Methods and tools for GDPR Compliance through Privacy and Data Protection 4 Engineering

Multi-stakeholder specification

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Abbreviations and Definitions

Abbreviation	Definition
DPbD	Data Protection by Design
DPIA	Data protection impact assessment
GDPR	General Data Protection Regulation
ICT	Information and Communication Technologies
IOT	Internet of Things
OEM	Original Equipment Manufacturers
PDP4E	Privacy and Data Protection 4 Engineering
PET	Privacy-enhancing Technologies
TFEU	Treaty on the Functioning of the European Union
WP29	Data Protection Working Party

Executive Summary

This document summarizes the challenges faced by the organizations to create GDPR-compliant systems, by analysing the context in which those systems are developed from a twofold perspective: the external constraints posed by the said legal text, and the internal settings of the organizations' processes and the business domain (with focus on two vertical domains of application). Thus, the deliverable includes both a legal analysis of the General Data Protection Regulation (GDPR) with regards to data protection by design, in application since 25th May 2018, and an initial analysis of the associated needs elicited from industry. The interrelation between both dimensions is considered, by reflecting the technical impact of the GDPR and detailing the specific legal challenges faced by the domains considered.

On the one hand, as we will show during the legal analysis of the regulation, organizations are required to have a proactive attitude when safeguarding the privacy of European citizens. In particular, the principle of *Data Protection by Design* is defined and enforced upon all data processing activities involving personal data. In practice, organizations must plan and implement the necessary security mechanisms to preserve citizens' privacy prior to the collection of their personal data. This document highlights other responsibilities of organizations that collect or process personal data, as well as the newly introduced citizens' rights such as the right to be forgotten or to object.

On the other hand, the document also summarizes the organizational challenges that organizations are facing to comply with this regulation. In the software development arena, some trends are shifting the development process towards including security across all the development phases, including the planning and design of new developments. The document reviews this trend, as this poses a good entry point for PDP4E to make *Data Protection by Design* tangible. Then, associated changes on the development actors' responsibilities are described.

Finally, we describe the type of personal data processing activities derived from the analysis of our two target verticals: Automotive and Smart Grid. The core business of both verticals involves the usage of state-of-the-art techniques for profiling and adapting their services to customers. The document also describes associated technical and organizational challenges that these types of organizations are facing.

In future deliverables, requirements for the PDP4E tools will be formalized based on the information collected in this document. The description of the two verticals will set a basis for populating the knowledge bases of the project, and a starting point to set up the validation of the PDP4E tools.

1 Introduction

1.1 PDP4E's objectives and motivation

The General Data Protection Regulation (GDPR)[1], in force since 24th May 2016 and in application since 25th May 2018, sets an array of binding data protection principles, individuals' rights, and legal obligations so as to ensure the protection of personal data[2] of European Union citizens while improving the free movement of such data in the European Union and regulates movement to areas outside the European Union. But **the legal approach is not enough if it does not come along with technical and concrete measures** to protect privacy and personal data in practice.

Protection of personal data must be proactively considered during the design and development of products, services and systems. This notion is captured by the **principles of Data Protection by Design (DPbD)**, which promotes that privacy and data protection must be considered since the onset of a project and throughout all the activities involved during and after its development. **For DPbD to be viable, engineers must be effectively involved in the loop**, as they are ultimately responsible for conceiving, elaborating, constructing, and maintaining the systems, services, and software and hardware products that need to abide by the GDPR. Otherwise, DPbD risks becoming a bare principle without any real impact, or even worse, being voided of its content and becoming a fashionable term subject to false claims by pretenders[3].

Academic research has consistently shown [2] [20] [39] that developers and engineers, find privacy and data protection alien to their work and, most importantly, **seldom use privacy management tools, as they find these are more oriented to the legal arena** rather than to the engineering activities.

The mission of PDP4E is to **bring established privacy and data protection knowhow into mainstream practice of software and systems engineering, by providing engineers with methods and tools that operationalise data protection principles and regulation, and which are integrated** with those others which they customarily use in the different activities that take place throughout the stages of the SDLC (System Development Lifecycle), hence realising the paradigm of Data Protection by Design; so that they can ultimately create systems that comply with the GDPR, stick to data protection principles and look after the rights of the data subjects.

1.2 Objective of the document

This document is the deliverable titled D2.1 Multi-stakeholder specification of the PDP4E Project. It describes the usual processing activities and data collected by the two verticals covered by the project, synthesises the technical and organizational challenges that they usually face to comply

[1] http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32016R0679

[2] Personal data is no longer limited to only a person's name or identification number, but also location, digital identifier or any other information that can be used to identify a natural person (or *data subject*). See Article 4 (1) of the GDPR.

[3] http://i-comp.org/wp-content/uploads/2013/07/privacy-by-design.pdf

with the law, and elicits legal and ethical constraints originated from the GDPR and other and other specific legal requirements related to privacy and data protection, as well as the case-law of the Court of justice of the European Union.

1.3 Structure of the document

Section 2 provides an analysis of the General Data Protection Regulation. This analysis covers the legal and ethical constraints that the GDPR enforces to European organizations, and also highlights the major technical challenges that these organizations are facing to be fully compliant with the regulation.

Section 3 briefly describes the organizational challenges that European organizations face to comply with the GDPR. Then, we provide a first analysis on how software development processes are being shaped to couple with the regulations and the increased relevance of security-specific responsibilities across all development phases. Section 3.2 provides a description of the two demonstration pilots of the project: Automotive and Smart Grid. Both pilots provide details of the type of data recollected and processing activities that they face in their daily business. Moreover, the document provides a description of the technical and legal challenges tailored to the pilots' needs.

The document ends with Section **Erreur ! Source du renvoi introuvable.** summarizing conclusions.

1.4 Relation with other deliverables

This deliverable contains a set of high-level needs from the different stakeholders involved in the development lifecycle and a legal analysis of GDPR and other related regulations. A description of the two demonstration pilots is also provided in this document, which will be further elaborated on the deliverable 7.3 *Multi-stakeholder validation report*.

The two industrial scenarios considered in this deliverable are dealing with complex systems managed within an ecosystem. One of the big challenges is to identify the specific role of each stakeholder in the ecosystem and its handling of the described challenges and requirements. PDP4E will investigate which preliminary analysis phase must be carried out to describe the ecosystem constraints in Deliverable 2.2 (*Technical gap analysis and synthesis of user requirements*), which will propose a solution to operationalize the requirements.

1.5 Methodology

The methodology followed in identifying requirements from the two PDP4E pilots (Automotive and Smart Grid) has been mainly based on a literature analysis of vehicle-to-vehicle protocols that support the future of autonomous vehicles, recommendations made by different stakeholders on the automotive sector and DPAs and several interviews with key persons from the Cybersecurity division of Trialog Energy and Environment division at Tecnalia. During the last years, Trialog has been involved in the application of the security and privacy initiative for

cooperative intelligent transport systems[4], being also acquainted with the Scoop@f pilot[5] and the FP7 Preserve project[6]. Their market position and experience allowed us to get a holistic view of the sector needs. Tecnalia counts with a Smart Grid lab and experts in conformity assessment services of Smart Meters and Smart Data Concentrators. There is also a cross-division entity in Tecnalia called Digital Energy which aims to tackle the high demand of digital solutions in the energy domain. They also co-organize forums for practitioners about cybersecurity in the energy sector where we have participated.

[4] https://ec.europa.eu/transport/themes/its/c-its_en
[5] http://www.scoop.developpement-durable.gouv.fr/IMG/pdf/20171013_c-its_french_use_cases_catalog_v4.pdf
[6] https://www.preserve-project.eu

2 Legal challenges under the GDPR

This section will identify the legal framework for PDP4E in relation to the processing of personal data, by detailing and explaining the data protection principles that shall be abided by the organizations that process personal data in any way, the technical safeguards that suit the application of such principles, and the specific obligations set for the controller and rights recognized for the data subjects. Throughout the section, special consideration is given to the impact of this regulation in the technical realm.

Discussions on personal data and privacy have been vivid the last decade due to the development of the digital world that has allowed, on the one hand, the monetisation of data, and on the other hand, unprecedented supervision of one's thoughts and habits. More and more data are now accessible due to an increase in digitalisation of daily activities. In fact, EU authorities struggled to tackle the issue of interference with the right to the protection of personal data since **the former legal framework was not up to technology developments**, albeit article 8 of the Charter[7] that guarantees the right to the protection of personal data[8]. However, the entry into force of the GDPR marks a new era in the processing of personal data, not only regionally but also internationally. **Processing** is "*every operation or set of operations which is performed on personal data or on sets of personal data, whether or not by automated means, such as collection, recording, organisation, structuring, storage, adaptation or alteration, retrieval, consultation, use, disclosure by transmission, dissemination or otherwise making available, alignment or combination, restriction, erasure or destruction*"[9], covering therefore a broad scope or activities that engineers and software engineers are confronted with daily.

From its name solely, one can see that the purpose of the instrument is to protect "*natural persons with regard to the processing of their personal data" while still ensuring "the free movement of such data*". Thus, the main goal of the Regulation is to **protect individuals by giving them control over their data and through placing important responsibilities on the controllers** in a way which is compatible with the Single Market. A controller under the GDPR is every natural or legal person, "*public authority, agency or other body which, alone or jointly with others, determines the purposes and means of the processing of personal data*", whereas "*where the purposes and means of such processing are determined by Union or Member State law, the controller or the specific criteria for its nomination may be provided for by Union or Member State law*"[10]. Different methods and tools are therefore foreseen in the text in order to ensure protection of the rights of the individuals.

[7] Charter of fundamental rights of the European Union

[8] The article states that "*everyone has the right to the protection of personal data concerning him or her. Such data must be processed fairly for specified purposes and on the basis of the consent of the person concerned or some other legitimate basis laid down by law. Everyone has the right of access to data which has been collected concerning him or her, and the right to have it rectified. Compliance with these rules shall be subject to control by an independent authority*"

[9] Article 4 (2) of the GDPR

[10] Article 4 (7) of the GDPR

Data subjects are "natural persons" that can be identified or identifiable. In fact, anonymised data do not fall under the scope of the GDPR. Recital 26 explicitly states that "*the principles of data protection should not apply to anonymous information, namely information which does not relate to an identified or identifiable natural person or to personal data rendered anonymous in such a manner that the data subject is not or no longer identifiable*". Whether a person is identifiable or not needs to be assessed in every situation using tools that usually allow for the identification of a data subject. Nevertheless, if it is still possible to identify the natural person to whom the data relate, the datasets at stake will still be considered as personal data and be subject to the application of the GDPR.

The GDPR introduces **data protection by design and by default** in the legal framework of the European Union, suggesting that the protection of personal data that will be collected by a software system should be considered from the moment of conception of such systems. Data protection by design under the GDPR asks controllers to implement technical and organisational measures at the earliest stages of the design of processing operations. In reality, this legal innovation acknowledges community efforts to encourage engineers and computer scientists in creating data protection friendly tools in the sense that privacy should be considered from the start with solutions that enable transparency, control, and intervenability.

Thus, article 25 of the GDPR states that "***taking into account the state of the art**, the cost of implementation and the nature, scope, context and **purposes of processing** as well as the **risks of varying likelihood** and severity for rights and freedoms of natural persons posed by the processing, the controller shall, **both at the time of the determination of the means for processing and at the time of processing itself**, implement appropriate technical and organisational measures such as pseudonymisation, which are designed to implement data-protection principles, such as data minimisation, in an effective manner and to integrate the **necessary safeguards into the processing in order to meet the requirements of this Regulation** and protect the rights of data subjects.*

The controller shall implement appropriate technical and organisational measures for ensuring that, by default, only personal data which are necessary for each specific purpose of the processing are processed. That obligation applies to the amount of personal data collected, the extent of their processing, the period of their storage and their accessibility. In particular, such measures shall ensure that by default personal data are not made accessible without the individual's intervention to an indefinite number of natural persons".

From the very first sentence of the article, it is acknowledged that the principle of data protection by design faces limitations in the sense that personal data should be protected as much as "the state of the art" allows. Moreover, the level of protection can be altered depending on the purposes of the processing, which indicates that **one solution does not fit all purposes**. Hence, it will be necessary to explore the pilot scenarios more in detail, in order to establish the requirements relating to data processing under more specific requirements.

Generally, although the principles set by the GDPR give leeway for innovation, they reinforce accountability for the controllers. In fact, the legal responsibility within the GDPR lies on the controller, not the system provider. This is where PDP4E will add a great value to GDPR

compliance for software technologies, in the sense that innovative methods and tools will enable engineers to better control the conformity of the processing to the legal requirements. Data protection by design under the GDPR acknowledges that a system's architecture shapes human conduct more effectively than through a more simplified compliance of legal principles and obligations [24]. Therefore, developers have a duty to embrace privacy-friendly tools that controllers will prefer in order to ensure compliance with the Regulation.

In this sense, recital 78 clarifies that **the controller should adopt policies and measures with regards to the principles of data protection by design and by default**, such as minimisation, pseudonymisation in early phases of the development, and transparency with regards to the processing. Controllers are obliged to use only processors that provide "*sufficient guarantees to implement appropriate technical and organisational measures*" that meet the requirements of data protection principles[11]. Thus, data protection by design does not only impose an obligation to consider data protection principles from conception of software systems, but also when developing organisational measures and business strategies with regards to the acquisition and exploitation of data. The demonstration of appropriate organisational and technical safeguards is also important when considering the fines in case of a breach[12]. As a consequence, when developing products, services and applications, producers should take into account the right to data protection in order to facilitate compliance for controllers. Such is the aim of PDP4E, by translating legal requirements into technical ones and providing methods and tools to validate the compliance of systems.

The focus being on the obligations of the controller, this potentially creates a gap between the legal definition of data protection by design and the software engineering one[13]. Processors are natural or legal persons that process personal data on behalf of the controller[14]. As noted by the Article 29 Working Party, this implies that the processor acts according to the instructions given by the controller. Article 28(3) of the GDPR explains that the relationship between the controller and the processor shall be governed by a contract or any other legal act that is binding and that sets out the subject-matter and duration of the processing, its nature and purpose, the type of personal data and categories of data subjects and the obligations and rights of the controller. It is therefore important to set a common vocabulary and methods in order to ensure legal compliance for the products and services designed under PDP4E. The Regulation provides for a number of definitions of terms and principles that can only be respected by concrete applications and in line with the further interpretation by the Court of Justice of the European Union.

GDPR recognises data protection by design and not privacy by design, as the concept was initially introduced[15]. Even though **the industry uses the term "privacy by design", the GDPR chooses rightfully the term "data protection by design"**, since the Regulation applies to the processing

[11] Article 28 of the GDPR
[12] Article 83 of the GDPR
[13] See "Navigating law and software engineering towards privacy by design: stepping stones for bridging the gap" session at the Computers, Privacy and Data Protection Conference 2018. Accessible via https://www.youtube.com/watch?v=NT378t_sZwY
[14] Article 4 (8 of the GDPR)
[15] Ann Cavoukian, Privacy by Design, The 7 Foundational Principles,

of personal data, so this will be the main focus of our analysis. This will of course mitigate privacy concerns in the sense that they encompass data protection by design considerations. The difference, overlap or matching of the right to privacy and the right to data protection have been extensively examined by academia [12] [23] [26]. Our focus will be on the protection of personal data since such is the focus of the Regulation that guarantees all fundamental rights of the persons in the processing of their data, including the right to privacy. Article 16 of the TFEU ensures that "*everyone has the right to the protection of personal data concerning them*". However, it should be reminded that the right to data protection as well as the right to privacy are not absolute rights; hence, they can be subject to limitations if it can be demonstrated that all appropriate measures and safeguards have been considered proportionally to the aim foreseen.

Therefore, the general compliance to the Regulation for the purposes of PDP4E can be divided in four fields. The following framework as set by the GDPR applies to all processing activities, irrespective of the industry specifications of the controller. First of all, data protection by design guarantees the implementation of the general principles relating to data processing (2.2), and provides for appropriate safeguards that the controller should establish in order to protect the data processed (2.3). The accountability of the controller is reinforced especially in case of data breaches (2.4) and the data subjects are guaranteed specific rights with regards to the processing of their data (**Erreur ! Source du renvoi introuvable.**). These will be examined below in order to highlight the important requirements and set the goals for PDP4E.

2.1 Differences between the Directive and the GDPR

On the basis of Article 16(2) TFEU, the European Parliament, the European Commission and the European Council approved the **Regulation 2016/679** on the protection of individuals with regard to the processing of personal data and on the free movement of such data (GDPR)[16], which replaced **Directive 95/46**[17] as of the 25th of May 2018. The GDPR represents the core element of the so-called Data Protection Reform package, aiming at modernising the legislative framework so as to allow both businesses and citizens to seize the opportunities of the Digital Single Market.

