloud services and their characteristics.
- ***User Management and Access Control:*** Implements user account management, access control, and authentication mechanisms.
- ***Cost and Resource Management:*** Monitors and manages resource usage, cost, and performance.
- ***Deployment and Scalability:*** Allows easy application deployment and supports horizontal and vertical scaling.
- ***API Gateway:*** Manages interactions between cloud services and applications by handling API calls.

- ***Database Services:*** Provides various types of database services for data management and processing.
- ***Application Deployment and Management:*** Offers tools and services for developing, deploying, managing, and monitoring applications.
- ***Business Continuity:*** Ensures business continuity through disaster recovery, backup, and high availability.

IV.5.2 Hybrid Cloud

The hybrid cloud architecture combines on-premises environments with public and private clouds. It enables organisations to use a mix of resources to meet their needs.
Key components of the hybrid cloud architecture include:

- ***On-Premises Environment:*** Includes existing on-premises data centres, servers, networks, and infrastructure.
- ***Public Cloud:*** Utilises resources from public cloud providers.
- ***Cloud Networking:*** Establishes secure and efficient network connections between on-premises and cloud environments.
- ***Cloud Gateway:*** Manages data and application integration between on-premises and cloud environments.
- ***Application Deployment and Orchestration:*** Deploys applications to both on-premises and cloud environments and automates resource management.
- ***Data Management and Migration:*** Manages data movement, synchronisation, backup, and restoration.
- ***Security and Authentication:*** Maintains security between on-premises and cloud environments.
- ***Cost Optimisation:*** Efficiently manages resource usage, cost, and budget allocation.
- ***Centralised Management and Monitoring:*** Monitors and manages resources and application states centrally.
- ***Automation and Orchestration:*** Optimises resource management and application deployment through automated workflows.

The hybrid cloud architecture offers a flexible and secure environment by combining on-premises and cloud resources to meet diverse requirements.

IV.5.3 Multi Cloud

The multi-cloud architecture represents a strategy of utilising multiple cloud environments simultaneously. This involves combining services and resources from various cloud providers or effectively managing and utilising distributed clouds across different regions.

The key components of a multi-cloud architecture are as follows:

- ***Multiple Cloud Providers:*** In a multi-cloud architecture, integration with two or more different cloud providers is established.
- ***Cloud Selection and Integration:*** The ability to choose and integrate the optimal clouds that meet organisational needs among different cloud providers is crucial. Efficient operation requires harmonising services, APIs, data models, etc., across different cloud environments.
- ***Application Deployment and Management:*** In a multi-cloud setup, applications must be distributed and managed across multiple cloud environments. Performance and availability of applications are managed using load balancing, auto-scaling, and orchestration.
- ***Data Movement and Integration:*** A strategy is required for moving and integrating data across multiple clouds. Data management considers aspects like data migration, flow, and compatibility.

- ***Security and Compliance:*** Adhering to various security policies and regulations is important in a multi-cloud environment. Security mechanisms such as data protection, access control, and encryption are implemented to ensure security.
- ***Cost Management:*** Understanding the cost models of each cloud provider and efficiently managing costs are necessary. Cost analysis, budget allocation, and cost optimisation minimise expenses and maximise benefits.
- ***Monitoring and Management:*** In a multi-cloud architecture, monitoring and managing the status and performance of multiple cloud environments is required. Centralised monitoring tools or services track operational status and detect issues early.

The multi-cloud architecture provides a strategy to harmonize multiple cloud environments for flexible and efficient operation aligned with an organisation's business requirements.

IV.5.4 Edge Cloud

The edge cloud architecture represents a model in which cloud computing resources are provided in regions close to edge devices. It is designed for applications that require fast data processing and real-time responses.

The key components of an edge cloud architecture are as follows:

- ***Edge Devices:*** Core components of the edge cloud architecture, including sensors, cameras, switches, and similar devices. They collect and transmit real-time data.
- ***Edge Gateway:*** Positioned between edge devices and the cloud, the edge gateway collects and preprocesses data before sending it to the cloud. It performs functions such as data compression, encryption, and filtering.
- ***Edge Server:*** Performs local data processing and analysis. Operating as an intermediary layer between edge devices and the edge cloud, it supports applications that require real-time responses.
- ***Cloud Resources:*** In the edge cloud architecture, the central cloud performs additional data processing, analysis, and long-term data storage. The central cloud handles tasks that edge devices and servers cannot perform.
- ***Edge Network:*** A stable network connection is required between edge devices, gateways, servers, and the cloud in the edge cloud architecture. A network supporting fast data transfer and secure communication is essential.
- ***Data Streaming and Analysis:*** Real-time data streaming and analysis platforms process and analyse data collected at the edge in real time. This enables the creation of real-time response applications.
- ***Security and Authentication:*** The edge cloud architecture must implement security mechanisms and authentication methods to maintain data security and device integrity.
- ***Business Applications:*** Applications developed for the edge cloud architecture provide features such as real-time analysis, predictive models, automated responses, and decision support.

The edge cloud architecture plays a critical role in fields requiring rapid data processing and response, allowing the construction and management of real-time applications through the combination of these components.

IV.5.5 Microservice Architecture

Microservices architecture is an architectural pattern that decomposes software systems into small, independent functional units. Each microservice can be deployed, scaled, and managed individually, and it can use various technology stacks and independent databases.

The key components of the microservices architecture are as follows:

- ***Microservices:*** The primary components of the microservices architecture are individual microservices that perform independent functions. Each microservice implements specific business functionality and is developed, deployed, and managed on a small scale.
- ***API Gateway:*** It manages communication between clients and microservices. The API gateway routes client requests to the appropriate microservices and handles authentication, authorisation, logging, load balancing, and more.
- ***Service Discovery:*** This mechanism tracks and discovers the dynamic locations of microservices. A service discovery system supports registration, updating, and querying of microservices.
- ***DevOps:*** DevOps, short for Development and Operations, represents a culture, philosophy, and methodology that integrates software development and deployment processes. It enhances collaboration between development and operations teams and aims to improve the frequency and quality of software development and deployment to respond more quickly and reliably to business demands.
- ***Load Balancing:*** It distributes traffic among multiple instances to evenly share the load of each microservice. This optimisation minimises response times and improves availability.
- ***Service Monitoring:*** It monitors the performance and availability of each microservice, collects logs, identifies, and resolves issues. Monitoring is a crucial element supporting operations and maintenance.
- ***Service Containers:*** Microservices run in isolated container environments, enabling isolation and scalability between services. This approach allows the use of different languages and technologies.
- ***Database and Data Management:*** Each microservice can have its own database as needed. Techniques like event sourcing and CQRS patterns can be used to manage data and maintain consistency.
- ***Security and Authentication:*** Security mechanisms like authentication and authorisation are implemented between microservices. Data protection and network security are also important considerations.
- ***Configuration Management:*** Microservices operate using configurations and environment variables. A centralised configuration management system is utilised to manage each service's configurations.
- ***CI/CD (Continuous Integration / Continuous Deployment):*** The microservices architecture employs CI/CD pipelines for automated development and deployment, supporting rapid deployment and integration.

Microservices architecture enables faster and more efficient application development and operations through modular design and flexible implementation.

IV.5.6 Serverless Architecture

The serverless architecture is a cloud computing model that minimises server management for application development and deployment. Developers are relieved of the burden of server management, and the model centres around event-driven function execution.

The key elements of a serverless architecture are as follows:

- ***Functions:*** In the serverless architecture, application functionality is divided into small units known as functions. Functions are automatically triggered by events, performing necessary calculations, and returning results.
- ***Event Triggers:*** Mechanisms that define events that activate functions. Events can be triggered by changes in application state or external inputs. Examples include HTTP requests, database changes, and timers.

- ***Cloud Services:*** Cloud services in a serverless architecture manage function execution and dynamically allocate resources as needed. This eliminates the need for developers to manage server instances, scaling, and maintenance.
- ***Function Containers:*** Isolated container environments used for each function execution. They provide isolation and security between function executions and ease scalability and management.
- ***Data Storage and DB Services:*** Data storage and database services are required to store and retrieve data for applications. This enables functions to access and process data.
- ***API Gateway:*** An interface that processes external requests and invokes functions. It transforms client requests into events to trigger functions and returns function results to clients.
- ***Security and Authentication:*** Security remains important in a serverless environment. Access control, data encryption, and authentication and authorisation mechanisms maintain the security of data and functions.
- ***Logging and Monitoring:*** Monitors function execution and performance, collects logs for debugging and performance enhancement.
- ***Configuration and Environment Setup:*** Serverless applications operate based on environment variables and configuration information, allowing developers to adjust function behaviour and integrate with external services.
- ***Auto-Scaling:*** Serverless environments automatically scale function instances based on request volume, optimising resource utilisation.

The serverless architecture enables developers to focus on code execution, providing event-driven processing and flexible scalability. It can be beneficial in various application development and deployment scenarios.

IV.6. Detailed Technical Components of Cloud Architecture

Cloud reference architecture components represent the fundamental principles and elements used in designing and constructing services in a cloud computing environment. These architecture components must be considered during the cloud design and implementation process. By combining these elements, efficient and stable cloud-based services and applications can be implemented.

IV.6.1 Cloud Security and Authorisation Management

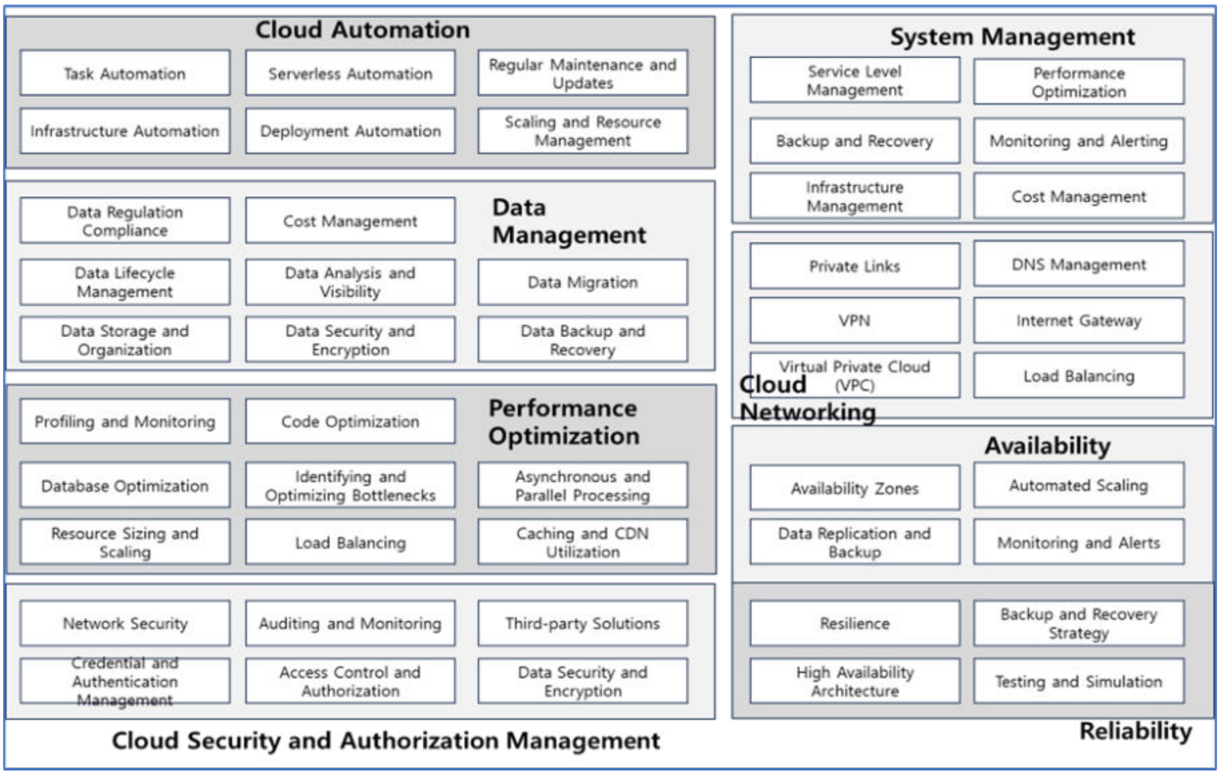
Cloud security and authorisation management are essential for protecting data and managing access permissions in a cloud computing environment. To effectively perform security and authorisation management in the cloud environment, the following functions should be included:

- ***Credential and Authentication Management:*** Protects access to users and resources using strong password policies. Multi-factor authentication (MFA) adds an additional layer of security. Role-based access control is implemented to adhere to the principle of least privilege.
- ***Access Control and Authorisation Assignment:*** Effective management of users, groups, and roles to grant only necessary permissions. Applying granular access control policies restricts access to necessary tasks. Enhances control over remote access and API access.
- ***Data Security and Encryption:*** Sensitive data is protected using appropriate encryption methods. Encryption is employed during data transmission and static/dynamic storage. Rigorous key management and rotation enhance data protection.
- ***Network Security:*** Configures virtual networks and firewalls to establish security groups and network policies. Utilises network protection mechanisms like DDoS attack defence.

- ***Auditing and Monitoring:*** Tracks system activities through event logging and monitoring, detecting abnormal activities. Regularly reviews audit logs for security incident response and investigation.
- ***Third-party Solutions:*** Leverages security tools provided by cloud providers and third-party security solutions for additional security features. Enhances security levels using vulnerability scanning, threat intelligence, and more.
- ***Regulatory Compliance:*** Adheres to industry regulations and legal requirements while safeguarding data protection and privacy.

Complying with these security and authorisation management practices maintains data and resource security in the cloud environment and minimises vulnerabilities in infrastructure and applications.

Figure 14: Detailed Technical Components of Cloud Architecture


Cloud Automation
Task Automation
Serverless Automation
Regular Maintenance and Updates
Infrastructure Automation
Deployment Automation
Scaling and Resource Management
Data Regulation Compliance
Cost Management
Data Management
Data Lifecycle Management
Data Analysis and Visibility
Data Migration
Data Storage and Organization
Data Security and Encryption
Data Backup and Recovery
Profiling and Monitoring
Code Optimization
Performance Optimization
Database Optimization
Identifying and Optimizing Bottlenecks
Asynchronous and Parallel Processing
Resource Sizing and Scaling
Load Balancing
Caching and CDN Utilization
Network Security
Auditing and Monitoring
Third-party Solutions
Credential and Authentication Management
Access Control and Authorization
Data Security and Encryption
Cloud Security and Authorization Management
System Management
Service Level Management
Performance Optimization
Backup and Recovery
Monitoring and Alerting
Infrastructure Management
Cost Management
Private Links
DNS Management
VPN
Internet Gateway
Virtual Private Cloud (VPC)
Load Balancing
Cloud Networking
Availability
Availability Zones
Automated Scaling
Data Replication and Backup
Monitoring and Alerts
Resilience
Backup and Recovery Strategy
High Availability Architecture
Testing and Simulation
Reliability

IV.6.2 Reliability and Availability

Cloud reliability and availability are important concepts in cloud computing, ensuring system stability and continuous accessibility.

- ***Reliability:*** In a cloud environment, reliability means the system operates normally and can recover appropriately from failures or issues. To enhance the reliability of cloud services, the following approaches are considered:
  - *Resilience:* The system's ability to have high durability during failures or problem situations, recovering quickly. Enhances resilience by distributing servers across multiple regions or establishing automated recovery processes.
  - *Backup and Recovery Strategy:* Regularly backs up data and implements effective recovery strategies in case of data loss.
  - *High Availability Architecture:* Utilises architecture patterns like load balancing, auto-scaling, replication, and more for high availability.
  - *Testing and Simulation:* Simulating failure scenarios and conducting regular recovery tests to ensure reliability.
- ***Availability:*** In a cloud environment, availability refers to the ability of users and applications to access services and resources whenever needed. The following approaches are relevant for enhancing availability in a cloud environment:

- *Availability Zones:* Cloud providers offer geographically distributed availability zones to ensure services can continue even in the event of failures.
- *Automated Scaling:* Resources are automatically scaled up or down based on fluctuations in traffic, maintaining availability.
- *Data Replication and Backup:* Data is replicated and backed up across multiple locations to prevent data loss and ensure availability.
- *Monitoring and Alerts:* Monitoring system and application states allows for quick alerts and responses to potential issues.

Cloud reliability and availability play a crucial role in ensuring business continuity and enhancing user satisfaction. To achieve this, cloud service providers offer various security and availability features, while users can contribute by designing and configuring the cloud environment appropriately to maintain reliability and availability.

IV.6.3 Performance Optimisation

Cloud performance optimisation refers to the process of enhancing the performance of applications and services within a cloud environment to improve user experience and efficiently utilise resources. To optimise cloud performance, several key factors and best practices should be considered:

- ***Resource Sizing and Scaling:*** Adjust the size of virtual machines or containers as needed to improve performance. Utilise automatic scaling settings to dynamically expand or shrink resources based on traffic fluctuations.
- ***Load Balancing:*** Use load balancers to distribute traffic across multiple servers or resources, ensuring balanced response times and improved availability.
- ***Caching and CDN Utilisation:*** Employ caching mechanisms to store frequently used data or content, reducing response times. Use Content Delivery Networks (CDNs) to cache content regionally for faster response to users.
- ***Database Optimisation:*** Improve database performance through techniques such as indexing and partitioning. Perform query optimisation and index tuning to enhance data retrieval speed.
- ***Identifying and Optimising Bottlenecks:*** Identify and address performance bottlenecks within the application. Resolve bottlenecks such as database queries or network connections.
- ***Asynchronous and Parallel Processing:*** Utilise asynchronous programming and parallel processing to efficiently handle tasks, reducing response times.
- ***Profiling and Monitoring:*** Monitor application and system performance, using profiling tools to identify bottlenecks and evaluate performance continually.
- ***Code Optimisation:*** Write efficient code and improve algorithms to optimise processing time and resource usage.

Cloud performance optimisation plays a crucial role in enhancing application efficiency and user experience. By considering optimisation from various aspects, such as resource utilisation, data processing, and application architecture, and by continuously monitoring and adjusting, you can maintain optimal performance.

IV.6.4 Cloud Networking

Cloud networking refers to the infrastructure and technologies that enable communication between applications, services, and resources within a cloud computing environment. It provides connectivity for users, ensures secure data transmission, and is a vital component in the cloud ecosystem.

Various networking concepts and features in cloud networking include:

- ***Virtual Private Cloud (VPC):*** Create isolated network environments logically using VPCs to protect and manage network traffic between resources.
- ***Load Balancing:*** Use load balancers to distribute traffic across multiple servers or resources, optimising response times and availability.
- ***Firewalls and Security Groups:*** Configure firewalls and security groups to enhance network security and manage access control.
- ***VPN (Virtual Private Network):*** Establish a virtual private network between cloud networks and on-premises networks for secure connections.
- ***Internet Gateway:*** Set up gateways to manage and protect communication between the internet and the cloud network.
- ***DNS Management:*** Manage internal and external Domain Name System (DNS) to resolve and manage domain names to IP addresses.
- ***Private Links:*** Establish dedicated network connections between the cloud provider and your network for improved data transfer speed and security.
- ***BGP Routing:*** Use Border Gateway Protocol (BGP) routing to manage efficient data transfer between multiple networks.
- ***IPv6 Support:*** Utilise IPv6 addressing to allocate more IP addresses and ensure network scalability.

Cloud networking is essential for managing data transmission, application communication, and security within the cloud environment. Effectively configuring and managing cloud networking is crucial for ensuring secure connections and optimising performance.

IV.6.5 Cloud Data Management

Cloud data management refers to the processes of storing, protecting, analysing, backing up, and managing data within a cloud environment. It ensures data safety, availability, and efficiency to achieve business objectives.

Key approaches and best practices for cloud data management include:

- ***Data Storage and Organisation:*** Utilise cloud storage to store data securely and efficiently. Services like databases and object storage can be used. Organise data in suitable formats for easy querying and analysis.
- ***Data Security and Encryption:*** Encrypt sensitive data at rest and during transmission, adding an extra layer of security. Control access and manage permissions for data.
- ***Data Backup and Recovery:*** Regularly back up data to prepare for potential data loss scenarios. Establish recovery strategies and processes for quick recovery of backup data.
- ***Data Lifecycle Management:*** Set policies for storing, retaining, and deleting data based on its lifecycle stages.
- ***Data Analysis and Visibility:*** Utilise cloud-based data analysis tools to extract value from data and gain insights. Monitor data status and trends through dashboards and visualisation.
- ***Data Migration:*** Plan and execute the migration of data from on-premises systems to the cloud. Maintain data consistency and stability during migration.
- ***Data Regulation Compliance:*** Adhere to data regulations and legal requirements even in a cloud environment.
- ***Cost Management:*** Evaluate and optimise data for unnecessary storage to manage data management costs.

Effective cloud data management plays a critical role throughout the data lifecycle. Proper management enhances data protection, analysis, visibility, and availability, contributing to improved business outcomes.

IV.6.6 Cloud Automation

Cloud automation refers to automating tasks, provisioning, deployment, management, and more within a cloud environment to efficiently manage system operations and optimise resource utilisation. By automating repetitive and cumbersome tasks, cloud automation enhances the productivity of developers and operators while reducing the complexity of infrastructure management. Below are key aspects and some best practices of cloud automation:

- ***Infrastructure Automation:*** Automate provisioning and management of cloud infrastructure components such as virtual machines, containers, and networks. Define infrastructure as code and use automation tools (e.g., Terraform, AWS CloudFormation) to configure environments automatically.
- ***Deployment Automation:*** Automate the process of deploying and updating applications in the cloud. Integrate with CI/CD pipelines to automatically build, test, and deploy code changes.
- ***Scaling and Resource Management:*** Automatically scale resources up or down based on increased traffic to maintain performance and save costs. Monitor resource usage and set up scaling triggers to adjust resources automatically.
- ***Task Automation:*** Automate repetitive tasks using scripts or automation tools. For example, automate tasks like backup, log management, and security audits.
- ***Serverless Automation:*** Utilise serverless architecture to automate code execution. Functions automatically scale and manage execution environments.
- ***Regular Maintenance and Updates:*** Automate regular tasks such as OS patching, security updates, and application updates to keep systems up to date. Cloud automation increases operational efficiency and saves time and effort by automating the management of infrastructure and applications. However, thorough testing and validation are essential when implementing automation to ensure accuracy and stability.

Leveraging cloud automation enhances the efficiency of system management, allowing for automatic handling of infrastructure and applications, thereby saving time and effort. However, when implementing automation, sufficient testing and validation are essential to ensure accuracy and reliability.

IV.6.7 Cloud Management and Monitoring

Cloud management and monitoring involve efficiently managing resources and services within a cloud environment and monitoring performance to maintain stability and availability. Due to the diversity and flexibility of resources in the cloud, effective management and monitoring are essential.

Approaches and best practices for cloud management and monitoring include:

- ***Infrastructure Management:*** Use automation tools (e.g., Terraform, Ansible) to provision and manage cloud resources. Define infrastructure as code for version control and reproducibility.
- ***Cost Management:*** Monitor cloud resource costs and use cost tracking tools to manage budgets. Prevent unnecessary resource usage and maintain efficient resource allocation.
- ***Security Management:*** Enhance cloud resource security by setting up access controls, security groups, and firewalls. Utilise vulnerability scans and audit logs to prevent and respond to security incidents.
- ***Backup and Recovery:*** Set up regular data backups and prepare recovery strategies for data loss scenarios. Maintain testing and processes for quick recovery of backup data.

- ***Monitoring and Alerting:*** Configure monitoring tools to monitor resource and application performance and detect potential issues early. Set up alerts and notifications for immediate response to problems.
- ***Performance Optimisation:*** Analyse resource usage, response times, and traffic to identify and optimise performance bottlenecks. Use auto-scaling and resource resizing to enhance performance.
- ***Service Level Management:*** Monitor service level agreements (SLAs) and ensure the service provider complies with SLAs. Manage recovery times and processes during incidents.

Cloud management and monitoring play a critical role in maintaining stability, availability, and fulfilling business requirements. Effective management and monitoring enable the prevention and swift resolution of system issues, enhancing user experience, and reducing costs.

IV.7. Public Administration Cloud Adoption Guidelines

When public administrative agencies consider adopting the cloud, they must first assess the current information systems and management organisation. Through this, they can clearly define the goals of cloud adoption and maximise the benefits of such adoption.

The cloud adoption project team should first evaluate the technical factors of the current on-premises information systems. Technical evaluation targets hardware, software, databases, network, and all aspects of IT infrastructure and applications. Through such evaluation, cost savings, virtualisation, sharing of IT resources, scalability, service flexibility, and automation potential can be diagnosed.

