Ontology Landscape

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AIOTI WG Standardization

Semantic Interoperability Expert Group

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Content

Executive Summary

Choosing the right ontologies is an important basis for successfully implementing semantic systems and achieving semantic interoperability between the systems. To make the choice of ontologies easier, the Semantic Interoperability Expert Group of the Alliance for Internet of Things Innovation (AIOTI) Working Group on Standardization has created an Ontology Landscape that currently includes 30 ontologies from different application areas of IoT. Apart from the application domain, the landscape visualizes how the ontology is maintained (by the colour used: *single maintainer*, *organization*, *group of organizations/industry association* or *standardization organization*). The intensity of the colour shows the technology readiness level, ranging from *technology validated in the lab* (very light) to *actual system proven in operational* environment (dark). This overview gives a first indication, which ontologies could be suitable candidates in a given use case. In the following, a summary of key information about each ontology is given, including technical specification, Universal Reference Identifier (URI) of ontology file, license, maintainer and a short description. The information has been collected from the maintainers of the respective ontology who filled out a survey. A link to the full survey information is also provided for each ontology. The Semantic Interoperability Expert Group plans to collect information about more IoT ontologies and provide an updated Ontology Landscape in the future.

1. Introduction

The Semantic Interoperability Expert Group of the AIOTI Working Group on Standardization is an open group of semantic experts, not limited to AIOTI members, with the main objective to identify gaps related to (semantic) interoperability standards and technologies within and across IoT domains, and provide recommendations to bridge these gaps. Previous activities of the Expert Group resulted in the publication in 2019 of two white papers on semantic IoT solutions for developers [1] and IoT system and standardization engineers [2]. As a follow-up, a tutorial has been recently released to guide practitioners without a background in semantic technologies on the use of ontologies (https://aioti.eu/semantic-tutorial-by-wg-standardisation/). In parallel, the Expert Group has been working to create an IoT Ontology Landscape, inspired by the AIOTI IoT Standardization Landscape that already provides an overview in the area of IoT Standardization.

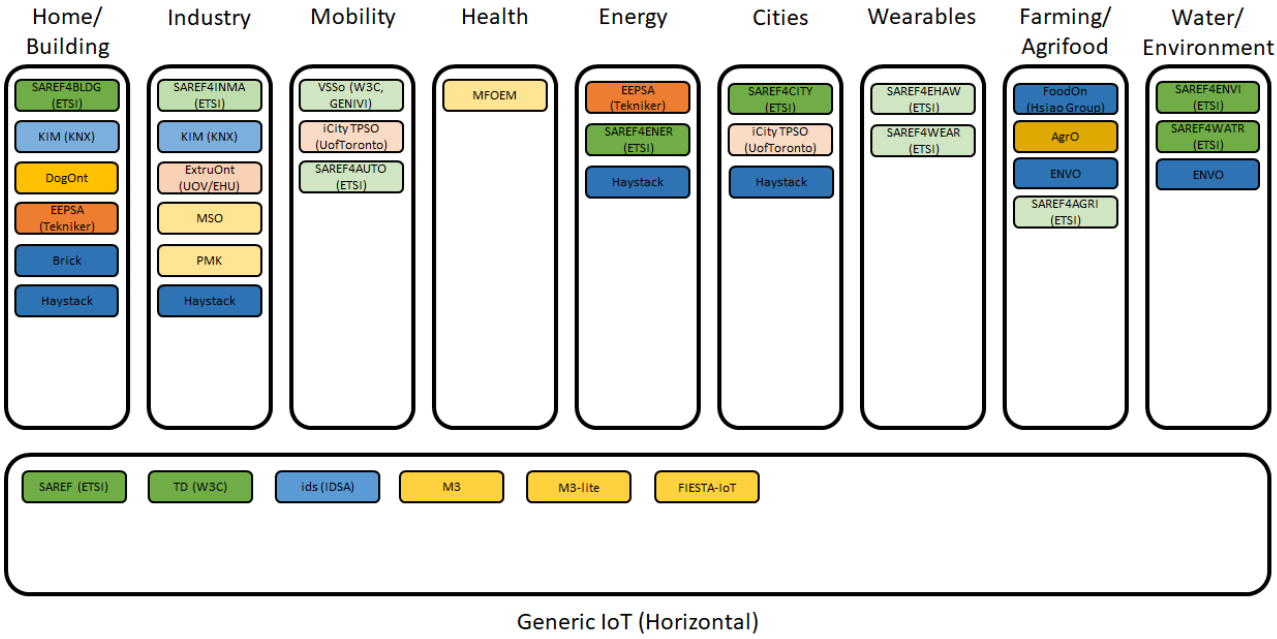
Our motivation for an additional landscape on IoT ontologies stems from the observation that, on the one hand, ontologies are perceived as a useful tool for interoperability by stakeholders, but, on the other hand, they are often perceived as difficult to understand in practice by industrial practitioners. This hinders the further uptake of semantic technologies in general and the use of ontologies in particular. For example, to start with, a common question we get from non-experts is about which ontology to choose for their particular purpose. Which ontologies are relevant in a certain domain? Where to find them? How to choose the most suitable? Who is maintaining and taking care of their evolution? These questions motivated our work on the IoT Ontology Landscape, which has the scope to guide stakeholders in the very first step of using ontologies in practice. This document provides the first results of this activity.