Crucial here is the **shift from a Directive** – which requires transposition into national legislation – **to a Regulation** – which is directly applicable in Member States' legal order [40]. In that sense, the Regulation clearly recalls that the still-into-force Directive 95/46 '*has not prevented fragmentation in the implementation of data protection across the Union*'. It then underlines that '*effective protection of personal data requires the strengthening and the setting out in detail of*

[16] Regulation 2016/679 of the European Parliament and of the Council of 27 April 2016 on the protection of natural persons with regard to the processing of personal data and on the free movement of such data, and repealing Directive 95/46/EC (General Data Protection Regulation) [2016] *O.J.E.U.*, L119/1. The Regulation will only apply as of the 25th of May 2018.

[17] Directive 95/46/EC of the European Parliament and of the Council of 24 October 1995 on the protection of individuals with regard to the processing of personal data and the free movement of such data [1995] *O.J.E.U.*, L281/31. This instrument will remain applicable until the 24 May 2018.

the rights of data subjects and the obligations of those who process and determine the processing of personal data'.[18] However, it should be noted that Member States still benefit from a wide margin of appreciation when it comes to complement, particularise or even diverge from the rules laid down in the GDPR. This is for example the case for the age threshold governing child's consent, the exceptions to some of the data subject's rights, the provisions dealing with the data protection officer and the rules on transfers.[19] However, the core principles remain pristine. All in all, the GDPR reinforces the regulatory framework introduced by the Directive. While relying on the same concepts and definitions, it complements them with welcome additions and expands the previous regime with regard to its territorial scope, the responsibilities and obligations of the controllers and processors and the powers and duties of the national supervisory authorities. Among other novelties, it now introduces a risk-based and accountability approach allowing controllers to tailor the extent of their compliance duty to the threats caused by their processing activities [41]. Finally, the enforcement of the rules has been paired with drastically increased administrative fines, new criminal penalties and more effective judicial remedies[20].

2.2 Principles relating to processing of personal data

One of the major achievements of the GDPR is to clearly refine data processing principles that guarantee that any processing is fair and lawful, limited to the purposes of the operation and used only if no other measure is adequate to mitigate desired solutions. These principles are listed under article 5 as minimum requirements. Therefore, all exceptions to the processing principles must be provided by law in order to be accepted.

2.2.1 Lawfulness, fairness and transparency

Personal data should be processed "*lawfully, fairly and in a transparent manner in relation to the data subject*"[21]. The principles of lawfulness, fairness and transparency guarantee that **data will be processed in accordance with the law, proportionally to the aim foreseen and with transparent means for the natural persons** who should be informed of the collection of their personal data, usage and consultancy and the extent to which such operations go.

Any processing must comply with the law, which implies not only data protection related law but also other legislations that applies to the specific sector such as automotive services or energy providers. The principle of **fairness** brings a balance test that needs to be carried out for each processing activity, since the right to the protection of personal data must be balanced with other potentially conflicting rights (for example, public security)[22]. Such balance can be achieved

[18] Recitals 9 and 11 of the GDPR, respectively.
[19] On that point, see Winfried Veil's map on the opening clauses in the GDPR <https://www.flickr.com/photos/winfried-veil/24134840885/in/dateposted> accessed 1 November 2017.
[20] Chapter 8 and, specially, Article 83 of the GDPR.
[21] Article 5(1) (a) GDPR
[22] See, for more information on the role of fairness within data protection law: CLIFFORD Damian and AUSLOOS Jef, Data protection and the role of fairness, 2017, CiTiP Working Paper 29/2017

through strict compliance with the general principles underpinning the processing of personal data, but also when ensuring the respect of data subjects' rights from the controller. In other words, personal data must not be processed in a way which unreasonably infringes the fundamental right to the protection of personal data of the data subjects. Hence, processing can be lawful but still considered unfair in respect of the means foreseen. It is therefore essential that the processing entailed is always clear to the data subject, and that the latter is aware of its rights under the GDPR.

As a fundamental principle of the GDPR, **transparency** applies at all stages of the processing activities i.e. before the processing starts, at the moment of consent and when the data are collected; throughout the whole processing period in communication with the data subject and specifically in case the original setup changes, for example because of a data breach[23]. Hence, for the aim of PDP4E, this entails that **the controller should be confident that data subjects are exhaustively aware of the processing activities of their data**. Introducing privacy and security patterns from the moment of conception of a software system allows for traceability and documentation of all activities susceptible to affect the protection of personal data.

Lawful grounds of processing are provided in article 6 of the GDPR. **Lawfulness** is guaranteed if the data subject has consented to the processing for specific purposes, if such processing is necessary for the performance of a contract or for compliance with a legal obligation, to protect the vital interests of the subject or of another natural person, or "*for the purposes of the legitimate interests pursued by the controller or by a third party, except where such interests are overridden by the interests or fundamental rights and freedoms of the data subject which require protection of personal data*" and particularly when the data subject is of young age. Lawfulness should be further explored under the specific sectorial requirements.

The PDP4E methods and tools should allow for the elicitation of personal data categories and the system models should be annotated with information regarding the personal data, processing activities, and processing location. These measures enable quick identification and localization of personal data in the system and are necessary to satisfy several principles and data subject rights. In order to ensure complete transparency, an assurance process should exist to demonstrate compliance with the GDPR. This is where traceability becomes important, for example to trace back consent to the time and date when it was given [11].

2.2.2 Purpose limitation

The collection of data should be limited to "*specified, explicit and legitimate purposes*"[24]. The purpose must be specific; **a controller cannot collect data without knowing how and when these data will be used**. When the purpose of data collection is determined, then the appropriate data will be collected and stored, only for as long as necessary. Whether further processing is

[23] See Article 29 Working Party', Guidelines on transparency under Regulation 2016/679 adopted on the 29th of November 2017, last revised and adopted on the 11th of April 2018.
http://ec.europa.eu/newsroom/article29/item-detail.cfm?item_id=622227
[24] Article 5 (1) (b) GDPR

compatible with the original purposes of processing can be assessed by analysing a number of factors, such as the relationship between the initial purpose and the ulterior one, the nature of the data, the impact such further processing would have on the data subject, as well as the safeguards adopted by the controller in order to ensure that subject's rights are respected.

This "internal assessment"[25] is the first assessment of legal compliance and a necessary condition for accountability[26]. The controller responsible for the processing should thoroughly reflect on the purposes of the processing beforehand. **The purpose should be specific and not only based for example on business interests, IT system security or research**.

Hence, the collection of data should also be explicit, not only to the data subject but also to the authorities. This requires a detailed explanation of the purposes of processing, in order to reinforce accountability and transparent operations. Moreover, if the processing allows for profiling in order to guarantee better performance of a contract, then further justification needs to be provided in order to demonstrate the necessity of the operations. In this case, necessity should be interpreted narrowly[27].

Once again, a categorization of personal data and annotation of the system models with information regarding personal data, processing activities, and processing location are necessary. Traceability is crucial to ensure that personal data is always processed for a specified, explicit, and legitimate purpose. This can be achieved by attaching metadata to personal data to demonstrate for what purpose the data was collected and for how long it will be stored. Adding metadata to personal data is also useful for the principles of data minimization and storage limitation. It shows the controller whether or not personal data is still being processed for a specific purpose, allowing the controller to erase unnecessary data [11]. It is possible to implement a mechanism where personal data is automatically erased when it does not serve a specific purpose anymore, or where the specified storage duration has elapsed.

2.2.3 Data minimisation

Data minimisation asks whether the same purpose can be achieved with a narrower collection of data and is one of the principles that is linked with data protection by design under the Regulation. **The data collected should be adequate, relevant and limited to what is necessary for the purpose foreseen**. In reality, it can be more complicated to access since the added value of minimisation depends on a multitude of criteria and the purposes of processing[28]. In some cases, such as police profiling, quality data are essential in order to ensure non-discrimination, and acquiring more data ensures more accurate and fair results. For what concerns business purposes, collectors tend to acquire more data than what they actually need, and this can be

[25] WP29 203, Opinion 03/2013 on purpose limitation, adopted on 2 April 2013
[26] PARIS Deliverables D2.1, p. 107 (see https://www.paris-project.org/index.php/deliverables)
[27] See guidelines on legitimate interest under Directive 95/46/EC, WP29 17, Opinion 06/2014 on the notion of legitimate interests of the data controller under article 7 of Directive 95/46/EC, adopted on 9 April 2014
[28] Berendt Bettina, 'Better Data Protection by Design Through Multicriteria Decision Making: On False Trade-offs Between Privacy and Utility', Privacy Technologies and Policy (Springer, Cham 2017), WP29 Opinion 1/2009 on e-Privacy Directive, 10 February 2009

problematic according to the GDPR. It should be examined whether the collection is detrimental to the data subject since a balance of rights should be foreseen. In any case, minimisation is always linked to the purpose of the processing, so it cannot be abstractly assessed. The pilots of PDP4E and the aims foreseen in each case will allow to examine this principle more in detail.

As mentioned before (section 2.2.2), attaching metadata to personal data can make it easier to comply with this principle. It allows the controller to erase personal data when it does not serve a specific purpose anymore, or when it becomes unnecessary for that purpose. Secondly, storing personal data in a central location in combination with appropriate access controls can lower the risk of disclosure or disruption of the personal data [11]. For certain types of personal data, such as sensitive data, it is recommended to use encryption techniques to prevent linkage between the data and the data subject, thereby reducing the risks for data subject. This would also require technical and organizational measures to prevent re-identification by using the encryption key [11].

2.2.4 Accuracy

Data should be accurate and kept up to date. As a matter of fact, **controllers should ensure accuracy at all stages of collecting and processing personal data**, taking every reasonable step to ensure that inaccurate data are erased or rectified without delay. Thus, controllers should make sure that outdated data are eliminated, or that data are correctly interpreted. The importance of this step varies according to the type of data collected and the sector to which these safeguards apply.

The system should notify data subjects of their right to object or change personal data, as well as provide a communication channel where the user can inform about data disputation. Data should be analysed for its quality and inaccurate or incomplete data should be erased either manually or automatically [11].

2.2.5 Storage limitation

The **data should only be stored for as long as necessary and the retention period should be decided at the moment of collection**. However, in case of a new purpose that respects the legal requirements of the GDPR, the data retained for a longer period should again be limited to what is necessary to accomplish the new cause.

Traceability is once again essential for this principle. Being able to trace personal data to different locations is crucial when personal data has been backed up or distributed to different locations [11]. Attaching metadata makes it easier to identify the specific purpose and defined storage duration of personal data, allowing for a more streamlined data management or (automatic) erasure procedure.

2.2.6 Integrity and confidentiality

The processing of personal data should be as secure as possible, "*including protection against unauthorised or unlawful processing and against accidental loss, destruction or damage, using appropriate technical or organisational measures*"[29]. For data protection by design purposes, **it is important to limit unauthorised access**, as well as implement systemic quality controls in order to ensure that an appropriate level of security is reached.

Personal data contained in the system should be encrypted end-to-end, where the level of encryption depends on the risks of processing that personal data. Backups and distributed copies must also be taken into account. In order to ensure its integrity, personal data should be validated (e.g. using hashes), which also contributes to the accuracy of that data. Thirdly, a suitable authentication mechanism should be implemented, taking into account the sensitivity of personal data. Lastly, access rights must be managed in order to prevent unauthorised access [11].

2.2.7 Accountability

The principle of accountability[30] does not ensure that potential security problems will be avoided, but guarantees the data subject that its rights will be lawfully respected. The significant fines under the new legislation illustrate the importance of ensuring that processing activities are well thought through, explained to the data subject, and respectful of privacy principles. Accountability is an overarching principle that is reflected in several provisions of the Regulation.

According to the GDPR, **the controller is responsible for the processing and must be able to demonstrate that processing operations are lawful**. The controller is responsible of mitigating risks of infringement of the rights of the data subject throughout the entire software development lifecycle. Hence, the controller should keep records of all processing activities[31] including information on the name and contact details of the controller, the Data Protection Officer (DPO) when applicable and the processor if any, the purpose of processing, a description of the categories of persons affected and which data about them will be processed, the categories of recipients to whom the data will be disclosed, possible transfers to recipients in third countries or international organisations, stating which third country/international organisation and documentation of the suitable safeguards for this transfer, planned time limits for erasure of the different categories of data, and where possible, a general description of the security measures adopted.

Accountability is fulfilled through demonstration of legal compliance. Enforcing the liability of the controller seeks to increase visibility and appease concerns of the data subject about surveillance, profiling or victimisation through targeted content. In fact, individuals expect that

[29] Article 5(1)(f) of the GDPR
[30] Article 5(2) of the GDPR
[31] European Data Protection Supervisor, Accountability on the ground Part I: Records, Registers and when to do Data Protection Impact Assessments, Febru https://edps.europa.eu/sites/edp/files/publication/18-02-06_accountability_on_the_ground_part_1_en_0.pdf

their data are not used in a way they are not aware of or do not understand and allows to shape their everyday choices, from simple to fundamental ones.

Accountability requires an assurance process to demonstrate compliance with the GDPR. The system should store the necessary records of processing activities and it should also have strong authentication and authorization based on the sensitivity of the personal data. Additionally, there should be tamper proof audit trails which have specific information (when? where? why? whom? how?) about the system and system actions. Encryption techniques can strengthen this audit trail in case of sensitive personal data. The final measure is to continuously monitor the system and prevent possible threats to the data subject [11].

Besides the general principles of data processing, the GDPR provides for a number of safeguards that should be considered when examining data protection from the conception of new technologies.

2.3 Appropriate safeguards for the protection of personal data

It is important to take into account that not all data are of the same importance, and that **safeguards can vary with respect to the "sensitivity" of the data collected**. There are several technical measures that the developer can implement in order to ensure accountability of a system. For data protection by design considerations, the Regulation refers to pseudonymisation and encryption as appropriate techniques, but they are only given as examples of Privacy-enhancing Technologies (PETs) in order to avoid limiting technological innovation. There is also the option of anonymizing personal data. This means that there is no reasonable possibility of re-identification anymore. Note that, under the GDPR, the act of anonymizing personal data qualifies as a processing activity on that personal data, while the resulting anonymized data is not considered to be personal data anymore.

2.3.1 Special categories of data

The GDPR defines personal data broadly in order to increase protection of the individuals. Hence, personal data are "*any information relating to an identified or identifiable natural person*", i.e. the **data subject**, "*who can be identified, directly or indirectly, in particular by reference to an identifier such as a name, an identification number, location data, an online identifier or to one or more factors specific to the physical, physiological, genetic, mental, economic, cultural or social identity of that natural person*"[32]. Furthermore, "*data revealing racial or ethnic origin, political opinions, religious or philosophical beliefs, or trade union membership, [as well as] genetic data, biometric data […], data concerning health or data concerning a natural's person sex life or sexual orientation*" are considered "sensitive"[33]. Controllers can only process these data if they respond to the requirements listed under article 9(2), *inter alia* the explicit consent of the data subject or

[32] Article 4 GDPR
[33] Article 9 GDPR

public interest. However, it should be noted that profiling can create special categories of data by correlating data that are not considered sensitive, yet they can provide information about health, religious beliefs or sexual orientation[34] for instance. In that case, the controller should inform the data subject and make sure that there is a legal basis that allows such processing.

2.3.2 Pseudonymisation

Pseudonymisation is a method of processing personal data in a way that they can no longer be attributed to a specific data subject albeit the use of additional information, if that information is kept separately with appropriate technical and organisational measures to ensure that the data cannot be attributed to a data subject[35]. In an experiment to assess the importance of anonymization, Berendt [3] proved that for example if the purpose is solely to prevent unauthorised use of a tool, then an anonymization of the logs and replacement of pseudonyms by "authorised" and "unauthorised users" are enough to fulfil the purpose with no actual personal data being collected, and with thus better respect of privacy.

2.3.3 Encryption

Encryption is mentioned several times[36] by the GDPR as an example of a privacy friendly measure, since it guarantees that data are protected and raises the trust of the data subject to the data controller. Strong and efficient encryption is necessary in order to guarantee integrity of data as well as a secure flow of information. As it was stated by the former Article 29 Working Party, "*encryption must remain standardised, strong and efficient, which would no longer be the case if providers were compelled to include backdoors or provide master keys*"[37]. Personal data should be encrypted when stored (including creation of backups) and in transition.