Secondly, the project team should assess the level of IT resource provision, IT management, and the current status of IT resource provision processes. Through such assessments, the potential for improving IT service provision levels for business organisations, which are IT consumers, and the level of IT operations and management can be diagnosed.

Thirdly, the project team should evaluate the structure, roles and responsibilities, management style, work environment, goals, and training status of the IT organisation. This will help determine whether a transition from an IT organisation specialised in individual technologies to a service-oriented and business-oriented IT organisation is possible.

Fourthly, the project team should assess the demand of the business organisation for IT services and the current level of response by the IT organisation. By diagnosing whether IT governance can be transformed into a model where budget allocation and expenditure are made based on enterprise-wide IT demand and usage, the team can determine the feasibility.

Through such assessments, the organisation must decide on the cloud adoption area, methods, and cloud forms (IaaS, PaaS, SaaS). The type of cloud to be adopted may vary depending on factors such as the characteristics of the systems the organisation possesses, budget, sensitivity to performance, security compliance, and other considerations.

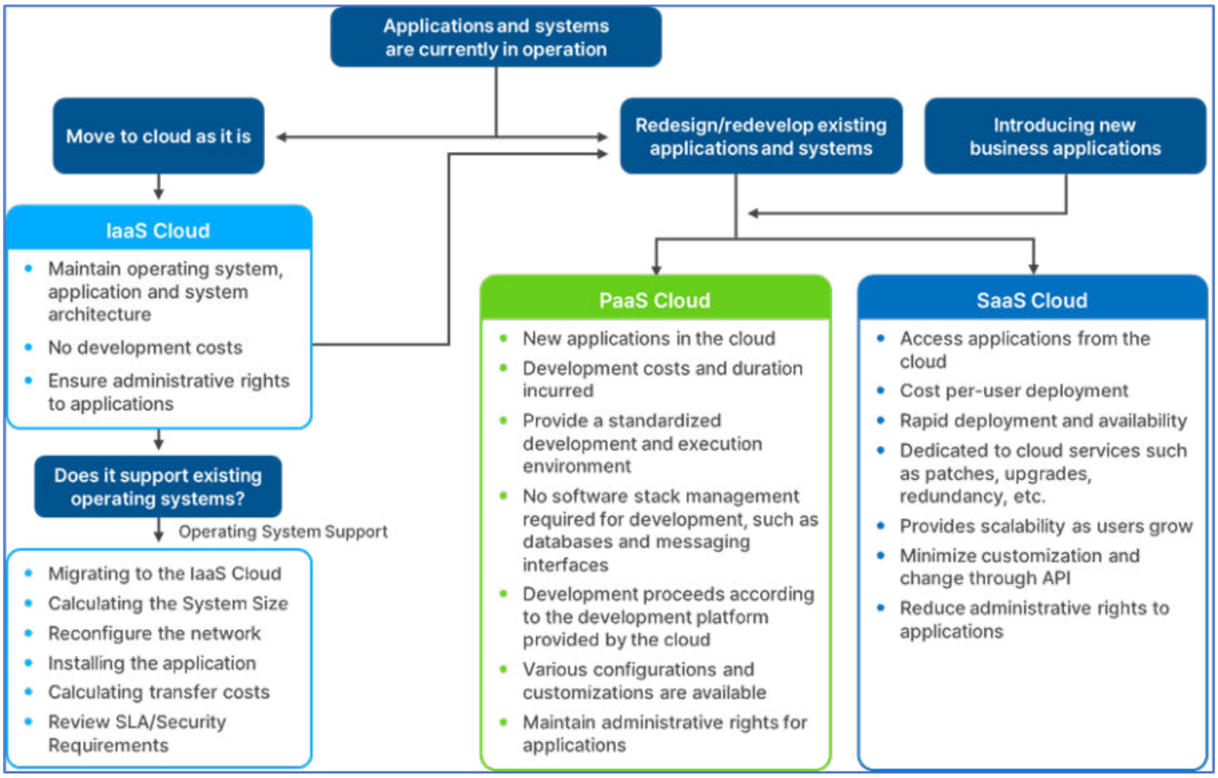
IV.7.1 Migration to IaaS

Depending on the situation of public institutions and systemic conditions, an assessment is made to determine the feasibility of adopting Infrastructure as a Service (IaaS) for the target systems. If the evaluation results indicate that IaaS cloud is not suitable or if redevelopment, redesign, or the introduction of new applications is required, consideration is given to adopting Software as a Service (SaaS) cloud or Platform as a Service (PaaS) cloud.

The criteria for assessing the feasibility of adopting cloud infrastructure services are as follows:

- Are the current enterprise system's operating systems supported by cloud services?
- If an OS upgrade is necessary, will it be compatible with existing applications or databases?
- Is it difficult to change business processes, necessitating the maximum preservation of the existing system?
- Are there any licensing issues with applications due to the move to the cloud?

Figure 15: Cloud Type Adoption Criteria and Characteristics


Applications and systems are currently in operation
Move to cloud as it is
Redesign/redevelop existing applications and systems
Introducing new business applications
IaaS Cloud
Maintain operating system, application and system architecture
No development costs
Ensure administrative rights to applications
Does it support existing operating systems?
Operating System Support
Migrating to the IaaS Cloud
Calculating the System Size
Reconfigure the network
Installing the application
Calculating transfer costs
Review SLA/Security Requirements
PaaS Cloud
New applications in the cloud
Development costs and duration incurred
Provide a standardized development and execution environment
No software stack management required for development, such as databases and messaging interfaces
Development proceeds according to the development platform provided by the cloud
Various configurations and customizations are available
Maintain administrative rights for applications
SaaS Cloud
Access applications from the cloud
Cost per-user deployment
Rapid deployment and availability
Dedicated to cloud services such as patches, upgrades, redundancy, etc.
Provides scalability as users grow
Minimize customization and change through API
Reduce administrative rights to applications

If public institutions are able to use the same OS in the cloud and continue using enterprise databases and other components without significant compatibility issues, choosing Infrastructure as a Service (IaaS) could indeed be an optimal solution. When opting for IaaS, several steps must be taken, including system sizing, network configuration, application installation, cost estimation for migration, reviewing Service Level Agreements (SLAs), and addressing security requirements.

After completing these pre-migration preparations, the process of migrating systems and data takes place, followed by validation of the integrity of the transferred systems and data. Once the migration is complete, the public institution can initiate pilot operations in the cloud environment to monitor and check various aspects. Subsequently, the public institution proceeds with service stabilisation efforts, ensuring that operations, monitoring, and control are operating smoothly in their normal state.

IV.7.2 Migration to PaaS

When public institutions are unable to use cloud infrastructure services, they can develop new software on PaaS (Platform as a Service). It is possible to develop customised SaaS (Software as a Service) by accommodating the requirements of public institution users as much as possible. Alternatively, existing applications can be refactored based on PaaS. Cloud service providers offer the necessary environment for SaaS development in the form of PaaS, including development and operational environments, databases, web application servers (WAS), messaging, and more. When using PaaS, development time and costs are incurred, and development must proceed by adopting the development environment provided by PaaS.

After development, there may be a dependency on the cloud service provider's PaaS environment, so public institution managers should be mindful of this.

Recently, when developing SaaS using PaaS, cloud-native architecture is preferred. In the cloud-native approach, a single SaaS is composed of a combination of multiple independent microservices and uses containers as the execution environment for microservices. Cloud service providers require tools for managing numerous containers. Additionally, for continuous application deployment, CI/CD (Continuous Integration/Continuous Deployment) functionality is needed, and tools like DevOps are required to ensure that development and operations work together within a single organisation. SaaS developed in a cloud-native format can provide much stronger load balancing capabilities and the advantage of seamless SaaS upgrades.

IV.7.3 Migration to SaaS

This is the form of adopting SaaS (Software as a Service) services provided by SaaS service providers. In this case, a prerequisite is that there must be SaaS offerings on the marketplace that are suitable for the needs of public institutions. If the SaaS offerings do not fully meet the demands of public institutions, it may be necessary to request customisation of certain applications from the SaaS provider. Among the forms of cloud adoption, this is the most rapid deployment and usage method. When using SaaS, there are user-based implementation costs, and there is the issue of reduced application management authority. Issues such as resource scaling due to user growth, application changes or upgrades are managed under the responsibility of the SaaS provider. Therefore, any changes or upgrades to the SaaS should be carried out in sufficient advance consultation between the service users and the provider. Control over the quality and service level management of SaaS can be conducted by public institution officials through SLA (Service Level Agreement) contracts.

IV.7.4 Migration to Hybrid Cloud

If the cloud adoption team decides to keep some systems on-premises due to reasons such as system complexity, data privacy, or cost concerns, they can consider adopting a Hybrid Cloud solution. In such cases, it is essential to ensure seamless integration and consistent control between the public cloud and on-premises systems. Some cloud service providers even offer integrated management consoles for on-premises and public cloud resources specifically designed for Hybrid Cloud deployments. Additionally, they provide features for managing networking between virtual machines or containers across public cloud and on-premises systems in a unified manner.

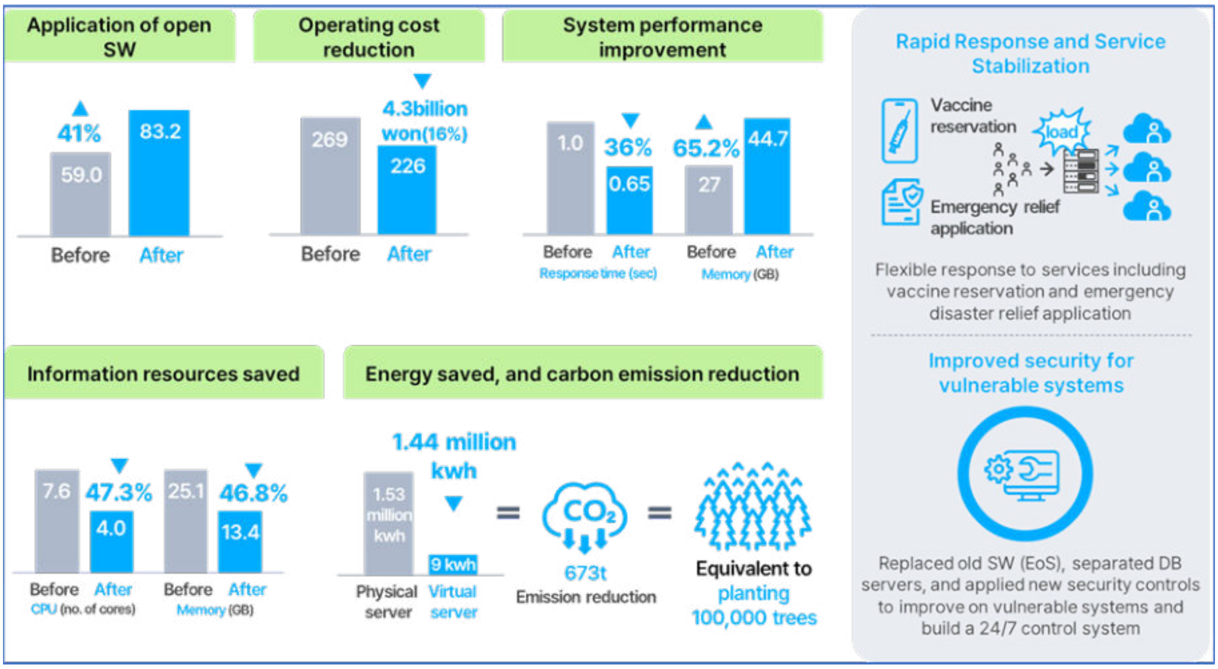
IV.8. Case Studies and Outcomes of Cloud Adoption in Public Institutions

IV.8.1 Adoption of IaaS

Under the leadership of the South Korean Ministry of Public Administration and Security, a project was conducted from 2020 to 2021 to migrate 302 systems operated by over 30 public institutions to the cloud. Each institution migrated systems that were previously individually managed in their data centres to the G-Cloud (a cloud operated by the Government Integrated Data Centre) to achieve system integration and enhance system uptime by leveraging virtualised servers, networks, and storage resources.

As a result, each institution was able to save approximately 16% of the operational costs that were incurred when individually managing their data centres. On average, system response times improved by approximately 36%, and system resource usage was reduced by about 40%. This led to an annual energy savings of 1.44 million kWh, which is estimated to be equivalent to reducing emissions by 673 metric tons of carbon dioxide.

Figure 16: Effects of IaaS adoption by public institutions

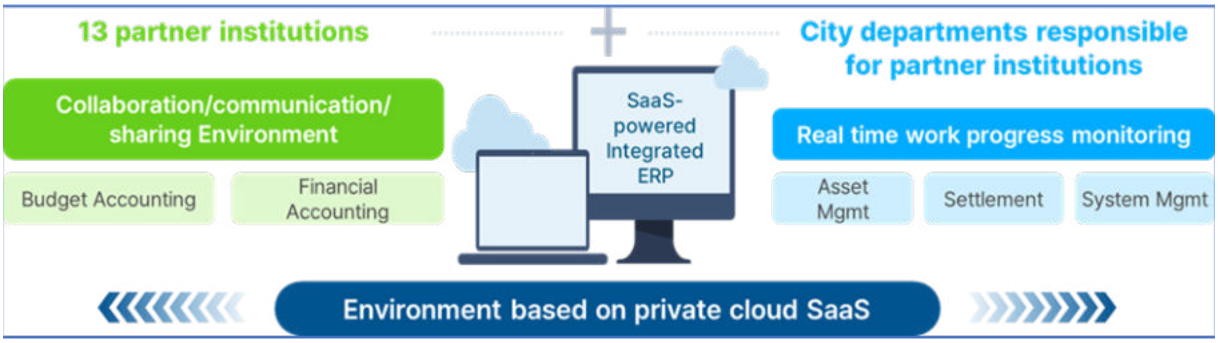


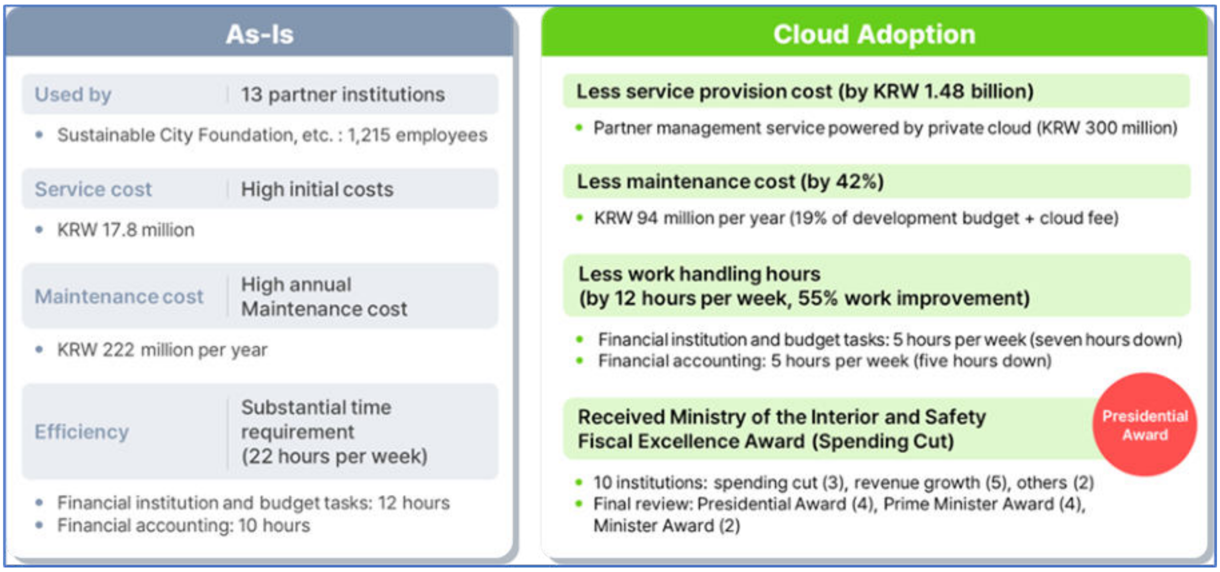
IV.8.2 Adoption of PaaS/SaaS

Suwon City, was the first local government in South Korea that established integrated budget accounting services with 13 partner agencies using private cloud SaaS. Suwon City built a cloud-based information environment to digitise budget accounting data and integrate internal and external systems. Previously, Suwon City dedicated a significant amount of time (22 hours per week) to processing budget accounting for partner agencies, and maintenance costs were high. To address these issues, Suwon City developed and operates a financial accounting management SaaS in an integrated format with the participation of 13 partner agencies.

As a result of adopting SaaS cloud solutions, Suwon City was able to reduce the manpower required for financial accounting processes by 50% and lower operating costs by 42%. This led to an annual savings of approximately 1.48 billion KRW in the budget.

Figure 17: Effects of SaaS/PaaS adoption by public institutions


13 partner institutions
+
City departments responsible for partner institutions
Collaboration/communication/ sharing Environment
Budget Accounting
Financial Accounting
SaaS-powered Integrated ERP
Real time work progress monitoring
Asset Mgmt
Settlement
System Mgmt
Environment based on private cloud SaaS



As-Is

Used by | 13 partner institutions

- Sustainable City Foundation, etc. : 1,215 employees

Service cost | High initial costs

- KRW 17.8 million

Maintenance cost | High annual Maintenance cost

- KRW 222 million per year

Efficiency | Substantial time requirement (22 hours per week)

- Financial institution and budget tasks: 12 hours
- Financial accounting: 10 hours

Cloud Adoption

Less service provision cost (by KRW 1.48 billion)

- Partner management service powered by private cloud (KRW 300 million)

Less maintenance cost (by 42%)

- KRW 94 million per year (19% of development budget + cloud fee)

Less work handling hours
(by 12 hours per week, 55% work improvement)

- Financial institution and budget tasks: 5 hours per week (seven hours down)
- Financial accounting: 5 hours per week (five hours down)

Received Ministry of the Interior and Safety Fiscal Excellence Award (Spending Cut)

Presidential Award

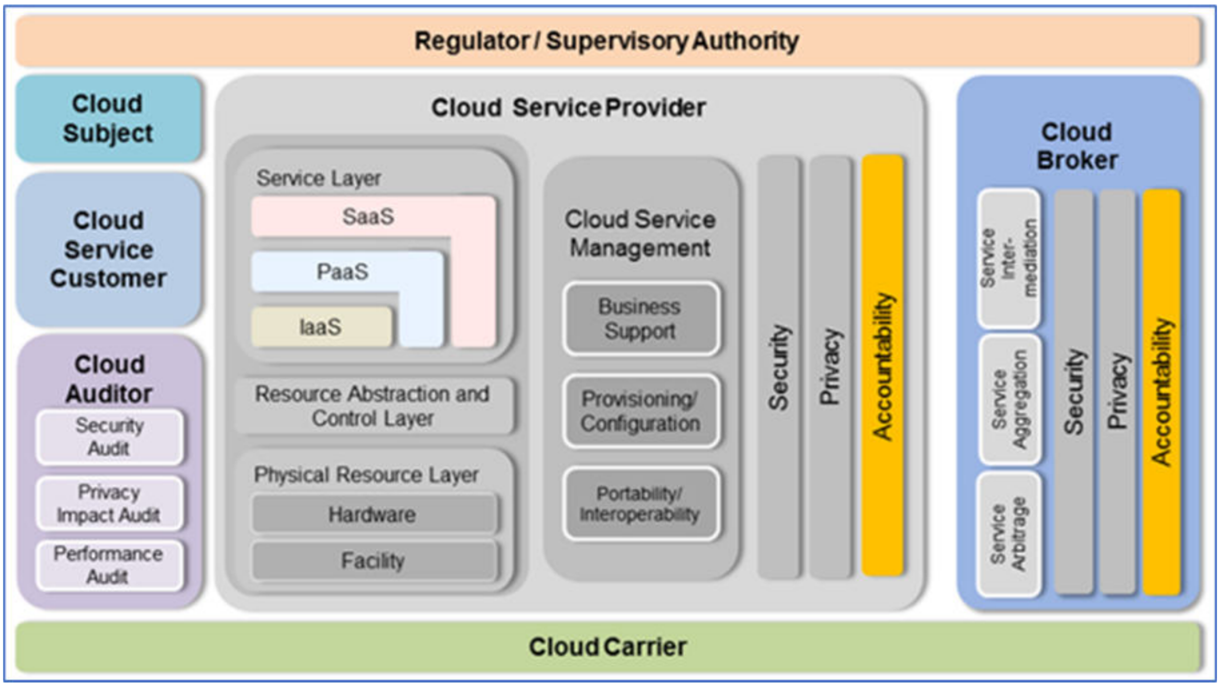
- 10 institutions: spending cut (3), revenue growth (5), others (2)
- Final review: Presidential Award (4), Prime Minister Award (4), Minister Award (2)

IV.9. Comparison with Other Cloud Frameworks

IV.9.1 NIST Cloud Framework

NIST is a comprehensive cloud reference architecture that encompasses the services and functionalities of cloud stakeholders. This reference architecture includes the functions of cloud service consumers, auditors, service providers, and cloud brokers. NIST CCRA (Cloud Computing Reference Architecture) introduces the concept of a resource abstraction and control layer between the service layer and the physical layer, suggesting that services should use abstracted resources rather than directly accessing physical resources. Cloud service management encompasses functions such as business support management, provisioning/configuration management, and portability/interoperability management. Cloud service providers must offer common functions such as security, privacy, and accountability. Cloud brokers perform tasks like service mediation, service integration, and service orchestration, requiring specific functionalities for these operations. Cloud auditors conduct activities such as security audits, privacy impact assessments, and performance audits.

Figure 18: NIST's Cloud Computing Reference Architecture



IV.9.2 ISO/IEC 17789 Cloud Reference Architecture

In ISO/IEC 17789 CCRA (Cloud Computing Reference Architecture), four layers are defined from the perspective of cloud users, and it aims to provide standards for common functionalities used across these layers.

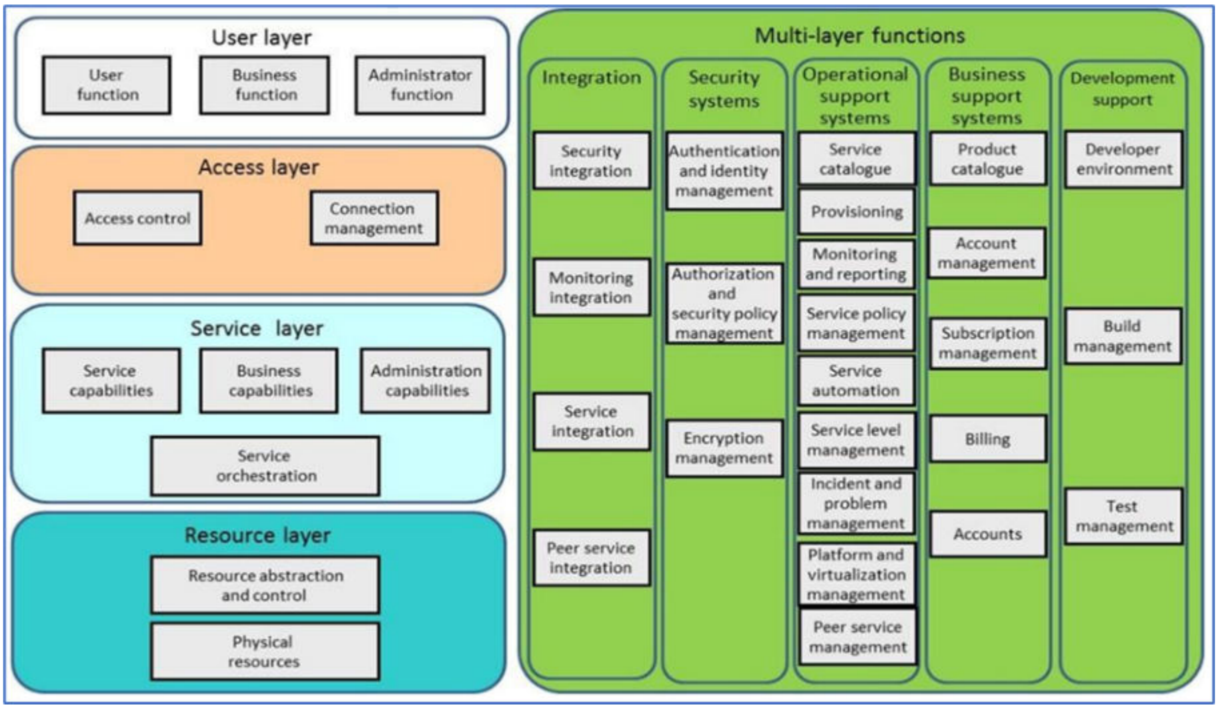
The four layers from the perspective of cloud users are as follows:

- ***User Layer:*** Functional components that support cloud computing activities of cloud service customers and cloud service partners.
- ***Access Layer:*** Includes functional components that facilitate function deployment and interconnection.
- ***Service Layer:*** Comprises functional components that provide the cloud service itself, along with management and business functionalities related to it. This layer also includes orchestration functionalities required for its realisation.
- ***Resource Layer:*** Contains functional components representing the resources necessary for implementing the cloud computing system.

