# A Taxonomy to Harmonize Actors, Rights, and Obligations across AI and Data Regulations

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**Abstract.** European Data and Artificial Intelligence (AI) laws use natural language to dictate norms and define the rights and duties of citizens and organisations. Defining and enforcing each law creates challenges in the coherence and consistency of enforcement due to overlapping and potentially conflicting requirements. This risks a fragmented law implementation, which can reduce innovation and the upholding of rights. To address this, it is necessary to first identify the overlaps between relevant laws in terms of the actors, their roles, the rights and when they apply, and the obligations to be fulfilled. Furthermore, harmonising these concepts can reduce the efforts to enforce cross-regulatory compliance and ensure future laws are aligned at the design stage. This doctoral research presents the methodology for implementing a cross-regulatory ontology using semantic web technologies and addresses the need for such research in light of the European Union (EU) omnibus simplification proposal.

**Keywords:** Legal Ontologies · Taxonomy Harmonisation · Regulatory Interoperability · EU Data and AI Regulations

## 1 Introduction

European digital governance is exposed to complexities in global regulations and technology advancements, especially with the proliferation of Artificial Intelligence (AI) and data-driven technologies. Policy makers and public authorities, who must promote progress while ensuring the technology impact is done responsibly, are also influenced by incidents due to technologies developed with limited oversight, affecting the rights and freedoms of individuals and organisations [24].

European regulations address specific concerns, such as data protection with the General Data Protection Regulation (GDPR)[1], data access with the Data Act (DA)[2], and AI with the AI Act (AIA)[3]. They include cybersecurity requirements through the Network and Information Security 2 Directive (NIS2)[4] that must be implemented in Member States. These frameworks, acknowledge the existence of others in their texts, but lack interoperability as they are expressed in

[1] https://eur-lex.europa.eu/eli/reg/2016/679/oj/
[2] https://eur-lex.europa.eu/eli/reg/2023/2854/oj
[3] https://eur-lex.europa.eu/eli/reg/2024/1689/oj/
[4] http://data.europa.eu/eli/dir/2022/2555/oj

natural language with diverse legal terminologies (for concepts of rights, obligations), formats, and enforcement mechanisms, creating "semantic fragmentation", constraining their practical efficacy. They function separately and regulate different aspects of the same process or system, yet they create potentially repetitive and unaligned obligations, making it difficult to coordinate compliance efforts. Regulations apply directly (i.e., become a law in Member States immediately when enforced) and identically (i.e., provide a uniform set of rules) in Member States, bypassing demands for national legislation, whereas Directives, as binding legislative acts, define a mandatory goal, but let EU countries determine the approach to achieve it, and adapt the rules to their national contexts. This compromises legal uniformity as the goal is subject to distinct interpretations. Despite the regulations' harmonising intent, the structural gaps between them reshape how users and organisations benefit from them. The "Digital Omnibus" [8] addresses some of this normative fragmentation by combining laws and obligations such as for the DA, or to dilute obligations such as for the GDPR and the AIA. However, these problems persist as laws largely remain the same.

This PhD focuses on AI and EU Data regulations to address semantic fragmentation by mapping terminologies across laws and identifying ways to harmonise them to handle normative fragmentation. While existing compliance tools [12, 3] and legal ontologies [25] have been developed – they interpret narrowly the GDPR requirements and do not investigate the wider issue of overlaps and gaps across regulations. This work will examine how ontologies can be a foundation for their identification and addressing. The outcomes will provide the semantic layer needed for the development of a Regulatory Technology[5] to address EU's complex legal framework, ensuring legal provisions do not operate in isolation. This framework presents a multifaceted challenge and the work proposed can be a step towards improving the EU laws' accessibility. Artefacts to be produced, covering: a legal analysis with concept extractions per regulation in lists; a cross-regulatory analysis with findings, mapping law intersections; a website for work dissemination, can further support it. Ultimately, this doctoral work aims to contribute to regulatory interoperability by aligning fundamental rights and obligations, simplifying compliance enforcement, and defining a blueprint for subsequent regulatory development by policymakers.