2.4 Obligations for the controller and processor

Once processing of personal data has started, three major obligations lie on the controller: to protect the data, to mitigate the risks, and to detect security breaches. The risk is not qualified only when data are leaked or used without consent for different purposes. In fact, the risk to the rights of individuals "*may result from personal data processing which could lead to physical, material or non-material damage, in particular: where the processing may give rise to discrimination, identity theft or fraud, financial loss, damage to the reputation, loss of confidentiality of personal data protected by professional secrecy, unauthorized reversal of*

[34] See WP29 Guidelines on Automated individual decision-making and profiling for the purposes of Regulation 2016/679; Adopted on 3 October 2017, revised and adopted on 6 February 2018, p. 15
[35] Article 4(5) of the GDPR
[36] See Articles 6, 32 and 34 of the GDPR.
[37] WP29, statement on encryption and their impact on the protection of individuals with regard to the processing of their personal data in the EU, 11 April 2018, p. 3

pseudonymisation."[38] Consideration of the risks is actually one of the most important changes of the new legislation, that wishes to ensure that data controllers evaluate, through every operation, how a person's rights are affected through the processing. This risk mindset should focus not only when processing is done according to the initial planning (2.4.1), but also in case of a system failure (2.4.2).

2.4.1 Prevention

2.4.1.1 Security of processing

The controller is obliged to adopt all appropriate organisational measures in order to ensure compliance to data protection principles and should be able to demonstrate such compliance, according to the accountability principle. The Regulation highlights under different provisions the importance of data quality and data security[39]. **Depending on the processing activities and the extent to which they interfere with data subject's rights, the controller is obliged to assess and mitigate all potential risks**. The Regulation provides that this obligation depends on "the state of the art" as well as the "cost of the implementation", the purposes of processing and the risks of varying likelihood attached to them, as well as the rights and freedoms affected when establishing the level or security required and the safeguards that are more appropriate[40]. When it comes to data protection by design from a general perspective, the developer is therefore obliged to ensure security of the system but also embed PETs into the architecture of the system in order to maximize protection to the degree that it is adequate. The likelihood and severity of the risks should be determined in accordance with the nature, scope, context and purposes of the processing in an objective assessment that should determine whether "*data processing operations **involve a risk or a high risk***"[41]. Thus, "*in assessing the appropriate level of security account shall be taken in particular of the risks that are presented by processing, in particular from accidental or unlawful destruction, loss, alteration, unauthorised disclosure of, or access to personal data transmitted, stored or otherwise processed*"[42]. It is therefore essential to document every activity and ensure compliance with the law in order to demonstrate compliance with policy and practice for the procedures foreseen.

In fact, when it comes to security obligations, both the controller and the processor are linked by compliance to the law. Moreover, "*the controller and processor shall take steps to ensure that any natural person acting under the authority of the controller of the processor who has access to personal data does not process them except on instructions from the controller, unless he or she is required to do so by Union or Member State law*"[43]. Thus, the Regulation enhances the principle that the personal data should be processed only for purposes for which it was collected.

[38] Recital 75 of the GDPR
[39] See for example articles 9 and 47 of the GDPR
[40] Article 32 §1 GDPR
[41] Recital 76 of the GDPR
[42] Article 32 §2 GDPR
[43] Article 32 §4 GDPR

2.4.1.2 Data Protection Impact Assessment (DPIA)

A new obligation introduced by the reformed data protection framework is the carrying out of the so-called data protection impact assessment (hereinafter DPIAs) prior to likely risky operations. More specifically, it consists of a mandatory exercise in the event that the controller, based on her or his own judgment and taking into account the nature, scope, context and purposes, finds that the processing activities to be performed are likely to result in a high risk for the rights and freedoms of natural persons.

Indicatively, the GDPR lists three specific situations that are de facto considered likely to result in a high risk, namely in the case of a systematic and extensive evaluation of personal aspects bases on automated processing leading to decisions that produce legal effects for the individual, in the case of processing on a large scale of special categories of data and in case of a systematic monitoring of a publicly accessible area on a large scale.

In addition, a DPIA must include a thorough description of the processing activities, an **assessment of the necessity and proportionality** of the processing activities in relation to their purposes, an assessment of the rights and freedoms of the individuals concerned and the **measures envisaged to address the risks**.[44] As such, the DPIA seeks to provide for safeguards, security measures and mechanisms in order to mitigate the potential high risk for individuals. Compliance with approved codes of conduct is encouraged by the GDPR.

Furthermore, in the case where the DPIA leads to the conclusion that the envisaged processing activities are indeed likely to result in a high risk for the individuals, then the controller will have to consult with the national supervisory authority.[45]

2.4.1.3 Processor

Vis-à-vis the processor, the controller is obliged to use processors that provide for sufficient guarantees of compliance with the requirements of the GDPR. In other words, one does not outsource part of its activities to processors that do not comply with the rules themselves. Furthermore, an assignment of processing activities must be based on a contract or another type of valid legal act setting out the subject-matter and duration of the processing, the nature and purpose of the processing, the type of personal data and categories of data subjects and the obligations and rights of the controller.[46]

[44] More information on DPIAs: CNIL's guides to Privacy Impact Assessment, available at https://www.cnil.fr/en/PIA-privacy-impact-assessment-en (last access on 01.03.2019); ULD's Standard Data Protection Model, https://www.datenschutzzentrum.de/uploads/sdm/SDM-Methodology_V1.0.pdf last access on 01.03.2019); ICO's Code of Practice, https://ico.org.uk/for-organisations/guide-to-the-general-data-protection-regulation-gdpr/accountability-and-governance/data-protection-impact-assessments/ (last access on 01.03.2019); Article 29 Working Party, *Guidelines on Data Protection Impact Assessment (DPIA) and determining whether processing is 'likely to result in a high risk' for the purposes of Regulation 2016/679'*, 17/EN WP 248, 04 April 2017.

[45] Article 36 Regulation (EU) 2016/680, article 28 Directive (EU) 2016/680.

[46] Article 28 of the GDPR

The processors in their turn must act only on the instructions from the controller while they may only employ sub-processors that provide for sufficient guarantees of confidentiality and compliance with the data protection framework. Processors must assist the controllers with responding to data subjects exercising their rights as well as with responding to requests from the national data protection supervisory authorities.

2.4.2 Reaction in case of personal data breach

It should be noted that a security breach is not always a personal data breach. For the GDPR, a "personal data breach" is "*a breach of security leading to the accidental or unlawful destruction, loss, alteration, unauthorised disclosure of, or access to, personal data transmitted, stored or otherwise processed*"[47]. Therefore, the GDPR applies only when the security issue results in a breach of personal data[48]. The WP29 has previously[49] identified three types of breaches. First of all, the **confidentiality breach**, that results from an unauthorised or accidental disclosure of, or access to, personal data. Secondly, the **integrity breach**, in case data is altered by an unauthorised or accidental intervention and lastly, the **availability breach**, in case of an accidental or unauthorised loss or access to, or destruction of, personal data.

The processor is obliged to inform the controller "*without undue delay*", i.e. as soon as he or she is aware of the personal data breach, no matter how important the risk entailed is, "*with further information about the breach provided in phases as more details become available*"[50]. However, in the event of a data breach affecting the rights of individuals, he or she must immediately notify the competent national supervisory authorities, in order to limit the damage occurred for the individuals[51]. **In some cases, the breach should also be notified to the data subjects**. Article 29 Working Party notes that "*the threshold for communicating a breach to individuals is […] higher than for notifying supervisory authorities and not all breaches will therefore be required to be communicated to individuals, thus protecting them from unnecessary communication fatigue*"[52]. However, according to article 34 of the Regulation, the controller should always be transparent about data breaches to the data subjects and the communication should satisfy article 12 requirements about information[53] (see section 2.2.1 for more information). Additionally, following the requirements of article 33(5), the controller shall keep documentation of all data breaches, regardless of whether the breach needs to be notified to a supervisory authority.

[47] Article 4 of the GDPR
[48] WP29, Guidelines on personal data breach notification under Regulation 2016/679, Adopted on 3 October 2017, Revised on 6 February 2018, p. 7
[49] WP29 opinion 03/2014 on data breach notification
[50] WP29, Guidelines on personal data breach notification, p. 14
[51] Recital 85 of the GDPR
[52] WP29, Guidelines on personal data breach notification, p. 20
[53] WP29, Guidelines on transparency under Regulation 2016/679, Adopted on 29 November 2017, Revised on 11 April 2018, p. 34

Hence, processors need to implement measures and procedures that immediately detect data breaches. From a data protection by design scope, it is important that an effective alert system is created that would not only notify the breach, but also the origins of such breach and the extent to which it is detrimental to the data subjects.

2.5 Consent of the data subject

Consent is one of the legal bases that allow lawful processing of personal data according to article 6 and must be given prior to any processing activity[54]. According to the GDPR, "*'consent' of the data subject means any freely given, specific, informed and unambiguous indication of the data subject's wishes by which he or she, by a statement or by a clear affirmative action, signifies agreement to the processing of personal data relating to him or her*"[55]. Thus, consent should be given freely, in a specific manner, clearly and after the data subject was informed of the processing activities. Evidence of consent should be stored in order to comply with the obligation to demonstrate valid consent.[56]

2.5.1 Freely given consent

The notion of consent has evolved substantially under the new legal framework, that provides very specific criteria in order to accept that consent is freely given. Free consent exists only when the data subject has complete control over it. "*Consent is presumed not to be freely given if it does not allow separate consent to be given to different personal data processing operations despite it being appropriate in the individual case, or if the performance of a contract, including a provision of a service, is dependent on the consent despite such consent not being necessary for such performance*"[57]. If the data subject feels compelled to consent because of the potential negative consequences of non-consent, or if consent is mixed up with non-negotiable parts of a contract, then such consent cannot be deemed as freely given[58]. This requirement therefore might entail a more detailed and contextual analysis in order to assess it.

Thus, **the data subject should be offered control over its personal data and the choice to accept or decline the terms offered by the controller**. Consent is not given if it is just mixed with the general acceptance of terms and conditions of a contract where processing of personal data is not necessary for the service provided. Freedom of consent can also be questioned if it appears that the data subject was compelled (for example with financial advantages) to agree to provide

[54] WP29 opinion 15/2011 on the definition of consent, pp. 30-31
[55] Article 4 (11) of the GDPR
[56] Article 5, 2 and article 7, 1 of the GDPR.
[57] Recital 43 of the GDPR
[58] WP29, Guidelines on consent under Regulation 2016/679, Adopted on 28 November 2017, Revised and adopted on 10 April 2018, p. 5

more data than necessary in order to benefit from a product or a service. In fact, "*when assessing whether consent is freely given, utmost account shall be taken of whether, inter alia, the performance of a contract, including the provision of a service, is conditional on consent to the processing of personal data that is not necessary for the performance of that contract*"[59]. The latter should be interpreted strictly[60] (i.e., processing must be necessary in order to provide the service to each individual concerned). Also, "*consent should cover all processing activities carried out for the same purpose or purposes. When the processing has multiple purposes, consent should be given for all of them*"[61]. In fact, if the processing is based on consent, the **controller needs to be able to demonstrate that the consent was given to such processing operation**[62]. Most importantly, if a controller requests to process personal data that are necessary for the performance of the contract, then the lawful basis for the contract is other than consent of the data subject[63].

It should also be assessed whether withdrawal would be detrimental to the data subject in terms of the services provided. Both consent and/or withdrawal should be protected from inappropriate pressure or influence, which can be exercised explicitly or implicitly on the data subject. Normally, **consent can be withdrawn with no consequences whatsoever for the data subject, and all the personal data should be erased**. However, withdrawal of consent does not affect the lawfulness of processing activities before the withdrawal.

2.5.2 Consent in a specific manner

Consent should be given specifically for each processing activity, which guarantees control and transparency. If a controller wishes to use the data obtained on the basis of consent for different processing activities, then additional consent is required. Moreover, "***a controller that seeks consent for various different purposes should provide a separate opt-in for each purpose****, to allow users to give specific consent for specific purposes*", as well as the additional information that is required in order to guarantee that consent is freely given[64].

2.5.3 Informed consent

For the consent to be valid, information should be provided to the data subject about the identity of the controller as well as of other entities that might acquire access to the data, the type of data collected, the purpose of the processing operations, their rights as data subjects such as the right to withdraw, and the possible risks of data transfers[65]. This information should be provided in plain and simple language, which the average person can understand. Furthermore, the

[59] Article 7 (4) of the GDPR
[60] Opinion 06/2014 on the notion of legitimate interest of the data controller, p. 16-17
[61] Recital 32 of the GDPR
[62] See recital 42 of the GDPR
[63] WP29, Guidelines on consent, p. 8
[64] WP29, Guidelines on consent, p. 12
[65] WP29, Guidelines on consent, p. 13

controller is responsible for providing evidence of freely given and explicit consent, according to the appropriate lawful ground for the envisaged processing.

2.5.4 Clear and explicit consent

The Regulation stipulates that "*consent should be given by **a clear affirmative act** (…), such as by a written statement, including by electronic means, or an oral statement. This could include ticking a box when visiting an internet website, choosing technical settings for information society services or another statement or conduct which clearly indicates in this context the data subject's acceptance of the proposed processing of his or her personal data. Silence, pre-ticked boxes or inactivity should not therefore constitute consent […] If the data subject's consent is to be given following a request by electronic means, the request must be clear, concise and not unnecessarily disruptive to the use of the service for which it is provided*"[66]. In consequence, consent to general terms and conditions cannot be considered clear enough. Moreover, the Regulation establishes special rules for children since they are considered vulnerable.

In any case, even if consent is free and explicit, the controller still needs to ensure that the principles of processing are guaranteed, especially with regards to fairness, as well as the balancing of rights. Therefore, a data subject's consent does not discharge the data controller of his or her legal obligations. Additionally, given that consent is only one of the lawful grounds of processing, it must be noted that these grounds are not interchangeable, in the sense that if a controller makes a commitment to obtain consent for the processing, this choice should be respected throughout all related processing operations. When the personal data are collected, controllers have the obligation to disclose the legal basis of that collection that they will not be able to alter later on.

2.6 Data subjects' rights

The user has the right to choose, to control, and is thus empowered by the new legal framework.

Although the rights of data subjects have been previously present in former legal texts or case-law, GDPR's accomplishment is to list them in clear terms within other data protection rights and obligations. In fact, GDPR's focus on the data subjects, aims to strengthen their protection by all means. Our focus will be on the rights that are important for the purposes of data protection by design such as, first and foremost the right to be forgotten (2.6.1), the right to be informed (2.6.2), the right of access (2.6.3), the right to data portability (2.6.42.6.3), the right to rectification (2.6.5), the right to restriction of processing (2.6.6), the right to object (2.6.7), and the right not to be subject to a decision based solely on automated processing (2.6.8).

[66] Recital 32 of the GDPR

2.6.1 Right to be forgotten

The right to be forgotten is one of the most fundamental principles in current data protection legislation, that has been developed in the EU legal framework under the *Digital Rights* case-law[67], and now is protected under article 17 of the GDPR. Hence, **the data subject has the right to obtain erasure of all his or her personal data without undue delay**, if such personal data are no longer necessary for the purposes for which they were collected, if consent is withdrawn, if the data subject objected the processing of its personal data, in case the processing is unlawful or for compliance with the further EU legal framework. Furthermore, article 17 (2) compels **the controller to inform other controllers who are processing the data that erasure of data was requested**. This is a very important aspect for data protection by design principles since the data should not only be erasable, but also traced and linked to all the processing activities they contributed, in order to guarantee that the data subject will effectively disappear from the system. This is unquestionably an important challenge from a technical perspective, since the architecture of some systems (for example blockchain) does not allow for a data subject, and its data, to disappear completely. It should be noted that the Regulation exceptionally allows for further retention of data if necessary, "*for exercising the right of freedom of expression and information, for compliance with a legal obligation, for the performance of a task carried out in the public interest or in the exercise of official authority vested in the controller, on the grounds of public interest in the area of public health, for archiving purposes in the public interest, scientific or historical research purposes or statistical purposes, or for the establishment, exercise or defence of legal claims*"[68]. These exceptions do not seem to apply to the pilots given by PDP4E.

It can be difficult to erase all personal data relating to an individual when these data are stored in multiple locations. To achieve this, personal data should be identifiable as such and must be traceable throughout the system.