It is not necessary for all layers or functional components to be instantiated in a specific cloud computing system. Multi-layer functionalities include functional components that provide functions used across multiple functional layers. This includes:

- ***Development Support:*** Developer environments, build support, test management.
- ***Integration:*** Security integration, monitoring integration, service integration, peer service integration.
- ***Security Systems:*** Authentication and identity management, authorisation management, security policy management, encryption management.
- ***Operations Support Systems:*** Service catalogue, provisioning, monitoring, and reporting, service automation, service level management, incident and problem management, platform and virtualisation management, peer service management.
- ***Business Support Systems:*** Product catalogue, account management, subscription management, billing, account reconciliation.

Figure 19: Cloud Computing Reference Architecture in ISO/IEC 17789



IV.9.3 Comparison with Other Architectures: Advantages and Expected Effects

NIST or ISO's cloud architectures aim to encompass content related to cloud computing as a whole, resulting in architectures centred around all cloud stakeholders involved in service delivery and usage. This perspective has the advantage of widening the architecture's scope, making it a broad standard that can be referenced extensively. However, when public institutions need to refer to the architecture more concretely or technically, it can be challenging.

Furthermore, since NIST or ISO's cloud reference models are primarily focused on IaaS (Infrastructure as a Service), public institutions may lean toward IaaS-based adoption when introducing cloud computing. However, the current forms of cloud adoption are becoming highly diversified, and the adoption of SaaS services is increasingly recommended. In Korea, for example, public institutions actively promote cloud adoption with a focus on SaaS through the Digital Service Special Contract System. Therefore, a reference architecture should align with these current trends.

The architecture we have presented offers the following advantages compared to existing cloud reference architectures:

- It reflects the latest cloud architecture trends. Cloud computing is rapidly evolving from virtual machine-based to container-based, emphasising cloud-native architecture. Additionally, various forms of cloud adoption, such as hybrid cloud and multi-cloud, are on the rise. This document strives to provide an architecture that can be referenced when adopting such forms of cloud.
- It presents functional elements required for architecture configuration centred around IaaS, PaaS, and SaaS, allowing organisations to check all items as criteria when adopting cloud computing. Moreover, it facilitates easy technical reference when institutions want to choose one of IaaS, PaaS, or SaaS when adopting cloud computing.
- Cloud stakeholders continue to increase, and a wide range of business forms continually emerge. Therefore, an architecture centred around stakeholders can quickly become outdated. The architecture presented in this document excludes a stakeholder-centric perspective.
- It thoroughly considers functional elements that must be taken into account when introducing hybrid or multi-cloud services.
- Security is a crucial aspect when public institutions adopt cloud computing, which is emphasised at the national level. In the United States, for instance, there is FedRAMP, while in Korea, there is CSAP. These systems certify cloud security frameworks before public institutions can adopt cloud computing. These certifications have different assessment criteria for each type of cloud (IaaS, PaaS, SaaS). Therefore, it is necessary to present security frameworks for each type in the reference architecture.

IV.10. References

ITU-T Y.3502, ‘Information technology - Cloud computing – Reference architecture’, 2014. 8.

ISO/IEC 17789:2014 Information technology — Cloud computing — Reference architecture

Amazon Web Services (AWS) Architecture: https://aws.amazon.com/architecture/

Microsoft Azure Architecture: https://docs.microsoft.com/en-us/azure/architecture/

Google Cloud Architecture: https://cloud.google.com/architecture

OpenStack Documentation: https://docs.openstack.org/

NIST Cloud Computing Publications: https://www.nist.gov/cloud-computing

Cloud Security Alliance (CSA): https://cloudsecurityalliance.org/

V. General Data Protection Regulation (GDPR) in Public Administration

V.1. Introduction

The General Data Protection Regulation (GDPR), which came into effect on 25 May 2018, represents a significant milestone in the realm of data protection and privacy. To understand the essence of GDPR, we must delve into its historical background and the driving factors that led to its enactment.

The roots of GDPR can be traced back to the mid-20th century, a time when the digital landscape was unrecognisable compared to today. During this period, the fundamental principles of data protection began to emerge as a response to growing concerns about personal privacy and data security. It was a time when personal information was largely stored on paper records, and the concept of sharing data across borders was still in its infancy.

As the world rapidly embraced the digital age, data became the lifeblood of industries, governments, and societies. With the internet, data could traverse the globe in seconds, leading to unprecedented opportunities for innovation and communication, but also to increasing risks of data breaches and privacy infringements. These developments prompted the European Union to embark on a journey to modernise data protection laws that had become outdated.

The predecessor to GDPR was the Data Protection Directive of 1995, a directive that provided the foundational principles for data protection in Europe. However, the directive was recognised as insufficient in the face of evolving digital landscapes and cross-border data flows. It lacked the necessary teeth to regulate and enforce data protection effectively.

The need for a more robust and comprehensive framework became increasingly evident as data breaches, cybercrimes, and privacy violations continued to make headlines. The European Union recognised that a more stringent and harmonised approach was necessary to protect the rights and freedoms of its citizens. This recognition paved the way for the development of the GDPR.

GDPR was designed not only to strengthen the rights of individuals concerning their personal data but also to create a unified legal framework across the European Union. Its creation was a collaborative effort, involving lawmakers, privacy experts, and stakeholders from various sectors. The regulation was developed with the aim of providing individuals with more control over their personal data, obligating organisations to be more transparent about data processing, and imposing substantial fines for non-compliance.

The GDPR's narrative is one of a transformative response to the evolving data landscape, emphasising the importance of safeguarding individual privacy rights while enabling responsible data use. Its principles of consent, data portability, the right to be forgotten, and stringent security measures have far-reaching implications not only for European citizens but for organisations worldwide that handle European data subjects' information.

V.2. Importance of GDPR in Public Administration.

GDPR holds significant importance in the realm of public administration, as it reshapes the way governments collect, process, and protect citizens' personal data. To fully understand the profound implications of GDPR in this specific context, it is essential to delve into how it influences public administration across a range of dimensions.

- ***Empowering Citizens:*** GDPR, as a response to the increasing data-driven environment, places a strong emphasis on individual rights. In the realm of public administration, this means that citizens have more control over their personal data. Governments are now required to seek explicit consent when collecting data, be transparent about how the data will be used, and provide easy mechanisms for citizens to access their own data. This empowers citizens, giving them greater control over their information held by public institutions.
- ***Enhancing Transparency:*** Public administration is often associated with bureaucracy and opacity. GDPR changes this narrative by obligating governments to be transparent about their data processing activities. This means that citizens have the right to know why their data is being collected, how it will be used, and who will have access to it. Public institutions are required to communicate these processes clearly, fostering a sense of trust and accountability between the government and its citizens.
- ***Data Security and Accountability:*** In the realm of public administration, GDPR enforces a heightened sense of responsibility. Government agencies are now held to stricter standards when it comes to data security. They must implement robust security measures to protect citizens' data from breaches and unauthorised access. The status quo shifts from one of complacency to one of vigilance, where data protection becomes a paramount concern for public administrators.
- ***Penalties for Non-Compliance:*** The GDPR introduces significant fines for non-compliance. In the public administration context, this legal change has a profound impact. It means that government agencies face real consequences for mishandling personal data. This not only encourages them to take data protection seriously but also signals to citizens that their privacy is a matter of great importance.
- ***Cross-Border Data Flows:*** Public administration often involves international collaboration and data sharing. GDPR's effect extends beyond national borders, creating a harmonised framework for data protection across the European Union. For public administrations, this means a streamlined process when dealing with data from multiple EU member states, simplifying the procedures for cross-border data flows.
- ***Innovation and Compliance:*** GDPR's scope and purpose in public administration is not just about compliance; it is also about fostering innovation. By mandating that data protection be built into systems from the start, GDPR encourages public institutions to think creatively about how they can fulfil their duties while respecting privacy. This policy shift promotes the development of privacy-enhancing technologies and practices.

In sum, GDPR transforms public administration by placing data protection and citizen privacy at its core. It empowers citizens, enhances transparency, enforces data security, and instils a sense of accountability. Public administrations are no longer mere data custodians but are now the custodians of citizen trust and data rights, fostering a more responsible and citizen-centric approach to governance in the digital age.

V.3. Overview of GDPR and its key provisions.

GDPR has emerged as a safeguard that reshapes how organisations handle personal data. Its key provisions, which we will delve into more detail further down, underscore the fundamental principles and rules that define this landmark regulation. These are:

- ***Territorial Scope:*** Picture this — a regulation that knows no boundaries. The territorial scope of GDPR is a defining feature, extending its reach not just to organisations within the European Union but to those outside the EU as well, as long as they process the personal data of EU residents. This extraterritorial application means that companies around the world must comply with its principles when handling the data of EU citizens.

- ***Consent:*** Imagine a prospective customer browsing a website. He/she is asked to accept cookies, a process made clear and simple. This essence of clear and unambiguous consent lies at the heart of GDPR. It insists that organisations must seek this consent from data subjects before processing their data. The consent must be freely given, and specific, informed, and easily retractable. GDPR places the power of data control firmly in the hands of individuals.
- ***Data Subjects' Rights:*** Imagine having a key to one's own data kingdom. Under GDPR, individuals have been granted several rights related to their personal data. First, the right to access their data, akin to turning the key and accessing a treasure chest of information about what organisations hold about them. The right to rectify inaccurate data is like having the power to correct their own story. Then, there is the right to erasure, often dubbed the "right to be forgotten". This right empowers individuals to request the removal of their data, in certain circumstances. Lastly, the right to data portability is like one being given the keys to unlock their data and take it with them, moving seamlessly across different services.
- ***Data Protection Officers (DPOs):*** Imagine navigating a vast organisation with extensive data operations. Someone is needed to guide you through the data maze. That is the role of a Data Protection Officer (DPO). GDPR mandates that certain organisations, particularly those processing significant volumes of sensitive data, must appoint a DPO. The DPO's mission? To ensure the organisation complies with GDPR and safeguards the privacy rights of data subjects.
- ***Data Breach Notification:*** In a world where data breaches are a looming threat, GDPR introduces a vital concept — timely notification. Organisations must report data breaches to the relevant authorities and affected individuals within 72 hours of becoming aware of the breach. This notification includes essential details about the nature of the breach and its potential impact. It is akin to a swift alarm system, ensuring that breaches do not stay hidden for long.
- ***Data Protection Impact Assessments (DPIAs):*** Imagine a diligent risk assessment before embarking on a journey. GDPR mandates Data Protection Impact Assessments (DPIAs) for processing activities that pose high risks to individuals' privacy. These assessments are like mapping out potential pitfalls before a journey, helping organisations identify and minimise privacy risks, thereby aligning their data processing with GDPR's principles.
- ***Privacy by Design and by Default:*** Think about building a house with security in mind from the get-go. That is the essence of "privacy by design" and "privacy by default" under GDPR. Privacy by design encourages organisations to integrate data protection into the development of systems and services right from the outset. Privacy by default requires that the strictest privacy settings apply automatically. This means that the foundational structure of data handling is inherently secure and respects privacy.
- ***Data Transfers:*** Imagine data as a valuable, fragile cargo being transported across borders. GDPR establishes guidelines for transferring personal data outside the EU, ensuring that such transfers comply with GDPR standards and are protected through appropriate safeguards. The analogy here is like ensuring that valuable cargo is protected during transit, regardless of its destination.
- ***Accountability and Governance:*** Accountability and governance are like the rule book and referee on the field of data protection. GDPR emphasises that organisations must maintain detailed records of data processing activities, conduct regular audits, and implement appropriate data protection policies and measures. This promotes a culture of responsibility and transparency, ensuring that everyone plays by the rules.
- ***Penalties:*** Think of GDPR's penalties as the sword of justice for data protection. One of the most notable aspects of GDPR is the substantial fines it introduces for non-compliance. Organisations can be fined up to 4% of their global annual revenue or €20 million, whichever is higher, for serious violations. This financial risk places a significant incentive on organisations to prioritise GDPR compliance.

In sum, in a world where personal data is a valuable commodity and a potential source of harm, GDPR stands as a pivotal safeguard. Its key provisions put individuals in control of their data and set strict guidelines for organisations to follow. Compliance with GDPR is essential for a safer, more responsible, and privacy-focused digital landscape, where data protection is not just a regulation but a fundamental right.

V.4. Historical development of data protection regulations.

The historical development of data protection regulations, culminating in the General Data Protection Regulation (GDPR), is a journey through time that reveals a growing recognition of the importance of safeguarding personal information. The story begins with the realisation that personal data is not only valuable but also vulnerable. It was in the early 1970s that Sweden became one of the pioneers, introducing the world's first data protection law. The data protection movement, having found its roots, spread across Europe and other parts of the world.

The Dawn of Data Privacy is placed around 1981, at a time the digital revolution began to accelerate, and concerns about the handling of personal data grew. In fact, the Council of Europe adopted the Convention for the Protection of Individuals with Regard to Automatic Processing of Personal Data in 1981; a landmark treaty. This marked the first international attempt to address data protection and privacy issues. The journey continued in 1995 with the adoption of the European Union Data Protection Directive. This directive laid the foundation for data protection laws across EU member states, emphasising the need to protect personal data and outlining principles for its lawful processing. These principles formed the basis for later developments in data protection.

With the exponential growth of the internet and digital technologies, the need for more robust data protection measures became evident. As data flows transcended borders and new forms of data processing emerged, concerns grew about the inadequacy of existing regulations. As the 21st century progressed, data protection laws required a significant update to address the evolving landscape of data privacy. The result was the General Data Protection Regulation (GDPR), which came into force in May 2018. GDPR was a pivotal moment in the history of data protection. It combined the principles and concepts of earlier regulations with a contemporary understanding of the digital age. GDPR aimed to harmonise data protection laws across the EU and provide individuals with greater control over their personal data.

Undoubtedly, GDPR has yielded many benefits, but it has also generated several challenges. It has enhanced individual privacy rights, it has strengthened data security, and it fosters public trust in a digital world often plagued by data breaches. However, GDPR also poses significant challenges to organisations worldwide, particularly those not accustomed to such stringent data protection requirements. Compliance efforts require substantial investments in technology and changes in organisational culture. It is also evident that GDPR's influence extends beyond the borders of the European Union. The regulation's extraterritorial scope impacts organisations worldwide, compelling them to adapt to its principles if they process the personal data of EU residents. This global impact underscores GDPR's significance and its relevance on a global scale.

The narrative of data protection regulations, culminating in GDPR, is a story of evolving awareness and response to the challenges posed by the digital age. It highlights the growing recognition of the value of personal data and the need to protect it. GDPR represents the culmination of these efforts, offering a comprehensive framework for safeguarding personal information in an increasingly interconnected and data-driven world. This trajectory, spanning several decades, reveals that data protection has evolved from a niche concern to a global imperative, setting a standard for responsible data handling and individual privacy in the modern era.

V.5. Key Principles of GDPR

The GDPR is built on several key principles that guide the handling and processing of personal data:

- ***Lawfulness, Fairness, and Transparency:*** GDPR requires that personal data be processed lawfully, fairly, and transparently. This means that organisations must have a legal basis for processing data, such as consent, a contractual obligation, or a legitimate interest. Furthermore, organisations must be transparent about how data is used, providing individuals with clear and easily understandable information about data processing activities. Transparency is crucial in fostering trust between individuals and organisations.
- ***Purpose Limitation:*** Personal data must be collected for specific, explicit, and legitimate purposes and not further processed in a manner that is incompatible with those purposes. This principle prevents organisations from using data for purposes unrelated to the original intent of collection, ensuring that individuals' data is not subject to misuse.
- ***Data Minimisation:*** GDPR emphasises that organisations should collect only the data that is necessary for the specified purposes. Data minimisation reduces the risk of data breaches and protects individuals' privacy by limiting the amount of data collected to the essentials.
- ***Accuracy:*** Organisations are responsible for maintaining the accuracy of personal data. Data must be kept up-to-date and corrected when inaccuracies are identified. Inaccurate data can lead to incorrect decisions, harming individuals' interests.
- ***Storage Limitation:*** Personal data should not be retained for longer than necessary for the purposes for which it was collected. Organisations must establish retention policies and delete data when it is no longer needed, reducing the risk associated with storing excessive data.
- ***Integrity and Confidentiality:*** This principle requires organisations to implement security measures to protect personal data from unauthorised access, disclosure, alteration, or destruction. Encryption, access controls, and regular security assessments are essential to ensuring data integrity and confidentiality.
- ***Accountability and Governance:*** GDPR mandates that organisations be accountable for their data processing activities. They must establish policies, procedures, and documentation to demonstrate compliance with the regulation. Data protection impact assessments and data protection officers play crucial roles in ensuring accountability.
- ***Data Subject Rights:*** GDPR empowers data subjects with several rights over their data. These rights include the right to access their data, correct inaccuracies, request deletion (the "right to be forgotten"), and object to data processing, among others. Organisations are obligated to facilitate the exercise of these rights, giving individuals control over their personal information.

Overall, GDPR's key principles collectively create a strong framework for data protection and privacy in the digital age. These principles ensure that personal data is processed lawfully, fairly, and transparently, with clear purposes and minimal data collection. They also emphasise the importance of data accuracy, secure storage, and accountability. The rights granted to data subjects put individuals in control of their personal information, reinforcing the importance of respecting privacy and data protection in an increasingly interconnected world.

V.6. Certification

Under Article 42 of the General Data Protection Regulation (GDPR), the legal framework allows each country's Data Protection Authority to establish its own certification system. However, the establishment of a European Union-wide certification mechanism necessitates approval from the European Data Protection Board (EDPB). In May 2022, the *“Commission nationale pour la protection des données”* (CNPD) embraced GDPR-CARPA as a certification mechanism, marking a significant development. Later in the same year, in October, the EDPB granted its approval for Euro privacy to serve as the European Data Protection Seal for certification under Article 42(5). These two distinct certification mechanisms bring unique characteristics and criteria, contributing to the landscape of GDPR compliance and data protection in Europe. Let's us now delve into the specifics of GDPR-CARPA and Euro privacy to gain a deeper understanding of their purposes, scopes, and implications. Based on Article 42, each country's Data Protection Authority can establish its own certification system, while a European Union-wide certification mechanism requires approval from the European Data Protection Board (EDPB). In May 2022, the Luxembourg National Data Protection Commission (CNPD) adopted GDPR-CARPA as a certification mechanism. Later in the same year, in October, the EDPB approved Euro privacy as the European Data Protection Seal for certification under Article 42(5).

V.6.1 GDPR-CARPA

GDPR-CARPA is the first certification mechanism to be designed and adopted on a national and international level under the GDPR by CNPD in May 2022. This mechanism is characterised by several key attributes, including its purpose, maintenance, and scope, which are crucial in understanding its role in ensuring GDPR compliance and data protection.

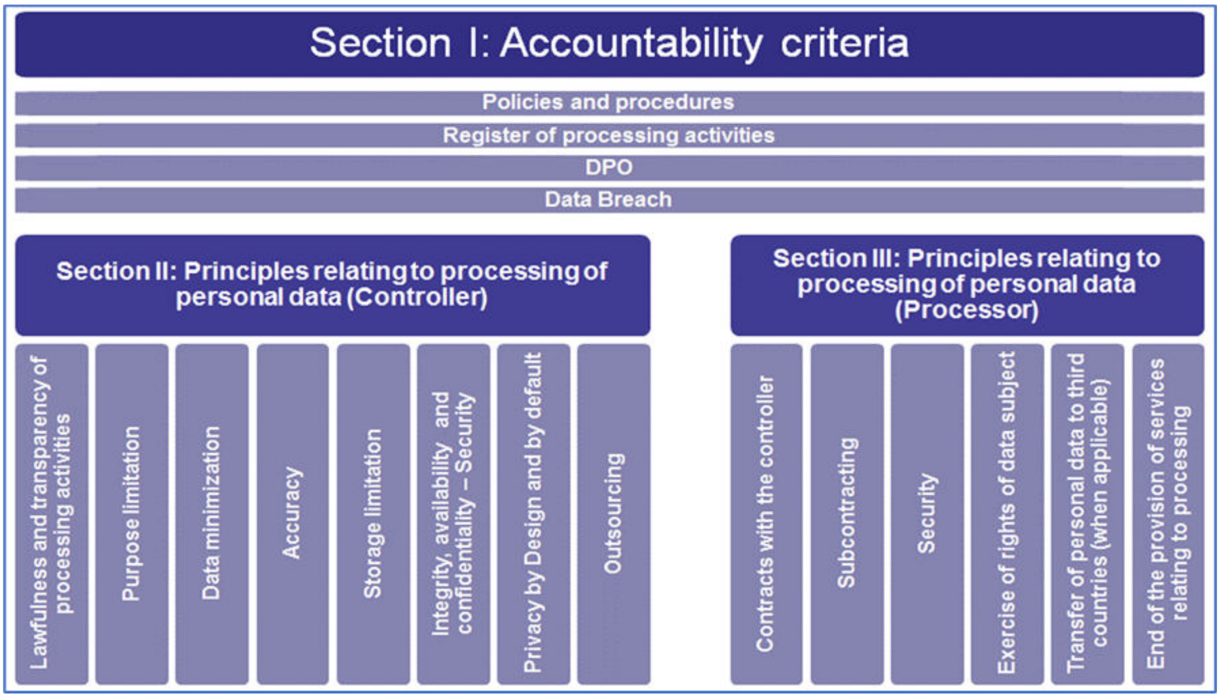
- ***Purpose*** - The certification is designed to provide data controllers and processors with a high level of GDPR compliance and assurance that they apply technical and organisational measures to comply with their GDPR obligations.
- ***Maintained by*** - The Luxembourg DPA (*Commission nationale pour la protection des données*, CNPD).
- ***Requirement of the applying entity*** - Only the controllers or processors established in Luxembourg under the supervision of the CNPD can request GDPR-CARPA certification.
- ***Scope of the certification*** - The certification mechanism does not certify an organisation but rather specific processing operations.
- ***Limitation of a legal effect*** – The certification shows GDPR compliance but doesn't reduce the controller or processor's responsibility. GDPR-CARPA focuses on their governance system for defining and implementing information security measures within its scope. In essence, certification demonstrates alignment with GDPR requirements through good governance practices.
- ***Validation period*** - A certificate is valid for 3 years and renewable subject to an annual audit.
- ***Assessing criteria*** - The GDPR-CARPA certification criteria are divided into three sections.

  Section 1 General data protection governance such as policies and procedures, records of processing activities, data subjects' rights, DPO, data breaches.

  Section 2 Controllers' obligations regarding data protection principles under Article 5.

  Section 3 Processors' obligations such as contracts with controllers and subcontracting, security, transfer of personal data to third countries.