## 2 State of the Art

### 2.1 Legal Domain

EU laws shift from sector-specific rules to a cohesive set of rules. It is argued that this constitutes an embodiment of digital constitutionalism, where the digital realm is reshaped by the principles for legal processes and human dignity [25]. The "Act-ification" makes this operational [32]. Conversely to periods when Directives superseded, the present regulatory landscape is characterised by a "hexagram" of Acts [9]. An analysis of the EU digital information ecosystem

[5] https://www.fca.org.uk/firms/innovation

presents the term as a framework of key pillars (regulations) of EU Digital Law [9], aiming to safeguard established rights and regulatory rules. It is further aligned with work on digital oversight, emphasising the uniform embedding of regulations and ethical norms in the technical and procedural efforts to govern digital technology [33]. The "hexagram", thereby, covers regulations, grouped by fundamental rights (AIA, GDPR), data package (DA, Data Governance Act (DGA)), information security (NIS2 Directive, Cybersecurity Act (CSA), Cyber Resilience Act (CRA)), online platforms (Digital Service Act (DSA), Digital Market Act (DMA)) and product legislation (new legislations) [15]. They are cornerstones for transforming regulations, defending human rights and freedoms, whereby the GDPR underpins emerging Acts (e.g., AIA as an extension for systemic risk control and human rights safeguards).

Such replications are termed as "GDPR Mimesis" [32], forming a reliance between regulations to an extent. While obligations and rights under the GDPR persist when the AIA operates, actors may face colliding requirements. GDPR Art. 9 prohibits special data processing (e.g., biometric), whereas the AIA Art. 10(5) permits it for bias detection and correction in high-risk systems with safeguards in place. This tension arises as the GDPR requires exceptions (e.g., explicit consent) for such processing. [15]. Terminology describing risks and harms is also inconsistent. The GDPR outlines risks concerning natural persons' data rights and freedoms, whereas the AIA focuses on safety, health, systemic fundamental rights and product safety [15]. An interplay between the GDPR, the AIA and the NIS2 Directive occurs as overlaps in incident reporting, risk management and cybersecurity measure applications [15]. This demonstrates that a cross-regulation perspective is important to reveal convergence, divergence, and coordination challenges [10, 37].

Current work addresses methodologies for term alignment. They combine expert legal analysis with computational methods to extract concepts or propose terms aligned with the context of extracted ones to achieve consistency [6]. Semantic approaches exist [1], yet doctrinal work on term alignment processes across regulations is scarce. The focus is on the regulatory interplay explanation.

### 2.2 Ontological modelling of laws

The Legal Knowledge Interchange Format (LKIF) provides a reusable ontology of concepts, differentiating normative knowledge presented as legal rules from entities, extended for domain-specific uses such as building a semantic representation of rights, permissions, obligations, definitions, and concepts of interest to an actor [19]. For the "hexagram" of laws, most work is GDPR focused. This includes addressing its' representation as a taxonomy and a linked data resource [31], and a framework for modelling its concepts for legal reasoning and compliance checking [20, 29]. Other work annotates privacy policies using ontologies [27], and represents privacy requirements [14]. Existing work models AI system risks [18], fundamental rights impact assessments [35], risk assessments [17], and concept alignments with ISO standards [18]. For the DA, rights and obligations are ontologically modelled [23]. Text extraction aids in developing knowledge

graphs [7] and ontologically representing NIS2 concepts [4, 5]. Furthermore, the Special Project (H2020) produced a machine-readable log vocabulary for actors and processing events, utilising the Web Ontology Language (OWL2) for compliance checking [2]. Different languages and vocabularies also support ontology engineering, provide frameworks to formalise obligations, constraints [28] and legal norms [13]. The Data Privacy Vocabulary (DPV) facilitates the representation and understanding of data (e.g., personal data), technologies and processing activities [30]. It acts as a framework with high-level concepts (e.g., purpose, legal basis) and provides a base vocabulary, making concepts specific through hierarchies of concepts in namespaces for laws (e.g., EU-DGA). This supports its reusability (e.g., risks, rights within the EU-AIAct). The Resource Description Framework Schema (RDFS) and the Simple Knowledge Organization System (SKOS) support DPV's taxonomies with OWL2's formalisation for automated reasoning. Tech-specific extensions separate technological activities from legal processing, with a "context" module providing non-functional metadata (e.g., temporal dimensions) for compliance analysis. These decisions make the DPV a means for addressing semantic interoperability and fragmentation. Still, there are scarce contributions, facilitating the semantic interpretation of cross-regulatory overlaps and harmonisation.