2.6.2 Right to be informed

Henceforth, **data subjects have the right to obtain information about all processing activities, how the data are being controlled, monitored or used further**, in order to enable transparency and control over their data. As stated before, information should also be provided in case of a data breach or a repurpose of processing. Recital 60 specifies that data subjects "*should be informed of the existence of the processing operation and its purposes. The controller should provide the data subject with any further information necessary […] taking into account the specific circumstances and context in which the personal data are processed. Furthermore, the subject should be informed of the existence of profiling and the consequences of such profiling. Where the personal data are collected from the data subject, the data subject should also be informed whether he or she is obliged to provide the personal data and of the consequences, where he or she does not provide such data. That information may be provided in combination*

[67] CJEU, Gd. Ch., 8 april 2014, *Digital Rights Ireland*, C-293/12
[68] Recital 65 of the GDPR

with standardised icons in order to give in an easily visible, intelligible and clearly legible manner, a meaningful overview of the intended processing. Where the icons are presented electronically, they should be machine-readable". Article 12 of the GDPR provides that the information must be concise, transparent, intelligible and easily accessible, in clear and plain language. The controller is obliged to facilitate communication. Furthermore, the information must be provided in writing and be free of charge. This entails that the controller must be able, at any moment, to define clearly what data of a particular data subject are used and for what purposes. Therefore "*controllers should also separately spell out in unambiguous language what the most important consequences of the processing will be*"[69]. In other words, what kind of effect will the specific processing described in a processing described in a privacy statement/notice actually have on a data subject? Such a description of the processing should not simply rely on predictable "best case" examples of data processing, but should provide an overview of the types of processing that could have the highest impact on the fundamental rights and freedoms of data subjects in relation to protection of their personal data. This information must also be differentiated from non-privacy related information so that it can be accessed easily in a clear and plain language, and should be described in non-generic privacy terms.

In order to adequately inform the data subject, personal data should be traceable and metadata can be attached to provide the necessary information about the nature and purpose of the data.

The controller should also be aware that when the product or service addresses a child, special information needs to be provided as well as when addressing people with particular vulnerabilities.

2.6.3 Right of access

Article 15 of the GDPR grants data subjects the **right to obtain details of their personal data in the possession of the controller**. Individuals can make the request verbally or in writing, and the data controller has one month to answer to this demand, without the possibility to request compensation. This is an important first step in guarantying other rights also recognised by the EU legal framework such as data portability or the right to erasure. In case of a positive answer, i.e. when the data controller does process the personal data of that subject, then the information should explain the processing purposes, the categories of personal data that are processed, the receiver(s) of these data, the duration of storage and information about their rights, the origin of the data and whether they are transmitted to third parties.

However, data should not be retained just for the sole purposes of answering access requests[70]. Recital 63 offers some exceptions to the principle in order to protect trade secrets or intellectual property. However, this exception should be justified further. In fact, "*where possible, the*

[69] WP29 guidelines on transparency, p. 7
[70] Recital 64 of the GDPR

controller should be able to provide remote access to a secure system which would provide the data subject with direct access to his or her personal data"[71].

The implementation of this right is similar to the right of data portability. Personal data should be recognizable as such and it should be traceable in the system. The data should be compiled in the same format in order to give access to the data subject. Making a distinction between personal data of lower and higher sensitivity can act as an extra protection as it allows to confirm a users' identity before giving access to sensitive data.

2.6.4 Right to data portability

Article 20 of the GDPR introduces the new right to data portability, which is the right of the data subjects to ask a **controller to receive the personal data they provided to another controller, in a structured, commonly used and machine-readable format**. Such obligation not only wishes to rebalance the relationship between data subjects and data controllers, but is also an important aspect for businesses, since the data subject can contact a business competitor and transfer their data to them. Data portability cannot be used as an excuse for a data controller in order to delay the erasure of personal data, if such erasure was requested by the data subject. However, data portability does not trigger automatically erasure of the personal data[72], and should not affect the rights and freedoms of others in a negative way[73]. Furthermore, the right to data portability seems to be limited to the cases where processing operations are based on consent or a contract[74]. Therefore, if for example financial institutions are requested to detain personal data in their obligation to prevent and detect financial crimes, such as money laundering, the right to data portability does not apply[75].

The exact letter of the law provides for the approach that the personal data concerned by this right should be limited to the ones initially given to the controller by the data subject. However, this approach seems to be limited since the initial personal data provided allow for the creation and evolution of the digital identity of the data subject, and observation of online activity that enables further profiling of the individual. This is a question to be examined further on, but taking into account the purposes of the new legal framework, it is suggested that data portability extends to other personal data, besides the ones provided by the data subject himself/herself to the controller such as activity logs, history of web usage or raw data processed by a smart meter.

The personal data relating to an individual should be identifiable as such and should be traceable to allow the gathering of personal data in the system. In order to satisfy a request by the data subject, the personal data should be stored or converted into the same format in order to be sent to another controller.

[71] Recital 63 of the GDPR
[72] Article 17 of the GDPR
[73] Article 20(4) of the GDPR
[74] WP29 Guidelines on the right to data portability, p. 8. See also recital 68 and article 20(3) of the GDPR
[75] WP29 Guidelines on the right to data portability, p. 8

2.6.5 Right to rectification

The data subject has the right to the rectification of inaccurate personal data concerning her or him without undue delay. This also covers the completion by the controller of incomplete personal data concerning the data subject.[76] This right reflects the general data protection principle of accuracy.

Personal data should be traceable in order to respond to data subject requests. The personal data must be modifiable in order to keep the data up-to-date and complete. The request must be dealt with without undue delay.

2.6.6 Right to restriction of processing

In certain situations, it is possible for the data subject to request and obtain from the controller the restriction of processing of personal data. Article 18 of the GDPR lists four possible grounds: (1) when the data subject contests the accuracy of the personal data, (2) when the processing is unlawful and the data subject opposes the erasure of the personal data, (3) when the controller has no further need for the personal data but the data subject requires the personal data for the establishment, exercise or defence of legal claims, (4) and when the data subject has objected to the processing based on article 21, (1).

As a result of the exercise of this right the controller may not further process personal data, with the exception of storage, unless; (1) with the data subject's consent, (2) for the establishment, exercise or defence of legal claims, (3) for the protection of the rights of another natural or legal person, (4) or for reasons of important public interest of the Union or of a Member State.

In order for the data subject to exercise this right, the personal data must be traceable in the system and the controller must be able to stop the processing activities related to that personal data through a reliable method. Depending on the processing activities, different methods can be used to restrict processing. Examples are temporarily moving the data, making the data unavailable to users, or temporarily removing the data.[77]

2.6.7 Right to object

The controller is obliged to inform explicitly the data subject of its right to object according to article 21 of the GDPR. If a data subject objects the processing activities for personal or professional reasons, then the controller can only continue processing if he or she can demonstrate compelling legitimate grounds that justify overriding the rights and freedoms of the data subject. A list or examples of such legitimate grounds are not provided by the Regulation,

[76] Article 16 of the GDPR

[77] Right to restrict processing, Information Commissioner's Office, https://ico.org.uk/for-organisations/guide-to-data-protection/guide-to-the-general-data-protection-regulation-gdpr/individual-rights/right-to-restrict-processing/.

but one can assume that they need to be of extreme importance in order to justify an imbalance of rights. The controller holds the burden of proof and business interests of the controller do not seem to fit this definition. Additionally, the data subject has an unlimited right to object to processing that entails profiling for direct marketing reasons[78]. The controller must always respect this right that can be exercised at any time and free of charge[79]. This right can be implemented by creating a list of "restricted data" which is used as a reference by the system to decide whether or not to process a piece of personal data. Identifying the specific purpose of processing is important to determine if the controller can continue processing based on compelling legitimate grounds.

2.6.8 Right not to be subject to a decision based solely on automated processing

Data subjects have the right not to be subject to decisions based solely on automated processing, including profiling, i.e. the evaluation of certain personal aspects relating to a natural person, in particular the analysis and prediction of personal aspects concerning that person's inter alia behaviour, location or movements. This restriction applies to decisions which are **purely automatic** (where the objectionable element is the lack of human intervention) and which **produce legal effects or similarly significantly affect** the data subject. It should be made clear that if a human being reviews and takes account of other factors in making the final decision, that decision would not be considered to be 'based solely' on automated processing.[80] Furthermore, a decision producing legal effects refers to a decision that affects the legal rights or legal status of the individual, which may be for instance the cancellation of a contract or the refusal of admission to a country. On the other hand, whether a decision '*similarly significantly affects the individual*' is assessed depending on how the decisions affects the circumstances, behaviour or choices of the individual, the potentially prolonged impact on the individual and whether it potentially leads to the exclusion or discrimination of the individual. For instance, such a decision may affect the individual's financial circumstances or employment opportunities or may have little impact in general but a significant effect vis-à-vis minority groups.[81]

More specifically, this restriction is interpreted as a **general prohibition** of automated decision making, unless one the following conditions apply.[82] Automated processing can be used **exceptionally** (1) where the decision is necessary for the entry into or the performance of a contract, (2) when it is authorised by EU or Member State law applicable to the controller or (3) when it is based on the individual's explicit consent. However, appropriate measures to protect the individual's interests must still be in place.

[78] Article 21(2) of the GDPR
[79] Recital 70 of the GDPR
[80] Article 29 Data Protection Working Party, *Guidelines on Automated individual decision-making and Profiling for the purposes of Regulation 2016/679*, 17/EN, WP251rev.01, as last revised and adopted on 06 February 2018.
[81] Article 29 Data Protection Working Party, *Guidelines on Automated individual decision-making and Profiling for the purposes of Regulation 2016/679*.
[82] Idem.

These exceptions come with additional restrictions where profiling is based on sensitive data – in such a case (and provided one of the grounds from previous paragraph apply), profiling can only be based on explicit consent, or authorization by EU or Member State law which is necessary for substantial public interest grounds.[83]

Compliance to the GDPR offers some challenges for data protection by design because of the importance of flexibility in building software systems and tech neutrality[84]. Automated compliance cannot be fully guaranteed and human intervention is important in order to ensure supervision and legitimate processing. Thus, a format of multiple criteria needs to be embedded in data protection by design from a computational standpoint [3]. It appears also that sometimes the interests are conflicting; for example, even though data minimisation is linked to data protection by design, in reality such principle can be detrimental to the individuals in some cases, for example in cases of algorithmic profiling (see Section 3). Data protection by design cannot provide fixed solutions [38]. **Data protection principles are not absolute and respecting them depends on the concrete challenges of the system that will be created**. This is why it is important to examine the pilots more in detail, in order to establish a more precise legal framework for the project. From a software architecture perspective there are a number of principles that can be encoded in different tools in order to facilitate data protection considerations and raise awareness through the different processes so that engineers could be alerted on the data protection rules affected by each engineering step.

[83] Article 22, 4 of the GDPR
[84] See Mauro D. Rios, "Technological neutrality and conceptual singularity" (2013).

3 Industrial needs for GDPR implementation

Albeit the GDPR entered into force two years prior to its date of application (25th May 2018), organizations are still struggling to adapt their IT systems and processes to fully comply with the regulation. In this section we describe the challenges that organizations are facing to make this transition. Firstly, we cover main organizational challenges. This analysis covers current trends in development processes that are being adopted as a response to the Regulation. Secondly, we describe the two pilots that will validate the results of PDP4E, with the objective of describing the type of processing activities that they perform daily and the specific challenges in their own vertical (with an emphasis on the specifics of the impact of the legal regulation onto such domains). Finally, we compile a list of needs from the organizational, technical, and legal challenges that have been covered in this analysis.

3.1 General industrial challenges to comply with the GDPR

GDPR operationalization across European organizations is still unknown at enforcement date, but several studies [4] [7] [8] have highlighted the struggles that organizations have been facing to comply with the GDPR during the last two years. We summarize below the five major organizational challenges highlighted by these market studies. In Section 3.2 we describe the specific technical challenges of the two pilots of the project to comply with the regulation.

- **Compliance costs.** There is a general belief that the GDPR will significantly increase operating expenses or have a negative impact on the companies' revenue [7]. This might have led organizations to delay the GDPR implementation until last minute, underestimating the efforts required to change organizational processes. As a result, one year prior to the enforcement date, more than half of European organizations did not have plans to comply to the GDPR or acknowledged that they would not be able to comply on time [7].
- **Consent management.** The regulation asks organizations to "*use clear and plain language*"[85] when seeking data subject's consent (see Section 2.5), and allows data subjects to object to such consent at any moment (see Section 2.6.7) and, hence, effectively stopping further processing of personal data. But this *clear and plain* language must be translated into tangible, auditable, and automatable mechanisms to prove that data is not used outside the agreed usage. Some organizations are still struggling to decide how to ensure that they are processing personal data under a valid consent.
- **Identification of personal data.** Under the GDPR, data subjects have the right to ask controllers to remove, amend or provide access to all their personal data (see Section **Erreur ! Source du renvoi introuvable.**). This poses a challenge as finding all this information requires governance mechanisms across different systems, including backups, data transferred to third parties and information (internally) shared by

[85] WP29, guidelines on consent, p. 14

organization's employees. It is reported [8] that a significant number of organizations decided to establish a manual process to find all this information, expecting that the number of data subjects' requests is going to be low. Yet, some reports indicate that a significant number of EU citizens are willing to make use of these rights [7].

- **Coordination with third parties**. Related to the two issues above, controllers will spend extra time to coordinate with processors and third parties. From the data management perspective, controllers must have mechanisms to comply with the abovementioned data subject's rights on their own infrastructures, but they must also coordinate with processors for making the necessary changes on their side. Changes in a data record might require triggering specific processes for each processor that might happen to have a copy of such record. From the security perspective, the controller should consider others' data protection mechanisms when deciding which third party will perform the requested processing activities. Finally, from the consent management point, the controller needs to ensure that the formal consent allows the controller to hire such third-party services, and that the processor acts on the terms agreed on the consent form. As the number of third parties grow, a systematic, automated mechanism to tackle all these issues will be required by the controller.
- **Putting *Data Protection by Design (DPbD)* into practice.** A proactive attitude towards securing personal data is enforced by the regulation, recommending implementing state of the art security tools and techniques. In recent years, a plethora of Privacy-Enhancing Technologies (PETs) have been created to foster data protection and respond to privacy concerns, and the systematization of such knowledge has been tackled by several reviews, handbooks and surveys [9] [19]. Yet, many organizations still consider security controls as a post-development activity and most Privacy-Enhancing Technologies remain unknown for most engineers, leading to strongly unrecommended practices such as not encrypting stored personal data[86]. PETs are considered the most promising short-term approach for protecting privacy, and there should be policies stimulating their adoption [36]. Unless clear and tangible guidance is provided to organizations, there is a significant risk in making DPbD (and the GDPR in general) useless.

In addition to all the organizational changes that are required to tackle the abovementioned challenges, organizations are also facing a fast change in their software development processes as we detail below. We will see that the latest development trends are aligned with putting DPbD into practice. Section 3.1.1.1 will cover these data protection related changes in the development process and the implications on development actors and working habits.

[86] https://www.cso.com.au/article/630353/unencrypted-data-becomes-negligence-business-leaders-taking-encryption-strategy-away-from-it/

3.1.1 Changes in the software development process

In the software engineering discipline, multiple methodologies have been devised for planning, creating, testing, and deploying new pieces of software. Figure 1 depicts a simplified **Software Development Life Cycle (SDLC)**[87] that broadly covers all development methodologies into a single, simple model. Firstly, the development team needs to plan the features to be developed and elicit the requirements of the different stakeholders. Secondly, the organization designs the technical architecture and description of the system, as well as design the user interface. Then, a significant amount of time is devoted to put all these plans into effect. And, finally, the system is tested and deployed into production. Each development methodology builds on top of the SDLC to accommodate to specific business models and development environments.

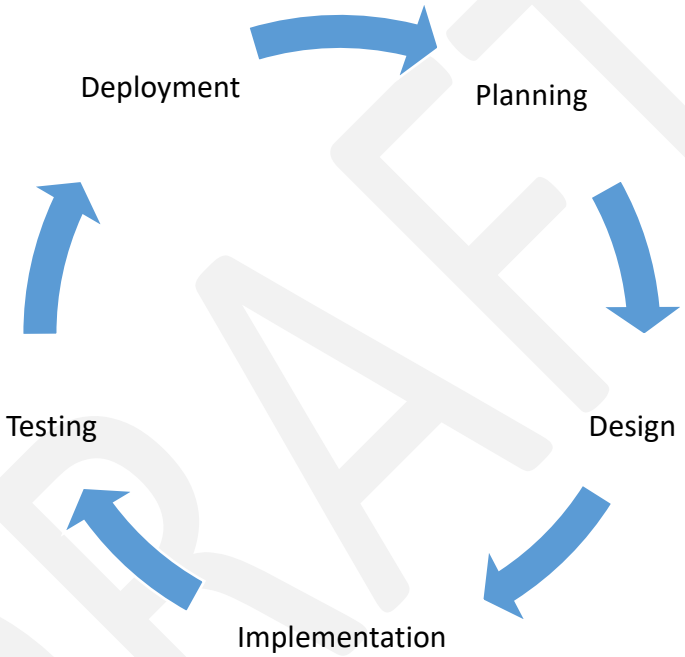

Figure 1 – Representation of a simplified Software Development Life Cycle.