In the past two years (2020-2021), we have reached out to relevant stakeholders in the IoT domain with the request to fill out a survey, so that their ontology could become (more) visible via the IoT Ontology Landscape. The survey can be found at https://ec.europa.eu/eusurvey/runner/OntologyLandscapeTemplate. We intend to collect more ontologies, so if you maintain an ontology yourself, please fill out the template, or if you know the maintainers of other relevant ontologies, please forward the link to the survey to them as we plan to extend the Ontology Landscape in the future.

This document presents an overview of the 30 ontologies we have currently integrated into the Ontology Landscape. Interested stakeholders can use it to have an overview of the existing ontologies per IoT domain, understand their scope, maturity - as expressed by the Technology Readiness Level (TRL) - and the maintainers.

In the remainder of the document, firstly, the authors present the first overview of the current version of the Ontology Landscape and explain the methodology used to represent the type of maintainer (i.e., single maintainer, organization, industry association, standardization body) and the maturity level of each one. In the following, a summary of key information about each ontology is given, including technical specification, URI of ontology file, license, maintainer and a short description, plus a link to the full survey information is also provided for each ontology.

2. Ontology Landscape Overview



The Ontology Landscape visualization shown above is structured according to the different IoT application domains. Generic IoT ontologies that do not target a specific application domain are shown in the vertical box below.

The colour coding is explained in the table below. The colour identifies the maintainer of the ontology. Ontologies that have a single maintainer or come from a research project have a yellow colour. Ontologies that have an organization like a company, research laboratory or university that provides continuous support, not limited to a single project, are coloured in orange. Ontologies that have a group of organizations like an industry association supporting them are shown in blue. Finally, ontologies maintained by a formal standardization organization are coloured in green.

Sustainability & Maintainability Level

Technology Readiness Level (TRL)	TRL / Level	Level 1 Single Maintainer / Project	Level 2 Organization	Level 3 Group of Organizations	Level 4 Standardization Body
	4				
	5				
	6				
	7				
	8				
	9				

The colour intensity shows the maturity of the ontology based on the Technology Readiness Level as it is also used in European Projects. For the Ontology Landscape, only ontologies that have at least a TRL of 4 are considered:

- TRL 4 – technology validated in lab
- TRL 5 – technology validated in relevant environment (industrially relevant environment in the case of key enabling technologies)
- TRL 6 – technology demonstrated in relevant environment (industrially relevant environment in the case of key enabling technologies)
- TRL 7 – system prototype demonstration in operational environment
- TRL 8 – system complete and qualified
- TRL 9 – actual system proven in operational environment (competitive manufacturing in the case of key enabling technologies; or in space)

3. Ontology Summaries

In the following, a short summary of each ontology is given with its acronym, name, technology readiness level, main areas of application, links to technical specification and ontology file, the license, the maintainer and a short description.

Acronym	AgrO	TRL	8		
Name	Agronomy Ontology		Main Areas	Farming/Agrifood	
Technical Specification			https://bigdata.cgiar.org/resources/agronomy-ontology/ https://github.com/AgriculturalSemantics/agro		
URI of Ontology File			https://github.com/AgriculturalSemantics/agro/blob/master/agro.owl		
License			Creative Commons Attribution 4.0 International License		
Maintainer			Aubert Céline		
Complete Survey Information			https://drive.google.com/file/d/164JRhOc9wt2mmcV5wlrT4S24VZbvqQZG/view		
Short Description	The Agronomy Ontology has been developed to enable the description of agronomic data variables using standard terms. This allows leveraging standards for metadata and data annotation to address the challenges in current ways to manage agronomic data, which are currently collected, described, and stored in inconsistent ways, impeding data comparison, mining, interpretation reuse.				