## 3 Problem Statement and Contributions

### 3.1 The Problem Statement

AI and EU data laws lay out intricate scopes for actors, rights and responsibilities. While these frameworks promote compatible legislative goals, they use distinct terminology and legal constructs to define regulatory concepts where the '*actors*', the '*rights*' they hold, and their '*obligations*' are distinct but occasionally overlapping. This exposes the regulatory landscape to semantic and normative fragmentation, which with the reliance on natural language for legal analysis, hinders manual interpretations and legal compliance. This risks creating systemic legal confusion, innovation cost increase, economic impacts, and reduced protection of rights and freedoms in society [16, 38, 22]. The demands for operationalising legal requirements and automated governance processes add to these challenges [26]. A key challenge arises when an '*actor*' is subject to several regulations. For instance, an entity can be a Controller (GDPR) and a Deployer (AI Act) [15]. These regulations define obligations based on the actor's role, but impose different constraints and scopes. The GDPR focuses on personal data processing and data minimisation based on data protection requirements, whereas the AIA defines requirements for AI systems based on calculated risk levels[6]. The *'actor'* may hold overlapping obligations with respect to the pertinent regulation, creating a compliance bottleneck. Without a semantic representation, to align fragmented rules, interoperability challenges for automated compliance and legal uncertainty can escalate across domains and jurisdictions [36, 11].

[6] https://artificialintelligenceact.eu/article/50/

The PhD is, thereby, guided by the research question (RQ): *"To what extent can an ontology-based representation of actors, rights and obligations assist in addressing their potential overlaps and harmonisation across EU Data and AI regulations?"*. Important premises include: (i) Ontology-based representation: a machine-readable format, capturing relationships and logic; (ii) Actor, rights, obligations: entities, their roles, rights defined across laws, and requirements to be fulfilled for compliance; (iii) Potential overlaps: identical or subsumed concepts and requirements which may address the same activity or enforce comparable rules; (iv) Harmonisation: making regulations consistent with each other to reduce combined effort to comply with them; (v) EU Data and AI regulations: a set of EU laws. The primary question will be answered with sub-questions (SQ):

- ***SQ1:*** *What are the actors, their rights and obligations?*
- ***SQ2:*** *How can the actors, their rights and obligations be represented in a machine-readable format through semantic web standards?*
- ***SQ3:*** *How can the semantic web presentation of concepts for actors, rights and obligations aid the identification of potential overlaps across regulations?*
- ***SQ4:*** *How can the identified potential overlaps across regulations be used to harmonise compliance in real-world contexts?*

### 3.2 Research Scope

The PhD is limited to: **(i)** Actor Scope of individual actors (e.g., data subject (GDPR)), functional actors (e.g., Deployer (AIA)), authorities (e.g., AI Office); **(ii)** Regulatory Scope that excludes laws at the Member State level, but covers the GDPR, AIA, NIS2, DA, DGA, the Electronic Health Data Space (EHDS), using their final published texts. For ongoing legislative processes, laws published before 2026 will be considered.

### 3.3 Outcomes and Contributions

- **Legal Analysis on AI and Data regulations, obligation overlaps and taxonomies (SQ1, SQ2):** A rigorous methodology for translating legal documents into a structured representation will be produced with a contribution of regulation-specific taxonomies of actors, rights, and obligations. These representations are confined to the extraction of explicitly defined obligations and rights that will be the bridge for identifying cross-regulatory ambiguities, overlaps, and relations. Legal scholars will primarily intervene in taxonomies' alignment, navigating conceptual divergence and convergence.
- **Ontology extending the state-of-the-art (SQ2, SQ3):** A formalised RDF[7] ontology with regulation-relevant taxonomies, grounded in community best practices will be developed with guidelines for knowledge engineering in collaboration with legal scholars. The work will enrich community efforts (DPV), and will be used in standardisation efforts (e.g., W3C[8]).

