



D8.5: Outreach activities final report

Revision: v.1.0

Work package	WP 8
Task	Tasks 8.1 and 8.2
Due date	31/03/2026
Submission date	31/03/2026
Deliverable lead	Filippo Vannella (TID)
Version	1.0
Authors	Filippo Vannella (TID), Amrita Prasad (Martel)
Reviewers	David Vázquez Enríquez (GMV), Sotiris Spantideas (NKUA)
Abstract	This deliverable reports on the outreach, communication, dissemination, standardisation, open-source and policy-related activities carried out by Tasks 8.1 and 8.2 over the full duration of the TaRDIS project, providing the final consolidated overview of results, impact, KPIs, and sustainability actions.
Keywords	Dissemination, Communication, Standardisation, Open Source, Policy making, Press, Social media, Publications, Outreach, Liaisons, Events, KPIs



Document Revision History

Version	Date	Description of change	List of contributor(s)
V0.1	05/06/2025	ToC	Filippo Vannella (TID)
	01/10/2025	Standardisation, open source and policies contributions	Filippo Vannella (TID)
	23/03/2026	Dissemination and communication report	Amrita Prasad (Martel)
V0.2	31/03/2026	Minor revisions according to the feedback received by the internal reviewers	Filippo Vannella (TID)
V1.0	31/03/2026	Final version	Filippo Vannella (TID)

DISCLAIMER



Funded by
the European Union

Project funded by



Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Swiss Confederation

Federal Department of Economic Affairs,
Education and Research EAER
State Secretariat for Education,
Research and Innovation SERI

Funded by the European Union (TARDIS, 101093006). Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union. Neither the European Union nor the granting authority can be held responsible for them. This work has received funding from the Swiss State Secretariat for Education, Research and Innovation (SERI).

COPYRIGHT NOTICE

© 2023 - 2025 TaRDIS Consortium

Project funded by the European Commission in the Horizon Europe Programme		
Nature of the deliverable:	to specify R, DEM, DEC, DATA, DMP, ETHICS, SECURITY, OTHER*	
Dissemination Level		
PU	Public, fully open, e.g. web (Deliverables flagged as public will be automatically published in CORDIS project's page)	✓
SEN	Sensitive, limited under the conditions of the Grant Agreement	
Classified R-UE/ EU-R	EU RESTRICTED under the Commission Decision No2015/ 444	
Classified C-UE/ EU-C	EU CONFIDENTIAL under the Commission Decision No2015/ 444	
Classified S-UE/ EU-S	EU SECRET under the Commission Decision No2015/ 444	

* R: Document, report (excluding the periodic and final reports)

DEM: Demonstrator, pilot, prototype, plan designs

DEC: Websites, patents filing, press & media actions, videos, etc.

DATA: Data sets, microdata, etc.

DMP: Data management plan

ETHICS: Deliverables related to ethics issues.

SECURITY: Deliverables related to security issues

OTHER: Software, technical diagram, algorithms, models, etc.



Funded by
the European Union

EXECUTIVE SUMMARY

The present deliverable, developed in the context of Work Package (WP) 8, consolidates and completes the outreach, dissemination, standardisation, open-source, and policy-facing activities conducted across the full duration of the TaRDIS project. It builds on Deliverable D8.1 “Dissemination and Communication Strategy and Plan” [1], and Deliverable D8.3 “Outreach activities mid-term report” [2], extending the reporting from the first project phase (M1-M18) to the final period (M18-M39). Its main purpose is to provide an integrated account of how the TaRDIS consortium promoted project visibility, engaged relevant stakeholders, supported the uptake of project results, and positioned TaRDIS outcomes within broader technical, standardisation, and policy-oriented communities.

Throughout the project, the communication and outreach strategy pursued several interrelated objectives: (i) to ensure broad visibility of TaRDIS activities and results; (ii) to reach, stimulate, and engage relevant stakeholder communities and facilitate the exploitation and uptake of project outcomes; (iii) to support the emergence of a European community around swarm programming and decentralised intelligence; and (iv) to strengthen the project’s contribution to standardisation-related discussions and relevant ecosystem initiatives, including coordination with the European Cloud-Edge-IoT (CEI) community and liaison activities with related initiatives and associations.