Acronym	Brick	TRL	9		
Name	Brick		Main Areas	Home/Building	
Technical Specification			https://brickschema.org/ontology/		
URI of Ontology File			https://brickschema.org/schema/Brick		
License			BSD 3-Clause		
Maintainer			Brick Consortium Inc. (non-profit membership corporation)		
Complete Survey Information			https://drive.google.com/file/d/17aWyGIWKA2UbVryU99wBlS7fd7MSCiev/view		
Short Description	Brick focuses on modelling the entities, relationships and contexts surrounding data sources in buildings. To this end, Brick defines (a) a comprehensive class organization of building equipment spanning multiple subsystems including HVAC, lighting and electrical infrastructure, (b) a set of Point definitions defining the semantics of data sources, (c) a set of object properties (called "relationships" in Brick parlance) that describe how entities are composed into complex systems. The ultimate goal of the ontology is to enable "portable" analytics and control software that accesses a Brick model in order to configure its operation to a particular building environment.				

Acronym	DogOnt	TRL	7		
Name	Ontology Modeling for Intelligent Domotic Environments		Main Areas	Generic IoT, Smart Home/Buildings	
Technical Specification			http://elite.polito.it/ontologies/dogont		
URI of Ontology File			http://elite.polito.it/ontologies/dogont.owl		
License			Apache 2.0		
Maintainer			Luigi De Russis, Politecnico di Torino		
Complete Survey Information			https://drive.google.com/file/d/1LIi1pADLb35XTOzuKwYFl9hOBjyLeX05/view		
Short Description	The DogOnt ontology aims at offering a uniform, extensible model for all devices being part of a "local" Internet of Things inside a smart environment. Its major focus is on device modeling, for all the aspects needed to abstract device "capabilities" from low-level idiosyncrasies and communication issues. This enables both abstract reasoning on devices, e.g., to find similar devices or to identify the most suitable output to which forward urgent notifications, and actual integration of different technologies, and paradigms.				

Acronym	EEPSA ontology	TRL	7		
Name	Energy Efficiency Prediction Semantic Assistant ontology		Main Areas	Generic IoT, Smart Home/Buildings, Energy	
Technical Specification			https://w3id.org/eepsa		
URI of Ontology File			https://w3id.org/eepsa		
License			CC-BY4.0		
Maintainer			Tekniker Research and Technology Centre		
Complete Survey Information			https://drive.google.com/file/d/1ay8WLwWqwoTJ9YNOCxILjabdKi9Z9dKX/view		
Short Description	The EEPSA ontology is a modular ontology based on ODPs (Ontology Design Patterns) and focused on energy efficiency and thermal comfort in buildings but it is aimed at being reusable and easily customizable for other use cases in similar domains.				

Acronym	ENVO	TRL	9	
Name	Environment Ontology		Main Areas	Farming/AgriFood, Water/Environment
Technical Specification			https://github.com/EnvironmentOntology/envo	
URI of Ontology File			http://purl.obolibrary.org/obo/envo.owl	
License			CC0	
Maintainer			ENVO Consortium, Obo Foundry	
Complete Survey Information			https://drive.google.com/file/d/1pSWLgpAKUlApPoAfVEsBx_gO9AUBd7aH/view	
Short Description	ENVO is an expressive, machine-actionable knowledge representation of environmental entities. Using ENVO to describe things like ecosystems, entire planets and other astronomical bodies, their parts, or environmental processes increases the interoperability of environmental descriptions, helping (meta)data records achieve demonstrable FAIRness.			

Acronym	ExtruOnt	TRL	5		
Name	An RDF/OWL schema for representing an extruder		Main Areas	Generic IoT (horizontal), Industry	
Technical Specification			http://bdi.si.ehu.es/bdi/ontologies/ExtruOnt		
URI of Ontology File			http://siul02.si.ehu.es/bdi/ontologies/ExtruOnt/ExtruOnt.owl		
License			CC-BY4.0		
Maintainer			Idoia Berges (University of the Basque Country UPV/EHU)		
Complete Survey Information			https://drive.google.com/file/d/1Z3rA1kk4cZViqGEMyxD6wKUKKXfuNo42/view		
Short Description	ExtruOnt ontology describes a type of manufacturing machine, more precisely, a type that performs an extrusion process (extruder). Although the scope of the ontology is restricted to a concrete domain, it could be used as a model for the development of other ontologies for describing manufacturing machines in Industry 4.0 scenarios.				

Acronym	FIESTA-IoT	TRL	6	
Name	FIESTA-IoT (Federated Interoperable Semantic IoT/Cloud Testbeds and Applications)	Main Areas	Generic IoT	
Technical Specification		Paper: Unified IoT Ontology to Enable Interoperability and Federation of Testbeds [Agarwal et al. WF-IoT 2016] https://ieeexplore.ieee.org/abstract/document/7845470/ Paper: GDPR-inspired IoT Ontology enabling Semantic Interoperability, Federation of Deployments and Privacy-Preserving Applications https://arxiv.org/pdf/2012.10314.pdf		
URI of Ontology File		http://purl.org/iot/ontology/fiesta-iot		
License		Copyright EU H2020 FIESTA-IoT		
Maintainer		Rachit Agarwal		
Complete Survey Information		https://drive.google.com/file/d/1m1Hi7-CcTPdZqoqwITuMrF-cVUQXF3qN/view		
Short Description	FIESTA-IoT ontology (a unified semantic model) that follows best practices. FIESTA-IoT Ontology is a merge of concepts from various ontologies such as IoT-lite, M3-lite Taxonomy, SSN, Time and DUL.			