Figure 20: Accountability criteria

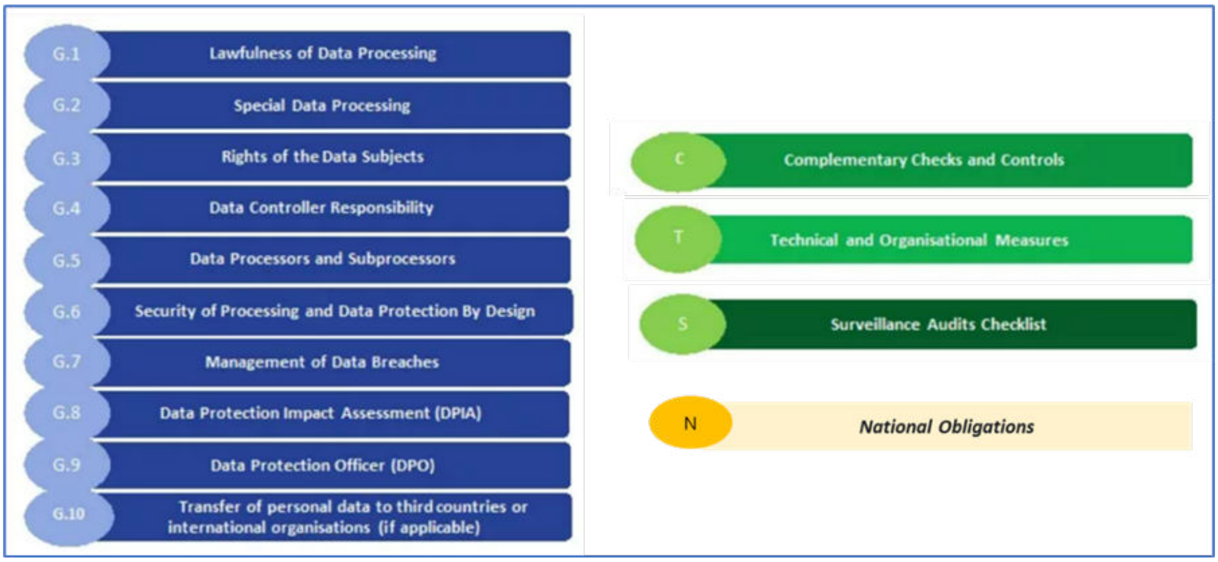

Section I: Accountability criteria
Policies and procedures
Register of processing activities
DPO
Data Breach
Section II: Principles relating to processing of personal data (Controller)
Section III: Principles relating to processing of personal data (Processor)
Lawfulness and transparency of processing activities
Purpose limitation
Data minimization
Accuracy
Storage limitation
Integrity, availability and confidentiality – Security
Privacy by Design and by default
Outsourcing
Contracts with the controller
Subcontracting
Security
Exercise of rights of data subject
Transfer of personal data to third countries (when applicable)
End of the provision of services relating to processing

V.6.2 Euro privacy

Euro privacy is adopted as the European Data Protection Seal (Article 42(5)) by EDPB in 2022 and currently is the very first and only certification mechanism recognised in all EU Member States. Its significance is underscored by several key attributes, including its purpose, maintenance, and scope, which are pivotal in understanding its role in demonstrating GDPR compliance and data protection on a pan-European scale.

- ***Purpose*** - Demonstrating compliance with the GDPR of processing operations by controllers and processors.
- ***Maintained by*** - the European Centre for Certification (ECCP).
- ***Requirement of the applying entity*** – N/A.
- ***Scope of the certification*** - Data processing activities (a whole company or its whole management system cannot be certified).
- ***Limitation of a legal effect*** – the certification does not reduce the responsibility of the controller or the processor for compliance with this Regulation and is without prejudice to the tasks and powers of the supervisory authorities which are competent pursuant to Article 55 or 56 (Article 42(4)).
- ***Validation period*** – 3 years.
- ***Assessing criteria*** – The assessing criteria of Euro privacy can be easily integrated with ISO/IEC 27001 and are divided into two parts: the core criteria, which cover various GDPR obligations, and additional criteria denoted as C, T, S, N.
- ***Core criteria*** – Lawfulness of Data Processing, Special Data Processing, Rights of the Data Subjects, Data Controller Responsibility, Data Processors (or sub- Processors), Security of Processing and Data Protection by Design, Management of Data Breaches, Data Protection Impact Assessment (DPIA), Data Protection Officer (DPO), Transfers of personal data to third countries or international organisations.
- ***Complementary Checks and Control (C)*** - assessing compliance with domain-specific and technology-specific obligations.

Figure 21: GDPR Core Criteria

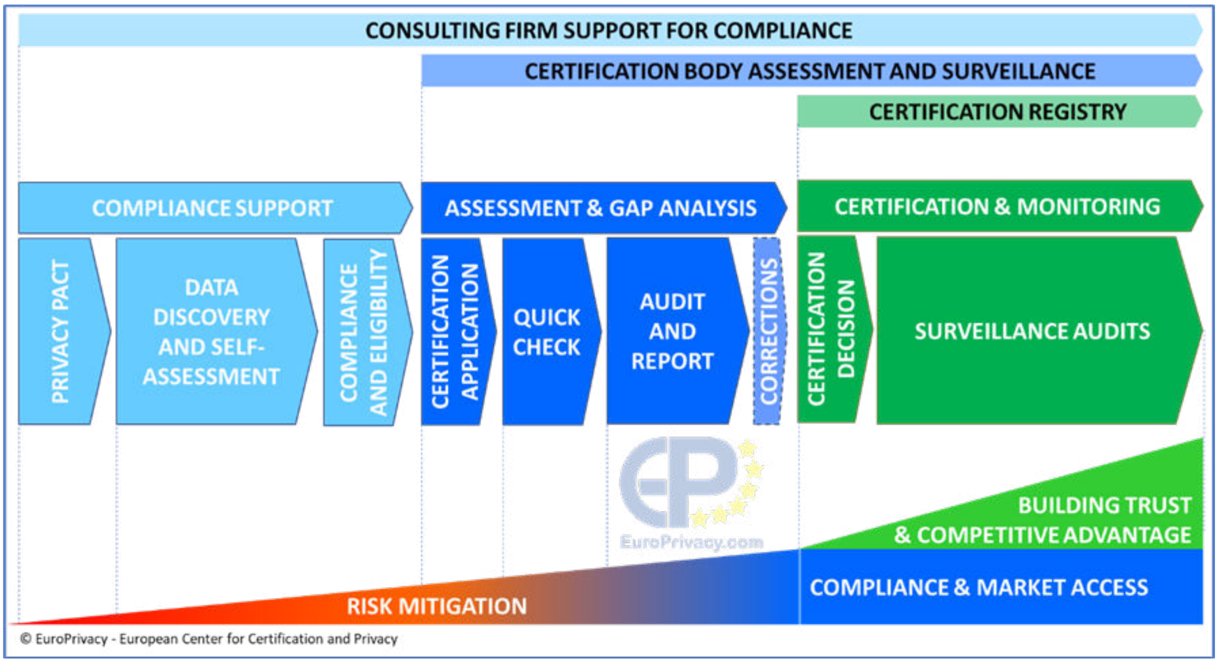

G.1
Lawfulness of Data Processing
G.2
Special Data Processing
G.3
Rights of the Data Subjects
G.4
Data Controller Responsibility
G.5
Data Processors and Subprocessors
G.6
Security of Processing and Data Protection By Design
G.7
Management of Data Breaches
G.8
Data Protection Impact Assessment (DPIA)
G.9
Data Protection Officer (DPO)
G.10
Transfer of personal data to third countries or international organisations (if applicable)
C
Complementary Checks and Controls
T
Technical and Organisational Measures
S
Surveillance Audits Checklist
N
National Obligations

- ***Technical and Organisational Measures (T)*** - measures in place to secure the processed data. In case of high-risk data processing, it can be replaced by a valid ISO/IEC 27001 certificate.
- ***Surveillance Audits Checklist (S)*** – assessing and ensuring continuous compliance over time.
- ***National Obligations (N)*** - assessing complementary national obligations through the national obligation profiles for each one of the European Economic Area Member States, and the optional and expanded assessing on the non-EU jurisdiction(s).

V.6.3. Certification process

The European Centre for Certification provides various online resources and following advice of ECCP could be useful to implement GDPR or prepare the Euro privacy certification.

Figure 22: Certification process


CONSULTING FIRM SUPPORT FOR COMPLIANCE
CERTIFICATION BODY ASSESSMENT AND SURVEILLANCE
CERTIFICATION REGISTRY
COMPLIANCE SUPPORT
ASSESSMENT & GAP ANALYSIS
CERTIFICATION & MONITORING
PRIVACY PACT
DATA DISCOVERY AND SELF-ASSESSMENT
COMPLIANCE AND ELIGIBILITY
CERTIFICATION APPLICATION
QUICK CHECK
AUDIT AND REPORT
CORRECTIONS
CERTIFICATION DECISION
SURVEILLANCE AUDITS
EuroPrivacy.com
BUILDING TRUST & COMPETITIVE ADVANTAGE
COMPLIANCE & MARKET ACCESS
RISK MITIGATION
© EuroPrivacy - European Center for Certification and Privacy

V.7. Specific Impacts of GDPR on Public Administration

The General Data Protection Regulation (GDPR) stands as a beacon of data rights and privacy in the digital age. As this regulation permeates various sectors, its implications for public administration are particularly noteworthy. Entrusted with vast volumes of personal data, public entities play a critical role in upholding the principles of GDPR. This section delves into the specific impacts of GDPR on public administration, shedding light on the transformative shifts it has triggered in governance and public service delivery.

- ***Changes in Data Collection Methods:*** With the implementation of GDPR, public administration has witnessed a significant shift in data collection methods. The principle of data minimisation means that only data that is necessary for a specific purpose can be collected. This has required public bodies to re-evaluate and often streamline the data they solicit from the public. Moreover, the principle of transparency demands that citizens are clearly informed about the purpose of data collection. As a result, public departments have had to redesign forms, applications, and online portals to ensure explicit consent is obtained and the purpose of data collection is unambiguously stated.
- ***Changes in Data Storage and Security:*** The security mandates of the GDPR have necessitated sweeping changes in the way public administrations store and protect personal data. Agencies have had to invest in modernising their data storage systems to ensure encryption and other protective measures are in place. Furthermore, GDPR's insistence on storage limitation means that data can no longer be retained indefinitely. Public entities must implement clear retention schedules and periodically review and purge data that no longer serves a legitimate purpose. Additionally, contingency plans, including robust backup systems and data breach response protocols, have become essential.
- ***Enhanced Rights for Data Subjects:*** One of the most significant impacts of GDPR on public administration has been the need to recognise and facilitate the enhanced rights of data subjects. Citizens now have the right to access their data, correct inaccuracies, and even demand erasure in certain circumstances (often referred to as the 'right to be forgotten'). Public departments, from health to housing, have had to create channels and systems that allow citizens to exercise these rights seamlessly. This includes providing platforms for data access requests, ensuring timely responses, and offering mechanisms for data rectification or deletion.
- ***Accountability and Reporting Requirements:*** Under GDPR, public administrations bear the brunt of proving their compliance with data protection principles. This sense of accountability requires comprehensive record-keeping of all data processing activities. In the case of a data breach or any other violation, public entities have a strict timeline (usually 72 hours) within which they must report the incident to the appropriate supervisory authority. This has led to the establishment of dedicated data protection teams within many public bodies, responsible for ongoing GDPR compliance, risk assessments, and liaising with data protection authorities.
- ***Impact on Third-party Contracts and Relationships:*** GDPR's reach extends beyond public bodies to any third-party organisations they collaborate with or contract out services to. This means that any vendor or partner dealing with personal data on behalf of a public administration entity must also be GDPR compliant. As a result, public agencies have had to revisit and renegotiate contracts, embedding stringent data protection clauses. Due diligence checks on third-party GDPR compliance have become the norm, and in many cases, continuous audits are conducted to ensure that data protection standards are consistently upheld.

In essence, the GDPR has ushered in a transformative era for public administration in the realm of data protection. From the foundational methods of data collection to the intricate dynamics of third-party relationships, every aspect of public administration has been recalibrated to respect the sanctity of personal data and uphold the rights of citizens. The ripple effects of these changes are profound, reinforcing a more transparent, accountable, and citizen-centric model of governance.

V.8. Practical Steps for Implementation

This section aims to highlight the critical measures that public administrations need to adopt for successful GDPR alignment. The focus is on fostering a unified strategy that underscores the importance of building citizen trust while ensuring the utmost protection of data integrity.

- ***Designating a Data Protection Officer (DPO):*** The appointment of a Data Protection Officer (DPO) is one of the primary steps in aligning with GDPR. The DPO plays a pivotal role in ensuring that an organisation adheres to data protection regulations. They act as the focal point for all data protection activities, from advising on compliance measures to representing the organisation before data protection authorities. Particularly for public administrations that handle extensive amounts of sensitive data, a DPO ensures consistent monitoring, timely interventions, and acts as a bridge between data subjects and the entity.
- ***Conducting Data Protection Impact Assessments (DPIA):*** DPIAs are essential tools in the GDPR compliance toolkit. They involve systematically evaluating potential risks associated with data processing activities. By conducting a DPIA, public administrations can identify vulnerabilities in their data handling processes and introduce mitigating measures before any harm occurs. This proactive approach ensures that privacy concerns are addressed at the outset, making it integral for any data-intensive project or initiative.
- ***Adopting a Data Protection-by-Design and by-Default Approach:*** This principle necessitates that data protection measures are integrated right from the design phase of any project or system and are operational by default. It means that when a new digital service or infrastructure is envisioned, its foundational elements must prioritise data protection. For public administrations, this requires a paradigm shift from retroactive compliance checks to proactively embedding data protection in the design ethos. Whether it is a new public health database or a digital service portal, the architecture must inherently safeguard personal data.
- ***Ensuring Secure Data Processing and Storage:*** At the heart of GDPR is the secure and lawful processing of personal data. Public administrations must employ state-of-the-art encryption techniques to ensure data in transit and at rest is protected. Moreover, secure access controls, regular system updates, and vulnerability assessments are mandatory to prevent unauthorised access and potential breaches. This goes beyond just digital storage; even physical documents containing personal data need to be securely stored and access to them tightly controlled.
- ***Developing and Implementing Data Breach Protocols:*** Despite the best precautions, data breaches can still occur. It is imperative for public administrations to have a clear and efficient response protocol in place. This includes immediate containment of the breach, assessment of the scale and impact, timely notification to affected individuals, and reporting to supervisory authorities within the stipulated 72-hour window. Having a well-rehearsed protocol can significantly minimise the damage and ensure swift recovery from any breach.
- ***Training and Awareness Campaigns for Staff:*** The human factor is often the weakest link in data protection. Therefore, regular training and awareness campaigns for staff are crucial. Employees at all levels need to be informed about the principles of GDPR, the rights of data subjects, and the protocols to follow in various scenarios. From recognising phishing attempts to understanding the nuances of consent, a well-trained workforce is an organisation's first line of defence against potential data protection infringements.

In essence, the practical implementation of GDPR within public administrations is a multi-faceted endeavour that demands both technological adaptations and cultural shifts. Each of these steps, from designating a DPO to training staff, contributes to building a resilient, transparent, and accountable data protection ecosystem, ensuring that citizens' rights are upheld and their trust in public entities remains unwavering.

V.9. Challenges in Implementing GDPR in Public Administration

This section delves into the various obstacles that public entities encounter in their quest to align with GDPR mandates, exploring the intricate interplay between technological, bureaucratic, and practical concerns.

- ***Technological Challenges:*** The implementation of GDPR within public administration has brought about a series of technological challenges. As data systems and infrastructure used in many public sectors often date back several years, updating them to meet the modern requirements of GDPR can be daunting. This includes encryption for data at rest and in transit, integrating systems for seamless yet secure data access, and ensuring that they are resilient against cyber threats. Moreover, older systems may lack compatibility with newer security protocols, necessitating comprehensive system overhauls rather than incremental updates.
- ***Bureaucratic Hurdles:*** Public administrations, by their nature, are entwined with layers of bureaucracy. This can pose challenges when attempting to implement GDPR provisions swiftly and efficiently. For instance, obtaining necessary approvals for system changes, coordinating between different departments, or simply navigating the maze of administrative processes can delay GDPR alignment. Additionally, the decision-making process in public entities often involves multiple stakeholders, which can slow down the adoption of critical data protection measures.
- ***Financial Implications:*** The financial burden of GDPR compliance can be substantial, especially for public administrations that operate on tight budgets. The costs associated with updating IT infrastructure, hiring, or training specialised personnel like Data Protection Officers, and conducting regular audits and assessments can quickly add up. Furthermore, the potential financial penalties for non-compliance make it imperative for public entities to invest adequately in GDPR-related initiatives, straining already limited resources.
- ***Balancing Transparency and Data Protection:*** One of the core tenets of public administration is transparency. However, GDPR demands stringent data protection, and striking a balance between the two can be challenging. While citizens have the right to access information and understand governmental processes, ensuring that this does not compromise personal data protection can be a tightrope walk. Deciding what to disclose, how much to disclose, and ensuring that disclosures do not inadvertently leak personal data requires meticulous planning and execution.
- ***Ensuring Consistent Application Across Various Public Entities:*** Public administrations are not monolithic entities but rather a conglomerate of various departments, each with its own set of challenges, resources, and priorities. Ensuring that GDPR is applied consistently across all these entities can be a significant challenge. A measure that works seamlessly in one department might face resistance or implementation issues in another. Coordinating GDPR compliance across diverse entities, ensuring consistent standards, and addressing unique challenges for each department necessitate a holistic, well-orchestrated approach.

In sum, while GDPR brings forth a blueprint for data protection and privacy, its implementation within public administration is fraught with challenges. These hurdles, ranging from technological constraints to bureaucratic red tape, require not just resources but also a nuanced understanding of both GDPR and the intricacies of public governance. However, with concerted effort, these challenges can be navigated, aligning public administration with the gold standard of data protection.

V.10. Case Studies: Examples of GDPR Implementation in Public Administration

Various countries have developed their own frameworks and standards to ensure the safeguarding of personal data and compliance with the General Data Protection Regulation (GDPR) set by the European Union. These initiatives aim to provide practical guidance and measures for organisations to meet legal requirements and enhance data security.

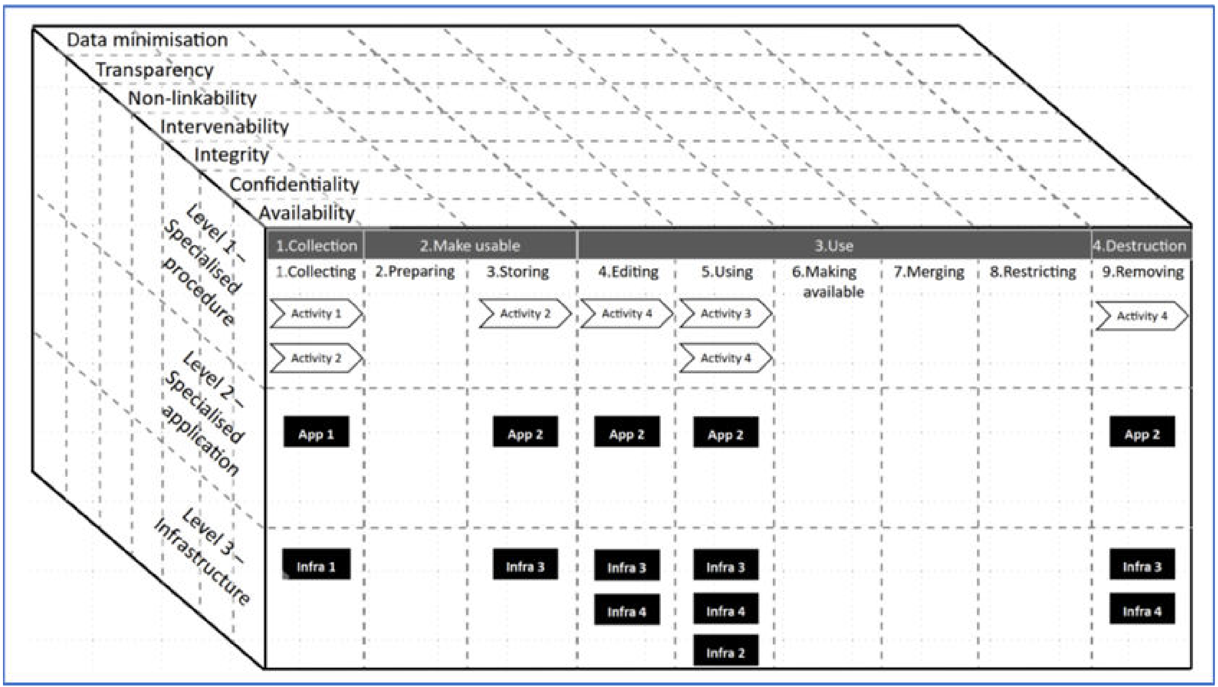
V.10.1 Germany – Standard Data Protection Model (SDM)

The Standard Data Model (SDM), developed by the Conference of the Independent Data Protection Authorities of Germany (*Datenschutzkonferenz* or "DSK"), serves as a practical framework that transforms the legal requirements of the GDPR into concrete technical and organisational measures. This simplifies the transition from abstract legal obligations to specific, actionable steps. The latest version (3.0) was adopted in 2022.

The Standard Data Protection Model (SDM) is applicable to the planning, implementation, operation, examination, and evaluation of personal data processing activities. It is designed to assist organisations in both the business and public sectors in meeting the GDPR's proof and accountability requirements.

The legal requirements are translated into seven key "guarantees to be achieved," encompassing (1) data minimisation, (2) availability, (3) integrity, (4) confidentiality, (5) unlikability, (6) transparency, and (7) intervenability (data subjects' control).

Figure 23: SDM cube



V.10.2 The Netherlands – Information Security and Data Protection Standards Framework for Fundamental Education

The Ministry of Education of the Netherlands established Kennisnet in 2007. Kennisnet is an organisation integrating Information and Communication Technology into educational curricula and providing a wide range of educational resources, educational technology tools, and information related to education.

In 2023, Kennisnet published the first version of the Information Security and Data Protection

Standards Framework for Fundamental Education (I*nformatiebeveiliging en Privacy voor het Funderend Onderwijs,* "IBP FO"). This framework includes specific example measures for school organisations against the data breach or cyber-attacks. It helps school organisations to control the security and data protection level objectively.

This framework comprises an information security section, consisting of 15 parts and 69 standards, and a data protection section that is currently under development and is set to be established in the second half of 2023. All educational organisations are mandated to incorporate this framework by 2027.

V.10.3 France – The Educational Module for Local Governments

The French data protection authority, known as the Commission Nationale Informatique & Libertés (CNIL), offers numerous free GDPR compliance resources. Particularly for local governments, CNIL has recently updated its educational module on handling citizens' personal data.[22]

The educational module for local governments covers the following areas:

- Use of individual cameras by municipal police officers.
- Management of the electoral list.
- Management of civil status files.
- Appointment by a community of its data protection officer (DPO).
- Implementation of processing within the framework of political communication.
- Provision of teleservices.
- Municipal alert and population protection registers.
- Communicating information to "authorised third parties".
- Institutional communication files.
- Files of school and extracurricular activities.
- Focus on "ransomware": a serious threat to communities.
- Population census.
- Social and medico-social files.
- Right of access to administrative documents and the protection of personal data.
- Parking control by communities.

By providing practical frameworks and guidance, these initiatives help bridge the gap between legal requirements and concrete implementation, thereby promoting accountability and transparency in data processing activities. As the digital landscape continues to evolve, these models and frameworks serve as valuable resources for organisations and educational institutions striving to uphold data protection standards and compliance with GDPR regulations.

V.11. Conclusion

While the GDPR provides a robust framework for data protection, its efficacy lies in its implementation. It is apparent from the steps outlined that the heart of GDPR is not just about regulatory compliance but building a sustainable culture of respect for personal data. This culture is pivotal as we transition deeper into a data-driven era, where data is likened to a valuable resource. However, as with any significant transformation, especially within the expansive and multifaceted realm of public administration, there will be teething issues.

The challenges faced by public entities resonate with the broader struggles of merging age-old bureaucratic systems with rapidly evolving digital expectations. Technological advancements, while providing solutions for efficient data processing and storage, also

[22] https://www.cnil.fr/fr/comprendre-le-rgpd/le-mooc-de-la-cnil-est-de-retour-dans-une-nouvelle-version-enrichie

present potential threats in the form of cyber-attacks and breaches. But it is the intersection of these technologies with established bureaucratic processes that often poses the most substantial challenge. In trying to ensure a seamless integration of GDPR mandates, public entities grapple with both the tangible (financial and technological) and intangible (cultural and administrative) aspects of their operations.

The diverse strategies employed by countries across Europe further emphasise the point that there is not a 'one-size-fits-all' approach to GDPR implementation. The adaptability and flexibility of the regulation are evident, allowing countries to tailor their strategies based on their specific circumstances, historical contexts, and governance models. This adaptability, however, also brings forth the challenge of ensuring consistent standards across varying public entities.

A pivotal takeaway from the provided case studies is the universal recognition of GDPR's significance. Whether through dedicated roles, updated policies, or rigorous assessment methodologies, each country showcased an earnest attempt to align with GDPR's essence. These efforts, although varied, reflect a global commitment to elevate data protection standards, reinforcing public trust and confidence.

In the broader context, the GDPR journey within public administration serves as a testament to the evolving dynamics between citizens and their governments in the digital age. As data continues to redefine these dynamics, the emphasis on robust data protection measures will only grow. Public administrations, by ensuring GDPR alignment, are not just adhering to regulations but reaffirming their commitment to their citizens – a promise of safeguarding their rights, trust, and data in an increasingly interconnected world.

In conclusion, while the road to GDPR alignment presents challenges, it also offers an opportunity. An opportunity for public administrations to revamp their operations, re-establish public trust, and set a gold standard for data protection, all while navigating the intricacies of the digital revolution.