As an example of one of such software development methodologies, the **Agile methodology** [1] requires development teams to squeeze software development in batches of new features (also known as sprints, typically executed within two weeks). Each sprint goes through the aforementioned five development phases, and several sprints are required in the development of a complete software system. End-users are typically engaged in the process to ensure continuous alignment with their needs. The agile development methodology creates a culture of rapid prototyping, where the working results of a sprint are validated by the end-user and influences the planning of future system features. Moreover, agile development teams tend to reduce time spent in creating documentation for the project, as working software is usually more appreciated. An increase in the overhead of maintaining a fluent communication among

[87] https://en.wikibooks.org/wiki/Introduction_to_Software_Engineering/Process/Life_Cycle

stakeholders is compensated by the cost reduction of adapting to changes in system requirements.

Other SDLC models can be found in practice, but most of them are a refinement on the phases described in Figure 1 with special constraints on when and who executes each phase, as well as variances on the scope and magnitude of each iteration. Independently of the development methodology chosen, Table 1 describes the main actors involved in each development phase.

Main actor	Description	Phase
Product Manager	The product manager is responsible for prioritizing features of a product, ensure alignment with customer needs, and create a long-term product vision.	Planning
Requirements Engineer	The requirements engineer is in charge of eliciting the functional and non-functional requirements of the system.	Planning
Architect	The architect translates the set of features and the different requirements into tangible, technical descriptions of the system to be implemented.	Design
Developer	Developers take the technical description of the system and put it into practice. Technical changes on the plan are expected during the Implementation phase, and the Developers might have been empowered to do so.	Implementation
Test Engineer	The test engineer makes sure that the implementation complies with the requirements, as well as he or she ensures that no errors are being introduced by the implemented features.	Testing
System administrator	The system administrator supervises the execution of the system and the IT infrastructure that supports the system. The system administrator looks for deviations on the normal behaviour of the system that might be indicators of external attacks and security breaches.	Deployment

Table 1 – Main actors involved in the development of a product, system or service. A brief description of their usual responsibilities and involvement in the SDLC is also included.

3.1.1.1 The "shift-left" strategy for implementing Data Protection by Design

The DevOps culture[88] was born from the rapid prototyping culture of the agile model, where information from Operations (business and performance data obtained after the deployment of the system) is used by Development teams to plan next iterations of the system. Agile and DevOps are becoming the *standard* methodology for new development teams [5] and, hence, any systematic approach to embed privacy and data protection into the development of new software products should be aligned with the agile and DevOps culture, artefacts and methodologies.

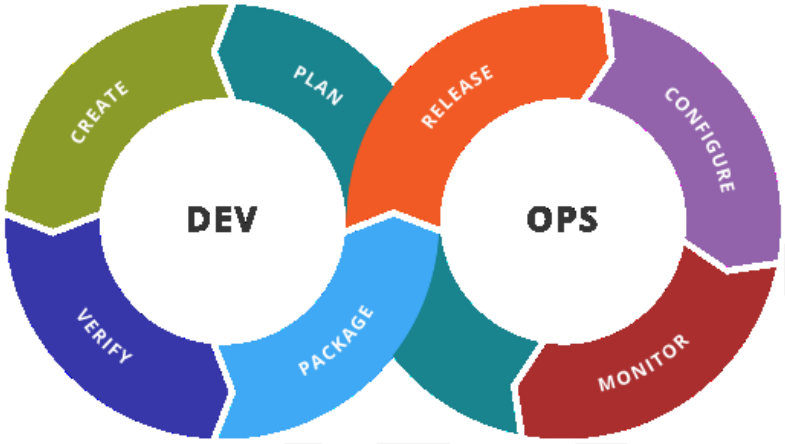

Figure 2 – Graphical representation of the DevOps model, which details the Deployment phase of the SDLC in Figure 1. This representation emphasizes the underlying collaboration between the Development and Operation teams. Figure created by Kharnagy and publicly available in Wikipedia.

Under the DevOps model, security and privacy breaches are usually detected during the Monitoring phase and security controls are considered during the Plan phase of the next iteration. This poses a reactive attitude against Security (and Data Protection), as fixes are usually implemented after an attack has been perpetrated. This approach to application security is not aligned with the GDPR, as development organizations should have a proactive attitude towards securing their IT systems and personal data from their end-users. Some examples of such proactive attitude can be seen in the DPbD principle, in the obligation to perform privacy risk assessments and assessing the purpose of data recollection prior to start gathering such data.

Industry realized that the original DevOps approach is not enough, and developed DevSecOps as a new concept to emphasize the importance to embed security in DevOps, with a generalized recommendation for their development teams to "shift-left" security in their development processes. By shifting left, industry is referring to the idea that some of the security concerns contemplated during Operations (the right side of the DevOps cycle) should be anticipated during the Development phase (left side of the cycle)[89]. The GDPR is the legal motivation for companies to start putting this security strategy in practice. This is quite in line with the principle of Data Protection by Design, that is, the consideration of data protection aspects since the onset of a

[88] https://theagileadmin.com/what-is-devops/
[89] https://www.veracode.com/blog/managing-appsec/security-needs-shift-left-%E2%80%93-and-right

project, rather than as afterthought. Unfortunately, this is a strategy that cannot be implemented with a pure technical transformation as this requires changing the responsibilities, skills and behaviours of all the development actors in the SDLC.

Table 2 describes some of the new responsibilities for development actors when adopting a shift-left security strategy. Security teams are usually understaffed, and shortage of cybersecurity skills in the workforce is getting worse[90]. Hence, security analysts are expected to play a coaching role in which they facilitate the shared responsibility of producing secure systems. Nonetheless, albeit developers are expecting to have a clear guidance about application security, one in four organizations do not have a formal security program in place yet [5]. Even those organizations that have formal application security programs fail to be up to date with the latest security threats, as 50% of the organizations are not aware of the contents of the OWASP Top 10 applications risks[91] and do not have an inventory of all third-party components and, hence, are incapable of protecting themselves to the latest threats nor applying security fixes [5].

Main actor	Description	New responsibilities
Product Manager	The product manager is responsible for prioritizing features of a product, ensure alignment with customer needs, and create a long-term product vision.	The product manager is responsible for updating data dependencies of the product and assesses trade-offs between business value and the loss in trust generated by asking for more personal data.
Requirements Engineer	The requirements engineer is in charge of eliciting the functional and non-functional requirements of the system.	Requirements engineers must also consider privacy and data protection requirements when eliciting functional and non-functional requirements of the system.
Architect	The architect translates the set of features and the different requirements into tangible, technical descriptions of the system to be implemented.	The architect assesses security threats of the proposed system architecture and suggests security controls and mitigation actions.
Developer	Developers take the technical description of the system and put it into practice. Technical changes on the plan are expected during the Implementation phase, and the	Developers reassess the security threats, especially for those changes that they might introduce on the plan or by the introduction of specific libraries and/or third-party services in the system.

[90] https://www.csoonline.com/article/3247708/security/research-suggests-cybersecurity-skills-shortage-is-getting-worse.html
[91] https://www.owasp.org/index.php/Category:OWASP_Top_Ten_Project

	Developers might have been empowered to do so.	
Test Engineer	The test engineer makes sure that the implementation complies with the requirements, as well as he or she ensures that no errors are being introduced by the implemented features.	The test engineer must validate the correct implementation of the chosen security controls and compliance with the privacy and data protection requirements.
System administrator	The system administrator supervises the execution of the system and the IT infrastructure that supports the system. The system administrator looks for deviations on the normal behaviour of the system that might be indicators of external attacks and security breaches.	System administrator support and coach the above actors in their new responsibilities. Uses previous threat analysis to look for unforeseen breaches. Updates the development team about advances in the state of the art in security controls.

Table 2 – Responsibilities of the actors in Table 1 under the shift-left strategy.

Under this scenario, PDP4E does not only aim at creating technological tools, but use them as a strategy for making this cultural change possible by introducing privacy and data protection practices in their usual engineering responsibilities. Table 3 depicts a first relation between the SDLC, the main actors involved, and the four main contributions of the PDP4E project.

Notice that PDP4E's outcomes spans across multiple development phases. In practice, this suggests that the separation between these phases is no longer clear. As an example, product managers might need to assess risks and prioritize their respective mitigation actions, but architectural information is required to do this analysis. Agile methodologies seem to be a good fit in this scenario, as the short time between iterations allows continuous changes in the planning and design of the project. On a cautious note, development teams may take literally the Agile value "*working software over comprehensive documentation*"[92] which might hamper the organizational changes required to comply with the GDPR. As we have seen in Table 3, a shared documentation might be key to enable the collaboration necessary to accomplish DPbD. Hence, PDP4E's outcomes should support development teams in creating such documentation without adding too much overhead.

	Main actor	PDP4E's outcome	In relation to GDPR compliance
PLANNING	Requirement Engineer	Requirements Engineering	To elicit privacy and data protection requirements for the project.

[92] http://agilemanifesto.org/

	Product Manager	Model-driven Design	To support the transparent communication of personal data usage to data subjects. To describe data dependencies in the product, purpose, storage limitations and actors with access.
		Risk Management	To prioritize development efforts based on risks.
DESIGN	Architect	Model-driven Design	To design the technical architecture of the software system.
		Risk Management	To assess the security-readiness of the proposed architecture.
CODE	Developer	Risk Management	To select the final third-party libraries and vendors; to notify the security team of potential privacy and data protection threats during the development phase.
TESTING	Test Engineer	Requirements Engineering	To validate the privacy and data protection requirements of the project and establish the mechanisms to the automated accountability methods.
		Assurance	
DEPLOYMENT	System administrator	Model-driven Design	To provide a holistic view of the application to the system administrator so that he or she can effectively plan mitigation actions in case of a data breach.
		Risk Management	To assess the security of the application, and proactively look for potential threats.
		Requirements Engineering	To notify the development team of further privacy and data protection requirements based on the analysis of the system model and associated risks.
		Assurance	To look for potential data breaches. To keep updated the documentation necessary to comply with the GDPR.

Table 3 – Description of how PDP4E's outcomes support the SDLC actors in the shift-left strategy.

3.2 Analysis of PDP4E industrial scenarios

In order to validate the outcomes of PDP4E, they will be applied by software and system engineers to introduce data protection issues in the SDLC activities of products they are creating. Such products are not ad hoc developments for PDP4E, but exist outside the project in real development scenarios, where the engineers will employ our methods and tools to deal with data protection aspects. With this in mind, this section aims at describing a high-level overview

of the framework in which such developments will be implemented and deployed. In particular, this section covers the connected vehicle framework in the automotive sector, whereas section 3.2.2 describes the recent trends on big data analytics in the energy sector. These two sections also cover the key issues that have been highlighted by privacy-savvy representatives of both sectors, and relevant legal concerns that have been raised during an initial analysis of the scenario.

3.2.1 Automotive scenario

Before the digital era, the business model of the automotive sector has been grounded on long customer life cycles. Car manufacturers had to design and market vehicles that will last more than 5 years, and between two consecutives purchases the relation between manufacturer and end-user was minimal. Nonetheless, the increased popularity of data processing, and the decreasing costs of mobile connections and sensors, are challenging the industry to change this model.

In the automotive sector it is important to understand nowadays supply chain to assess the impact of the GDPR implementation. The car manufacturers are commonly known as Original Equipment Manufacturers (OEMs), their focus in the cars design, assembling, promotion of models and ordering from vendors. These companies rely on Tier 1, 2 and 3 suppliers. We call Tier 1 suppliers to those companies that supply systems directly to OEMs. These companies work in close collaboration with the OEMs, although they usually provide systems to more than one car company. Tier 2 suppliers are experts in a specific domain, they do not sell directly to the OEMs. Tier 3 refers to companies that sell raw materials such as metal or plastic. Over this supply chain new services and products are being provided over the vehicle “product” such as finance, insurance or leisure services creating a new value chain. When the GDPR is applied to the product the collaboration between all parts becomes necessary.

OEM are now capable of learning from end-users driving behaviour and, hence, can be designed to better adapt these behaviours. Car maintenance can also be improved, by measuring and predicting the real status of the different mechanical pieces of the vehicle. A direct communication with the OEM would also allow them to prepare stock, reducing the time that vehicles spend in reparation. In general, manufacturers and suppliers will have a more active role on the operational, and customer-facing, aspects of the automotive market.

Nowadays, cars make use of cameras and proximity sensors and location services (GPS) to ease the driving experience. For instance, some vehicles can fully stop whenever an obstacle is too close during a parking manoeuvre. But a more in-depth leverage of sensorial data processing on always-connected vehicles could lead to fully automatize the transportation experience. Full

automation will not only improve the experience, but also could lead to a more energy-efficient transportation, safer roads[93], improved traffic flows and new shared transportation models[94].

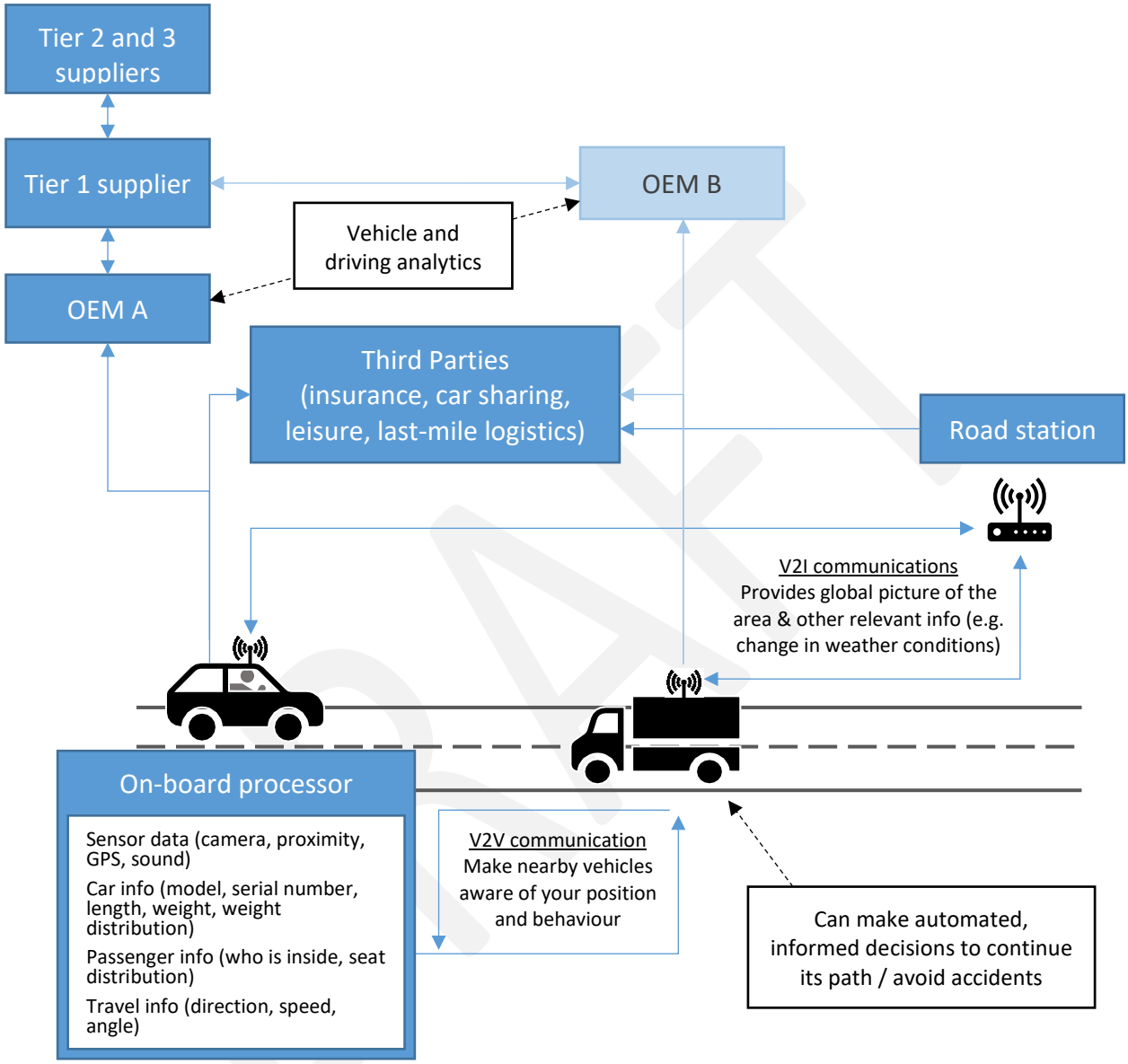

Figure 3 – High-level overview of the Vehicle-to-Vehicle (V2V) and Vehicle-to-Infrastructure (V2I) communications that are foreseen on the Cooperative Intelligent Transport Systems (C-ITS) framework, and other relevant parties. Communications with OEMs and other Third Parties are depicted on the top half of the diagram.