Acronym	FoodOn	TRL	9	
Name	Food Ontology		Main Areas	Industry, Health, Farming/AgriFood
Technical Specification			https://foodon.org/	
URI of Ontology File			https://github.com/FoodOntology/foodon/blob/master/foodon.owl	
License			Creative Commons Attribution 4.0 International	
Maintainer			Damion Dooley	
Complete Survey Information			https://drive.google.com/file/d/1hBL7N-ASPK6GxCg6j57jdy_9D_dXP4Yg/view	
Short Description	The need to represent knowledge about food is central to many human activities including agriculture, medicine, food safety inspection, shopping patterns, and sustainable development. FoodOn is an ontology to name all parts of animals and plants which can bear a food role for humans and domesticated animals, as well as derived food products and the processes used to make them.			

Acronym	Haystack	TRL	9	
Name	Project-Haystack.org		Main Areas	Smart Home/Building, Energy, Industry, Cities
Technical Specification			https://project-haystack.org/	
URI of Ontology File			https://project-haystack.org/download/defs.ttl https://project-haystack.org/download/protos.ttl	
License			Academic Free License 3.0 https://project-haystack.org/doc/License	
Maintainer			Project Haystack tax-exempt non-stock corporation	
Complete Survey Information			https://drive.google.com/file/d/1U8lofOL2CPWsGPlmOdQIPsfqttHV4NBq/view	
Short Description	An Open Source initiative to streamline working with IoT Data We standardize semantic data models and web services with the goal of making it easier to unlock value from the vast quantity of data being generated by the smart devices that permeate our homes, buildings, factories, and cities.			

Acronym	iCity TPSO	TRL	4	
Name	iCity Transportation Planning Suite of Ontologies		Main Areas	Mobility, Cities
Technical Specification			http://ontology.eil.utoronto.ca/icity/iCityOntologyReport_1.2.pdf	
URI of Ontology File			http://ontology.eil.utoronto.ca/icity/UrbanSystem.owl	
License			MIT	
Maintainer			Megan Katsumi, Department of Mechanical & Industrial Engineering - University of Toronto	
Complete Survey Information			https://drive.google.com/file/d/1i1xknFF9wlPCtqtRZXYX4sDTBGC2lSiO/view	
Short Description	The Transportation Planning Suite of Ontologies (TPSO) provides a common set of terms for unambiguously storing and accessing data. The key purpose of the iCity TPSO is to address the challenges of data integration and reuse in the context of transportation planning.			

Acronym	ids	TRL	7	
Name	International Data Spaces Information Model		Main Areas	Generic IoT (Horizontal)
Technical Specification			Namespace: https://w3id.org/idsa/core Repository: https://github.com/International-Data-Spaces-Association/InformationModel/	
URI of Ontology File			https://w3id.org/idsa/core	
License			Apache 2.0	
Maintainer			Sebastian Bader, Fraunhofer IAIS	
Complete Survey Information			https://drive.google.com/file/d/1-c8JonwqH22gNqPdFY3UNc3FSE-Fm6kO/view	
Short Description	The Information Model is an RDFS/OWL-ontology covering the fundamental concepts of the International Data Spaces (IDS), i.e. the types of digital contents that are exchanged by participants by means of the IDS infrastructure components.			

Acronym	IES	TRL	4	
Name	GECAD's Intelligent Energy Systems Ontologies		Main Areas	Energy
Technical Specification			N/A	
URI of Ontology File			http://www.gecad.isep.ipp.pt/ontologies/ies/	
License			N/A	
Maintainer			Tiago Pinto, ISEP - Instituto Superior de Engenharia do Porto	
Complete Survey Information			https://drive.google.com/file/d/13QJbNYA6bF_RYkc3EL7_SZIbpoqRPBjz/view	
Short Description	The ontology has been developed for semantic interoperability between agent-based systems within the smart grid and demand flexibility domain.			