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VI. ISO/IEC 27001:2022

VI.1. Introduction and overview of the ISO/IEC 27001:2022

The ISO/IEC 27001 standars is internationally the most authoritative Information Security Management System (ISMS) to protect the confidentiality, availability, and integrity of organisation information assets. ISO/IEC 27001 is a framework that provides requirement and security control items to systematically establish and continuously operate security management procedures and processes, security policy, etc to protect the organisation information assets. It can overcome the limitations of fragmentary and one-time management through systematic and continuous management system operation. It helps organisations understand how to set organisational security policies and objectives to strengthen information security, implement necessary security controls, and set clear objectives to mitigate risks. By adopting ISO 27001, organisations can manage legal requirements, such as regularly checking their compliance status.

Assets to be protected are very extensive, including not only digital information but also physical assets such as documents, so technical protection for the system as well as physical and administrative protection must be performed at the same time.

The ISO 27001 framework helps to continuously find, fix, and improve systematic, physical, and administrative vulnerabilities that can become threat factors. ISO 27001 was first enacted as BS7799, and after revision in 1999, it was enacted as an international standard ISO 27001:2005 by ISO in 2005. Also, after being revised to ISO 27001:2013 in 2013, it was recently revised again to ISO 27001:2022 in 2022.

VI.2. Principles and Objectives

The principle of ISO 27001 is to protect three aspects of information, confidentiality, integrity, and availability. For this protection, ISO 27001 aims to continuously improve security levels by establishing, implementing, and maintaining ISMS.

This is achieved by the PDCA (Plan Do Check Action cycle). PDCA has full-cycle core activities that can drive long-term improvement.

Figure 24: PCA model application to ISMS processes.

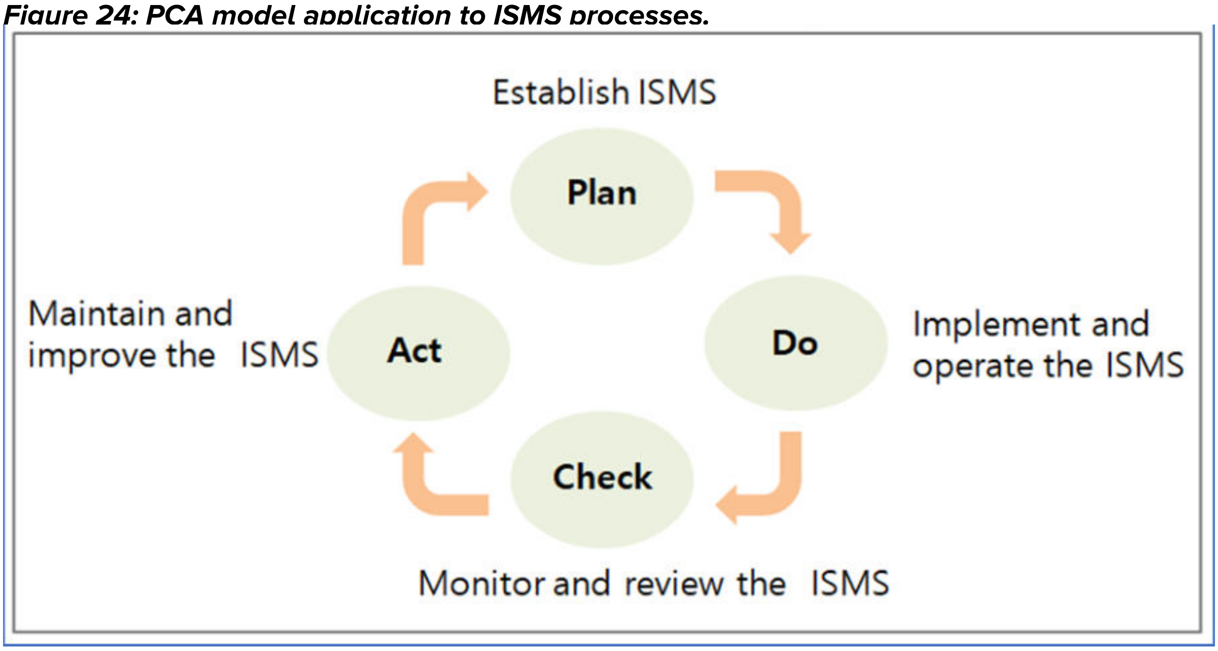

Establish ISMS
Plan
Do
Implement and operate the ISMS
Check
Monitor and review the ISMS
Act
Maintain and improve the ISMS

Table 13: PDCA cycle mapped to the ISO 27001 standard framework.

Step	Question
Plan	Establish ISMS policies, objectives, processes, and procedures to improve information security or manage risk to align with organisation-wide policies and objectives
Do	Implementation and operation of ISMS policies, controls, processes, and procedures
Check	Evaluate and measure ISMS policies, objectives and practical experience, and report measurement results for management review
Act	Perform corrective and preventive actions based on internal ISMS audits, management reviews, and other information for continuous ISMS improvement

Each phase of the PDCA cycle mapped to the ISO 27001 standard framework is described below.

PLAN

Identify customer and interested parties' needs related to information security and establish ISMS objectives, and policies. Establish all necessary activities to identify and address risks and opportunities in order to achieve the intended results in accordance with the organisation's policies related to information security.

The following four clauses among the main clauses of ISO 27001 correspond to this step. Each clause supports each in the internal environment to establish ISO 27001.

Clause 4. Context of the organisation
Clause 5. Leadership
Clause 6. Planning
Clause 7. Support

DO

This is the stage of executing the plan. It means putting plans and designs into action. Implement and operate established processes and procedures in this stage. Members should be educated and trained, and the necessary equipment should be provided for successful implementation.

In ISO 27001, there is one clause corresponding to this stage.

Clause 8. Operations

CHECK

This phase evaluates the implementation and operation of the ISO 27001 framework. By measuring and evaluating performance against the results of its actions, it identifies areas for improvement in implementation and operations, as well as emerging vulnerabilities and threats that the organisation may face. The performance evaluation usually will be performed in the form of an Audit.

There is only one clause corresponding to this stage among the main clauses of ISO 27001.

Clause 9. Performance Evaluation

ACT

There is one correlated clause in ISO 27001 that belongs to this stage.

We carry out improvement activities based on information on weaknesses and gaps identified in the 'CHECK' stage, such as audit results. After the 'ACT' stage, we return to the objectives and strategies we set out in the initial planning phase and start the PDCA cycle again. Through these cycles, ISMS can be continuously improved.

Clause 10. Improvement

VI.3. Detailed analysis of the technical specifications and requirements

The ISO 27001 standard is a management system model that provides applicable objectives and controls. It consists of management process requirements and Information security control requirements.

There are seven clauses for management process requirements: ① **Context of the organisation,** ② **Leadership** ③ **Planning,** ④ **Support,** ⑤ **Operation,** ⑥ **Performance evaluation,** and ⑦ **Improvement.**

Information security control requirements have 93 controls in 4 categories as per Annex A control purpose and control.

Statement of Applicability (SoA) to be published based on Annex A.

- Organisational (37 controls)
- People (8 controls)
- Physical (14 controls)
- Technological (34 controls)

Figure 25: Information security management process requirements

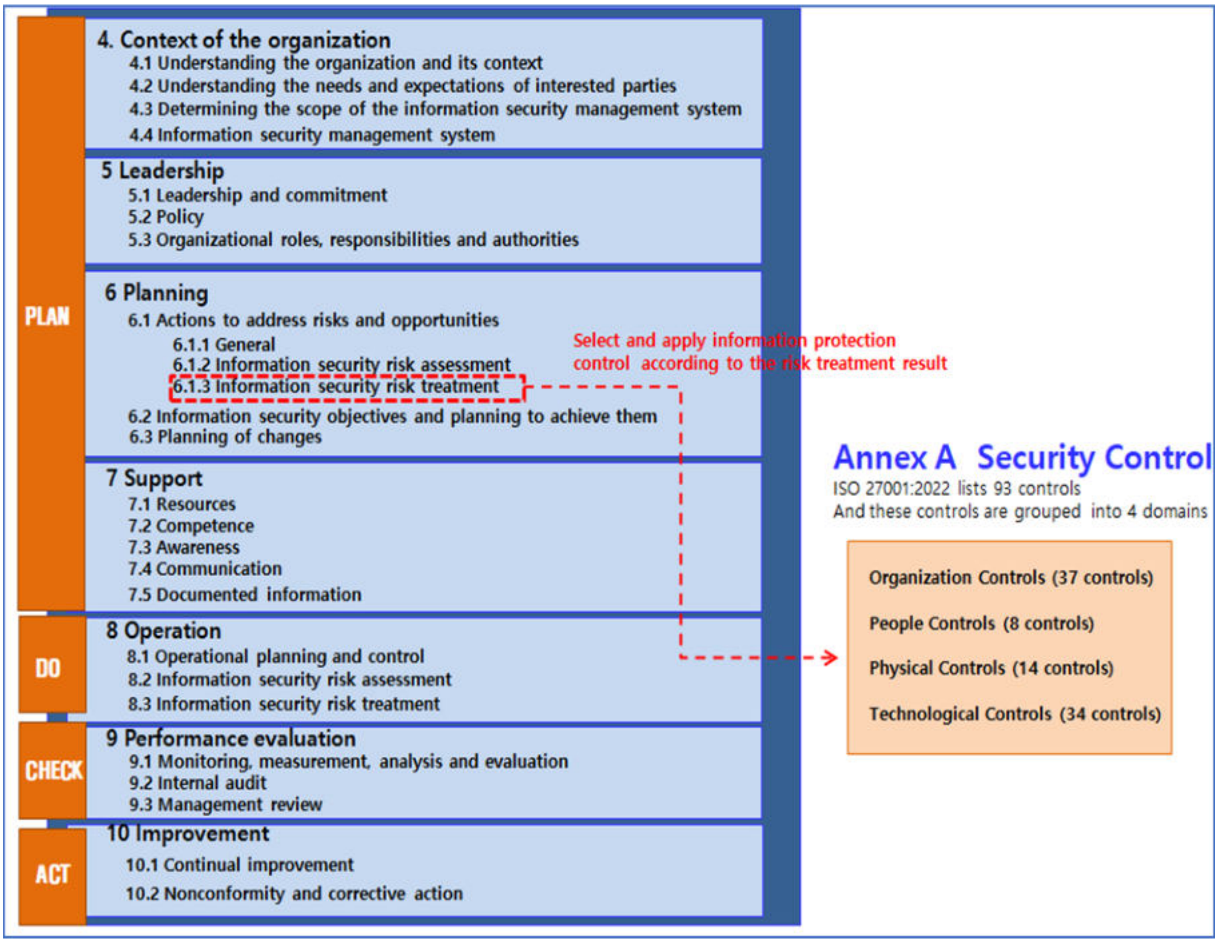

PLAN
4. Context of the organization
4.1 Understanding the organization and its context
4.2 Understanding the needs and expectations of interested parties
4.3 Determining the scope of the information security management system
4.4 Information security management system
5 Leadership
5.1 Leadership and commitment
5.2 Policy
5.3 Organizational roles, responsibilities and authorities
6 Planning
6.1 Actions to address risks and opportunities
6.1.1 General
6.1.2 Information security risk assessment
6.1.3 Information security risk treatment
6.2 Information security objectives and planning to achieve them
6.3 Planning of changes
Select and apply information protection control according to the risk treatment result
7 Support
7.1 Resources
7.2 Competence
7.3 Awareness
7.4 Communication
7.5 Documented information
DO
8 Operation
8.1 Operational planning and control
8.2 Information security risk assessment
8.3 Information security risk treatment
CHECK
9 Performance evaluation
9.1 Monitoring, measurement, analysis and evaluation
9.2 Internal audit
9.3 Management review
ACT
10 Improvement
10.1 Continual improvement
10.2 Nonconformity and corrective action
Annex A Security Control
ISO 27001:2022 lists 93 controls
And these controls are grouped into 4 domains
Organization Controls (37 controls)
People Controls (8 controls)
Physical Controls (14 controls)
Technological Controls (34 controls)

Table 14: Information security management process requirement

Clause	Requirement
4. Context of the organisation	4.1 Understanding the organisation and its context. 4.2 Understanding the needs and expectations of interested parties. 4.3 Determining the scope of the information security management system. 4.4 Information security management system.
5. Leadership	5.1 Leadership and commitment 5.2 Policy. 5.3 Organisational roles, responsibilities, and authorities.
6. Planning	6.1 Actions to address risks and opportunities. 6.1.1 General. 6.1.2 Information security risk assessment. 6.1.3 Information security risk treatment. 6.2 Information security objectives and planning to achieve them. 6.3 Planning of changes.
7. Support	7.1 Resources. 7.2 Competence. 7.3 Awareness. 7.4 Communication. 7.5 Documented information. 7.5.1 General. 7.5.2 Creating and updating. 7.5.3 Control of documented information.
8. Operation	8.1 Operational planning and control. 8.2 Information security risk assessment. 8.3 Information security risk treatment.
9. Performance evaluation	9.1 Monitoring, measurement, analysis, and evaluation. 9.2 Internal audit. 9.2.1 General. 9.2.2 Internal audit programme. 9.3 Management review 9.3.1 General 9.3.2 Management review inputs 9.3.3 Management review results
10.Improvement	10.1 Continual improvement 10.2 Nonconformity and corrective action

Table 15: Annex A Information security controls

Domains	Controls
Organisational (37 controls)	5.1 Policies for information security. 5.2 Information security roles and responsibilities. 5.3 Segregation of duties. 5.4 Management responsibilities. 5.5 Contact with authorities. 5.6 Contact with special interest Groups. 5.7 Threat intelligence. 5.8 Information security in project Management. 5.9 Inventory of information and other associated assets. 5.10 Acceptable use of information and other associated assets. 5.11 Return of assets. 5.12 Classification of information. 5.13 Labelling of information. 5.14 Information transfer. 5.15 Access control. 5.16 Identity management. 5.17 Authentication information. 5.18 Access rights. 5.19 Information security in supplier relationships. 5.20 Addressing information security within supplier agreements. 5.21 Managing information security in the information and communication technology (ICT) supply chain. 5.22 Monitoring, review, and change management of supplier services. 5.23 Information security for use of cloud services. 5.24 Information security incident management planning and preparation. 5.25 Assessment and decision on information security events. 5.26 Response to information security incidents. 5.27 Learning from information security incidents. 5.28 Collection of evidence. 5.29 Information security during disruption. 5.30 ICT readiness for business continuity. 5.31 Legal, statutory, regulatory, and contractual requirements. 5.32 Intellectual property rights. 5.33 Protection of records. 5.34 Privacy and protection of personal identifiable information (PII). 5.35 Independent review of information security. 5.36 Compliance with policies, rules, and standards for information security. 5.37 Documented operating procedures.
People (8 controls	6.1 Screening. 6.2 Terms and conditions of employment. 6.3 Information security awareness, education, and training. 6.4 Disciplinary process. 6.5 Responsibilities after termination or change of employment. 6.6 Confidentiality or non-disclosure agreements. 6.7 Remote working. 6.8 Information security event reporting.
Physical (14 controls)	7.1 Physical security perimeters. 7.2 Physical entry. 7.3 Securing offices, rooms, and facilities. 7.4 Physical security monitoring. 7.5 Protecting against physical and environmental threats. 7.6 Working in secure areas. 7.7 Clear desk and clear screen. 7.8 Equipment siting and protection. 7.9 Security of assets off-premises. 7.10 Storage media. 7.11 Supporting utilities. 7.12 Cabling security. 7.13 Equipment maintenance. 7.14 Secure disposal or re-use of equipment.

Technological (34 controls)	8.1 User end point devices. 8.2 Privileged access rights. 8.3 Information access restriction. 8.4 Access to source code. 8.5 Secure authentication. 8.6 Capacity management. 8.7 Protection against malware. 8.8 Management of technical vulnerabilities. 8.9 Configuration management. 8.10 Information deletion. 8.11 Data masking. 8.12 Data leakage prevention. 8.13 Information backup. 8.14 Redundancy of information processing Facilities. 8.15 Logging. 8.16 Monitoring activities. 8.17 Clock synchronisation. 8.18 Use of privileged utility programmes. 8.19 Installation of software on operational Systems. 8.20 Networks security. 8.21 Security of network services. 8.22 Segregation of networks. 8.23 Web filtering. 8.24 Use of cryptography. 8.25 Secure development life cycle. 8.26 Application security requirements. 8.27 Secure system architecture and engineering principles. 8.28 Secure coding. 8.29 Security testing in development and acceptance. 8.30 Outsourced development. 8.31 Separation of development, test and production environments. 8.32 Change management. 8.33 Test information. Protection of information systems during audit testing

VI.4. The main stage for establishing ISMS.

The main stage performed when establishing an ISMS are as follows:

Stage 1: Context analysis

- Analyse internal and external (client, legal) issues, interested parties, and needs.
- Analysing the organisation's information security status. Gap analysis between ISO 27001 requirements and the existing security system
- Define certification scope and identify assets.

Stage 2: Risk analysis and risk assessment

- Establish and maintain criteria for performing risk assessment and risk acceptance criteria.
- Identify risks associated with the loss of confidentiality, integrity, and availability of information.
- Assess the realistic likelihood of the occurrence of the risks identified and determine the risk levels.
- Compare the results of risk analysis with the risk criteria and prioritise the analysed risks for risk treatment.

Stage 3: Risk treatment according to risk assessment results

- Determine all controls that are necessary to implement the information security risk treatment.

Stage 4: Information security control (Annex A control objectives and controls)

- Compare the controls determined with those in Annex A and verify that no necessary controls have been omitted.
- Produce a Statement of Applicability (SoA) that contains the following:
    - The necessary controls.
    - The justification for including or excluding controls.
    - Whether the necessary controls are implemented or not.

Stage 5: Operation (Operation and management according to risk assessment results)

- Plan, implement and control the processes needed to meet requirements and to implement the actions determined in stage 3 and 4.
- The organisation shall perform risk assessments at planned intervals or when significant changes are proposed or occur.
- The organisation shall implement the risk treatment plan.

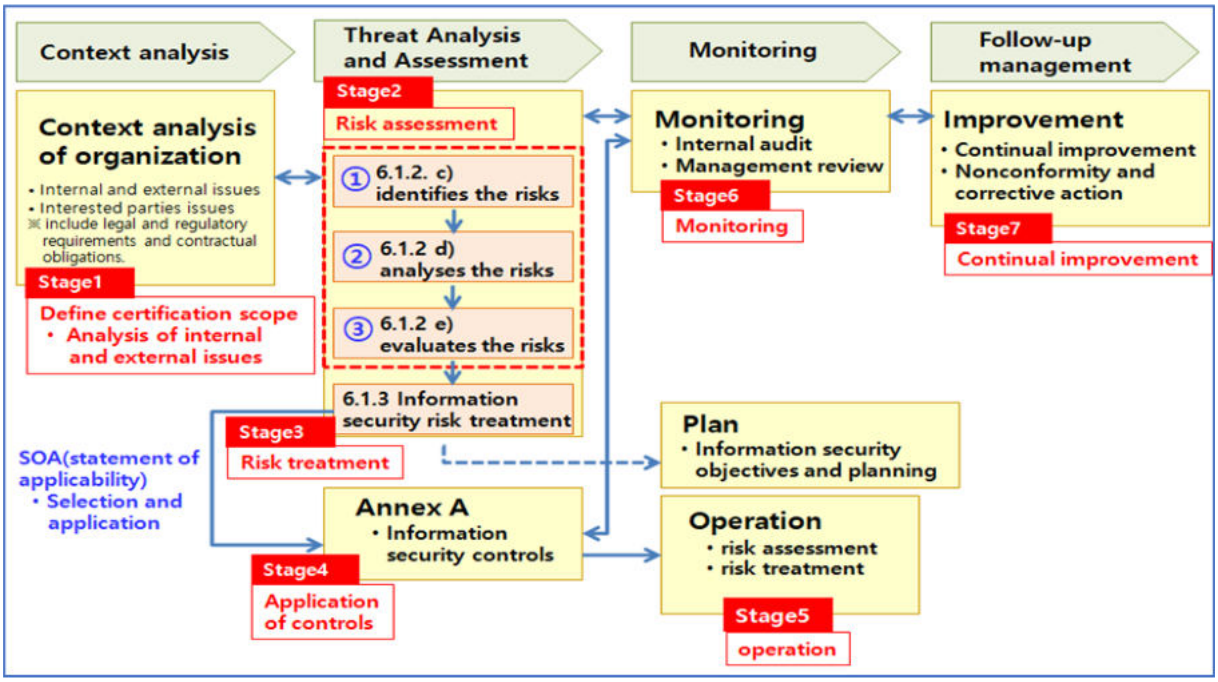
Stage 6: Monitoring (Internal audit and management review activities)

- Performance evaluation by Monitoring, measurement, Internal audit, Management review.

Stage 7: Follow-up management (post-certification audit once a year)

- Continually improve the suitability, adequacy, and effectiveness of the information security management system, and when a nonconformity occurs, take corrective action.

Figure 26: The main stage for establishing ISMS.



Context analysis
Threat Analysis and Assessment
Monitoring
Follow-up management
Context analysis of organization
• Internal and external issues
• Interested parties issues
※ include legal and regulatory requirements and contractual obligations.
Stage1
Define certification scope
• Analysis of internal and external issues
Stage2
Risk assessment
① 6.1.2. c) identifies the risks
② 6.1.2 d) analyses the risks
③ 6.1.2 e) evaluates the risks
6.1.3 Information security risk treatment
Stage3
Risk treatment
SOA(statement of applicability)
• Selection and application
Annex A
• Information security controls
Stage4
Application of controls
Monitoring
• Internal audit
• Management review
Stage6
Monitoring
Improvement
• Continual improvement
• Nonconformity and corrective action
Stage7
Continual improvement
Plan
• Information security objectives and planning
Operation
• risk assessment
• risk treatment
Stage5
operation

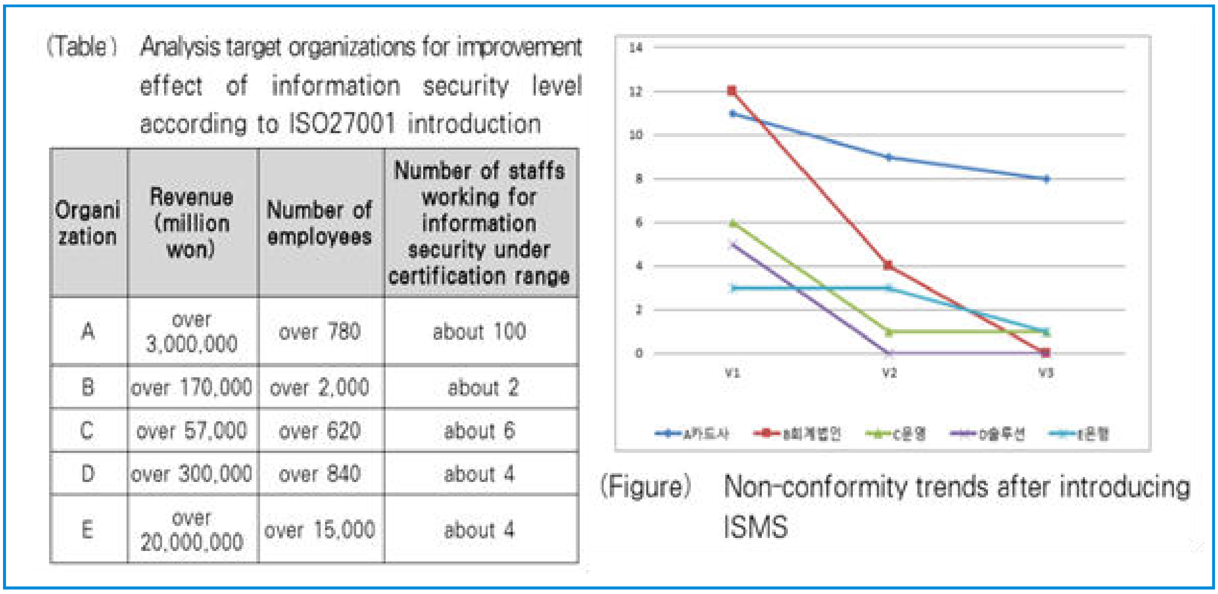
VI.5. Overview of real-world use cases

The following is an example of research results by Youn-Chul Kang and Jong-Chang Ahn. It shows that the level of information security was positively improved by ISMS operation based on ISO 27001. According to Youn-Chul Kang and Jong-Chang Ahn, the method for selecting companies to be analysed is to first select 38 companies that can collect quantitative data, regardless of the size of the organisation, among all domestic companies certified by ISO 27001. It is said that five financial-related organisations that can be provided are finally selected. In addition, the companies subject to analysis were initially audited after 2009 or 2010, and follow-up audits were completed by 2013 according to the three-year certification cycle.