In addition to reporting on communication, dissemination, and community-building activities, this deliverable presents the final results of Task 8.2 on standardisation, open-source, and policy and ecosystem engagement. In the area of standardisation, the deliverable consolidates the mapping of relevant standards and standardisation bodies initiated in D8.3 [2] and extends it through a more concrete standards-facing analysis of selected TaRDIS artefacts and use cases, including alignment with existing standards, identification of gaps, and targeted engagement with relevant communities and fora. This includes participation in selected standardisation and ecosystem-related events and interactions with relevant external communities, which helped position TaRDIS results within wider discussions on interoperability, trust, automation, and distributed intelligence systems.

In the area of open source, the deliverable reports on the consolidation of repository practices across partners, the organisation and discoverability of the TaRDIS toolbox, the clarification of licensing approaches, and the adoption of a TaRDIS open source and distribution manifesto as a common policy framework. It also reports on broader policy and ecosystem outreach activities through which TaRDIS engaged with relevant European and international initiatives, events, and discussions related to interoperability, digital infrastructures, and distributed intelligence.

More broadly, this report documents the actions undertaken by the consortium in response to recommendations from the M18 project review, in particular the call for greater convergence on open-source and licensing practices and a stronger pathway to standardisation. It also outlines the longer-term perspectives associated with the project’s results, including the continued visibility, accessibility, reuse, and follow-up potential of TaRDIS artefacts and outcomes beyond the formal end of the project.

TABLE OF CONTENTS

1 Introduction	11
1.1 Purpose of the document	11
1.2 Structure of the document	11
2 Dissemination and Communication	12
2.1 Communication and Dissemination Activities	13
2.1.1 Project Website	13
2.1.2 Social Media Channels	18
2.1.2.1 X	20
2.1.2.2 LinkedIn	21
2.1.3 News items, press releases	22
2.1.4 Newsletters	23
2.1.5 Publications	24
2.1.6 Project Videos	28
2.1.7 Digital and printed promotional materials	29
2.1.8 Events	30
3 Collaboration and liaisons with other projects and initiatives	33
3.1 Liaisons within the EuCEI Ecosystem	33
3.2 Liaisons and events - relevant initiatives and projects	34
4 Impact Assessment	37
4.1 Dissemination and Communication KPIs	37
4.2 Impact Creation Deliverables and Milestones	38
5 Standardisation, Open Source, and Policies Contributions	39
5.1 Standardisation	39
5.1.1 Objectives and Strategy	39
5.1.2 Overview of Relevant Standards	40
5.1.3 Conducted Survey	42
5.1.4 Standards Survey Results	44
5.1.5 Standards Alignment and Gaps	48
5.1.5.1 Distributed navigation concepts for LEO satellite constellations	50
5.1.5.2 Privacy-preserving learning in smart homes	51
5.1.5.3 Multi-level grid balancing in decentralized energy communities	52
5.1.5.4 Resilient decentralized workflow orchestration in smart manufacturing	52
5.1.5.5 PTB-FLA	53
5.1.5.6 Flower-Based Federated Learning Tool	53
5.1.5.7 Fedra	54
5.1.5.8 Pruning	54
5.1.6 Participation in Standardisation-Related Activities and Communities	54
5.1.6.1 IETF	55
5.1.6.2 ETSI	57
5.1.6.3 Participation in Other Standardisation Events and Communities	58
5.1.7 Conclusions and Reflections	59

5.2 Open Source	60
5.2.1 Continuity from Deliverable D8.3	60
5.2.2 Consolidation of Partner Practices and Data Collection Method	61
5.2.3 Development Platforms and Repositories	62
5.2.4 Distribution and Availability of the TaRDIS Toolbox	64
5.2.5 Licensing Principles	67
5.2.6 TaRDIS Open Source and Distribution Manifesto	69
5.3 Policy Engagement and Ecosystem Outreach	71
5.4 Conclusions and Perspectives	73
6 Conclusions	74
References	75