To materialize this vision, a set of vehicle-to-vehicle (V2V) protocols[95] have been designed to proactively share position and short-term intentions with other vehicles. Connected vehicles would then be able to understand their surroundings, act in accordance, and cooperate in case

[93] International Transport Forum report, "*Safer Roads with Automated Vehicles?*" (May 2018). https://www.itf-oecd.org/safer-roads-automated-vehicles-0

[94] PwC report, "*Five trends transforming the automotive industry*" (2018). https://www.pwc.nl/en/publicaties/five-trends-transforming-the-automotive-industry.html

[95] See specification of the Cooperative Awareness Basic Service ETSI TS 102 637-2 and the technical report ETSI TS 102 638, which also includes some uses cases of this protocol.

of conflict. Besides, it has also been devised that vehicle-to-infrastructure (V2I) communications can be deployed to provide further aggregated information (e.g. traffic congestion) and other relevant conditions on the area (such as change in weather conditions). Moreover, road stations could provide unbiased evidences in case of a severe infraction or during an insurance process. Figure 3 depicts the suggested communications between vehicles and infrastructure. A complete catalogue of use cases on top of such infrastructure has been prepared by the SCOOP@F project[96].

Despite the technical and policy revisions to the above-mentioned vision and protocols, there are still privacy and data protection concerns raised by DPAs such as the 'Berlin Group' which has published a Working Paper on Connected Vehicles[97], or the US Department of Transportation's PIA for vehicle-to-vehicle communications. A call for a holistic approach to privacy-by-design is needed as pointed out in the BearingPoint study[98].

3.2.1.1 Technical and organizational challenges

3.2.1.1.1 Personal data collected by vehicles

At first, it might seem that autonomous vehicles could easily avoid processing of personal data, as automated driving decisions do not necessarily need to consider anything about passengers' identities nor any other vehicle identifier (such as its serial number). Nonetheless, the behavioural information generated by the different sensors could be easily linked to specific individuals. As an example, it is known that one can identify an individual by the start and end of a trip, yet many engineers do not have in mind such data linkage when developing systems. Other useful information such as vehicle model, detailed length, weight and weight distribution might need to be carefully treated, as it could be used to locate the same vehicle in previous records, and even detect if there were noticeable differences in the passengers. In general, there is a high risk [44] that individuals not privacy-savvy might underestimate the importance of this behavioural data and hence hamper data subject's privacy.

3.2.1.1.2 Trade-off between road safety and privacy

Data processing use cases in the automotive sector highlights that, in some cases, it is unclear whether data controllers can completely mitigate privacy risks. Vehicle position, direction and speed seem to be indispensable information for intelligent systems to avoid traffic accidents. But, at the same time, this information could be misused by a malicious eavesdropper. It is, hence,

[96] SCOOP@F, C-ROADS FRANCE, INTERCOR. "C-ITS French Use Cases Catalog, Functional descriptions". Available at http://www.scoop.developpement-durable.gouv.fr/en/french-c-its-use-cases-catalog-a27.html

[97] Connected Vehicles, International Working Group on Data Protection in Telecommunications, 9-10 April 2018, 4, https://www.datenschutz-berlin.de/fileadmin/user_upload/pdf/publikationen/working-paper/2018/2018-IWGDPT-Working_Paper_Connected_Vehicles.pdf

[98] https://www.bearingpoint.com/files/BEI008_06_GDPR_Connected-cars-and-privacy-shifting-gear-for-GDPR_final.pdf&download=0&itemId=434626

assumed that data subjects need to sacrifice their privacy in favour of increasing road safety or obtaining any other major benefit.

The setup depicted in Figure 3 poses an extra threat to the data subjects' rights, as personal data is unencrypted[99] and broadcasted to all nearby devices and road stations. The limited processing capabilities of on-board systems and low-latency requirements make, in practice, unfeasible to hold a list of all devices that received such information. For legitimate use cases, vehicles and devices would not store data more than a few minutes because of storage limitations. But this does not preclude that a malicious user can hold data indefinitely.

This should not be an excuse to not implement privacy mitigation actions at all, as there might be technical and organizational measures (e.g. discretization to achieve some k-anonymization) that reduce the risk. The challenge to data controllers is to perform an analysis of the available countermeasures, understanding when a risk would be acceptable and explain the benefits and associated risks to the end-users (so that they are willing to give their explicit consent). The National Transport Commission also believes that further legislative protections might be needed to improve public perception[100] and limit law enforcement capabilities of governments.

3.2.1.1.3 Security to guarantee privacy and safety

In the case of connected vehicles, a poor cybersecurity and data protection plan does not only hamper data subjects' privacy but also their safety. Remote unauthorized access to the vehicle connectivity module could facilitate individual surveillance and, in extreme cases, alter the decision-making process to provoke vehicle accidents. In market study conducted by the Allied Market Research[101], data hacking is recognised as one of the main threats to the growth of the connected vehicles' market.

Security has become a key topic to develop for the automotive industry and the main standardizations bodies ISO and SAE have agree to cooperate in two areas: Road Vehicles and Intelligent Transportation Systems. The first result of this collaboration is the upcoming ISO/SAE 21434 standard for Automotive cybersecurity engineering. In this standard a common terminology for use throughout supply chain is defined, providing consensus on the minimum criteria for vehicle cybersecurity engineering.

3.2.1.1.4 Complexity of the automotive value chain

Figure 3 also highlights the complexity of the automotive value chain. Whereas OEMs are usually in charge of collecting the data from the vehicles, Tier 1 suppliers may also need to process some

[99] Messages in V2V would be unencrypted, but signed, to avoid latency. Signature is necessary to ensure that data has been emitted by a *trusted* device, whereas low latency would give extra time for vehicles to manoeuvre and avoid crashes. See specification of the Cooperative Awareness Basic Service ETSI TS 102 637-2 and the technical report ETSI TS 102 638 for more details.

[100] See National Transport Commission, "*Cooperative Intelligent Transport System*" (Recommendation 4) and "*Regulatory options for automated vehicles*" (Chapter 12),

[101] https://www.alliedmarketresearch.com/connected-car-market

of this information to improve their service. As we briefly describe in Section 3.2.1, knowing the overall status of vehicle could help these suppliers to prepare stock for future vehicle reparations. Tier 1 suppliers are not tied to a specific OEM; hence they may need to implement data governance tailored to the needs of each OEM, which may influence the data supplied to their Tier 2 and 3 suppliers. All this complexity will need to be understood, synthesized and simplified when the OEM asks for data subjects' consent. Other data controllers are depicted as Third Parties in Figure 3. It will also be important to understand when one of these Tier 1, 2 and 3 suppliers acts as a data controller or as a data processor. For instance, a leisure application that is pre-installed on a car may be considered a data processor when basic services (e.g. public TV channels) are provided but may act differently when the full service is provided (e.g. on-demand video).

3.2.1.2 Legal challenges

3.2.1.2.1 C-ITS from a legal perspective

Cooperative Intelligent Transport Systems (C-ITS) gather and send different types of data in different ways. Connected vehicles in this ecosystem broadcast Cooperative Awareness Messages (CAMs) and Distributed Environment Notifications Messages (DENMs) quasi-continuously. These messages are broadcasted to other vehicles (V2V) and/or to road infrastructure (V2I) with the aim of improving traffic safety and efficiency. They are signed but not encrypted, which allows for malicious actors to intercept messages and extract valuable data. CAMs contain different types of data; including kinematic data (e.g. car trajectories) and static data (e.g. car length and width). DENMs contain information (e.g. location data) on specific events for emergency situations (e.g. accidents).[102]

Although not apparent on first sight, these CAM and DENM messages contain extensive personal data. This includes data that can be directly linked to an individual; such as owner/driver data, location data, identifiers, and tracking via correlation of CAM certificates. CAM messages in particular could be used to identify natural persons in several ways. Timestamped CAMs contain location data which can reveal an individual's route from start to finish. This information can then be combined with other data in order to identify the owner/driver of the vehicle [44]. There is also data that could be indirectly linked to an individual; such as telematics data (e.g. speed, acceleration, etc.)[97] or by combining location data and static data (e.g. dimensions of a car). Although CAM messages pose the most privacy risks, DENM messages can also contain personal data. An individual could be identified on the basis of a DENM message in case of a very specific event that would allow for identification.[103]

[102] Opinion 03/2017 on Processing personal data in the context of Cooperative Intelligent Transport Systems (C-ITS), 4 October 2017, 3.
[103] Opinion 03/2017 on Processing personal data in the context of Cooperative Intelligent Transport Systems (C-ITS), 4 October 2017, 6.

It is important to note that article 10 of the GDPR is relevant in this situation. This article prohibits the processing of data relating to criminal convictions and offences unless it is processed under the control of official authority or when the processing is authorized by Union or Member State law. This means that in absence of these conditions; data falling under article 10 must not be collected and processed.[104]

3.2.1.2.2 Risks to privacy

The processing of personal data in the context of C-ITS poses several risks to the privacy of individuals:

(1) Location data can reveal a lot about an individual and allows for singling out of that individual. Personal driving behaviour will be collected and broadcasted to multiple parties, including nearby vehicles. This can result in a form of behavioural tracking, which can in turn create a feeling of surveillance.[105]

(2) The lack of transparency is another risk posed by this ecosystem. Data subjects need to be sufficiently informed about the processing activities and the broadcasting of that data. There is a real chance that the required information is not given to the right person (e.g. vehicle owner instead of driver). [97]

(3) There is also the risk of a lack of control over data. Data will be broadcasted to nearby peers and infrastructure in an unrestricted fashion. This can result in an information asymmetry between the sender and receiver of that information, as the sender will not have information about the receiver.[106] It is also possible that subsequent users of a vehicle have access to the data of previous users. [97] Data subjects should be in a position where they can exercise their rights and control their personal data.

(4) The value of the data in question is another important factor. Many different parties will be interested in kinematic and location data (e.g. car manufacturers, insurance companies, etc.). Unrestricted access to such data can result in the 'datafication' of driving for the purpose of offering goods and services.[106]

(5) Connected vehicles collect data in various ways. The use of sensors and/or wireless devices, if not contained, can result in the excessive collection and processing of personal data. Data minimization and purpose limitation are especially important to prevent such a scenario. [97]

(6) Another risk exists in the unauthorized use of the broadcasted personal data. Broadcasted messages can be intercepted and are thus not protected against access by (malicious)

[104] *Ibid*, 7.
[105] *Ibid*, 8.
[106] Opinion 03/2017 on Processing personal data in the context of Cooperative Intelligent Transport Systems (C-ITS), 4 October 2017, 8.

third parties. Law enforcement authorities could also be interested in using these types of data.[107]

(7) There could also be a lack of accountability between parties. The C-ITS ecosystem involves a number of actors which can qualify as data controllers and processors. This requires a responsible and transparent allocation of responsibilities between these entities. Some controllers may even qualify pieces of data as non-personal data.[108]

3.2.1.2.3 Legal basis

There exists a bit of uncertainty on what legal basis would be most suitable for the processing of personal data in the context of C-ITS. There are several legal grounds which seem to fit at first sight but might not be ideal in practice.

(1) Consent. Obtaining informed consent would be difficult in practice for several reasons. Consent would have to be granulated, taking into account the many different applications and purposes of processing. It is also possible that the data subject is not aware of the identity of the controller, which makes consent a difficult option.[109] In the end, consent is a possible legal ground if all conditions (section 2.5) are met. Consent must also be explicit in case of special categories of personal data (article 10 of the GDPR).

(2) Necessary for the performance of a contract. This legal basis is only possible in very specific scenarios where there exists a contract between the data subject and the data controller. This will, however, often not be the case. An example would be a contract with a private road operator.[110]

(3) Legal obligation. This is a straightforward ground that could be invoked if the controller is subject to the legal obligation to collect personal data in this context. The scope of data collection will depend on the law in question.[111] This could be a useful legal basis in the future; when Member States, or preferably the EU, decide to create a legal framework for C-ITS.

(4) Public interest. This legal basis applies where the processing of personal data is necessary for the performance of a task in the public interest. It is required that this necessity is laid down in national or EU law. Based on existing policies, the purposes of road safety and traffic efficiency could be considered as serving the public interest.[112]

(5) Legitimate interest. The legitimate interests of the controller or third party is another possible legal basis. This would require the controller to perform a balancing test; taking

[107] *Ibid*, 7.
[108] *Ibid*, 9.
[109] Processing personal data in the context of C-ITS, Data Protection Work Group of the C-ITS Platform, 1st March 2017, 26. Accesible via https://smartmobilitycommunity.eu/sites/default/files/images/2017.03.01_Processing_personal_data_C_ITS_context_vF.PDF
[110] *Ibid*, 27.
[111] *Ibid*.
[112] *Ibid*, 27-28.

into account the interests and fundamentals rights and freedoms of the data subjects. The application of this legal basis will depend on the accompanying balancing test, which can only be determined on a case-by-case basis.

Considering the unclear distinction between data controllers and processors, as well as the varying purposes for data processing, some legal grounds may be more suitable than others. The legal grounds of 'consent', 'performance of a contract', and 'legitimate interest' would be more difficult to rely on in practice. The most reliable ground would be the ground of 'legal obligation', but only if the EU decides to enact an EU wide legal instrument. Taking this into account, there currently is no real legal certainty as to what legal basis should be relied on.[113]

3.2.1.2.4 The application of the ePrivacy Regulation

The European ePrivacy Directive[114] aims to ensure the confidentiality of electronic communications. The proposed ePrivacy Regulation[115] seeks to extend this protection to all forms of electronic communications, including new electronic communication tools. The Regulation will replace the current ePrivacy Directive, resulting in greater harmonization and alignment with the GDPR. The ePrivacy framework is *lex specialis*; meaning that it will complement and override the GDPR in cases where it provides more specific requirements and conditions.

To what extent the proposed ePrivacy Regulation applies to connected vehicles is not yet fully clear. Article 2 of the proposal sets out that:

> *"This Regulation applies to the processing of electronic communications data carried out in connection with the provision and the use of electronic communications services and to information related to the terminal equipment of end-users."*

The concept of 'electronic communications service' is defined in Directive 2018/1972 establishing the European Electronic Communications Code:

> *"'electronic communications service' means a service normally provided for remuneration via electronic communications networks, which encompasses, with the exception of services providing, or exercising editorial control over, content transmitted using electronic communications networks and services, the following types of services:*
>
> *(a) 'internet access service' as defined in point (2) of the second paragraph of Article 2 of Regulation (EU) 2015/2120;*
> *(b) interpersonal communications service; and*

[113] Third High-Level Meeting on Connected and Automated Driving, Regulatory briefing paper, European Automotive and Telecom Alliance, 18 june 2018, 1-2, https://www.acea.be/uploads/news_documents/EATA_regulatory_briefing_paper-Data_protection_ePrivacy.pdf.
[114] Directive 2002/58/EC of the European Parliament and of the Council of 12 July 2002 concerning the processing of personal data and the protection of privacy in the electronic communications sector.
[115] Proposal for a Regulation of the European parliament and of the Council concerning the respect for private life and the protection of personal data in electronic communications and repealing Directive 2002/58/EC.

(c) services consisting wholly or mainly in the conveyance of signals such as transmission services used for the provision of machine-to-machine services and for broadcasting;"

Recital 12 of the proposed ePrivacy Regulation also notes that:

"Connected devices and machines increasingly communicate with each other by using electronic communications networks (Internet of Things). The transmission of machine-to-machine communications involves the conveyance of signals over a network and, hence, usually constitutes an electronic communications service. In order to ensure full protection of the rights to privacy and confidentiality of communications, and to promote a trusted and secure Internet of Things in the digital single market, it is necessary to clarify that this Regulation should apply to the transmission of machine-to-machine communications. Therefore, the principle of confidentiality enshrined in this Regulation should also apply to the transmission of machine-to-machine communications. Specific safeguards could also be adopted under sectorial legislation, as for instance Directive 2014/53/EU."