As a measurement index, based on 'the number of non-conformities' in the ISO 27001:2005 certification audit report used in Boehmer's study, it was statistically analysed how much the number of non-conformities found in the initial audit after establishing the ISMS of each company decreases as the follow-up audit is conducted every year. As a result of analysing the comparison target companies for ISO 27001 certification, it was confirmed that the number of non-conformity cases decreased every year during the 3-year cycle from the initial audit in all companies that received ISO 27001 certification, as shown in Figure below.

In Figure, the X-axis represents the initial examination (V1) and the post-inspection (V2, V3), and the Y-axis represents the number of cases of minor nonconformities found. Analysing the data, a minimum of 27% and a maximum of 100% of improvement were made based on the initial review standard, and only non-conformity, improvement recommendations, or simple observations that are recommended were found.

Figure 27: The effect of introducing ISMS based on ISO 27001.



(Table) Analysis target organizations for improvement effect of information security level according to ISO27001 introduction

Organization	Revenue (million won)	Number of employees	Number of staffs working for information security under certification range
A	over 3,000,000	over 780	about 100
B	over 170,000	over 2,000	about 2
C	over 57,000	over 620	about 6
D	over 300,000	over 840	about 4
E	over 20,000,000	over 15,000	about 4

(Figure) Non-conformity trends after introducing ISMS

Source Youn-Chul Kang, Jong-Chang Ahn (2018)

As for the performance cases in public institutions, the introduction of ISO 27001 in the National Science and Technology Information Service (NTIS) and its results can be reviewed. According to the results of the study by Byeong-Hee Lee, Il-Yeon Yeo, and Jae-Soo Kim, in the case of NTIS, which is an introduction case in public institutions, the number of non-conformity and improvement recommendations decreased for 3 years after the introduction of ISO 27001, as shown below.

Table 16: Changes in the number of nonconformities and improvement recommendations

Year after introduction	Significant nonconformities	Light nonconformities	Improvement recommendation
1st year	0 (2)	1 (19)	17 (7)
2nd year	0 (1)	0 (11)	11 (12)
3rd year	(0)	(0)	(8)

Source Byeong-Hee Lee, Il-Yeon Yeo, Jae-Soo Kim (2011)
** The number in parentheses is the number received from internal audit.*

In addition, it is said that there have been the following achievements and changes after introducing ISO 27001:

- The organisational KPI (Key Performance Indicator) changed to be more objective.
- The application rate of Information security controls increased from 75% (100 items) in the first year to 79% (105 items) in the second year.
- Security inspection programme applied to all PCs and expanded the application to resident service companies.
- Full implementation of network access control systems such as NAC, and introduction of USB security management system.
- Introduction of secure printers/copiers within the organisation.
- Application DRM to service.
- Reinforcement of information asset management within the organisation.

Also, as a qualitative result, it is said that security awareness enhancement, security education reinforcement, and security reliability evaluation from external organisations such as the National Intelligence Service have been improved.

VI.5.1 Specific real case of successful ISO 27001 introduction[23]

Company K recruited a capable security manager and successfully introduced ISO 27001. First, the security manager openly identified all problems, including organisation and solutions, in order to establish correct measures. To solve the problems identified, a security department was organised, and manpower and budget were secured.

The security manager first focused on establishing an information security management system. He specifically showed the company's existing risks to management and effectively persuaded them that the company would not be able to grow sustainably if security investments were not made. He emphasised that if an information security management system is not established, there is a high possibility that problems that have been improved will recur. Management also shared this perception, and the investment was able to be made.

By arranging security personnel based on ISO 27001 control items, work roles and responsibilities were clarified to ensure that no work was missed. In addition, auditors were assigned to perform tasks efficiently. Before the actual review, a mock review was conducted to check whether there were any items that needed additional improvement. After receiving ISO 27001 certification, overall security awareness has increased.

As the areas that can be resolved administratively become clear, security solutions can be introduced only where absolutely necessary, reducing costs. Security work does not operate according to instructions but operates on its own through the management system. The time it takes to detect a security problem and take action to respond to it has been significantly shortened. Additionally, the security organisation was able to understand the company's overall systems and processes during the certification review process, enabling smooth collaboration with other departments.

VI.6. Benefits of implementing ISO 27001 framework

- The ISO 27001 framework helps you comply with laws and regulations. This reduces the risk of fines or other penalties for non-compliance.
- Improve not only external corporate image but also customer’s, business partner’s reliability and trust for information security safety by obtaining ISO 27001 certification.

[23] Gil Min-kwon, “[Success Story] ISMS Introduction Case”, Daily Secu, May 29, 2013.

- Through systematic and continuous information security risk management, business safety can be continuously improved, and the risk of intrusion can be reduced.
- ISO 27001 framework makes it possible to establish a security management system at a very specific level, and work in detail at all times.
- Through the operation of the ISO 27001 framework, it is possible to prevent the development of large-scale security incidents in advance by discovering viable risks and security problems at an early stage.
- Trust in information security through international standard certification makes it easy to enter the global markets for business.
- In the case of e-government services and public administration services, if a cyber security incident occurs, the damage scale and effect can be very large, so the importance of security in these fields is even greater.

In the case of e-government and public administration services, if a cyber security incident occurs, the damage scale and effect can be very large, so the importance of security in these fields is even greater.

It is necessary to introduce the systematic management framework of ISO 27001 in order to overcome the limitations of heteronomous regulation-oriented fragmentary, one-time, partial security management. By introducing ISO 27001 framework to e-government services and public administration services, the foundation for continuous improvement of information security level can be laid every year, and the level of information security can be dramatically improved through systematic management. In addition, through international standard certification, internal and external reliability of e-government services and public services can be increased.

VI.7. Limitations and weaknesses of ISO 27001 framework

- ISMS is to verify that business processes for information protection are continuously established and maintained, but it does not guarantee that it is a safe system that is not hacked.
- In order to establish ISO 27001, costs and manpower are required, which can cause a burden on the organisation. Also, costs and manpower are required to maintain ISO 27001.
- ISO 27001 is a system that helps organisations systematically manage and improve information security, but the level of information security of an organisation does not increase if it responds only to audits temporarily to pass certification audits.

VI.8. Recommendation for effective application and implementation of the ISO 27001

- Since the information security management system helps detect security threats early and prevent accidents, it is good to establish and operate it as soon as possible. Once an information security management system is established and put into operation, the organisation's security level can be improved every year.
- In order to successfully apply the ISO 27001 standard to the organisation and upgrade information security to a safe level, the management's active and strong will and participation in information security are essential.
- Since there is no perfect security, it is necessary to minimise managerial, technical, and physical security vulnerabilities every year by continuously investing in budget and operating professional personnel.
- If the organisation's situation is a new technology application and a special environment, the framework can be made perfect by newly applying security control items suitable for the organisation's situation as well as the security control items suggested by ISO 27001.

VII. Cybersecurity & Privacy Frameworks

VII.1. Introduction

VII.1.1 Importance of cybersecurity & privacy in today's digital landscape.

In today's digital landscape, where technology is increasingly relied upon and sensitive data is frequently stored and transmitted online, cybersecurity and privacy have become critical. Cyber-attacks are becoming more sophisticated and common, with severe consequences such as financial loss, damage to reputation, and even physical harm. The significance of cybersecurity and privacy is underscored by the numerous high-profile data breaches that have occurred in recent years, such as the Equifax data breach in 2017 that exposed the personal information of 143 million consumers, the SolarWinds hack in 2020 that compromised the networks of multiple government agencies and private companies and most recently data breaches of T-Mobile, Kroger, California DMV, and Microsoft Exchange Server, and a ransomware attack on Colonial Pipeline in 2022. In addition to the financial and reputational damage that can result from a cyber-attack, there are also legal and regulatory implications.

Many countries have implemented data protection laws and regulations that require organisations to protect their customers' and employees' personal information, with non-compliance resulting in fines and legal action, such as the European Union's General Data Protection Regulation (GDPR) which can impose fines of up to 4% of a company's global annual revenue for non-compliance with data protection requirements.

Moreover, individuals are increasingly concerned about their privacy and how their personal data is used by companies and governments. The Cambridge Analytica scandal in 2018, where millions of Facebook users' data were harvested without their consent for political advertising, highlighted the need for greater transparency and control over personal data.

The key reasons for the importance of cybersecurity and privacy in today’s digital landscape can be suggested as follows:

- ***Defence against Cyber Threats:*** Cyber threats, such as hacking, data breaches, ransomware attacks, and identity theft, are becoming more common and sophisticated. Strong cybersecurity measures are necessary to protect sensitive information, including personal data, financial records, intellectual property, and national security assets.
- ***Privacy Protection:*** In the digital age, we generate a large amount of personal data through various online activities. Protecting privacy ensures that individuals have control over their data and reduces the risk of unauthorised access or misuse.
- ***Protection of Business Interests:*** Cyberattacks can have a significant impact on businesses of all sizes. Cybersecurity breaches can result in financial losses, damage to reputation, legal liabilities, and loss of customer trust. Implementing cybersecurity safeguards helps protect valuable business assets and information.
- ***National Security:*** Cybersecurity is closely linked to national security and safety. Critical infrastructure systems are increasingly reliant on digital technologies and defending these systems against cyber threats is essential to prevent disruptions that could impact public safety or national defence.
- ***Compliance with Data Protection Regulations:*** Governments around the world have introduced data protection regulations to enforce privacy rights and hold organisations accountable for protecting personal data. Compliance with these regulations is necessary to avoid penalties and demonstrate a commitment to customer privacy.
- ***Building Trust and Customer Confidence:*** Cybersecurity and privacy are important for maintaining trust and confidence in digital services. Businesses that prioritise cybersecurity measures and respect customer privacy build trust and enhance their reputation.

- ***Prevention of Cyber Crime and Fraud:*** Cybersecurity measures act as a deterrent to cybercriminals and fraudsters. Strong security practices make it more difficult for criminals to exploit vulnerabilities or engage in malicious activities online, helping to protect individuals, businesses, and society as a whole.

In our connected world, it is crucial to have strong cybersecurity and privacy measures in place to protect against cyber threats, safeguard personal information, and ensure national security. With the increasing reliance on technology and the growing sophistication of cyber-attacks, it is more important than ever to adopt effective cybersecurity practices to protect our digital lives. Organisations and individuals must take proactive steps to secure their data, while governments must continue to develop and enforce laws that promote cybersecurity and privacy. By doing so, we can establish trust, comply with data protection regulations, and combat cybercrime. In short, cybersecurity and privacy are essential for navigating the changing digital landscape and protecting our digital lives.

VII.2. Function of cybersecurity & privacy framework for organisation and country.

The cybersecurity and privacy framework provides a structured approach to managing and mitigating cyber risks for organisations and countries. It outlines the necessary policies, procedures, and technical measures to protect against cyber threats and ensure privacy rights are respected. Below is a detailed explanation of the functions of a cybersecurity and privacy framework:

- ***Risk Assessment and Management:*** The framework guides organisations and countries in conducting comprehensive risk assessments to identify vulnerabilities, threats, and potential impacts. It enables them to prioritise risks, allocate resources effectively, and develop risk management strategies to mitigate threats and reduce the likelihood and impact of cyber incidents.
- ***Policies and Procedures:*** The framework establishes policies and procedures that govern cybersecurity and privacy practices. These policies define roles and responsibilities, set guidelines for data handling, establish incident response procedures, outline security awareness programmes, and ensure compliance with legal and regulatory requirements. Clear policies promote consistency and provide a framework for decision-making.
- ***Security Controls and Safeguards:*** The framework defines a set of security controls and safeguards that organisations and countries should implement to protect their networks, systems, and data. These controls can include network firewalls, encryption mechanisms, access controls, intrusion detection systems, secure coding practices, and regular security patching. They help organisations and countries defend against cyber threats and ensure the privacy of sensitive information.
- ***Incident Response and Recovery:*** The framework provides guidelines for incident response planning and management. It outlines processes for detecting and responding to security incidents promptly, mitigating their impact, and recovering systems and data. It establishes communication channels, incident reporting mechanisms, and coordination with relevant stakeholders, such as law enforcement agencies or national CERTs (Computer Emergency Response Teams).
- ***Awareness and Training:*** The cybersecurity and privacy framework emphasises the importance of cybersecurity awareness and training programmes. These programmes educate employees, contractors, and other stakeholders about best practices, potential risks, and their roles in maintaining cybersecurity and respecting privacy. By raising awareness and building knowledge, organisations and countries can create a security-oriented culture and strengthen their overall security posture.

- ***Compliance and Regulations:*** Frameworks help organisations and countries stay compliant with relevant laws, regulations, and industry standards regarding cybersecurity and privacy. They provide a framework to understand and implement requirements from different regulatory bodies, such as data protection regulations, industry-specific compliance standards (e.g., PCI DSS for payment card industry), or national cybersecurity policies. Meeting compliance requirements helps organisations and countries mitigate legal and reputational risks.
- ***Continuous Improvement:*** The cybersecurity and privacy framework promotes a culture of continuous improvement by emphasising regular assessments, monitoring, and evaluation of security measures. It encourages organisations and countries to stay abreast of emerging threats and technologies, update policies and controls accordingly, and incorporate lessons learned from incidents to enhance resilience against evolving cyber risks.
- ***Collaboration and Information Sharing:*** Frameworks often emphasise the importance of collaboration and information sharing among organisations and countries. They promote partnerships between the public and private sectors, encourage sharing of threat intelligence, best practices, and lessons learned, and foster cooperation in responding to cyber incidents. Such collaborative efforts strengthen overall cybersecurity and privacy posture by leveraging collective expertise and resources.

In summary, the cybersecurity and privacy framework provide guidelines and functions that enable organisations and countries to effectively manage cyber risks, establish policies and procedures, implement security controls, respond to incidents, raise awareness, ensure compliance, foster continuous improvement, and support collaboration and information sharing. Adhering to such a framework helps build resilience, protect sensitive information, and strengthen overall cybersecurity and privacy posture.

VII.3. Background and Context

VII.3.1 Introducing the concept of cybersecurity & privacy; their importance in today's digital landscape.

In today's interconnected world, where technology plays a central role in almost every aspect of our lives, the concepts of cybersecurity and privacy have gained tremendous significance. Cybersecurity refers to the protection of computer systems, networks, and data from digital threats, while privacy encompasses the control and safeguarding of personal information. As technology continues to advance and our reliance on digital platforms increases, the need to ensure the security of our digital assets and respect individual privacy has become paramount.

Cybersecurity is essential because it safeguards against cyber threats that can compromise the confidentiality, integrity, and availability of critical information. With the rise in cybercrime incidents such as data breaches, ransomware attacks, and identity theft, organisations and individuals alike face an ever-growing risk of financial loss, reputational damage, and even legal consequences. Effective cybersecurity measures, including robust firewalls, strong authentication protocols, and regular security assessments, help defend against malicious actors, minimise vulnerabilities, and ensure the trustworthiness of digital systems.

Alongside cybersecurity, privacy protection is crucial in preserving individual autonomy and trust in the digital world. Technological advancements have enabled unprecedented collection, analysis, and utilisation of personal data, necessitating safeguards to ensure the responsible handling of such information. Privacy breaches can lead to unauthorised access to sensitive data, infringements on personal freedoms, and erosion of trust in organisations and digital services. Maintaining privacy involves adopting transparent data practices, obtaining informed consent, implementing security controls, and adhering to applicable laws and regulations.

However, balancing cybersecurity and privacy is a delicate challenge. Striking the right balance allows for the secure and ethical use of digital technologies while protecting individual rights and minimising risks. As cyber threats become more sophisticated, cybersecurity measures must constantly adapt and evolve. Similarly, privacy concerns require ongoing attention and proactive efforts to protect personal information without impeding the benefits provided by data-driven technologies.

Fostering a culture of cybersecurity and respecting privacy rights are essential for individuals, organisations, and society as a whole. By prioritising robust cybersecurity practices and ensuring the responsible use of personal data, we can create a safer and more trustworthy digital landscape that promotes innovation, fosters trust, and safeguards individuals' rights to privacy and security.

VII.3.2 Overview of the challenges and threats faced in the cybersecurity & privacy domain.

The cybersecurity and privacy domain faces a wide range of challenges and threats that continue to evolve as technology progresses. Some of the key challenges and threats include:

- ***Cyber Attacks:*** Sophisticated cyber-attacks, such as malware, ransomware, phishing, and DDoS (Distributed Denial of Service) attacks, pose significant risks to organisations and individuals. These attacks can result in data breaches, financial losses, disruption of services, and reputational damage.
- ***Insider Threats:*** Insiders with privileged access to sensitive information can intentionally or inadvertently cause security breaches. Malicious insiders may steal or manipulate data, while negligent insiders may unknowingly compromise security through poor practices or lack of awareness.
- ***Regulatory Compliance:*** Meeting the requirements of various cybersecurity and privacy regulations, such as the European Union's General Data Protection Regulation (GDPR) or California Consumer Privacy Act (CCPA), can be challenging for organisations. Compliance involves understanding and implementing specific security measures, privacy practices, data breach notification protocols, and consent mechanisms.
- ***Third-Party Risks:*** Organisations often rely on third-party vendors and suppliers, creating potential security and privacy risks. Weaknesses in the security posture of third-party systems can be exploited by attackers to gain unauthorised access to critical data or systems.
- ***Rapidly Evolving Threat Landscape:*** Cybersecurity threats are constantly evolving as attackers develop new techniques and exploit emerging technologies. Staying ahead of the curve requires continuous monitoring, threat intelligence sharing, and proactive vulnerability assessments.
- ***BYOD and Remote Work:*** The widespread adoption of Bring Your Own Device (BYOD) policies and the rise of remote work have introduced new security challenges. Personal devices and remote connections may lack adequate security controls, increasing the risk of unauthorised access or data exposure.
- ***Insider Data Leakage:*** The unintentional or deliberate leakage of sensitive data by authorised users remains a persistent concern. This can occur through insecure file sharing practices, poor data handling, or insufficient training and awareness.
- ***Cloud Security:*** Organisations transitioning to cloud-based services face unique security considerations. Data protection, access controls, and encryption in cloud environments must be carefully managed to mitigate the risk of unauthorised access, data loss, or service vulnerabilities.
- ***Lack of Security Awareness:*** Human error and lack of security awareness among users pose significant risks to the overall security posture. Employees who are not well-versed in identifying phishing emails, using strong passwords, or adhering to security best practices can inadvertently compromise the organisation's systems and data.

- ***Artificial Intelligence and IoT Threats:*** The growing reliance on Artificial Intelligence (AI) and the proliferation of Internet of Things (IoT) devices introduce new vulnerabilities. AI-powered attacks, algorithmic biases, and inadequate security protocols in IoT devices can expose critical infrastructure and personal data to cyber threats.

It is crucial for organisations and individuals to continuously educate themselves about these challenges and threats, adopt proactive security measures, and stay vigilant to mitigate risks in the ever-changing cybersecurity and privacy landscape.

VII.4. Discussion of the need for cybersecurity & privacy frameworks to guide organisations in their cybersecurity & privacy protection efforts.

Cybersecurity and privacy frameworks are essential for guiding organisations in protecting their information assets and ensuring compliance with relevant laws and regulations. These frameworks provide a structured approach for establishing robust cybersecurity and privacy programmes. The importance of these frameworks is highlighted by the following key points:

- ***Comprehensive Risk Management:*** Frameworks provide a systematic way to identify, assess, and manage risks associated with technology use and sensitive information handling. They help organisations understand their unique risk landscape and prioritise risk mitigation efforts.
- ***Standardised Best Practices:*** Frameworks offer established best practices, methodologies, and controls developed by cybersecurity and privacy experts. These guidelines assist organisations in implementing effective security measures, privacy controls, and data management practices based on industry standards.
- ***Customisable Approach:*** Frameworks can be tailored to align with an organisation's specific industry, size, and risk profile. They provide a flexible structure that can be adapted to meet the organisation's unique needs while adhering to established principles and guidelines.
- ***Regulatory Compliance:*** Many frameworks incorporate legal and regulatory requirements to ensure compliance. They help organisations navigate complex laws and regulations by providing guidance on data protection, breach notification, user consent, and other privacy-related aspects.
- ***Increased Efficiency and Effectiveness:*** Adopting a framework can streamline an organisation's cybersecurity and privacy efforts. A well-implemented framework promotes efficiency by providing a roadmap for implementing controls, conducting risk assessments, and establishing incident response procedures. It enables organisations to optimise resource allocation and maintain a consistent security posture.
- ***Enhanced Communication and Collaboration:*** Frameworks facilitate clear communication between various stakeholders, including executives, IT personnel, legal teams, and auditors. They establish a common language and understanding of cybersecurity and privacy requirements, encouraging collaboration across different departments and disciplines.
- ***Continuous Improvement:*** A key aspect of frameworks is their focus on continuous improvement. They often emphasise regular assessments, monitoring, and evaluation of security and privacy practices to identify areas for improvement and adapt to evolving threats and regulations.
- ***Building Trust and Managing Reputation:*** Implementing a robust framework demonstrates an organisation's commitment to protecting information assets and respecting individual privacy. This can help build trust with customers, partners, and stakeholders, as well as preserve the organisation's reputation.
- ***Cross-Border Compliance:*** For organisations operating across borders, frameworks provide guidance on managing international data transfers and harmonising practices to comply with multiple jurisdictions. This ensures adherence to different legal requirements while maintaining a consistent level of security and privacy.

- ***Benchmarking and Certification:*** Many frameworks offer external assessments and certification processes for organisations. This provides independent validation of an organisation's cybersecurity and privacy practices, allowing them to demonstrate compliance and differentiate themselves in the marketplace.

Cybersecurity and privacy frameworks play a pivotal role in guiding organisations' efforts to protect their digital assets and ensure privacy compliance. They provide a structured approach, best practices, compliance guidance, and a continuous improvement framework to help organisations effectively manage risks, maintain regulatory compliance, and build trust in an increasingly connected and data-driven world.

VII.5. Overview of the Cybersecurity & Privacy Framework

VII.5.1 Detailed explanation of the Cybersecurity & Privacy Framework.

The Cybersecurity and Privacy Framework is an organisational blueprint that establishes guidelines, best practices, and controls to protect information assets and ensure privacy compliance. It provides a structured approach to managing cybersecurity and privacy risks and enables organisations to develop robust security programmes. Here is a detailed explanation of the key components of a typical Cybersecurity and Privacy Framework:

- ***Governance:*** The framework begins with establishing strong governance, which involves defining roles, responsibilities, and accountability for cybersecurity and privacy across the organisation. It includes the creation of policies, procedures, and frameworks that set the tone for security and privacy practices and provide oversight and decision-making structures.
- ***Risk Assessment and Management:*** The framework emphasises conducting comprehensive risk assessments to identify and prioritise threats, vulnerabilities, and potential impacts. Organisations assess risks associated with technologies, systems, processes, and the handling of sensitive data. Risk mitigation strategies, such as implementing controls and safeguards, are devised to minimise or eliminate identified risks.
- ***Security Controls:*** The framework outlines a set of security controls, based on industry best practices and regulatory requirements, to protect against common security threats. These controls encompass various aspects, including access management, network security, system hardening, incident response, data encryption, employee awareness training, and physical security measures. The framework helps organisations select, implement, and maintain appropriate controls tailored to their specific needs.
- ***Privacy Protection:*** Privacy is a critical aspect of the framework. It incorporates privacy principles and guidelines to ensure compliance with relevant privacy laws and regulations. The framework addresses data collection, consent mechanisms, data handling procedures, data retention, data subject rights, and breach notification protocols. It promotes privacy by design approaches in the development and implementation of systems and processes.
- ***Incident Response and Recovery:*** The framework emphasises the establishment of an incident response plan to effectively detect, respond to, and recover from cybersecurity incidents. It includes defining roles and responsibilities, incident escalation procedures, and communication protocols. The framework also emphasises learning from incidents through post-incident analysis to improve the organisation's security posture.
- ***Training and Awareness:*** The framework recognises the importance of continuous training and awareness programmes to educate employees about cybersecurity and privacy best practices. Organisations are encouraged to implement awareness campaigns, conduct regular training sessions, and provide resources to promote a culture of security and privacy awareness among all personnel.