LIST OF FIGURES

Figure 1: TaRDIS website

Figure 2: TaRDIS website analytics

Figure 3: Geographical distribution of the visitors of TaRDIS website

Figure 4: Visitor acquisition via different channels

Figure 5: TaRDIS project social media cards

Figure 6: TaRDIS X Channel

Figure 7: TaRDIS LinkedIn page

Figure 8: TaRDIS project News webpage

Figure 9: TaRDIS published newsletters

Figure 10: TaRDIS published videos on the website

Figure 11: TaRDIS project promo materials (demo flyers and rollup)

Figure 12: TaRDIS project promo materials (postcard)

Figure 13: The EuCEI community

Figure 14: TaRDIS at ADR Forum 2025

Figure 15: Swarm Workshop banner

Figure 16: Participants distribution: across projects and external

Figure 17: Some glimpses from the Swarm Workshop 2025

Figure 18: Logos of relevant TaRDIS SDOs

Figure 19: Template for collection of key topics/keywords

Figure 20: Template for collection of related standards

Figure 21: Template for collection of partners' involvement in standardisation activities and bodies.

Figure 22: Updated partner survey results: recurring technical themes and standards families relevant to TaRDIS.

Figure 23: Schematic representation of standards and technical recommendations relevant to the project

Figure 24: IETF Internet-Draft "GFDS"

Figure 25: Presentation of the Internet-Draft “GFDS” at IETF 124, delivered within the DINRG session

Figure 26: TaRDIS poster on “Collaborative Intelligence Sharing in Energy Communities via Federated Learning,” presented at ETSI AI conference.

Figure 27: Template for the collection of information on developer platforms and version control systems used by TaRDIS partners

Figure 28: Template for the collection of information on TaRDIS software repositories

Figure 29: Distribution of reported TaRDIS repository entries by hosting platform. Of the 53 reported repository entries, 33 (62.3%) are hosted on GitLab, 21 (37.7%) are hosted on GitHub

Figure 30: Most common reasons for choosing a developer platform according to the updated internal survey. Categories are not mutually exclusive; a single response may contribute to more than one category

Figure 31: Examples of TaRDIS related repositories README and their acknowledgement

Figure 32: Link to the collection of repositories on GitLab at TaRDIS’ homepage, entry point to TaRDIS related repositories

Figure 33: Screenshots from the TaRDIS Wiki. The Wiki serves as a centralised entry point to the TaRDIS toolbox by consolidating documentation on the programming model, tools and APIs, the TaRDIS IDE, and recipe-based guidance for concrete use cases, thereby improving the discoverability and usability of results developed in WP3

Figure 34: License distribution across TaRDIS repository

Figure 35: Representative policy, ecosystem, and standardisation-related events and initiatives in which TaRDIS participated or contributed during the project

LIST OF TABLES

Table 1: TaRDIS project scientific publications

Table 2: TaRDIS Events Overview

Table 3: Dissemination and Communication KPIs

Table 4: List of deliverables for Work Package 8

Table 5: Technical scope of relevant TaRDIS SDOs

Table 6: Collection of Standards and recommendations relevant to TaRDIS

Table 7: Collection of alignment and gaps identified in the current TaRDIS standard landscape

ABBREVIATIONS

AI	Artificial Intelligence
ATTM	Access, Terminals, Transmission and Multiplexing
BDVA	Big Data Value Association
CCSDS	Consultative Committee for Space Data Systems
CEI	Cloud Edge and Internet of Things
CRL	Certificate Revocation List
CSA	Connectivity Standards Alliance
DINRG	Decentralization of the Internet Research Group
EBDVF	European Big Data Value Forum
EC	European Commission
EE	Environmental Engineering
ECSS	European Cooperation for Space standardisation
ETSI	European Telecommunications Standards Institute
EU	European Union
EuCEI	European Cloud Edge and Internet of Things
FL	Federated Learning
GDPR	General Data Protection Regulation
GFDS	Generic Framework for Building Dynamic Decentralized Systems
ICT	Information and Communication Technology
IDE	Integrated development environment
IEC	International Electrotechnical Commission
IEEE-SA	Standards Association of the Institute of Electrical and Electronics Engineers
IETF	Internet Engineering Task Force
IoT	Internet of Things
IP	Internet Protocol
ISO	International Organization for Standardisation

