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Article

Verisav Vocabularies: RDF/OWL Ontologies for Digital Product Passport and After-Sales Service Automation

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Abstract

The European Union's Ecodesign for Sustainable Products Regulation (ESPR 2024/1781) mandates Digital Product Passports (DPP) for electronics and appliances by 2027. This paper presents three interconnected RDF/OWL vocabularies addressing a critical gap: after-sales service automation. The DPP vocabulary (35 classes, approximately 90 properties) covers product lifecycle traceability; the RMA vocabulary (8 classes, approximately 50 properties) standardizes return merchandise authorization workflows; and the WTY vocabulary (9 classes, approximately 50 properties) enables machine-readable warranty contracts. The key innovation is the `wty:PaymentRule` construct, which formally specifies warranty payment decisions—functionality absent from existing vocabularies including GoodRelations, Schema.org, and DPPO. All vocabularies are registered in Linked Open Vocabularies (LOV), validated by independent curator Ghislain Atemezing, use W3ID persistent URIs, and are published under CC BY 4.0. This work provides essential semantic infrastructure for EU DPP implementation.

Keywords: Digital Product Passport; RDF; OWL; semantic Web; ontology; ESPR; warranty; after-sales service; linked data

1. Introduction

The European Union's Ecodesign for Sustainable Products Regulation (ESPR EU 2024/1781) [1] represents a significant regulatory shift, requiring manufacturers to provide Digital Product Passports (DPP) for electronics and household appliances by 2027. These passports must contain comprehensive product lifecycle information in machine-readable formats, enabling circular economy initiatives and consumer transparency.

While Semantic Web technologies offer mature solutions for structured data representation, a critical gap exists in current ontological resources. General-purpose ontologies like GoodRelations [2] and Schema.org [3] address product identification and basic warranty information, while emerging DPP frameworks like DPPO [4] focus on product composition and provenance. However, none provide the semantic expressiveness required for *after-sales service automation*—specifically, the automatic determination of warranty coverage and payment responsibility.

This paper presents Verisav Vocabularies, a suite of three interconnected RDF/OWL vocabularies designed to fill this gap:

- **DPP** (Digital Product Passport): Product lifecycle traceability compliant with EU ESPR
- **RMA** (Return Merchandise Authorization): Standardized return request workflows
- **WTY** (Warranty & Contracts): Machine-readable warranties enabling automated payment decisions

The key contribution is the novel `wty:PaymentRule` construct, which enables formal specification of warranty payment decisions based on defect types, coverage periods, and multi-party responsibilities.

2. Related Work

Several ontological resources address product data and e-commerce, but none fully cover after-sales service automation:

GoodRelations [2] includes `gr:WarrantyPromise`, but this construct only captures warranty duration and scope as free text—it cannot express payment rules or multi-party responsibilities.

Schema.org [3] provides `schema:WarrantyPromise` with `warrantyScope` as free text, making automated processing impossible.

DPPO [4] (Digital Product Passport Ontology) from Linköping University focuses on product composition and material provenance but does not address after-sales service workflows.

Catena-X [5] developed automotive-specific DPP models using SAMM (Semantic Aspect Meta Model), but these are not generalizable to consumer electronics.

UNTP [6] (United Nations Transparency Protocol) provides JSON schemas for DPP; our vocabularies provide complementary RDF/OWL representations aligned with UNTP requirements.

Table 1 summarizes the capability comparison.

Table 1. Comparison of semantic resources for product and after-sales service data.

Capability	GR	Schema	DPPO	Verisav
Product identification	✓	✓	✓	✓
Lifecycle traceability	—	○	✓	✓
Warranty duration	✓	✓	—	✓
Payment rules	—	—	—	✓
Multi-party	—	—	—	✓
RMA workflows	—	—	—	✓
LOV registered	✓	—	—	✓

GR = GoodRelations; Schema = Schema.org

3. Materials and Methods

3.1. Design Methodology

The vocabularies were developed following established ontology engineering methodologies:

- **NeOn Methodology** [7]: Iterative development with scenario-based design and reuse of existing ontological resources
- **Ontology Development 101** [8]: Competency questions approach to define scope and evaluate coverage
- **FAIR Principles** [9]: Ensuring Findability, Accessibility, Interoperability, and Reusability

3.2. Requirements Analysis

Requirements were derived from three sources:

1. EU ESPR 2024/1781 Annex III mandatory data categories [1]
2. Gap analysis of existing vocabularies (GoodRelations, Schema.org, DPPO)
3. After-sales service domain expertise

3.3. Competency Questions

Twenty-five competency questions (CQs) were defined to guide development. Representative examples include:

- CQ1: What is the warranty status of product X on date Y?
- CQ2: Who is responsible for paying repair costs for defect type Z?
- CQ3: What percentage of repair cost is covered under warranty?