- ***Continuous Monitoring and Improvement:*** The framework underscores the need for continuous monitoring of systems, networks, and data to detect and respond to emerging threats. It encourages organisations to implement security controls to monitor events, conduct vulnerability assessments, perform penetration testing, and track compliance with established policies and procedures. Regular audits and reviews are conducted to evaluate the effectiveness of the security programme and identify areas for improvement.
- ***Compliance and Reporting:*** The framework helps organisations understand and comply with applicable laws, regulations, industry standards, and contractual obligations. It assists in establishing mechanisms for periodic reporting and assessment of compliance with relevant cybersecurity and privacy requirements.
- ***Vendor and Third-Party Management:*** The framework addresses the risks associated with engaging third-party vendors and provides guidelines for assessing and managing their security and privacy practices. It includes contractual obligations, due diligence processes, and ongoing monitoring mechanisms to ensure the security and privacy of shared data and systems.
- ***Business Continuity and Disaster Recovery:*** The framework acknowledges the need for business continuity planning and disaster recovery for cybersecurity incidents. It helps organisations develop strategies and processes to ensure the availability and integrity of critical systems and data during and after cyber incidents.

Overall, the Cybersecurity and Privacy Framework provides organisations with a systematic and holistic approach to protect information assets, mitigate risks, ensure privacy compliance, and respond effectively to cybersecurity incidents. It establishes a foundation for building a resilient and secure environment while enabling organisations to adapt to evolving threats and regulatory requirements.

VII.5.2 Cybersecurity Framework.

1) NIST Cybersecurity Framework

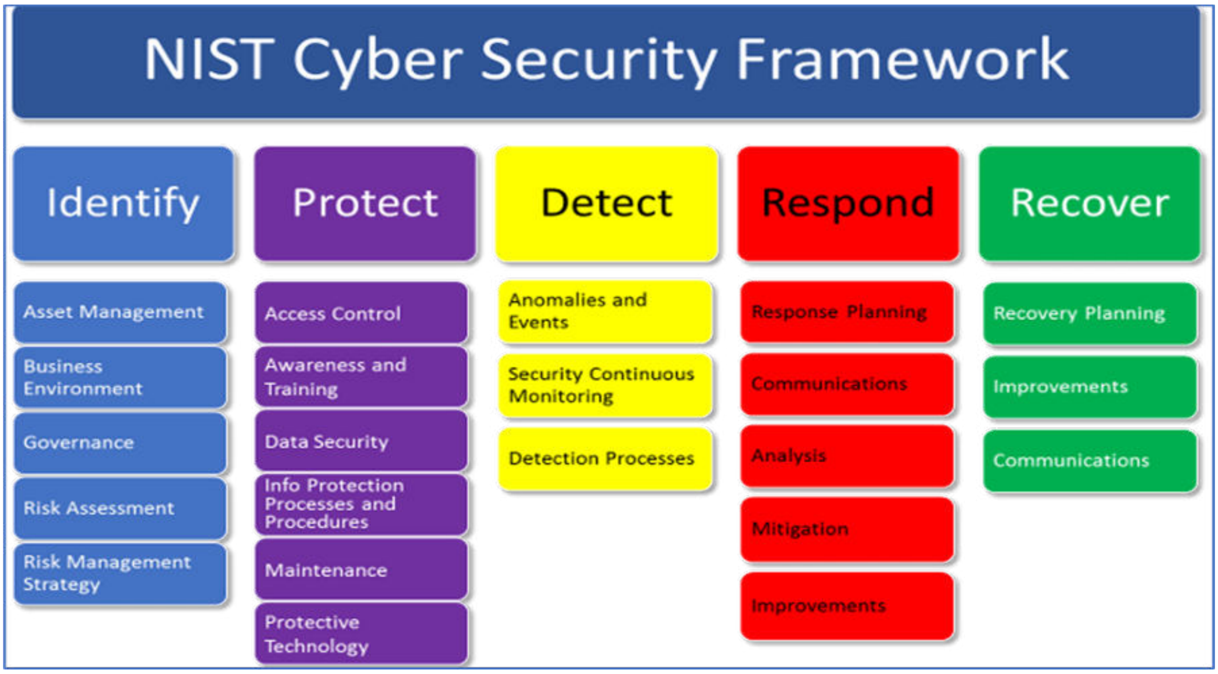
The National Institute of Standards and Technology (NIST) Cybersecurity Framework is a widely recognised guideline that provides organisations with a flexible and standardised approach to managing and reducing cybersecurity risks. It was created by NIST, a non-regulatory federal agency within the U.S. Department of Commerce, in response to an executive order by the US President in 2013. The framework serves as a voluntary framework for organisations of all sizes and sectors to improve their cybersecurity posture.

The NIST Cybersecurity Framework consists of three main components:

- ***Framework Core:*** The Framework Core is the heart of the NIST Framework and consists of five concurrent and continuous functions: Identify, Protect, Detect, Respond, and Recover.
  - *Identify:* The Identify function focuses on understanding the organisation's assets, identifying its cybersecurity risks, and establishing a risk management strategy. This involves conducting an inventory of assets, assessing vulnerabilities, and understanding the potential impact of cybersecurity risks on business operations.
  - *Protect:* The Protect function provides guidance on implementing safeguards to protect critical assets from cybersecurity threats. This includes measures such as access controls, data encryption, secure configurations, training and awareness programmes, and continuous vulnerability management.
  - *Detect:* The Detect function emphasises the implementation of systems and processes to identify and promptly detect cybersecurity incidents. This involves monitoring networks and systems, conducting threat intelligence analysis, and implementing intrusion detection mechanisms.

  - *Respond:* The Respond function guides organisations in developing and implementing response strategies to effectively mitigate the impact of cybersecurity incidents. This includes establishing an incident response plan, defining roles and responsibilities, and conducting forensic analysis to understand the nature and scope of incidents.
  - *Recover:* The Recover function focuses on restoring operations and services after a cybersecurity incident. It involves developing plans and strategies for system recovery, restoring data from backups, and conducting post-incident analysis to prevent similar incidents in the future.
- ***Framework Implementation Tiers:*** The Framework Implementation Tiers provide a way for organisations to assess their current cybersecurity posture and set goals for improvement. It classifies organisations into four tiers (Partial, Risk Informed, Repeatable, and Adaptive) based on their level of cybersecurity risk management.
- ***Framework Profile:*** The Framework Profile enables organisations to create a roadmap for aligning their cybersecurity practices and goals with the desired outcomes. It involves building a profile by selecting and prioritising specific objectives, activities, and references within the Framework Core.

Figure 28: The NIST Cybersecurity Framework Core



NIST Cyber Security Framework

Identify	Protect	Detect	Respond	Recover
Asset Management	Access Control	Anomalies and Events	Response Planning	Recovery Planning
Business Environment	Awareness and Training	Security Continuous Monitoring	Communications	Improvements
Governance	Data Security	Detection Processes	Analysis	Communications
Risk Assessment	Info Protection Processes and Procedures		Mitigation	
Risk Management Strategy	Maintenance		Improvements	
	Protective Technology			

The NIST Cybersecurity Framework has gained significant traction and adoption globally due to its practicality and scalability. It is not only used by organisations in the United States but also serves as a reference point for other countries and industries in developing their cybersecurity standards and frameworks.

2) ISO 27001

ISO 27001 is an internationally recognised standard for information security management systems (ISMS). It provides a framework for organisations to establish, implement, maintain, and continually improve an effective information security management system. Here is a detailed explanation of ISO 27001:

- ***Scope and Context:*** ISO 27001 defines the scope of the ISMS, outlining the boundaries and applicability of the information security management system within the organisation. It emphasises the need to consider the internal and external context, including legal, regulatory, and contractual requirements, as well as the organisation's information security risk environment.

- ***Leadership and Commitment:*** The standard highlights the importance of top management's leadership and commitment to information security. It requires management to establish an information security policy, define roles and responsibilities, allocate resources, and promote a strong culture of security throughout the organisation.
- ***Risk Assessment:*** ISO 27001 emphasises a risk-based approach to information security. It outlines a systematic process for assessing risks associated with the confidentiality, integrity, and availability of information assets. This involves identifying assets, assessing vulnerabilities, evaluating existing controls, and determining the likelihood and impact of potential threats.
- ***Risk Treatment:*** Once risks are identified, ISO 27001 guides organisations in selecting and implementing appropriate risk treatment measures. This includes developing a risk treatment plan, implementing controls to mitigate identified risks, and establishing a framework for incident response, business continuity, and disaster recovery.
- ***Support and Resources:*** The standard highlights the importance of providing adequate resources, training, and awareness programmes to support the information security management system. This includes defining operational processes, managing documents and records, ensuring competence of personnel, and providing the necessary infrastructure to support information security objectives.
- ***Performance Evaluation:*** ISO 27001 emphasises the need for ongoing monitoring and measurement of the ISMS to evaluate its effectiveness. This involves conducting internal audits, reviewing the performance of security controls, analysing security incidents, and collecting feedback from stakeholders. The standard also encourages organisations to perform regular management reviews to ensure the ISMS remains aligned with the organisation's context and objectives.
- ***Improvement:*** ISO 27001 promotes a culture of continual improvement for information security management. It requires organisations to identify areas for improvement based on performance evaluation results, incident analysis, and changing risk landscapes. This includes correcting identified weaknesses, implementing preventive measures, and updating security policies, procedures, and controls accordingly.

ISO 27001 provides a flexible framework that allows organisations to adapt the standard to their specific needs and context. It enables organisations to systematically approach information security management, protect critical assets, demonstrate compliance with regulations, and enhance stakeholder confidence.

VII.5.3 Privacy Framework.

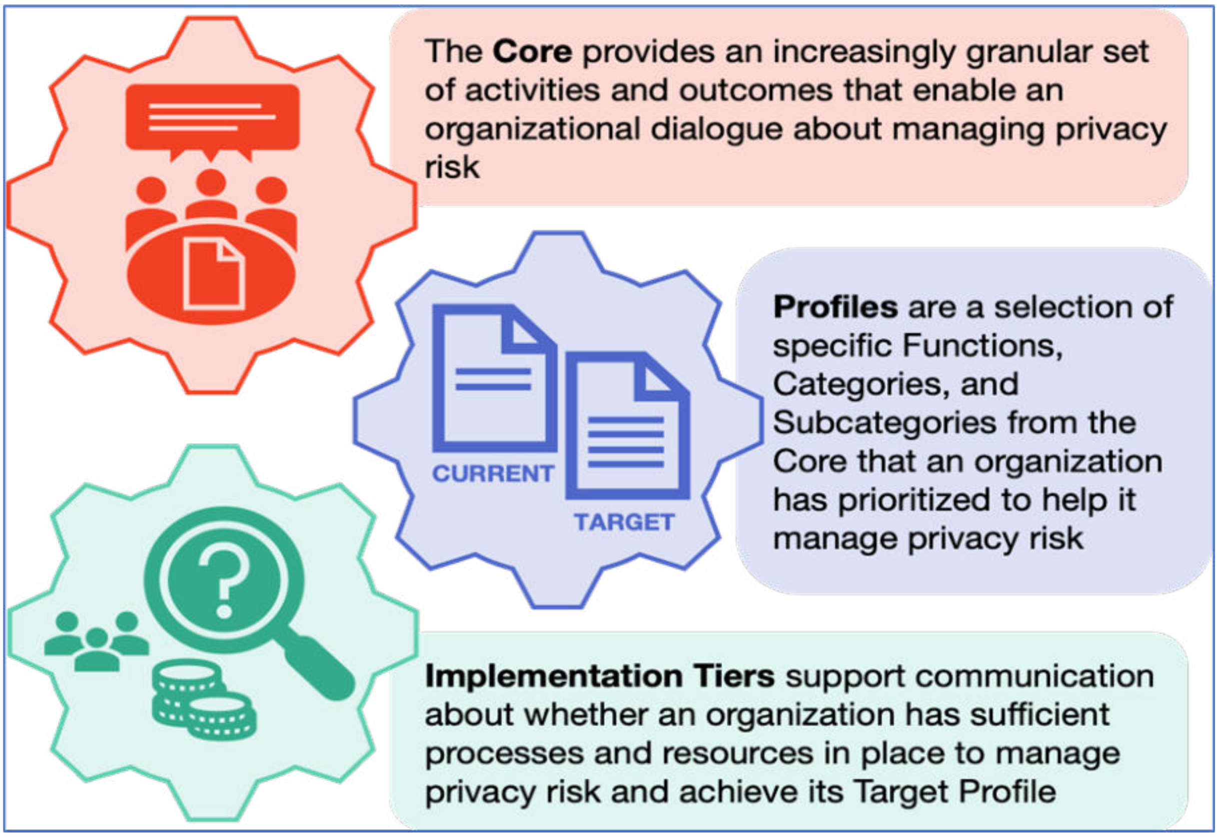
1) NIST Privacy Framework

The NIST Privacy Framework is a guideline developed by the National Institute of Standards and Technology (NIST) to help organisations effectively manage privacy risks and incorporate privacy considerations into their overall risk management processes. Here is a detailed explanation of the NIST Privacy Framework:

- ***Privacy Core:*** The Privacy Framework Core consists of five key functions, which are similar to the NIST Cybersecurity Framework functions:
  - *Identify:* Organisations are advised to understand and prioritise privacy risks by identifying the types of data they collect, the purposes for which they collect it, and the associated privacy risks.
  - *Govern:* This function focuses on establishing and implementing a comprehensive privacy governance structure within the organisation. It includes defining roles and responsibilities, assigning decision-making authority, and developing policies and procedures to guide privacy-related activities.

  - *Control:* The Control function involves implementing appropriate privacy safeguards to mitigate identified risks. This includes developing and implementing privacy controls, such as data minimisation, access controls, and data protection measures, to reduce privacy risks.
  - *Communicate:* This function emphasises the importance of transparency and effective communication with individuals whose personal information is being collected. Organisations should provide clear privacy notices, educate individuals about their privacy rights, and establish channels for individuals to exercise their privacy preferences.
  - *Protect:* The Protect function focuses on implementing measures to respond to privacy incidents and breaches effectively. This includes having incident response plans, conducting privacy impact assessments (PIAs), and establishing processes to detect, respond to, and recover from privacy breaches.
- ***Profiles:*** The NIST Privacy Framework allows organisations to build a privacy profile. Profiles help organisations align their privacy-related activities with their business objectives, risk appetite, and legal/regulatory requirements. A privacy profile can be created by selecting and prioritising relevant outcomes and activities from the Privacy Framework Core.
- ***Implementation Tiers:*** Similar to the NIST Cybersecurity Framework, the NIST Privacy Framework includes Implementation Tiers to help organisations assess the maturity of their privacy practices. The tiers include Partial, Risk Informed, Repeatable, and Adaptive, reflecting different levels of privacy risk management and programme integration.

Figure 29: The NIST Privacy Framework components



The **Core** provides an increasingly granular set of activities and outcomes that enable an organizational dialogue about managing privacy risk

Profiles are a selection of specific Functions, Categories, and Subcategories from the Core that an organization has prioritized to help it manage privacy risk

Implementation Tiers support communication about whether an organization has sufficient processes and resources in place to manage privacy risk and achieve its Target Profile

The NIST Privacy Framework is designed to be adaptable and scalable, making it suitable for organisations of varying sizes and sectors. It promotes a risk-based approach to privacy management, enabling organisations to identify and address privacy risks in a systematic and comprehensive manner.

2) ISO 29100

ISO/IEC 29100 is an international standard that provides a framework for protecting the privacy of personally identifiable information (PII). It outlines a set of privacy principles and emphasises the need for organisations to establish a privacy management programme. The standard distinguishes between the roles of PII controller and PII processor and specifies their responsibilities regarding PII protection. It also highlights the importance of providing clear privacy notices, obtaining consent for processing PII, and recognising the rights of individuals regarding their PII. ISO/IEC 29100 addresses the challenges associated with cross-border data transfers and promotes a proactive approach to privacy management.

Here are some key points about ISO/IEC 29100 in detail:

- ***PII Privacy Principles:*** The standard outlines a set of privacy principles that serve as a foundation for managing PII. These principles include accountability, accuracy, consent, purpose specification, limitation of collection, use, disclosure, retention, and accountability for onward transfer.
- ***Privacy Management:*** ISO/IEC 29100 emphasises the need for organisations to establish a privacy management programme. This involves defining roles and responsibilities, setting policies and procedures, conducting privacy impact assessments (PIAs) to identify privacy risks, and establishing mechanisms for ongoing monitoring and review.
- ***PII Controller and PII Processor Roles:*** The standard distinguishes between the roles of PII controller and PII processor. A PII controller is responsible for determining the purposes and means of processing PII, while a PII processor processes PII on behalf of the controller. ISO/IEC 29100 specifies the responsibilities and obligations of each role regarding PII protection.
- ***Privacy Notice:*** The standard highlights the importance of providing clear and transparent privacy notices to individuals whose PII is collected. It specifies the elements that should be included in a privacy notice, such as the identity of the PII controller, the purposes of processing, the categories of recipients, and the individual's rights regarding their PII.
- ***Consent:*** ISO/IEC 29100 addresses the issue of obtaining consent for processing PII. It emphasises that consent must be freely given, informed, and specific. The standard provides guidance on obtaining, recording, and managing consent in a privacy-compliant manner.
- ***Individual Participation:*** The standard recognises the rights of individuals regarding their PII. It highlights the importance of providing mechanisms for individuals to access, correct, delete, and restrict the processing of their PII. ISO/IEC 29100 also emphasises the need for organisations to handle individuals' requests and complaints regarding their PII effectively.
- ***Cross-border Data Flows:*** The standard addresses the challenges associated with the international transfer of PII. It emphasises the need to ensure that cross-border data transfers comply with applicable laws and regulations. ISO/IEC 29100 provides guidelines for assessing the adequacy of protection in the receiving country and establishing appropriate safeguards for the transfer.

Overall, ISO/IEC 29100 serves as a framework for organisations to establish privacy protection measures and comply with privacy laws and regulations. It promotes a proactive approach to privacy management, helping organisations build trust with individuals and demonstrate their commitment to protecting personal information.

VII.6. Comparison of different Cybersecurity & Privacy Frameworks

The NIST Cybersecurity Framework and ISO 27001 are both frameworks for managing cybersecurity risks. The NIST Cybersecurity Framework is a set of guidelines for mitigating organisational cybersecurity risks, published by the NIST based on existing standards, guidelines, and practices. ISO 27001 is an international standard that specifies the requirements for establishing, implementing, maintaining, and continually improving an information security management system (ISMS) within the context of an organisation.

The NIST Privacy Framework and ISO 29100 are both frameworks for managing privacy risks. The NIST Privacy Framework is a voluntary tool developed in collaboration with stakeholders intended to help organisations identify and manage privacy risk to build innovative products and services while protecting individuals' privacy. ISO 29100 provides a privacy framework which specifies a common privacy terminology, defines the actors and their roles in processing personally identifiable information (PII), describes privacy safeguarding considerations, and provides references to known privacy principles for information technology.

Both the NIST Cybersecurity Framework and ISO 27001 promote a holistic approach to information security, while the NIST Privacy Framework and ISO 29100 provide guidance on managing privacy risks. Organisations can use these frameworks to improve their security and privacy practices, depending on their specific needs and requirements. It is important to note that these frameworks are not mutually exclusive and can be used together to provide comprehensive protection for both cybersecurity and privacy risks. Here is table for comparison of different cybersecurity and privacy frameworks.

VII.7. Case studies

VII.7.1. Real-world examples of organisations that have successfully implemented the Cybersecurity & Privacy Framework.

Here are a few real-world examples of organisations that have successfully implemented cybersecurity and privacy frameworks:

1) Cisco Systems

Cisco Systems, a leading technology company, has adopted the NIST Cybersecurity Framework to manage cybersecurity risks and improve their cybersecurity programme. According to a white paper, Cisco adopts the NIST Cybersecurity Framework by aligning its cybersecurity products and services with the Framework's functions and categories. The paper explains how Cisco Secure can support each of the five functions of the Framework: Identify, Protect, Detect, Respond, and Recover.

For example, under the Identify function, Cisco Secure provides solutions such as Cisco Secure Endpoint, Cisco Secure Malware Analytics, and Cisco Umbrella SIG to help organisations identify and manage cybersecurity risks. Under the Protect function, Cisco Secure offers solutions such as Cisco Secure Firewall and Cisco Secure Workload to help organisations protect their systems and data from cyber threats.

Similarly, under the Detect function, Cisco Secure provides solutions such as Cisco Secure Firewall Threat Defence and Cisco Secure Network Analytics to help organisations detect and respond to cyber threats in real-time. Under the Respond function, Cisco Secure offers solutions such as Cisco Secure Email and Cisco Secure Web Gateway to help organisations respond to cyber incidents and mitigate their impact. Finally, under the Recover function, Cisco Secure provides solutions such as Cisco Secure Services to help organisations recover from cyber incidents and restore their systems and data.

Cisco adopts the NIST Cybersecurity Framework by providing a comprehensive portfolio of cybersecurity products and services that align with the Framework's functions and categories. This approach helps organisations to manage their cybersecurity risks effectively and improve their overall security posture.

2) Microsoft

Microsoft has implemented the NIST Cybersecurity Framework to manage cybersecurity risks and improve their cybersecurity programme. According to Microsoft, the company supports the NIST CSF and has developed solutions for each of the five core functions of the framework: Identify, Protect, Detect, Respond, and Recover. These solutions include asset management, risk assessment, access control, data security, anomaly detection, response planning, and recovery planning.

Microsoft Cloud services have undergone independent, third-party FedRAMP Moderate and High Baseline audits and are certified according to the FedRAMP standards. The NIST CSF references globally recognised standards including NIST SP 800-53 Security and Privacy Controls for Information Systems and Organisations. Each control within the CSF is mapped to corresponding NIST 800-53 controls within the US Federal Risk and Authorisation Management Programme (FedRAMP) Moderate baseline.

In addition to this, Microsoft has developed a NIST CSF Customer Responsibility Matrix (CRM) that lists all control requirements that depend on customer implementation, shared responsibility controls, and control implementation details for controls owned by Microsoft. Customers can download the NIST CSF CRM from the Service Trust Portal Blueprints section under NIST CSF Blueprints.

Overall, Microsoft’s implementation of the NIST Cybersecurity Framework demonstrates their commitment to managing cybersecurity risks and protecting their customers’ information assets.

3) Arlington County, Virginia

Arlington County, Virginia has faced number of challenges such as regulations not keeping pace with rapid introduction of new types of personal information, limited formal resources for County government agencies managing unregulated personal information, low levels of privacy literacy and few privacy professionals across the workforce.

The County government carried out number of projects such as formation of cross-agency Data Privacy Steering Group to provide insight on development of privacy principles, policy, impact assessment and training, pilot privacy programme practices within “smart city” technology pilot programmes, formation of academic/community-based project-specific privacy panels to provide independent, volunteer feedback and oversight on privacy risk management compliance, development of project-specific privacy impact assessment and risk mitigation plans associated with NIST Privacy Framework Subcategories.

As a result, workforce and community increased privacy literacy, improved community engagement through reliance on national privacy standard framework and ability to consistently balance privacy risk and anticipated benefits in making decisions and setting policy

Table 17: Comparison of different security-related frameworks

Framework	Description	Core Functions	Strengths	Weaknesses
NIST Cybersecurity Framework	A voluntary framework developed by the National Institute of Standards and Technology (NIST) to help organisations manage and reduce cybersecurity risk.	Identify, Protect, Detect, Respond, Recover.	Provides a common language and systematic methodology for managing cybersecurity risk. Enables cost-effective prioritisation and communication of improvement activities among organisational stakeholders.	Some organisations may find it difficult to adopt the framework due to personal resistance or extra cost. The framework doesn't reflect contemporary approaches to cloud computing.
ISO 27001	An international standard that specifies the requirements for establishing, implementing, maintaining, and continually improving an information security management system (ISMS).	Confidentiality, Integrity, Availability.	Provides a holistic approach to information security: vetting people, policies, and technology. Helps organisations become risk-aware and proactively identify and address weaknesses.	Some organisations may find it challenging to implement due to the sheer number of categories and subcategories involved.
NIST Privacy Framework	A voluntary tool developed by NIST in collaboration with stakeholders intended to help organisations identify and manage privacy risk to build innovative products and services while protecting individuals' privacy.	Identify, Govern, Control, Communicate, Protect.	Provides a common language for privacy risk management. Enables organisations to identify areas where existing processes may be strengthened or where new processes can be implemented. Allows for stronger communication throughout the organisation.	The framework doesn't reflect contemporary approaches to cloud computing. The framework is not a prescriptive requirement-based approach.
ISO 29100	An international standard that provides a privacy framework which specifies a common privacy terminology; defines the actors and their roles in processing personally identifiable information (PII); describes privacy safeguarding considerations; and provides references to known privacy principles for information technology.	Not specified.	Provides a common privacy terminology and defines the roles of actors in processing PII. Helps organisations manage risks related to the security of data owned or handled by the company. Respects all the best practices and principles enshrined in this International Standard.	The framework does not include formal requirements that a company must follow.