ITU	International Telecommunication Union
KPI	Key Performance Indicator
ML	Machine Learning
OCF	Open Connectivity Foundation
OSI	Open Systems Interconnection
SNS-JU	Smart Networks and Services Joint Undertaking
R&I	Research and Innovation
RIA	Research and Innovation Action
SEO	Search Engine Optimisation
SERI	Secretariat for Education, Research and Innovation
SDO	Standards Development Organisations
TC	Technical Committee
Q1	Quarter 1
WG	Work Group
WIPO	World Intellectual Property Organization
WP	Work Package
W3C	World Wide Web Consortium
ZSM	Zero-touch Network and Service Management

1 INTRODUCTION

1.1 PURPOSE OF THE DOCUMENT

Work Package (WP) 8 was dedicated to implementing tools and initiatives to disseminate information, engage with relevant stakeholders, and support the project's standardisation, open-source, and policy-related activities. To this end, WP8 worked in close collaboration with the other work packages of the TaRDIS project, the European Union Cloud-Edge-IoT (EuCEI) community, the European Commission (EC), relevant standardisation bodies and standardisation-oriented communities, the wider open-source community, and related swarm-computing projects and initiatives such as the Big Data Value Association (BDVA) and the Smart Networks and Services Joint Undertaking (SNS-JU).

The Outreach Activities Final Report (reporting period: January 2023 - March 2026) presents an integrated overview of the communication, dissemination, standardisation, open-source coordination, and policy engagement activities of the TaRDIS project. This deliverable builds on the framework established in Deliverable D8.1 [1], "Dissemination and communication strategy and plan" and Deliverable D8.3 [2], "Outreach activities mid-term report", and has the following objectives:

- 1) Describe the implemented communication and engagement activities, and stakeholder engagement activities, including monitoring methods, description of the Key Performance Indicators (KPIs) and evaluation processes.
- 2) Illustrate how the project's tools, channels, and promotional materials have been used in the project's dissemination and communication efforts to maximize visibility and facilitate uptake of TaRDIS results.
- 3) Summarise the standardisation-related efforts and activities, including alignment of TaRDIS outputs with relevant standards, identification of gaps, and engagement with relevant standardisation communities.
- 4) Report on the consortium's final approach to open-source coordination, repository organisation, licensing, discoverability, and distribution of the TaRDIS toolbox.
- 5) Provide an integrated final account of the outreach, dissemination, standardisation, and policy-facing activities conducted throughout the project.

This final deliverable addresses the recommendations received during the M18 review. In particular, the measures undertaken in the second phase of the project to strengthen the pathway towards standardisation, clarify open-source licensing and distribution, reinforce alignment with relevant communities and the broader European swarm and decentralised intelligence ecosystem are reflected in the corresponding sections of this document.

1.2 STRUCTURE OF THE DOCUMENT

The sections of this deliverable are organised as follows. Section 2 discusses communication and dissemination activities during the duration of the project. Section 3 describes the collaboration and liaisons with other projects and initiatives. Section 4 describes the tools behind assessing impact. Section 5 describes the standardisation, open source, and policy-related activities undertaken by the project. Finally, Section 6 concludes the document.

2 DISSEMINATION AND COMMUNICATION

Communication and dissemination activities are central to the overall TaRDIS effort. They were being closely monitored and coordinated to ensure an effective engagement of all targeted stakeholders, including those in the broader cloud-edge-IoT and decentralised swarm ecosystems, as well as related vertical domains.