Acronym	KIM	TRL	6	
Name	KNX Information Model Ontology		Main Areas	Smart Home/Buildings, Industry
Technical Specification			https://schema.knx.org/AN198.pdf	
URI of Ontology File			https://schema.knx.org/2020/ontology/	
License			-	
Maintainer			Andre Hanel, knx.org	
Complete Survey Information			https://drive.google.com/file/d/1blGLx6bFSubcsVh-Lldm_fuCW3Ss1V61/view	
Short Description	KNX is an open standard for commercial and domestic building automation. The KNX Information Model Ontology has been designed by KNX Association to allow expressing product and installation data in a well defined ontology.			

Acronym	LMO	TRL	4	
Name	Local Market Ontology		Main Areas	Energy
Technical Specification			N/A	
URI of Ontology File			http://www.gecad.isep.ipp.pt/mdpi/energies/845690/files/onto/local-market.ttl	
License			N/A	
Maintainer			Tiago Pinto, ISEP - Instituto Superior de Engenharia do Porto	
Complete Survey Information			https://drive.google.com/file/d/1pOvDTI3BnRTGBitxLNpL4mKw6L2hl8cZ/view	
Short Description	The ontology was developed for the simulation of local electricity markets with complex offers. It imports and extends the Electricity Markets Ontology (EMO - http://www.mascem.gecad.isep.ipp.pt/ontologies/).			

Acronym	M3	TRL	6	
Name	M3 (Machine-to-Machine Measurement)		Main Areas	Generic IoT
Technical Specification			PhD Thesis: Designing Cross-Domain Semantic Web of Things Applications [Gyrard 2015] http://www.eurecom.fr/fr/publication/4553/download/cm-publi-4553.pdf	
URI of Ontology File			http://sensormeasurement.appspot.com/m3#	
License			GNU GPLv3 license.	
Maintainer			M3 project (2012-2020-onwards)	
Complete Survey Information			https://drive.google.com/file/d/1fEE5tnDw9S75FYvXFV6B-9EzM6ixVkoq/view	
Short Description	The M3 Ontology references more than 30 sensors, measurements, units and about 10 domains. The M3 ontology is focused on the ssn:ObservationValue concept from the W3C SSN ontology which describes sensors and observations, and related concepts.			

Acronym	M3-lite	TRL	6	
Name	M3-lite		Main Areas	Generic IoT
Technical Specification			Paper: Unified IoT Ontology to Enable Interoperability and Federation of Testbeds [Agarwal et al. WF-IoT 2016] https://ieeexplore.ieee.org/abstract/document/7845470/	
URI of Ontology File			http://purl.org/iot/vocab/m3-lite#	
License			Copyright EU H2020 FIESTA-IoT	
Maintainer			Rachit Agarwal	
Complete Survey Information			https://drive.google.com/file/d/1fEE5tnDw9S75FYvXFV6B-9EzM6ixVkoq/view	
Short Description	M3-lite is a lighter taxonomy version of M3 and contains only the taxonomy for various QuantityKinds (commonly known as physical and environmental phenomena), Unit of measurements, different types of sensor and different types of domain of interests. It has evolved based on the specifications and needs from the different IoT testbeds and caters much wider IoT testbed needs.			

Acronym	MFOEM	TRL	5	
Name	Emotion Ontology		Main Areas	Health
Technical Specification			https://github.com/jannahastings/emotion-ontology/	
URI of Ontology File			http://purl.obolibrary.org/obo/MFOEM.owl	
License			https://creativecommons.org/licenses/by/3.0/	
Maintainer			Janna Hastings, UCL - London's Global University	
Complete Survey Information			https://drive.google.com/file/d/1ijsqzT8YG3_bd6IDG3rCJMcPaYnHSWEx/view	
Short Description	The MFOEM ontology aims to include all relevant aspects of affective phenomena including their bearers, the different types of emotions, moods, etc., their different parts and dimensions of variation, their facial and vocal expressions, and the role of emotions and affective phenomena in general in influencing human behavior.			

Acronym	MSO	TRL	5	
Name	Manufacturing Systems Ontology		Main Areas	Industry
Technical Specification			https://github.com/enegri/OFM	
URI of Ontology File			https://github.com/enegri/OFM/blob/master/OFM.owl	
License			-	
Maintainer			Elisa Negri, Politecnico di Milano	
Complete Survey Information			https://drive.google.com/file/d/1lrWfRQXhV6kBX_9umzaIkC6ykxaOHQbT/view	
Short Description	The Manufacturing Systems Ontology (MSO) is a structured representation of the domain of manufacturing systems and logistics systems, based on object-oriented methodology. The modelling method defines the system by addressing four main different aspects separately: the physical aspect, the technological aspect, the control aspect and the visualization aspect.			