VII.8. Challenges and barriers faced in adopting and implementing the frameworks.

Adopting and implementing cybersecurity and privacy frameworks can come with various challenges and barriers. Here are some of the common ones:

- ***Lack of Awareness and Understanding:*** One significant challenge is the lack of awareness and understanding regarding the frameworks and their benefits. Organisations may not fully comprehend the framework's requirements, objectives, and how they align with their business goals.
- ***Resource Constraints:*** Implementing a robust cybersecurity and privacy framework requires dedicated resources, both in terms of personnel and financial investment. Organisations may face challenges in allocating sufficient resources to train staff, acquire necessary tools and technologies, conduct assessments, and establish ongoing monitoring and maintenance processes.
- ***Complex Regulatory Environment:*** Organisations operating across different jurisdictions may face challenges in navigating the complex and evolving regulatory landscape. Depending on their industry and geographic location, they may have to comply with multiple frameworks, standards, and regulations, which can create confusion and compliance burdens.
- ***Organisational Culture and Resistance:*** Implementing cybersecurity and privacy frameworks often requires significant organisational culture and mindset changes. Resistance from employees, lack of buy-in from management, and resistance to adopting new processes and technologies can hinder successful implementation.
- ***Continuous Updates and Changes:*** Cybersecurity and privacy frameworks constantly evolve to address emerging threats and technological advancements. Keeping up with these changes and ensuring ongoing compliance can be challenging for organisations, especially those with limited cybersecurity expertise.

It is important to note that these challenges are not exhaustive, and organisations may encounter additional barriers based on their specific contexts.

VII.9. Future Trends and Emerging Frameworks

VII.9.1 Emerging trends and developments in the cybersecurity & privacy domain.

Exploring emerging trends and developments in the cybersecurity and privacy domain is crucial to staying ahead of evolving threats and understanding advancements in technologies and practices. Here are some notable trends and developments:

- ***Artificial Intelligence (AI) and Machine Learning (ML) in Cybersecurity:*** AI and ML technologies are increasingly being leveraged in cybersecurity to analyse massive amounts of data, detect anomalies, and identify patterns and potential threats more efficiently. They can enhance threat detection, automate security processes, and enable proactive defence mechanisms.
- ***Internet of Things (IoT) Security:*** With the rapid growth of IoT devices, ensuring the security and privacy of interconnected devices has become critical. The focus is on implementing robust security measures, including strong authentication, secure over-the-air updates, encryption, and vulnerability management, to protect IoT devices and the data they handle.
- ***Cloud Security:*** As organisations increasingly adopt cloud services, ensuring the security and privacy of data stored and processed in the cloud is paramount. Advancements in cloud security technologies, such as secure multi-tenancy, encryption, access controls, and threat intelligence, are continuously evolving to address emerging threats and vulnerabilities.

- ***Privacy Enhancing Technologies (PETs):*** With growing concerns around data privacy, there is a rise in the development and adoption of Privacy Enhancing Technologies. These technologies, including cryptographic techniques, anonymisation, and differential privacy, aim to protect sensitive information while enabling data analysis and sharing.
- ***Zero Trust Architecture:*** Zero Trust is an approach to cybersecurity that challenges the traditional "trust but verify" model. It focuses on verifying every access request and not trusting anything or anyone by default, regardless of their location, and adopting strict access controls and continuous monitoring throughout the network.

It is important to note that the cybersecurity and privacy domain is highly dynamic, and emerging trends and developments can vary over time. Regularly referring to reputable industry reports, research papers, and attending conferences or workshops can provide the most up-to-date information regarding emerging trends and developments.

VII.9.2 Introduction to other or upcoming cybersecurity & privacy frameworks that may impact the digital landscape.

Several other or upcoming cybersecurity and privacy frameworks have the potential to impact the digital landscape significantly. Here are a few notable examples:

- ***Cybersecurity Maturity Model Certification (CMMC):*** The Cybersecurity Maturity Model Certification is a framework introduced by the U.S. Department of Defence (DoD) to enhance the cybersecurity posture of organisations in the defence industrial base. It requires contractors to meet specific cybersecurity maturity levels and practices to protect sensitive information and systems.
- ***California Consumer Privacy Act (CCPA) and California Privacy Rights Act (CPRA):*** The CCPA and its successor, the CPRA, are privacy frameworks enacted in California, with the goal of protecting consumers' personal information and giving them control over its collection and usage by businesses. These frameworks introduce strict data protection requirements, including disclosure obligations, consumer rights, and increased penalties for non-compliance.
- ***General Data Protection Regulation (GDPR):*** The General Data Protection Regulation is a comprehensive privacy regulation introduced by the European Union (EU) to strengthen data protection rights and regulate the processing of personal data. It applies to organisations worldwide that handle EU citizens' data, imposing obligations related to consent, data breach notifications, data subject rights, and accountability.
- ***ISO/IEC 27701:2019:*** This is an international standard that provides guidelines for implementing a Privacy Information Management System (PIMS). It helps organisations establish, maintain, and continually improve a Privacy Information Management System aligned with the requirements of the ISO/IEC 27001 standard while addressing privacy concerns.
- ***NIST Cybersecurity Framework 2.0:*** NIST has released a draft of the Cybersecurity Framework (CSF) 2.0, which will be published in early 2024. This draft represents a major update to the CSF, which was first released in 2014 to help organisations reduce cybersecurity risk. The draft update reflects changes in the cybersecurity landscape and makes it easier to put the CSF into practice for all organisations. The CSF 2.0 draft reflects several major changes, including an expanded scope, the addition of a sixth function, Govern, and improved and expanded guidance on implementing the CSF—especially for creating profiles. NIST is also releasing a separate Discussion Draft of the Implementation Examples included in the CSF 2.0 Draft Core for public comment. These implementation examples are intended to help organisations, especially smaller firms, to use the framework effectively. The NIST also announced Cybersecurity Framework 2.0 Reference Tool, a new resource that was officially unveiled by NIST on August 15, 2023. This tool allows users to explore the Draft CSF 2.0 Core (Functions, Categories, Subcategories, Implementation Examples) and offers human and machine-readable

versions of the draft Core (in both JSON and Excel formats). Currently, the tool allows users to view and export portions of the Core using key search terms. This tool will ultimately enable users to create their own version of the CSF 2.0 Core with selected Informative References and will provide a simple and streamlined way for users to explore different aspects of the CSF Core.

The above explained frameworks reflect the growing emphasis on cybersecurity and privacy in various sectors and jurisdictions. Organisations that operate within the scope of these frameworks or are subject to relevant regulations need to understand and comply with their requirements to protect data and maintain regulatory compliance.

VII.10. Conclusion

This paper outlines the importance of cybersecurity and privacy in today's digital landscape, and it discusses how a cybersecurity and privacy framework can help organisations and countries protect their digital assets and information. This paper also provides background information on the concept of cybersecurity and privacy, including the challenges and threats faced in this domain as well as the need for frameworks to guide organisations in their efforts to protect against these threats.

The paper continues with an overview of the cybersecurity and privacy frameworks, including detailed explanations of the NIST Cybersecurity Framework, ISO 27001, NIST Privacy Framework, and ISO 29100. These frameworks provide guidelines and best practices for organisations to follow in order to improve their cybersecurity and privacy protection.

A comparison of different frameworks follows along with a presentation of case studies of organisations that have successfully implemented them. These case studies include companies such as Cisco Systems, Microsoft, and Arlington County, Virginia. It also outlines the challenges and barriers faced by organisations when adopting and implementing these frameworks.

Finally, this paper explores future trends and emerging frameworks in the cybersecurity and privacy domain. This includes an introduction to other or upcoming frameworks that may impact the digital landscape.

Here are some insightful takeaways from the report highlighting why every organisation needs to adopt a cybersecurity and privacy framework:

- ***Importance of cybersecurity and privacy:*** With the increasing use of technology and the growing amount of sensitive information being stored and transmitted digitally, it is essential for organisations and countries to have robust measures in place to protect their digital assets and information.
- ***Function of cybersecurity and privacy frameworks:*** The cybersecurity and privacy frameworks can help organisations and countries protect their digital assets and information. These frameworks provide practical guidelines and best practices for organisations to follow in order to improve their cybersecurity and privacy protection.
- ***Wide known cybersecurity and privacy frameworks:*** The cybersecurity and privacy frameworks, including the NIST Cybersecurity Framework, ISO 27001, NIST Privacy Framework, and ISO 29100 provide detailed guidance and cases for organisations on how to improve their cybersecurity and privacy protection. It would be a good initiative for organisation to consider adoption of these frameworks based on pre-existing use cases.
- ***Challenges and barriers to adoption:*** There are number of challenges and barriers faced by organisations when adopting and implementing these frameworks. This includes factors such as lack of understanding, resources constraint, complex regulatory environment, organisational culture, and resistance to change.

- ***Adopting suitable framework for readiness:*** With emerging frameworks in the cybersecurity and privacy domain are coming, it is better to understand what's suitable framework for each organisation to consider adoption and implement it into their organisation to prepare ever changing environment and risks.

The cybersecurity and privacy frameworks are not a silver bullet. They are effective tools that can help organisations to improve their security and privacy protection posture, but they do not guarantee perfect solutions. Organisations need to be constantly monitoring their environment and adapting their preparedness measures as threats and regulatory trends evolve.

Cybersecurity and privacy protection is everyone's responsibility. No single person or team can be responsible for protecting an organisation's information assets and personal data. The cybersecurity and privacy frameworks help to ensure that everyone in the organisation is aware of their role in protecting data and systems.

However, the cybersecurity and privacy frameworks should be tailored to the specific needs of the organisation. There is no one-size-fits-all approach to cybersecurity or privacy protection. The best framework for an organisation will depend on its size, industry, and risk profile.

The implementation of the cybersecurity and privacy framework is an ongoing process. It is not something that can be done once and then forgotten about. Organisations need to regularly review and update their security and protective measures to stay ahead of the threat landscape.

Lastly, cybersecurity and privacy protection are an investment, not an expense. The cost of implementing and maintaining the cybersecurity and privacy framework can be significant, but the cost of a data breach can be much higher. By investing in cybersecurity and privacy protection, organisations can protect their data, their reputation, and their bottom line.

Discussion

This publication has focused on standards and international best practices considered pivotal in navigating the complexities of the digital age and advancing digital transformation. It is a comprehensive review of international recognised standards frameworks, underscoring the commitment to establishing best practices, ensuring data security, and enhancing the efficiency of public services.

The publication also reflects the unique needs and interests of the regional capacity building project participating countries and their commitment to addressing these through a unified resource. It is expected that this publication will serve as a practical guide for applying these standards across various facets of digitalisation, thereby enhancing the efficiency, security, and effectiveness of government operations.

The selection of influential international standards frameworks, including ITIL, e-Government Interoperability Framework, TOGAF, COBIT, Cloud Computing Reference Architecture Framework, GDPR, ISO/IEC 27001, and Cybersecurity Framework, reflects a comprehensive approach to addressing the diverse aspects of digital transformation. These frameworks collectively form a robust foundation for governments and organisations on their digital journey, ensuring the integrity and security of their digital initiatives, ultimately benefiting citizens and stakeholders alike.

The incorporation of **ITIL** in government organisations has the potential to transform public service delivery by emulating the private sector's successes. ITIL prioritises citizen-centric service excellence, tailoring government services to meet public needs. This focus on service quality fosters trust, making the government appear reliable and responsive. ITIL's lifecycle approach aligns IT strategies with broader public interests, enhancing government effectiveness. ITIL mitigates risks, minimising service disruptions, critical in the government, where disruptions can have significant consequences. It streamlines operations, eliminates redundancies, and optimises resource allocation, resulting in cost-efficient government services. Interagency collaboration is encouraged, promoting teamwork and knowledge sharing, enabling comprehensive solutions to complex challenges. Clear documentation promotes transparency and accountability, while ITIL's iterative nature allows agencies to adapt to changing circumstances. Ultimately, ITIL optimises resource use, delivering better value and fostering collaboration and accountability among government stakeholders. In sum, ITIL adoption in government results in a citizen-centric, efficient, and accountable public service delivery system, enhancing service quality and alignment with public interests.

In turn, **e-GIF** sets out the technical policies and specifications for achieving interoperability and ICT systems coherence across the multitude of public organisations by defining the essential prerequisites for joined-up and web-enabled government. It is the technical cornerstone of interoperability among public sector digital systems that allows for providing modern, and improved public services. This framework defines the minimum set of technical policies and specifications governing information flows across government organisations with respect to interconnectivity, data integration, content management metadata, and e-services access.

The integration of **TOGAF** within government operations offers a structured and highly beneficial approach to managing IT systems. It focuses on efficient resource allocation, identifying cost-saving opportunities, and minimising waste. A key advantage is its emphasis on standardisation and interoperability, enabling government agencies to work cohesively and reduce duplication of efforts. Moreover, TOGAF plays a crucial role in enhancing security and compliance within government IT systems, addressing the increasing cybersecurity threats and regulatory requirements. It offers frameworks for secure IT architecture, safeguarding sensitive government data and ensuring regulatory compliance. TOGAF also excels in cost reduction and resource optimisation by analysing existing IT resources, eliminating redundancies, and streamlining operations. This not only saves expenses but ensures that resources are directed where most needed. In an era of budget constraints, TOGAF provides an effective tool for government entities to operate efficiently and responsibly in the ever-evolving technological landscape.

COBIT is a highly regarded framework with immense value for government organisations. It ensures that government IT strategies align with broader governmental objectives, making technology investments serve the public interest effectively. COBIT offers a comprehensive governance framework, vital for overseeing IT operations in government, ensuring efficiency while remaining aligned with public interests. In the context of government, where sensitive data and critical services are at stake, COBIT's risk management capabilities are of paramount importance. It helps identify and mitigate risks, safeguarding data and ensuring the continuity of essential services. Compliance with regulations is another critical aspect for government agencies, and COBIT provides clear guidance for meeting these standards, reducing the risk of legal issues and financial penalties. COBIT's resource optimisation features help government entities identify inefficiencies, reduce redundancy, and allocate resources cost-effectively, all while fostering informed decision-making. Interoperability and standardisation are also emphasised, facilitating better coordination among government entities and more efficient public service delivery. COBIT's core features and benefits enhance governance, risk management, resource optimisation, and compliance in government IT systems. Adopting COBIT allows government organisations to efficiently manage IT processes, align with government objectives, mitigate risks, ensure regulatory compliance, and ultimately deliver more transparent and efficient public services.

Introducing a **Cloud Computing Reference Architecture Framework** within government organisations brings a range of powerful benefits. It optimises resource use, reducing costs and ensuring budgetary efficiency. Scalability allows government agencies to adapt quickly to changing demands, while rapid deployment capabilities enable swift responses to evolving requirements. Interoperability ensures seamless collaboration among government entities, maintaining data security. Security and compliance standards are upheld, safeguarding sensitive data in an era of increased cyber threats. Effective data governance ensures data quality and accessibility, empowering data-driven decision-making. Resource optimisation, reduced IT maintenance, and cross-agency collaboration promote efficiency and innovation. The framework aligns cloud initiatives with broader government objectives, enabling the government to better serve citizens and achieve its mission while adhering to regulatory requirements. In essence, the adoption of a Cloud Computing Reference Architecture Framework in government enhances efficiency, security, and cost-effectiveness, modernising, and optimising IT systems to meet evolving public needs.

The adoption of the **GDPR** in government contexts carries several noteworthy advantages. It underscores data protection and privacy, critical for government agencies handling vast amounts of personal and sensitive data, thereby enhancing citizen trust. By complying with GDPR, governments can simplify the complex landscape of data protection laws, ensuring legal compliance, especially when dealing with EU citizens or entities. GDPR also promotes accountability and transparency, enabling government agencies to be more transparent about their data practices and governance. It places an emphasis on data security, an essential aspect considering the rising threat of data breaches and cyberattacks. Citizens' rights over their personal data are reinforced, empowering them, and increasing control. Furthermore, GDPR mandates timely reporting of data breaches, prompting government agencies to improve their response mechanisms. Data Protection Impact Assessments assist in proactive risk management, and adherence to the GDPR simplifies international data transfer processes. By encouraging data minimisation and purpose limitation, GDPR helps government agencies avoid excessive data collection and maintains privacy compliance. It also offers a framework for employee training and awareness, promoting a culture of privacy within government entities. The principles of consent, data processing agreements, and the appointment of Data Protection Officers provide a structured approach for handling personal data. Additionally, GDPR promotes cross-border cooperation among data protection authorities. Moreover, its global influence has led to the adoption of similar data protection and privacy principles worldwide. Governments outside the EU may see the advantages of aligning with GDPR for consistency and international data transfer purposes. In essence, the adoption of GDPR principles in government enhances data protection, legal compliance, transparency, and accountability. It fosters public trust and empowers citizens while ensuring government agencies remain proactive in addressing data protection and privacy concerns, adapting to their specific needs and regulatory environment.

The adoption of **ISO/IEC 27001:2022** in government organisations offers a structured and internationally recognised framework for information security management. This approach provides several key advantages, including heightened information security, compliance with legal and regulatory requirements, efficient risk management, and enhanced data protection. Furthermore, it promotes operational resilience, facilitates cross-agency collaboration, and bolsters public trust through robust data protection practices. Resource allocation becomes more cost-effective, and secure third-party relationships are facilitated. The standard's global recognition eases alignment with international best practices, while incident response, data governance, and regular audits ensure a proactive and evolving security approach. Training and awareness programmes empower government employees to understand and uphold information security standards. In essence, the adoption of ISO/IEC 27001:2022 empowers government agencies to elevate their information security measures, fostering public trust and robust responses to security risks. Its effectiveness, however, relies on the dedicated commitment of government agencies to maintain high information security standards.

The adoption of a **Cybersecurity Framework**, such as the NIST Cybersecurity Framework, in government organisations offers a structured and internationally recognised approach to enhancing cybersecurity. The benefits are numerous, including improved cybersecurity posture, effective risk management, and compliance with legal and regulatory requirements. It also fosters interoperability and collaboration, strengthens data protection, and ensures efficient incident response. Additionally, Cybersecurity Frameworks address supply chain security, optimise resource allocation, and boost public trust in government agencies. They promote collaboration with the private sector, international cooperation, and global influence in setting cybersecurity standards. Education and training of the workforce, incident information sharing, and audit and accountability measures contribute to a holistic and robust cybersecurity environment. In essence, the adoption of a Cybersecurity Framework empowers government agencies to navigate the complex and evolving landscape of cybersecurity threats, provided they commit to effective implementation and maintaining a high level of cybersecurity across their organisations.

The Astana Civil Service Hub Research and Knowledge Management Team, in collaboration with experts from the National Information Society Agency of the Republic of Korea, anticipates that this knowledge product will significantly enhance digitalisation within government operations and improve public service delivery. By sharing valuable information and promoting the highest standards for digital transformation, it will make a substantial contribution to the ongoing progress and success of the participating countries in the constantly evolving digital landscape.

Abbreviations and acronyms

ACSH	Astana Civil Service Hub
ADM	Architecture Development Method
AI	Artificial Intelligence
API	Application Programming Interface
APO	Align, Plan, Organise
ARM	Application Reference Model
BAI	Build, Acquire, Implement
BGP	Border Gateway Protocol
BRM	Business Reference Model
BSC	Balance Scorecard
CA	Certification Authority
CBRN	Chemical, Biological. Radiological, Nuclear
CCPA	California Consumer Privacy Act
CCRA	Cloud Computing Reference Architecture
CCTA	Central Computer and Telecommunications Agency
CD	Continuous Deployment
CDN	Content Delivery Network
CEO	Chief Executive Officer
CERT	Computer Emergency Response Team
CGSI	Core Government Systems Index
CI	Continuous Integration
CIO	Chief Information Officer
COBIT	Control Objectives for Information Related Technology Framework
CMMC	Cybersecurity Maturity Model Certification
CMMI	Capability Maturity Model Integration
CNIL	Commission National Informatique & Libertés
CNPD	Commission Nationale pour la Protection des Données
CPM	Cost per Mille
CQRS	Command and Query Responsibility Segregation
CRM	Consolidated Reference Model; Customer Relationship Management
CSF	Cybersecurity Framework
CSI	Continuous Service Improvement
DB	Data Base
DCEI	Digital Citizen Engagement Index
DDoS	Distributed Denial-of-Service
DGI	Digital Government Index
DGA	Data Governance Act
DMV	Department of Motor Vehicles
DNA	Data, Network, and AI
DNS	Domain Name System
DPA	Data Protection Agency
DPIA	Data Protection Impact Assessment
DPO	Data Protection Officer
DoD	Department of Defence
DODAF	Department of Defence Architecture Framework
DRM	Data Reference Model
DSK	Independent Data Protection Authority of Germany
DSM	Digital Single Market
DSS	Deliver, Service, Support
EA[F]	Enterprise Architecture [Framework]
EAMS	Enterprise Access Management Service
EC	European Community

ECCP	European Centre for Certification
EDPB	European Data Protection Board
EGDI	e-Government Development Index
e-GIF	e-Government Interoperability Framework
EGIT	Enterprise Governance of Information Technologies
e-GMS	e-Government Metadata Standard
EIF	European Interoperability Framework
EU	European Union
FAQ	Frequently Asked Questions
FDS	Federal Data Strategy
FEA[F]	Federal Enterprise Architecture [Framework]
FedRAMP	Federal Risk and Authorisation Management Programme
GCL	Government Category List
GDPR	General Data Protection Regulation
GDS	Government Data Standards
GDSC	Government Data Standards Catalogue
GEAP	Government Enterprise Architecture Process
GSI	Government Secure Intranet
GTEI	GovTech Enables Index
GTMI	GovTech Maturity Index
JSON	Java Script Object Notation
HR	Human Resources
HTTP	Hypertext Transfer Protocol
IaaS	Infrastructure as a Service
ICT	Information and Communication Technologies
IDE	Integrated Development Environment
IEC	International Electrotechnical Commission
IoT	Internet of Things
IP	Internet Protocol
IRM	Infrastructure Reference Model
ISACA	Information Systems Audit and Control Association
ISO	International Organisation for Standardisation
ISMS	Information Security Management System
ITSM	Information Technologies Service Management
IT	Information Technologies
ITIL	Information Technology Infrastructure Library Framework
KEPCO	Korean Electric Power Corporation
KPI	Key Performance Indicator
KRW	Korean Won
LAN	Local Area Network
MEA	Monitor, Evaluate, Assess
MILOPS	Military Operations
MIT	Massachusetts Institute of Technology
ML	Machine Learning
MOIS	Ministry of the Interior and Safety
NAC	Network Access Control
NATO	North Atlantic Treaty Organisation
NDS	National Data Strategy
NIA	National Information Society Agency
NIEM	National Information Exchange Model
NIF	National Interoperability Framework
NIIS	Nordic Institute for Interoperability Solutions
NIST	National Institute of Standards and Technology
NTIS	National Science and Technology Information Service

OECD	Organisation for Economic Development and Cooperation
OGC	Office of Government and Commerce
OMB	Office of Management and Budget
OS	Operating System
PaaS	Platform as a Service
PCI DSS	Payment Card Industry Data Security Standard
PDCA	Plan, Do, Check, Action Cycle
PET	Privacy Enhancing Technology
PII	Personal Identifiable Information
PRM	Performance Reference Model
PSDI	Public Service Delivery Index
REST	Representational State Transfer
RFC	Request For Comments Protocol
SaaS	Software as a Service
SDG	Sustainable Development Goal
SDM	Standard Data Protection Model
SIB	Standards Information Base
SLA	Service Level Agreement
SME	Small and Medium Enterprise
SMIME	Secure Multipurpose Internet Mail Extension Protocol
SMTP	Simple Mail Transfer Protocol
SoA	Statement of Applicability
SOAP	Simple Object Access Protocol
SRM	Service Reference Model
SSL	Secure Sockets Layer
SW	Software Application
TAFIM	Technical Architecture Framework for Information Management
TCP	Transmission Report Protocol
TEAF	Treasure Enterprise Architecture Framework
TOGAF	Open Group Architecture Framework
TRM	Technology Reference Model
TLS	Transport Layer Security
TSA	Time Stamping Authority
TSC	Technical Standards Catalogue
UAE	United Arab Emirates
UK	United Kingdom
UN	United Nations
UNDP	United Nations Development Programme
UNIDO	United Nations Industrial Development Organisation
URL	Uniform Resource Locator
US	United States
USB	Universal Serial Bus
VM	Virtual Machine
VPC	Virtual Private Cloud
VPN	Virtual Private Network
WB	World Bank
WWW	World Wide Web
XML	eXtensible Markup Language

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