[7] https://www.w3.org/RDF/
[8] https://www.w3.org

– **Ontological framework for finding overlaps across laws (SQ3):** An ontological framework utilising off-the-shelf reasoners (e.g., RDFox[9] for high-performance execution) including GraphDB's[10] reasoning support, which can support RDFS profiles and Protocol and RDF Query Language (SPARQL) querying to exploit the semantic richness and enable automatic overlap detection. This will provide a machine-interpretable bridge between distinct regulatory norms, enabling semantic interoperability and legal certainty.
– **Demonstrated feasibility of the approach (SQ4):** Applying the framework to align laws with the EHDS will show the approach's feasibility. This will be facilitated by a secondment at Ghent University (UGent, ongoing) and a planned one with the EU Commission's Joint Research Centre (JRC-ISPRA) to model taxonomies and harmonise ontology logic. They can inform guideline development, demonstrating the practical utility of regulatory representation, and outline legal overlaps or conflicts in a harmonised document.

## 4 Research Methodology and Approach

This section describes the early-stage plan (current PhD stage is 6 months since start), guided by Linked Open Terms [11] in Fig. 1.

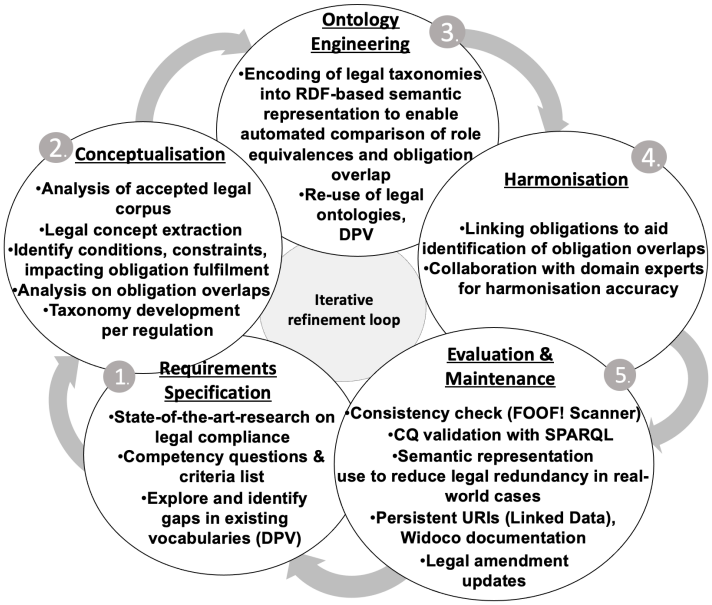


**Fig. 1.** PhD Methodology

[9] https://www.oxfordsemantic.tech/rdfox
[10] https://graphdb.ontotext.com/
[11] https://lot.linkeddata.es/v1/

*To answer SQ1: What are the actors, their rights and obligations?*, a structured analysis of the laws and these concepts will be prioritised. State-of-the-art research on legal compliance and domain challenges will also be conducted. This will follow Kitchenham's [21] literature review and guide the requirements development, while the analysis will address:

- *Which rights are granted to individual actors?*
- *What obligations must an actor uphold across regulations?*
- *Which actor assumes different functional roles across regulations?*
- *What conditions trigger a legal obligation?*
- *Which obligation violates a restriction imposed in another regulation?*
- *When is sensitive data processing allowed, but prohibited by another regulation?*

*To answer SQ2: How can the actors, their roles, rights and obligations be represented in a machine-readable format through semantic web standards?*, a model of the legal texts, requirements, obligations and rights an entity can exercise by enacting appropriate measures to be compliant, will be defined. The modelling will be grounded in (non)-functional requirements, documented in an Ontology Requirement Specification template[12]. This guarantees the competency questions (CQ) refinement, delimiting the area represented and the granularity level (e.g., depicting demands for hierarchical relations, demonstrating data subject rights properties above the data controller's ones). The concept extractions and their classification in hierarchical taxonomies will be prioritised to establish a semantic base as a prerequisite for defining relationships between the concepts and complex conditions and/or constraints for obligation fulfilment. RDFS will define the lightweight ontological base for the conceptual model. SKOS[13] will complement the concept arrangement into taxonomies for each law, while maintaining alignment with DPV. RDF serialization will provide organisational coherence and refinements prior to and post-collective feedbacks from legal scholars and the Data Privacy Vocabularies and Control Community Group (DPVCG). To support the ontology encoding, this phase will further analyse:

- *What research activities in Ontology Engineering and digital governance exist?*
- *What topics on Ontology Engineering in the legal domain have been probed?*
- *What approaches and tools are applied for Data Representation?*
- *What conditions trigger a legal obligation?*
- *What methods can determine the prioritisation of a regulation?*
- *How far is legislative traceability achieved in existing legal frameworks?*

Papers from scientific databases (e.g., ISWC) targeting web semantics, regulations, approaches for ontology visualisation and its applicability for cross-regulation harmonisation, will support this process. Research into unified regulatory concept representation and practical ontology use will be vital for regulatory integration. To be robust and semantically interoperable, its development needs to address challenges of term and hierarchy representation, especially where concepts, existing as a linguistic variation, are ambiguous or only a super-class of

[12] https://github.com/oeg-upm/ORSD-template?tab=readme-ov-file
[13] https://www.w3.org/TR/skos-reference/

the concept exists. In such instances, maximising the reuse of existing ontologies, standards and ontology patterns will reduce redundant class and term constructions. This will be determined by assessing compliance ontologies in terms of their purposes, concepts and relationships. Open-source ontology editors (e.g., Protégé[14]) will be used to manage the machine-readable RDF representation.

*To answer SQ3: How can the semantic web representation of concepts for actors, rights, and obligations aid the identification of potential overlaps across regulations?*, the question 'What is regulatory interplay, its impact, and how to identify it?' will be addressed to support the regulatory alignment. The overlap findings will be shown using the RDFS/SKOS structure (SQ2) to encode the regulatory intersections as linked entities. The semantic mapping will clarify where laws impose identical or divergent requirements on an actor, with CQs and SPARQL validating the resulting regulatory interplays.

*To answer SQ4: How can the identified potential overlap across regulations be used to harmonise compliance in real-world contexts?*, an empirical application can depict the ontology's compliance support. Operationalising the framework, including a high-risk categorisation extension, can contribute to the EHDS secondary data interface during a secondment at UGent, clarify cross-regulatory data access, or automate high-risk obligation identification. Liaising with stakeholders and legal experts will validate overlap modellings, and interviews will provide qualitative feedbacks on the cross-regulatory model utility. This will drive an agreement on the publication and human-readable documentation (e.g., Zenodo[15], Widoco[16]), while dissemination across venues, workshops and publications will drive wider acceptance of the research findings.

## 5 Evaluation

The evaluation will adopt a multi-layered approach: **Legal reliability of taxonomies of actors-rights-obligations with domain experts.** To address (SQ1, SQ2), technical evaluations throughout the ontology lifecycle will identify missing concepts and regulatory annotations. In the course of *concept harmonisation*, iterative collaboration with legal experts (e.g., compliance advisors) will support concept alignments in a unified vocabulary, address overlaps, and ensure concepts are neither misinterpreted, nor omitted. Research at JRC-ISPRA can advise on refining harmonisation decisions, reconciling overlapping duties, while DPVCG feedback ensures ontology reusability and property inclusions for knowledge representation (SQ2, SQ3).

**Technical integrity of the formalised legal ontology using evaluation tools, semantic methods.** To answer (SQ3, SQ4), interoperability and reusability will be fostered, adhering to validation and design methods for iterative development. The web-based service FOOPS! Pitfall Scanner[17] will cover

[14] http://protege.stanford.edu/
[15] https://zenodo.org
[16] https://dgarijo.github.io/Widoco/doc/tutorial/
[17] https://foops.linkeddata.es/FAIR_validator.html

the verification of *Findable*, *Accessible*, *Interoperable*, and *Reusable* (FAIR) dimensions to make the ontology set for international standardisation [34]. The Shapes Constraint Language (SHACL)[18] will assist the development of testable shapes, operationalising actor-right-obligation triples and integrity rules. SHACL constraints can assess the graph quality, pinpoint aligned concepts and trigger errors for incorrectly encoded obligation linkages. Validation reports will assess requirement convergence for actor-obligation subsumptions (SQ4), while SPARQL[19] translated CQs will test the ontology's data retrieval ability. Exante, the CQs will be refined with domain expert recommendations to promote inferential completeness. Ontological design experts will validate the semantic structure conformance to best practices in ontology engineering. The dissemination of questionnaires - addressing concepts, documentation, methodology, design - will drive discussions for ontology's alignment with FAIR principles.