Acronym	PMK	TRL	5	
Name	Perception and Manipulation Knowledge		Main Areas	Robotics, Industry
Technical Specification			https://github.com/srfiorini/IEEE1872-owl	
URI of Ontology File			https://sir.upc.edu/projects/ontologies/kb/pmk.owl	
License			CC-BY-4.0	
Maintainer			Mohammed Diab, Universitat Politècnica de Catalunya	
Complete Survey Information			https://drive.google.com/file/d/1ngIsBZDcEGMPe74vgEV9pZOgiVdh-Ft4/view	
Short Description	Perception and Manipulation knowledge framework (PMK) presents a standardized ontology framework for autonomous robot perception and manipulation, which follows the IEEE standards 1872 of representing knowledge for the robotic domain. Moreover, an inference mechanism for reasoning over the knowledge is included, which enhances the planning of manipulation tasks.			

Acronym	SAREF	TRL	6		
Name	Smart Applications REFerence Ontology		Main Areas	Generic IoT	
Technical Specification			https://www.etsi.org/deliver/etsi_ts/103200_103299/103264/03.01.01_60/ts_103264v030101p.pdf		
URI of Ontology File			https://saref.etsi.org/core/		
License			https://forge.etsi.org/etsi-software-license		
Maintainer			ETSI		
Complete Survey Information			https://drive.google.com/file/d/1J1wk0FCjtOjrMiCt9RPYmN9mP9-Wpl0x/view		
Short Description	The Smart Applications REFerence ontology (SAREF) is intended to enable interoperability between solutions from different providers and among various activity sectors in the Internet of Things (IoT), thus contributing to the development of the global digital market.				

Acronym	SAREF4AGRI	TRL	4		
Name	SAREF extension for the Smart Agriculture and Food Chain domains		Main Areas	Farming/Agrifood	
Technical Specification			https://www.etsi.org/deliver/etsi_ts/103400_103499/10341006/01.01.02_60/ts_10341006v010102p.pdf		
URI of Ontology File			https://saref.etsi.org/saref4agri		
License			https://forge.etsi.org/etsi-software-license		
Maintainer			ETSI		
Complete Survey Information			https://drive.google.com/file/d/1sT8Btj-7CDieFL2gqWG9GCRmPuv0nOj2/view		
Short Description	SAREF4AGRI extends the SAREF ontology for the Agricultural domain. SAREF4AGRI currently focuses on two examples, which are the "livestock farming" and "smart irrigation" use cases. Various other examples exist in the Smart Agriculture and Food Chain domains, such as arable farming, horticulture, agricultural equipment, greenhouses and food chain. As all the SAREF ontologies, SAREF4AGRI is a dynamic semantic model that is meant to evolve over time.				

Acronym	SAREF4AUTO	TRL	4		
Name	SAREF extension for the for the Automotive domain		Main Areas	Mobility	
Technical Specification			https://www.etsi.org/deliver/etsi_ts/103400_103499/10341007/01.01.01_60/ts_10341007v010101p.pdf		
URI of Ontology File			https://saref.etsi.org/saref4auto		
License			https://forge.etsi.org/etsi-software-license		
Maintainer			ETSI		
Complete Survey Information			https://drive.google.com/file/d/1Y7o69JX-qCKkmq6ixoiWWffYv_qTHf2T/view		
Short Description	SAREF4AUTO is an OWL-DL ontology that extends SAREF for the Automotive domain. SAREF4AUTO currently focuses on three examples, which are the "Platooning", "Automated Valet Parking (AVP)" and "Vehicle environment with Vulnerable Road Users (VRU)" use cases. Various other examples exist in the Automotive domain. As all the SAREF ontologies, SAREF4AUTO is a dynamic semantic model that is meant to evolve over time.				

Acronym	SAREF4BLDG	TRL	6	
Name	SAREF extension for the building domain		Main Areas	Smart Home/Building
Technical Specification			ETSI Technical Specification (v1.1.2): https://www.etsi.org/deliver/etsi_ts/103400_103499/10341003/01.01.02_60/ts_10341003v010102p.pdf	
URI of Ontology File			Latest version: https://saref.etsi.org/saref4bldg/ Permanent IRI for current latest version (v1.1.2): https://saref.etsi.org/saref4bldg/v1.1.2/	
License			https://forge.etsi.org/etsi-software-license	
Maintainer			ETSI	
Complete Survey Information			https://drive.google.com/file/d/1Z1IezTr7kFhliaFJaaVstBjckQMQxXHD/view	
Short Description	The SAREF4BLDG is an extension of the SAREF ontology that was created based on the Industry Foundation Classes (IFC) standard for building information, specifically focusing on the part of the standard related to devices and appliances within the building domain.			