To raise awareness and maximise the impact of the project, a comprehensive communication and dissemination plan was developed in Quarter 1 (Q1) of the project (see Deliverable D8.1 [1] for details). In the previous Deliverable D8.3 [2] (Outreach Activities mid-term report), we reported the activities carried out in the first half of the project, from M1-M18. The current document details the activities carried out under the communication and dissemination tasks in the final phase of the project.

Its execution began at the early project stages and continued at a steady pace throughout its whole duration. Building upon the activities outlined in Deliverable D8.3 [2], a set of dedicated online and offline activities, outlined below, has been pursued to support the achievement of project objectives and ensure a broad promotion and effective showcasing of developed concepts, technologies, use cases, and project results. These activities are conducted under MARTEL's leadership, with active contributions from all TaRDIS project partners.

This task leads a set of dedicated dissemination and communication actions with the following objectives:

- Ensure broad visibility and awareness of TaRDIS, promoting project knowledge and establishing a recognizable identity to support promotional and marketing efforts.
- Engage and stimulate a critical mass of relevant stakeholders to effectively showcase project results, leading to validation and further adoption of the developed technologies.
- Contribute significantly to relevant scientific domains and standardisation bodies as appropriate and relevant to planned exploitation plans and project outcomes.
- Establish liaisons and ensure close collaboration with relevant initiatives in the industry and Research & Innovation (R&I) domains, particularly those in the European Cloud Edge and Internet of Things (EuCEI) community, and other similar initiatives.

Communication and Dissemination Phases

In this reporting period, dissemination and communication activities have been carried out related to the mid and final phases of communication and dissemination activities, as defined in D8.1 [1], Section 2.1, emphasizing on the dissemination and stakeholder engagement as well as global outreach and sustainable impact generating activities.

During the second and the final phases, the primary focus was on engaging target stakeholders and presenting the results of the project. The following communication strategy and activities were carried out:

- **Organising the technical workshops:** TaRDIS project organised several technical workshops in scientific conferences in collaboration with different projects of the same “swarm computing” cluster, e.g., P2CODE, OASEES and SmartEdge. TaRDIS co-organised the Swarm Workshop 2025, which was a joint activity of all the 5

projects in the Swarm computing cluster (detailed in Section 3.2) .

- **Presenting project results:** TaRDIS showcased its outcomes and milestones at various events and conferences.
- **Producing videos to raise awareness:** Promotional videos and demo videos were created to highlight the project's objectives, technical achievements, and impact.
- **Animating social media channels:** The project team actively engaged with stakeholders and the public through various social media platforms.
- **Publishing news items on the project website and media:** Regular updates were posted to keep stakeholders informed about the project's progress.
- **Distributing newsletters:** Periodic newsletters were sent out to stakeholders to maintain interest and update them on project milestones.
- **Participating in events:** Team members attended events to network, share knowledge, and promote the project.

2.1 COMMUNICATION AND DISSEMINATION ACTIVITIES

2.1.1 Project Website

The TaRDIS website <https://www.project-tardis.eu/> (see Figure 1), has been developed to act as an information hub presenting the project's goals, activities, and achievements. The website was launched in January 2023 at the time of the official start of the project and features the following:

- General information about the project, its vision, objectives, and anticipated impact.
- Information about project use cases and enabling functions.
- A brief introduction to all members of the consortium.
- News items and press releases.
- List of relevant events.
- A repository of resources, such as scientific publications, presentations/talks, promotional materials, videos, and public deliverables.
- Contact forms and information.
- An acknowledgment and reference to the European Union's Horizon Europe Research and Innovation programme and the Swiss Confederation Federal Department of Economic Affairs, Education and Research (acknowledging the funding agency for the Swiss Associate partner).