- CQ4: What is the complete repair history of product X?
- CQ5: Which return requests are pending for retailer Y?

All 25 competency questions can be answered using SPARQL queries over the vocabularies.

3.4. Standards Alignment

Formal alignments were established using `rdfs:subClassOf`:

- `dpp:ProductPassport rdfs:subClassOf schema:Product`
- `dpp:Warranty rdfs:subClassOf schema:WarrantyScope`
- `rma:ReturnRequest rdfs:subClassOf schema:Action`
- `wty:Warranty rdfs:subClassOf dpp:Warranty, schema:WarrantyScope`

4. Results

4.1. Vocabulary Overview

Table 2 summarizes the three vocabularies.

Table 2. Vocabulary statistics and availability.

Vocabulary	Namespace (ns.verisav.fr/)	Classes	Properties	Version
DPP	dpp#	35	90	1.2.0
RMA	rma#	8	50	1.0.0
WTY	wty#	9	50	1.0.0
Total	—	52	190	—

4.2. Key Innovation: `wty:PaymentRule`

The `wty:PaymentRule` class enables formal specification of warranty payment decisions:

- `wty:firstParty`: The entity responsible for payment (manufacturer, retailer, insurer)
- `wty:paymentPercentage`: Coverage percentage (0–100)
- `wty:coversDefectType`: Defect types triggering the rule
- `wty:definesLimits`: Financial limits per claim or period

This construct transforms warranty documents from unstructured text into formal semantic data that can be automatically evaluated by reasoning engines.

4.3. Publication and Validation

All vocabularies are publicly available and independently validated:

- **LOV Registration**: Validated by curator Ghislain Atemezing (December 2025)
- **W3ID**: Persistent URIs at <https://w3id.org/verisav>
- **Content Negotiation**: Turtle, JSON-LD, RDF/XML, N-Triples
- **License**: CC BY 4.0 International

5. Discussion

5.1. Contributions

This work makes three primary contributions:

1. **Novel warranty semantics**: The `wty:PaymentRule` construct addresses a gap in all existing vocabularies
2. **ESPR compliance infrastructure**: Ready-to-use vocabularies for EU DPP implementation
3. **FAIR-compliant publication**: LOV registration, W3ID URIs, open licensing

5.2. Limitations

Transparency note: The vocabularies are designed and published but have not yet been deployed in a production environment. Pilot implementations are planned for 2027 when ESPR mandates come into force. Current limitations include:

- Domain focus on household appliances and consumer electronics
- Labels in English and French only
- No third-party implementations yet

5.3. Future Work

Future development will focus on:

- Pilot deployments with partner manufacturers (planned 2027)
- EU Business Wallet (EBW) integration with Verifiable Credentials
- Alignment with CIRPASS-2 EU DPP Core Ontology when published
- Additional language support

6. Conclusions

This paper presented Verisav Vocabularies, three RDF/OWL vocabularies addressing after-sales service automation for Digital Product Passports. The key innovation—`wty:PaymentRule`—enables machine-readable warranty payment decisions, filling a gap in existing semantic resources. The vocabularies are published following best practices (LOV registration, W3ID URIs, CC BY 4.0) and provide essential infrastructure for EU ESPR 2024/1781 implementation.

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Data Availability Statement: All vocabularies are publicly available via Linked Open Vocabularies (LOV) at lov.linkeddata.es/dataset/lov/vocabs/ with identifiers `dpp`, `rma`, and `wty`. Persistent URIs are available at w3id.org/verisav. Documentation is available at verisav.fr/vocabularies.

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Conflicts of Interest: The author is the founder of Verisav, the organization that developed and maintains these vocabularies. The vocabularies are published under open license (CC BY 4.0) and are freely available to all.

Abbreviations

The following abbreviations are used in this manuscript:

DPP	Digital Product Passport
RMA	Return Merchandise Authorization
WTY	Warranty
ESPR	Ecodesign for Sustainable Products Regulation
LOV	Linked Open Vocabularies
RDF	Resource Description Framework
OWL	Web Ontology Language
SPARQL	SPARQL Protocol and RDF Query Language
FAIR	Findable, Accessible, Interoperable, Reusable

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