Acronym	SAREF4CITY	TRL	6	
Name	SAREF extension for smart cities		Main Areas	Cities
Technical Specification			ETSI Technical Specification (v1.1.2): https://www.etsi.org/deliver/etsi_ts/103400_103499/10341004/01.01.02_60/ts_10341004v010102p.pdf	
URI of Ontology File			Latest version: https://saref.etsi.org/saref4city/ Permanent IRI for current latest version (v1.1.2): https://saref.etsi.org/saref4city/v1.1.2/	
License			https://forge.etsi.org/etsi-software-license	
Maintainer			ETSI	
Complete Survey Information			https://drive.google.com/file/d/1C4rXp5W2NnqmMu3Vud3g7KY4yAJ754aS/view	
Short Description	The present document is a technical specification of SAREF4CITY, an extension of SAREF for the Smart Cities domain. This extension has been created by investigating resources from potential stakeholders of the ontology, such as standardization bodies (e.g., Open Geospatial Consortium), associations (e.g., Spanish Federation of Municipalities and Provinces), IoT platforms (e.g., FIWARE) and European projects and initiatives (e.g., ISA2 programme).			

Acronym	SAREF4EHAW	TRL	4	
Name	SAREF extension for e-health and aging well		Main Areas	Health
Technical Specification			https://www.etsi.org/deliver/etsi_ts/103400_103499/10341008/01.01.01_60/ts_10341008v010101p.pdf	
URI of Ontology File			Latest version: https://saref.etsi.org/saref4ehaw/ Permanent IRI for current latest version (v1.1.1): https://saref.etsi.org/saref4ehaw/v1.1.1/	
License			https://forge.etsi.org/etsi-software-license	
Maintainer			ETSI	
Complete Survey Information			https://drive.google.com/file/d/12Y6PsZrCS8B6t4z-mYMpEThzzi8k6-hv/view	
Short Description	SAREF4EHAW is an extension of SAREF for the eHealth/Ageing-well domains. It has been specified and formalised by investigating EHAW domain related resources, such as: potential stakeholders, standardization initiatives, alliances/associations, European projects, EC directives, existing ontologies, and data repositories.			

Acronym	SAREF4ENER	TRL	6	
Name	SAREF extension for the Energy domain		Main Areas	
Technical Specification			https://www.etsi.org/deliver/etsi_ts/103400_103499/10341001/01.01.02_60/ts_10341001v010102p.pdf	
URI of Ontology File			https://saref.etsi.org/saref4ener	
License			https://forge.etsi.org/etsi-software-license	
Maintainer			ETSI	
Complete Survey Information			https://drive.google.com/file/d/1oDRxBGEaNOp115cNtiYzgmsqaspVP5m3/view	
Short Description	SAREF4ENER is an extension of SAREF that describes energy flexibility that customers can offer to the Smart Grid to manage their smart home devices by means of a Customer Energy Manager (CEM), which is a logical function for optimizing energy consumption and/or production that can reside either in the home gateway or in the cloud. Energy flexibility is expressed in SAREF4ENER in terms of power profiles exposed by devices to the CEM.			

Acronym	SAREF4ENVI	TRL	6	
Name	SAREF extension for the environment domain		Main Areas	Water/Environment
Technical Specification			ETSI Technical Specification (v1.1.2): https://www.etsi.org/deliver/etsi_ts/103400_103499/10341002/01.01.02_60/ts_10341002v010102p.pdf	
URI of Ontology File			Latest version: https://saref.etsi.org/saref4envi/ Permanent IRI for current latest version (v1.1.2): https://saref.etsi.org/saref4envi/v1.1.2/	
License			https://forge.etsi.org/etsi-software-license	
Maintainer			ETSI	
Complete Survey Information			https://drive.google.com/file/d/1zcfz7jQAnLAfgn-TZGiGSTkAZsClAoGd/view	
Short Description	SAREF4ENVI is an extension of SAREF for the environment domain. The extension was created in collaboration with domain experts in the field of light pollution currently working in the STARS4ALL European H2020 project.			

Acronym	SAREF4INMA	TRL	5	
Name	SAREF extension for the Industry and Manufacturing Domains		Main Areas	Industry
Technical Specification			ETSI Technical Specification (v1.1.2): https://www.etsi.org/deliver/etsi_ts/103400_103499/10341005/01.01.02_60/ts_10341005v010102p.pdf	
URI of Ontology File			Latest version: https://saref.etsi.org/saref4inma/ Permanent IRI for latest version (v1.1.2): https://saref.etsi.org/saref4inma/v1.1.2/	
License			https://forge.etsi.org/etsi-software-license	
Maintainer			ETSI	
Complete Survey Information			https://drive.google.com/file/d/1nlFWHktshwFyacBpyIbD9GVesXx8UKHV/view	
Short Description	SAREF4INMA extends SAREF for the industry and manufacturing domain to solve the lack of interoperability between various types of production equipment that produce items in a factory and, once outside the factory, between different organizations in the value chain to uniquely track back the produced items to the corresponding production equipment, batches, material and precise time in which they were manufactured.			