The ePrivacy Regulation will apply in case the provided service consists wholly or mainly in the conveyance of signals such as transmission services. Under the ePrivacy Regulation, service providers are limited in their choice of legal grounds. They would have to rely on consent every time they want to process certain types of data (e.g. metadata) because the other legal grounds are not part of the ePrivacy Regulation. Consequently, the performance of a contract or legitimate interest of the controller cannot be relied upon.

There exists a lot of uncertainty about the upcoming ePrivacy Regulation and changes are still possible. For this reason, no definitive answer on its applicability can be given at this time. Nonetheless, Vehicle-to-Vehicle communications might fall under the final scope of machine-to-machine communications protected by the ePrivacy Regulation. Future developments in the connected vehicles market will need to monitor and considered this regulation.

3.2.2 Smart Grid scenario

The Smart Grid is a world-wide challenge towards a more reliable, efficient and sustainable electrical grid. Electricity distributors and suppliers are experiencing profound changes and the impact on the final users is also evident. The times of manually reading or reconfiguring the electricity meter are gone. Smart meters automatically register and transmit the data through the Power Line Carrier (PLC) or wireless connections to data concentrators and central systems using Meter Data Management (MDM) Systems. Also, several services can be remotely applied such as changing the pricing policy or activating or deactivating the electrical service.

All the stakeholders in the value chain can benefit from the Smart Grid. End users are empowered through near real-time information (24 hours per day, 7 days a week) that they can use to adjust their consumption or change the pricing policy. Suppliers can perform profiling and provide innovative and personalized pricing policies that can be beneficial to avoid consumption peaks

or waste of energy [43]. Distributors have an effective tool to better monitor and manage their networks. In addition, smart metering promises to enable “prosumers” (both producers and consumers of energy) to be more easily rewarded for their contribution. The market around the Smart Grid includes big companies but also SMEs acting as distributors or suppliers as well as a dynamic market of third parties providing value-added services.

Data processed in a smart meter includes more than one thousand parameters and metrics such as the quality of the signal. but there is one metric of crucial importance for the privacy of a user: the electricity consumption, which is transmitted at very small intervals of time.

Energy consumption can be used for guessing the data subject habits, creating a personal behaviour profile, deducing personal and socioeconomic information, listing the existing electrical equipment and monitoring their usage, or guessing the presence, absence or current activity of the residents [6] [42]. Regarding the GDPR, it is conceived on top of the "*the respect for private and family life and home*"[116], and the definition of personal data includes the factors related to the "*economic, cultural or social identity of natural persons*"[117] among others. Therefore, energy consumption is personal data providing information of an identifiable natural person with great potential to be processed, solely or in combination with other data, for "*professional or commercial activities*"[118].

Other personal data such as the address, contact details, bank accounts etc. can be found in the Smart Grid context. However, these mainly appear in administrative or organisational processes such as the billing process of distributors, suppliers and third parties. These cases fall in the general category of privacy challenges for information technology services. The aspect that makes the Smart Grid special regarding privacy concerns is the energy consumption, the possibility to associate it with a data subject, and the consequences of disclosing these personal data or its usage without consent.

Electricity consumption is usually represented as a time series where [13] time is presented in the horizontal axis and the energy consumption, in watts, is presented in the vertical axis. The shape of the time series will be then defined based on the appliances used, or not used, in the daily lives of the residents. Several techniques for time series analysis can be then performed such as time series classification or forecasting [25]. A taxonomy of Smart Meter data analytics is available [42]. Figure 4 is an illustrative example of a time series from the Google PowerMeter project (discontinued in 2011) [13] which, once integrated with smart meters and with the appropriate consent, allowed the users to record and visualise their own electricity consumption.

[116] Article 7 of the Charter of fundamental rights of the EU
[117] Article 4(1) of the GDPR
[118] (18) of the GDPR

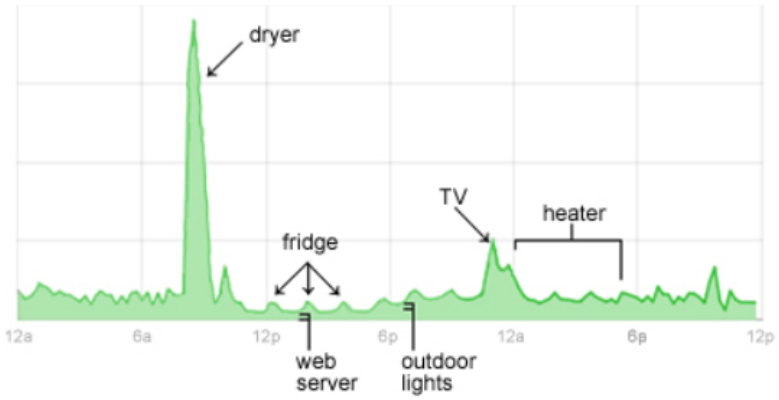

Figure 4 – Illustration of a time series of electricity consumption [13]

Each appliance has an electricity load signature which can be used to differentiate its shape from other appliances. For example, in Figure 4 we observed a peak corresponding to a dryer, and smaller and periodic peaks corresponding to a fridge. If the appliance can be configured by the user or if the circumstances change, this signature can be modified to some extent. Figure 5 [30] shows energy consumption time series for one hour and a half period where both Figure 5a and Figure 5b correspond to a Hotpoint washing machine. The former corresponds to a 40 ^{o}C cycle, and the latter to an 85 ^{o}C cycle. This practice of using energy consumption and appliance load signatures for nonintrusive load monitoring (NILM), or nonintrusive appliance load monitoring (NIALM) was already identified as problematic regarding privacy when the technologies enabling it started to appear [18].

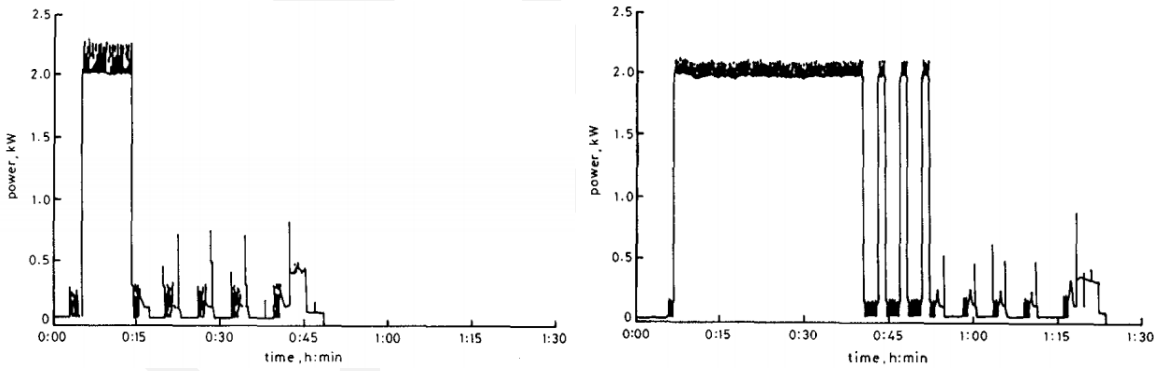

Figure 5 –Two time series of electricity consumption of the same washing machine using the 40ºC cycle and the 85ºC cycle [30]

Automatic analysis of time series was also used by Greveler et al. [15] to show how the information about which TV channel you are watching can be disclosed through smart meter power usage profiles. Given the brightness of the TV screen, a consumption prediction model can be defined and used for each channel, and compared with the actual consumption. Figure 6 presents the electricity consumption (solid line) for the first 5 minutes of the movie Star Trek 11, while the dashed line shows the prediction. This research concluded that a sample taken each 0.5 seconds during five minutes is in many cases sufficient to identify the viewed content. As an

example, a person's interests can then be guessed through the viewed contents and used for professional or commercial purposes.

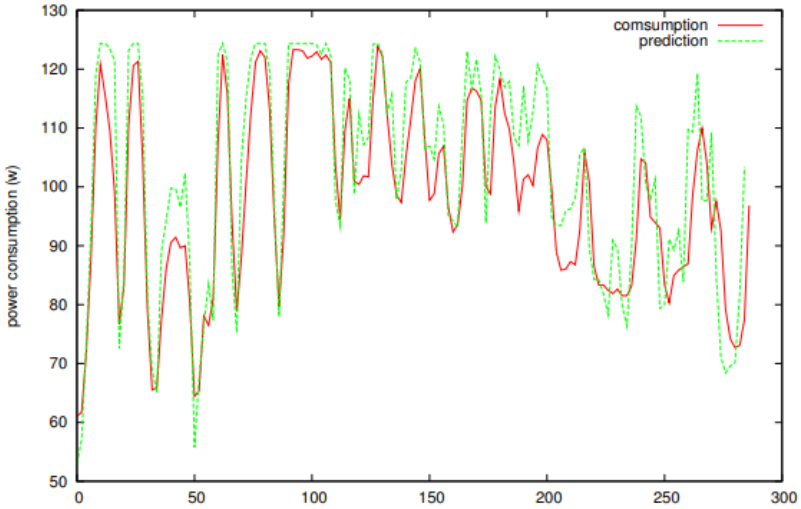

Figure 6 – Actual consumption and prediction model from a TV displaying the first five minutes of Start Trek 11 [15]

The simultaneous use of several appliances can make it difficult to automatically analyse time series (e.g., accumulative effect of energy consumption). However, this effect can be minimized if the load signatures were isolated at some point in time or through approximation techniques. A review by Wang et al. [42] of Smart Meter Data Analytics presented different applications and ten open data sets of smart meter data.

The Smart Meter, with its serial number (unique identifier assigned to the individual piece of hardware), MAC address (Media Access Control address, a unique identifier used as a network address for the data link layer), and the CUPs (Universal Supply Point Code; a unique identifier for each home or business electricity supply point which does not change in case of selecting a different supplier or energy consumption tariff) represent the different identifiers, which can be used to link a data subject with its electrical consumption. Figure 7 illustrates, at high level, how the data about the energy consumption is transferred in a Smart Grid scenario. The measures from the Smart Meter, including its identifier, are usually transferred through the Power Line Carrier (PLC) to a Data Concentrator. These concentrators, usually one per neighbourhood, are the intermediary points in the transmission to the distributor central system for around three hundred smart meters. PLC does not perform well in data transmission for long distances, thus, in case of remote locations, more expensive solutions should be put in place such as P2P protocols to send the data directly to the central system without the need of a data concentrator. The data concentrator might use PLC, General Packet Radio Service (GPRS), ftp, or web services to communicate with the central system. For more details we refer to a survey on Advanced Metering infrastructures [29].

The arrows are bidirectional, because the central system can remotely monitor and actuate in the smart meter through these protocols to respond to customer requests in real-time, change

date/hour, tariff or power demand threshold change, or other operations without customer request such as a power cut-off or adjusting certain Smart Meter metrics.

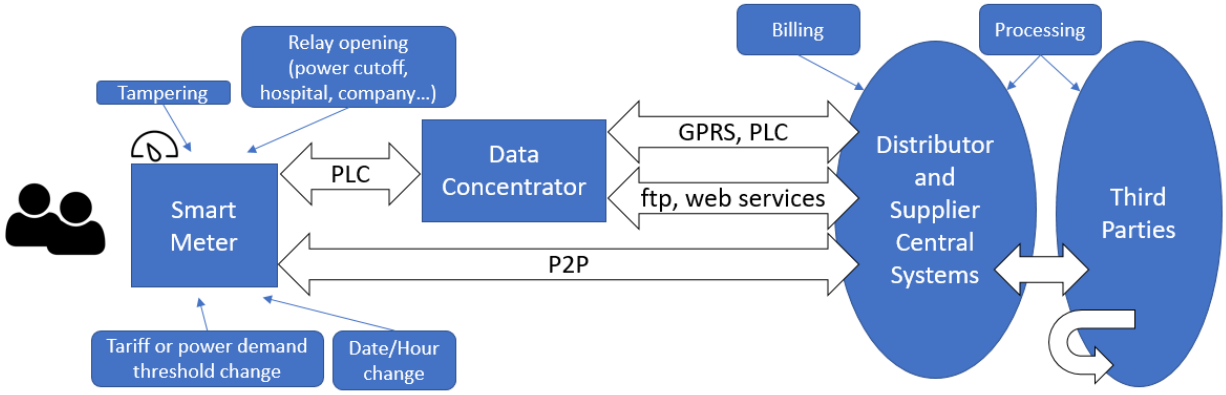

Figure 7 – High level illustration of the flow of information about energy consumption from a Smart Meter

The data is encrypted (e.g., AES 128) and Smart Meters that transmitted unencrypted data are being slowly replaced. As part of the billing process, both the distributor and the supplier share the customer's physical address, energy consumption metrics and the smart meter identifier (e.g., CUPs). Distributors and suppliers process personal data and they might transmit this information for further processing to third-parties (e.g. for business purposes or to improve the quality of service).

3.2.2.1 Technical and organizational challenges

3.2.2.1.1 Consent and data transmission

Among other benefits related to the sustainability of our environment, the Smart Grid was conceived as a new field to create innovative value-added services and businesses. In this context, data can be transmitted to third parties and the management of this consent might be technically difficult. The extent to which data subjects want to provide their data should be clear. A restrictive consent form could be limited to the distributor and the supplier and strictly for billing purposes. Other smart meter users can currently volunteer to be exhaustively monitored to receive offers from suppliers or to change the most adequate pricing policy from a supplier. The transmission to third parties can be used to have extended services or for marketing purposes.

3.2.2.1.2 Combined physical and digital security

Convergent security analysis (physical and digital) is needed to guarantee the privacy of the data subject. NIST [31] refers to it as combined cyber-physical attacks and they can affect also privacy concerns. Smart Meters are usually located in a shared place for several apartments. As examples

of security threats on a Smart Grid scenario, we can mention physically accessing to the smart meter, watching the visible display with the counter, observing the residence or identifying the names in the post boxes. These are actions that can make obvious the mapping between the energy consumption and the associated person. Smart Meters do not need the visible displays, but they are equipped with them and they also use to include a LED. This LED, which blinks more when the power consumption is higher could be used, not only to guess the power consumption, but also to associate a Smart Meter with a person if we can mix the physical observation of the residence with the blinking of the LED for singling out an apartment among the different apartments. While this kind of activities seems to be more related to modern approaches for the preparation of a burglary, their usage for professional or commercial purposes might not be discarded. Also, the operators from the distributor or the supplier have access to several personal information, so privacy adherence by operating personnel must be guaranteed.

3.2.2.1.3 Data minimisation of energy consumption data

The controllers must guarantee that third-party processors have the minimal amount of data to perform their processing. In contrast to other scenarios where this usually consists in not transmitting some columns from a database, the data minimisation of the energy consumption is different and requires manipulating the time series in different ways. A usual technique is to modify the resolution of the data. For example, the data with a time interval of seconds might not be needed, but maybe only each hour or just the global for a whole day or week. Some works suggest that a frequency of 30 minutes is sufficiently reliable for most purposes [14] while hiding the operation states of most of the appliances. Several works also explore the trade-offs between privacy and the needs of Smart Grid data mainly by investigating different data resolution schemas and load shaping [10] [22] [34] [35], but this research field is still considered to have many open challenges.

The data minimisation could be also performed in early phases (e.g., in the Smart Meter) considering the needs of processing in the whole chain from which the data subject gave his or her consent. Failing to guarantee data minimization, in top of being non-compliant to the GDPR and thus exposing the controllers to fines, could have the consequence that Smart Grid users start adopting techniques to preserve their privacy such as charging and discharging batteries [33] or the use of load shaping with storage and distributed renewable energy sources [22].

3.2.2.1.4 Security to guarantee privacy

The TACIT project [37] studied the different cyber-attacks that can take place in a Smart Grid scenario: Denial of Service (DoS) (e.g., sending large amount of data so that the device is overloaded and it is incapable of answering legit requests), untrusted and fraudulent firmware or software in the Smart Meter (which can be updated through close proximity wireless communication protocols such as ZigBee), identity theft, retrieved password from the supplier, attacks in the accountability and billing systems, attacks in the ICT solutions (e.g., Meter Data

Management (MDM) Systems), attacks to physical assets and communication sniffing. DPDbD should provide solutions to solve or mitigate the impact on privacy regarding the different attacks.