**Tangible utility.** The taxonomies/ontology will be assessed through a regulatory impact assessment with collaborations established during secondments, and a use case application for performing legal and data governance in technology and industry-related contexts. Consultations with legal experts (JRC-ISPA) can ensure the ontology reflects the laws' intention, with an architectural assessment (at UGent and primary supervisors) to ensure a logical mapping.

## 6 Results

Preliminary observations indicate that a semantic framework, rooted in a hierarchical actor-right-obligation taxonomy can enable the cohesive presentation of legal provisions and reduce interpretative conflicts. The GDPR-AIA analysis has yielded the actor-rights-obligations in a tabular form - a base for the regulatory taxonomies (SQ1) under development (Fig. 2) and systematic revision, where identifying conceptual overlaps will guide the regulatory interplay representation (SQ2) (e.g., an obligation from one regulation fulfils a narrower one in another). For this, unconditional and conditional obligations (i.e., constraints, hindering their execution), activity (mandated procedure), and requirements (i.e., constraints, conditions, exemptions) will be considered. Insights from the concept mining will be used to demonstrate similarities such as assessment duties (e.g., Data Protection Impact Assessment (GDPR, Art. 35), Fundamental Rights Impact Assessment (AIA, Art. 27)), including overlaps (e.g., AIA Art. 19(1)'s log retention and GDPR Art. 5(1)(e)'s mandate for personal data storage as long as needed). SQ1 and SQ2 are ongoing as concept extraction and obligation overlap pairings (SQ3) will be applied across remaining laws, and will persist during research stays. Work at JRC-ISPRA will initiate the overlap implementation in the semantic model (SQ4). This can include its embedding in interoperability assessments or policymaking frameworks for feedback by policy clusters (e.g., DG CNECT) on the obligation overlap correlation with their legislative intents.

[18] https://www.w3.org/TR/shacl/
[19] https://www.w3.org/TR/sparql11-query/

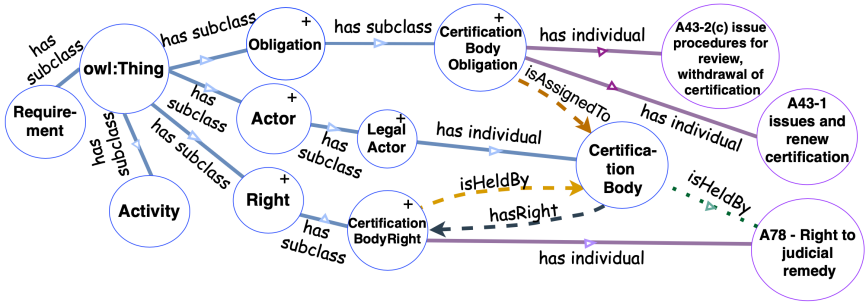


**Fig. 2.** Sample rights-obligations (GDPR)

## 7 Conclusion and Lessons Learned

This work establishes a semantic foundation for machine-readable EU compliance, framing legal redundancy as a safeguard for individuals through distinct legal instruments. This is fundamental for how overlap modelling is approached as a flow of choices, carrying legal and ethical aspects for drawing technological accountability, while respecting end-user and legislative body requirements. The project maps the problem and RQs, proposing a framework to formalise regulation taxonomies in a cross-regulatory ontology, capturing rights and obligations with overlapping characteristics. For long-term utility, aligning taxonomies with international standards and established frameworks will support cross-border adoption across ecosystems for enforceability. This work will propose definitions, reconciling overlapping terms across regulations to DPVCG, to establish a community-standardised vocabulary, while potential case studies (e.g., health protection, JRC-ISPRA) can show if audit trails can be mapped with legal mandates. Produced outputs can help policymakers to avoid logical and terminology conflicts when drafting laws. Legal engineers can use it to map system architectures to obligations, ensuring proper data provenance and actor responsibility representation for automated compliance checks. Compliance professionals (e.g., Data Protection Officers) can use it to streamline technical measures, fulfilling obligations across regulations to reduce administrative burdens, while authorities (e.g., Data Protection Authorities) to align their requirements, minimising redundant surveillance orders. This work contributes to demands for semantic interoperability, oversight, and transparency in an era where the fundamental rights, freedoms, and innovation are safeguarded by data governance.

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