Acronym	SAREF4WATR	TRL	6	
Name	SAREF extension for the water domain		Main Areas	Water/Environment
Technical Specification			ETSI Technical Specification (v1.1.1): https://www.etsi.org/deliver/etsi_ts/103400_103499/10341010/01.01.01_60/ts_10341010v010101p.pdf	
URI of Ontology File			Latest version: https://saref.etsi.org/saref4watr/ Permanent IRI for current latest version (v1.1.1): https://saref.etsi.org/saref4watr/v1.1.1/	
License			https://forge.etsi.org/etsi-software-license	
Maintainer			ETSI	
Complete Survey Information			https://drive.google.com/file/d/1M9bTQJbR-eLawyYVCJOpeVahVmIKqnRJ/view	
Short Description	SAREF4WATR is an extension of SAREF, which is based on a limited set of use cases and from available existing data models. This work has been developed in the context of the STF 566, which was established with the goal to create SAREF extensions for the domains of automotive, eHealth and ageing well, wearables, and water.			

Acronym	TD	TRL	7	
Name	Thing Description Ontology		Main Areas	Generic IoT
Technical Specification			https://www.w3.org/2019/wot/td	
URI of Ontology File			https://www.w3.org/2019/wot/td	
License			-	
Maintainer			W3C WoT working group	
Complete Survey Information			https://drive.google.com/file/d/1w5Smx3sbx7s0d-wMfEkrlfgZWlrYOqPE/view	
Short Description	The TD ontology is being developed within the W3C Web of Things Working Group. It is one of the concrete representations of the TD model, one of the building blocks of the Web of Things (WoT).			

Acronym	VSSo	TRL	4	
Name	The Vehicle Signal Specification Ontology		Main Areas	Mobility
Technical Specification			https://github.com/w3c/vsso	
URI of Ontology File				
License			CC 4.0 Licence	
Maintainer			W3C Community	
Complete Survey Information			https://drive.google.com/file/d/1gm74PE4FHtLOt16jZSDQ9GhlS99xeVFB/view	
Short Description	VSSo is a car signal ontology that derives from the automotive standard VSS, and that follows the Semantic Sensor Network (SSN)/Sensor, Observation, Sample, and Actuator (SOSA) pattern for representing observations and actuations.			

References

[1] M. Bauer, H. Baqa, S. Bilbao, A. Corchero, L. Daniele, I, Esnaola, I. Fernández, Ö. Frånberg, R. García-Castro, M. Girod-Genet, P. Guillemin, A. Gyrard, C. El Kaed, A. Kung, J. Lee, M. Lefrançois, W. Li, D. Raggett, M. Wetterwald: "Semantic IoT Solutions - A Developer Perspective". White paper, 2019. DOI: 10.13140/RG.2.2.16339.53286

[2] M. Bauer, H. Baqa, S. Bilbao, A. Corchero, L. Daniele, I, Esnaola, I. Fernández, Ö. Frånberg, R. García-Castro, M. Girod-Genet, P. Guillemin, A. Gyrard, C. El Kaed, A. Kung, J. Lee, M. Lefrançois, W. Li, D. Raggett, M. Wetterwald: "Towards Semantic Interoperability Standards based on Ontologies". White paper, 2019. DOI: DOI: 10.13140/RG.2.2.26825.29282

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About AIOTI

AIOTI is the multi-stakeholder platform for stimulating IoT Innovation in Europe, bringing together small and large companies, start-ups and scale-ups, academia, policy makers and end-users and representatives of society in an end-to-end approach. We work with partners in a global context. We strive to leverage, share and promote best practices in the IoT ecosystems, be a one-stop point of information on all relevant aspects of IoT Innovation to its members while proactively addressing key issues and roadblocks for economic growth, acceptance and adoption of IoT Innovation in society.

AIOTI's contribution goes beyond technology and addresses horizontal elements across application domains, such as matchmaking and stimulating cooperation in IoT ecosystems, creating joint research roadmaps, driving convergence of standards and interoperability and defining policies. We also put them in practice in vertical application domains with societal and economic relevance.

AIOTI is a partner for the European Commission on IoT policies and stimulus programs, helping to identifying and removing obstacles and fast learning, deployment and replication of IoT Innovation in Real Scale Experimentation in Europe from a global perspective.

AIOTI is a member driven organisation with equal rights for all members, striving for a well-balanced representation from all stakeholders in IoT and recognizing the different needs and capabilities. Our members believe that we are the most relevant platform for connecting to the European IoT Innovation ecosystems in general and the best platform to find partners for Real Scale Experimentation.