3.2.2.1.5 Energy consumption role in the Internet or Things (IoT)

The energy consumption is a relevant measure to satisfy the promises of the IoT in different contexts such as the Smart Home, Smart City, or the IIoT (Industrial IoT). This way, the devices can decide when to charge, operate, or shut down, to be more cost and energy efficient. The automatic and unsupervised use of this data by the inter-connected devices can be problematic. This is a challenge which is not specific of the Smart Grid, but the Smart Meter can be an inter-connected actor providing this metric as well as other data such as the current pricing policy to other actors. Though coordination mechanisms between machines can be established (e.g., formal and verifiable interfaces following Design by Contract principles [28]), devices disclosing data or transferring data without consent (e.g., to the manufacturers) might happen. IoT manufacturers are very diverse and it is not possible to control which devices will be part of the network at the design phase. Still they might need to transfer data between them (e.g., to accomplish their mission or to provide better and more efficient services) with the consequence of complicating the consent management for the data subject each time a new device is added. In addition, while the Smart Meter might be related to the controller for the energy consumption and the energy pricing policies, other IoT devices might be related to the controller of other type of personal data which will need to be aggregated to provide new or enhanced services.

3.2.2.1.6 Energy availability over data subject privacy

The order of priority regarding security in a Smart Grid scenario is: DoS attacks, Man in the middle/Sniffing and intrusion to the servers [37]. DoS has higher priority than sniffing because the availability of electricity is safety critical. In other scenarios such as a non-critical web page providing some service, a data breach can be stopped by shutting down the service until the security patch is in place. In the Smart Grid, shutting down the availability of electricity can have uncontrolled or catastrophic consequences (e.g., critical infrastructures connected to the Smart Grid might be affected). In a hypothetical case of a data breach, a higher priority may be given to the availability of the service. The trade-offs between disclosing personal data or cutting off the electricity should be investigated with appropriate risk assessments (e.g., the Data Protection Impact Assessment[119] mentioned in the GDPR). Microgrid operations or islanding (autonomously providing power to a location without being connected to the main electrical grid) is being investigated to mitigate cyberattacks and cascading effects [16] [31].

[119] Article 35 of the GDPR

3.2.2.1.7 Data portability among Smart Grid actors

When a citizen wants to change electricity provider, portability must allow the individual's personal data to be transferred directly to the new chosen company, in a simple way for the end user. This might include the historic of energy consumption.

3.2.2.1.8 The right to be forgotten in the Smart Grid

After a data subject request, it is technically challenging to guarantee the removal of the energy consumption information from all the Smart Grid actors. As in many other scenarios, the processing chain is complex (as shown in Figure 7) and coordinating the processing actors and validating a complete removal might require advanced operations. There is also an issue in removing consumption metrics as the data might be needed during the billing process. Therefore, the removal will have to take into account when, how and which data should be removed from each processing party. Finally, in the context of IoT mentioned in a previous challenge, there might be connectivity issues that disconnects the controller from a device for long periods of time, making difficult the actual and timely removal of the personal data.

3.2.2.1.9 Data fusion for more effective Smart Grid data analysis

The analysis of Smart Grid data such as personal energy consumption prediction and forecasting can be enhanced if other data sources are combined with the historic of energy consumption. A typical influential factor in predicting the consumption are weather conditions. However, there are other sources which might contain private data such as the location, age and gender of the occupants, socio-economic parameters like the income level, employment status, education level, whether they are the owners of the house, the number and type of appliances, or the number of pets (cats, dogs etc.) in the residence. Several studies are trying to identify which are the relevant variables which are worthy to use for the different analyses [17] [21] [27]. While some of these data sources might be discarded, others might be highly valuable for the Smart Grid data processors which might want to have access and get a consent for its usage (e.g., for providing better or new services).

3.2.2.1.10 Child's place of residence

The processing of the energy consumption data of a child (which can be isolated from the different residents using advanced techniques or guessing what corresponded to the child), for marketing or professional purposes should be controlled as they are more vulnerable. Therefore, special attention should be paid for the consent management where the residents include minors. This information might be not relevant for the electricity provider themselves, but it can be for other third-parties interested, for example, in appliances' usage.

3.2.2.2 Legal challenges

The digitalization of the energy sector presents a lot of advantages for the citizens, the environment and our economic growth. Furthermore, the free flow of personal data within the Single Market is essential for the functioning of smart meters and smart grid applications. Nevertheless, the Smart Grid scenario presents a multitude of challenges to the GDPR. Essentially, the challenges include the large amounts of data that can be extracted from the meter, giving a very precise profile of the user, data flows that should be ensured to the maximum, as well as the mandatory consent of data subjects before transmitting the data to third parties.

The dangers and limits of profiling have been previously examined (see section3.2.1.2.1). In the Smart Grid scenario, **profiling is extended to larger proportions since one can single out what the person is doing every hour of the day**. This is an important interference to the right to data protection, the right to privacy and the right to self-determination. Consequently, not only should energy providers limit the amount of data collected and use encryption methods as already suggested, but they should also highly ensure security of the meters.

3.2.2.2.1 (Cyber)security and smart meters

Physical security can be ensured by limiting the access to the meter, avoiding showing the data or maybe requiring an access code to see the data. However, as such Smart-Grid technologies require network connectivity, ensuring cybersecurity will be of paramount importance. Cyberattacks have caused important problems for the energy sector.

The EU has tried to address the issue with the Network and Information Security (NIS) Directive[120] that provides for different measures for harmonization of national laws of the Member states but there will still be discrepancies. The Directive applies to the energy sector and contains a list within an annex on of the types of energy sector organisations that could be considered as operators of essential services, although the appropriate measures that they should take in order to reinforce security and mitigate risks are not mentioned within the legal text. A risk is recognized as "*any reasonably identifiable circumstance or event having a potential adverse effect on the security of network and information systems*"[121]. Therefore, energy providers should implement a threat and risk management system, establish an effective incident response network, improve resilience to cyberattacks and ensure technical and human intervention in order to address such issues[122]. Moreover, the European Commission has provided the industry

[120] Directive (EU) 2016/1148 of the European Parliament and of the Council of 6 July 2016, concerning measures for a high common level of security of network and information systems across the Union

[121] Article 4 (1) of the NIS Directive

[122] Energy Expert Cyber Security Platform (EESCP), Recommendations for the European Commission on a European Strategic Framework and Potential Future Legislative Acts for the Energy Sector, February 2017, https://ec.europa.eu/energy/sites/ener/files/documents/eecsp_report_final.pdf

with recommendations on how to address such **risk impact assessments for smart metering systems** and smart grid applications[123].

Additionally, operators are asked to report incidents that affect the security, integrity and confidentiality of the service, if such incidents have a "significant disruptive effect on the provision of an essential service". With regard to energy suppliers, such factors could include the volume or proportion of national power generated[124]. In assessing whether an incident is "significant", providers should consider a number of factors including the number of persons affected, the impact on economic activities or public safety, the dependency of other sectors on the electricity provided by the smart meters and the geographic area affected. We can imagine for example that an incident that affects houses during work hours would be of less significance that one affecting a hospital. However, given the omnipresence of electricity for almost every activity of our daily lives, most of the incidents can have significant effects and disruption of the service should be rarely considered. In that aspect, it is suggested that under the condition that such measures are proportionate and transparent, public safety will often overrule protection of personal data.

The expansion of smart energy and smart meters has allowed rapid growth of networked intelligence. Consequently, smart meters are a part of a massive "*attack surface*" and are exposed to security failures. As electricity supply is also conditional to every other critical infrastructure network, the cyber security threat to the energy sector impacts the whole society. Ensuring data protection considerations from the design of the meters can allow for a safer society for all. However, security failures can originate from interconnected devices in one household solely, due to complications arising from the Internet of Things.

3.2.2.2.2 Data flows through smart devices

The Internet of Things refers to the connection of devices (other than typical fare such as computers and smartphones) to the Internet[125]. As the next step to the digitization of our economy or our society[126], the Internet of Things has also interested the EU institutions[127]. Any device that can be connected to the internet and be monitored and/or controlled from a remote location is considered an IoT device. IoT devices can collect and exchange data using embedded sensors, providing for a more personalized service.

A global network of interconnected smart devices that exchange data, can improve the quality of the personalized service provided being an advancement for consumers, public authorities

[123] 2014/724/EU: Commission Recommendation of 10 October 2014 on the Data Protection Impact Assessment Template for Smart Grid and Smart Metering Systems

[124] Recital 26 of the NIS Directive

[125] For more info on what is The Internet of Things : http://uk.businessinsider.com/what-is-the-internet-of-things-definition-2016-8?r=US&IR=T

[126] See the policy expectations of the European Commission on the Internet of Things : https://ec.europa.eu/digital-single-market/en/internet-of-things

[127] See the Communication of the European Commission on Standard Essential patents that provides a clearer framework in order to incentivize the development of key technologies, COM (2017) 712 of 29 November 2017.

and businesses. Kitchen appliances, light bulbs, cars or health devices can exchange data in order to make our lives easier, and the potential of the IoT resembles a futuristic reality. As our lives become more and more digital, the IoT becomes part of our everyday activities. However, not only does interconnectivity offer a more expanded network that can more easily come under (cyber)attack, in reality this plethora of data can be available to persons that are not authorized for it, and without the consent of the data subject. Vulnerability is exacerbated by the low security standards monitored on some devices, so manufacturers should provide for stronger safeguards from the design phase. It is reminded that controllers are obliged to choose manufacturers that provide for privacy friendly solutions.

As it appears that home devices are the most vulnerable[128], Smart meter data that can be accessed by such devices are even more prone to security flaws. Even if the meters themselves are fully compliant with the law, their connection to other devices makes them more vulnerable. However, given the advantages of the Internet of Things, solutions must be found in order to enhance security. Codes, secure keys or chips can make it more difficult to access these devices, as well as to extract information from them. Further works can provide for security checks before such devices are available on the market.

3.2.2.2.3 Data ownership

Data ownership and business to business re-use of data issues are not defined by the current EU legal framework and are subject to national law cultures and limitations[129]. Transferring data to third parties requires the data subject's consent, unless a national or European legislation enforces the provider and/or controller to do so (see previous analysis). However, transfers for business purposes are considerably more limited than transfers for ensuring safety or resilience of the service. Given the sector of this scenario, we can imagine more limitations to the right to data protection since electricity is vital to the functioning of society, although risks should, in any case, be assessed in advance and mitigated to the extent that it is possible. It is vital to obtain consent of the data subject even if data transfers ensure simply personalized pricing that avoids energy waste and environmental-friendly solutions. Further works in implementing tools enabling privacy by design might then need to focus on the specificities of certain EU Member states.

3.3 Consolidated list of stakeholders' needs

Need	More information in section

[128] http://www.itsecurityguru.org/2016/09/22/poor-security-is-holding-back-the-internet-of-things/

[129] Study on emerging issues of data ownership, interoperability, (re-)usability and access to data, and liability. https://ec.europa.eu/digital-single-market/en/news/study-emerging-issues-data-ownership-interoperability-re-usability-and-access-data-and

To **integrate the necessary safeguards** into data processing taking into account the state of the art, cost of implementations, the scope and nature of processing and the risks to the freedoms of the data subject.	2, 2.3, 2.4.1, 3.1
To implement technical and organisational measures for ensuring that personal **data collection and usage is minimized to the specific purpose of processing**. The controller may assess if the same purpose can be achieved by recollecting fewer personal data.	2, 2.2.3, 2.5, 3.2.2.1.3, 3.2.2.1.9
To **determine how and when personal data is processed**, prior to start personal data recollection.	2.2.2, 2.5
To **identify processing of non-trivial personal identifiable information**, such as geolocation and energy consumption that could identify data subjects when linked with other sources.	2.3.1, 3.2.1.1.1, 3.2.2.1.3
To determine the purpose of the data collection, and **assess if further processing activities are compatible with the initial purpose**.	2.2.2, 2.5, 3.2.1.1.4, 3.2.2.1.9
To **adopt** data protection policies and **measures in early phases of the development**.	2, 3.1, 3.2.2.1.4
To validate that any processor takes into account the right to data protection. **Controller and processor need a common vocabulary and methods to ensure legal compliance** of products and services.	2, 2.4.1, 3.2.1.1.4
To **effectively communicate all processing activities to data subjects** and notify them of any changes in the original setup (for example, as a consequence of a data breach or change in a third-party processor).	2.2.1, 2.5, 2.6.2, 3.2.1.1.4, 3.2.2.1.1, 3.2.2.1.5
To create data processing pipelines that are **traceable and documented**. Tracing might include third party services and cloud providers in a complex multi-stakeholder value chain.	2.2.1, 3.1, 3.2.1.1.4, 3.2.1.1.2
To maintain a **detailed explanation of the processing activities** for the data subject and other authorities.	2.2.2, 2.5, 3.2.1.1.4
To **demonstrate that consent was freely given** and is still valid.	2.5.1
To create mechanisms to **ensure that personal data contains no errors and it is always up to date**. Other controllers and processors should be notified of data updates.	2.2.4, 3.1, 3.2.1.1.4
To ensure that **data is not stored more than necessary**, as well as outdated data is permanently removed.	2.2.4, 2.2.5, 3.2.1.1.1
To **limit access to personal data to those strictly necessary**.	2.2.6
To have procedures to **inform the necessary actors of any data breach**. Moreover, data controllers and processors need	2.4.2

to implement any appropriate mechanism to detect suspicious accesses or data leakages.	
To implement the necessary mechanisms to ensure the data subjects' **rights to be forgotten, of access, of data portability and to object**.	2.6.1, 2.6.3, 2.6.4, 2.6.7, 3.1, 3.2.1.1.1, 3.2.2.1.7, 3.2.2.1.8
To **assess the impact that automated decisions** can have in the data subjects' privacy, life and environment.	3.2.2.1.2, 3.2.2.1.6
To **integrate privacy and data protection in the software development process**. Privacy requirements should be defined and tested their implementation prior to processing of personal data.	3.1.1
To **establish formal application security procedures**, including mechanisms to update outdated third-party libraries, and review risks and vulnerabilities.	3.1.1
To **update and coach development actors on the latest security practices**.	3.1.1

4 Conclusions

The document provided a description of the privacy and data protection needs as elicited by the actors targeted by the PDP4E project. In particular, the document provided:

- A legal analysis of the requirements elicited from the regulation, including:
    - requirements and constraints when collecting personal data (see section 2.2) and data subjects' consent (sec. 2.5);
    - the need for considering privacy and data protection risks in early stages of the software development (sec. 2.4.1);
    - the new obligations for the data controller (sec. 2.4), who is responsible for protecting the personal data and privacy of data subjects; and
    - a description of the new data subject's rights introduced by the GDPR (sec. **Erreur ! Source du renvoi introuvable.**);
- A description of the impact of the DPbD principle in the software development process and the actors involved (sec. 3.1.1);
    - Including a preliminary analysis of how the PDP4E tools support development actors in achieving their new responsibilities with respect to privacy and data protection;
- A summary of the organizational challenges that most companies and institutions have faced (and are currently facing) to comply with the regulation (sec. 3.1);
- A first introduction to the two verticals targeted by PDP4E (sec. 3.2) for the evaluation of the project, including:
    - a description of the processing activities that both verticals face in their daily activities (sec. 3.2.1 and 3.2.2); and
    - a vertical-specific summary of the technical and organization challenge (sec. 3.2.1.1 and 3.2.2.1), as well as a deeper legal analysis that takes into consideration other regulations and directives (sec. 3.2.1.2 and 3.2.2.2);

We have also seen that:

- The regulation puts a lot of emphasis on recollecting explicit consent from the data subject for allowing specific use of their personal data (sec. 2.2.2 and 2.5.2). Yet, as many organizations are transitioning to decentralized processing scenarios (sec. 3.2.1.1.1, 3.2.1.2.1 and 3.2.2.2.2), industry is struggling to figure out how they must recollect such consent (sec. 3.2.1.2.3 and 3.2.2.1.1) and how to enforce that there is no unauthorized usage by any of the involved processing actors.
- Organizations must have a proactive approach with respect to safeguarding privacy and data protection of the data subjects (sec. 2.4.1). The software engineering discipline has been recommending such approaches (when talking about data protection) and some changes in the development process have been recommended (sec. 3.1.1.1).

Nonetheless, this requires a slow, behavioural change on all the development actors, hindering the adoption of such proactive approaches.

- The GDPR empowers European citizens with new rights (such as the right to be forgotten, to be informed, to data portability, and to object) to have more control over their privacy. Yet, many organizations are struggling to fulfil a more essential requirement: finding all personal data linked to a data subject (sec. 3.1, 3.2.1.1.1, 3.2.2.1.8 and 3.2.2.2.2). Without the ability to effectively find this information, European citizens will not be able to make use of their rights.
- The rise of IoT devices poses new privacy threats (sec. 3.2.1.1.3, 3.2.2.1.2, 3.2.2.1.4 and 3.2.2.2.1). Due to the proximity of the devices to the physical space surrounding data subjects, accurate behavioural profiles can be created (e.g. geolocation, driving behaviour, family members in a house) and automated decisions can have a direct impact on the data subject's environment (e.g. cutting off electricity).

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