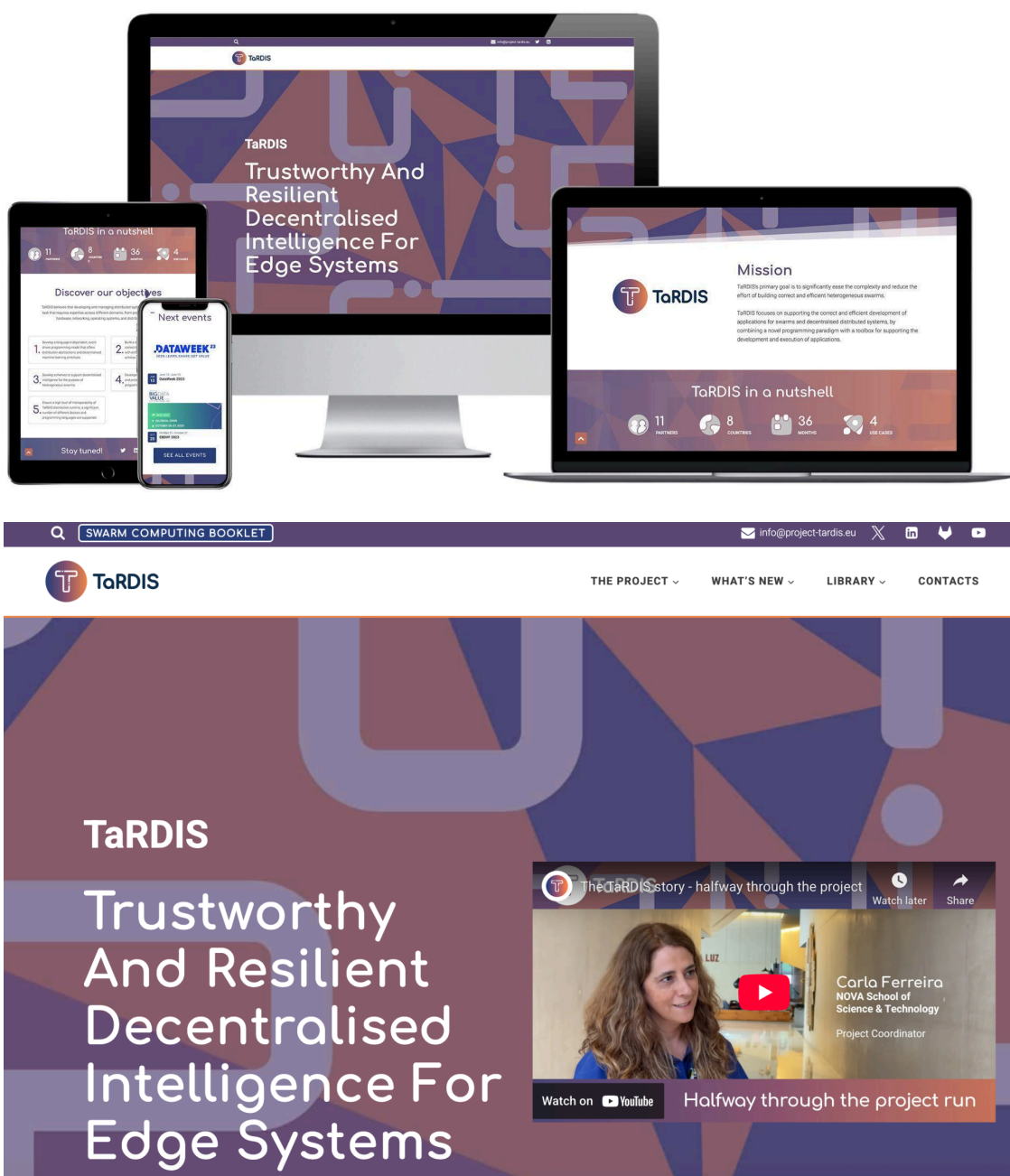


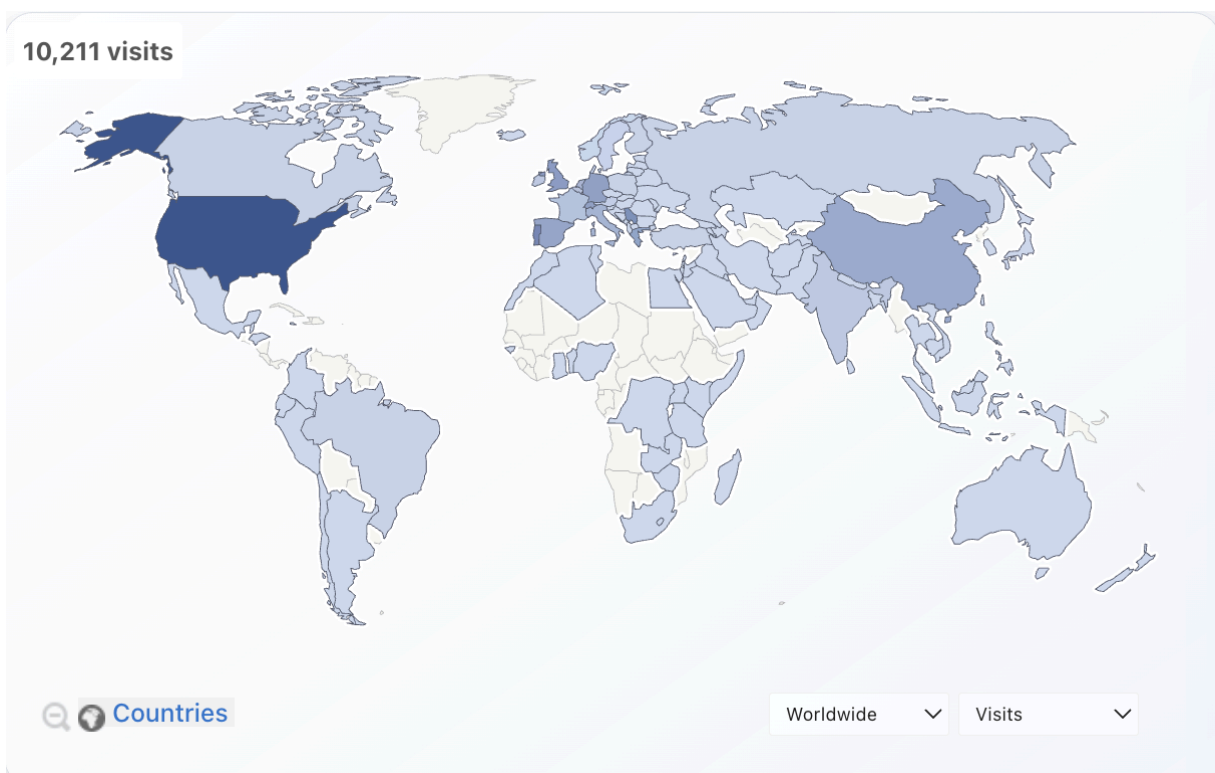
Figure 1: TaRDIS website.

The website has been periodically updated according to the evolution of the project. All data represented in the current document are based on the analytics from March 2026.

In terms of reach and engagement, during the entire course of the project, the website counts **10211 unique visitors** that have generated **almost 21000 page views**, as shown in Figure 2.



Figure 2: TaRDIS website analytics.



Country	
COUNTRY	VISITS
 United States	1,583
 Portugal	932
 Serbia	848
 United Kingdom	697
 Germany	658

1-5 of 111 [Next >](#)

Figure 3: Geographical distribution of the visitors of TaRDIS website.

Based on the provided analytics data for the TaRDIS website for the entire period of the project, we have observed the following traffic sources (see Figure 4):

- **Direct:** 6192 visits (61%): Direct traffic occurs when users type the website's URL directly into their browser's address bar, access it through browser bookmarks, or click on a link in an email or a document (e.g., a PDF). This traffic source often reflects users who are already familiar with the project or have visited the website before.
- **Organic Search:** 3095 visits (30%): Organic search traffic refers to users who found the website through a search engine (e.g., Google, Bing, Yahoo) by entering relevant keywords.
- **Referral:** 620 visits (6%): Referral traffic is generated when users visit the website by clicking on a link from another website. This can include links in blog posts, news articles, or online directories.
- **Social:** 258 visits (3%): Social traffic comes from users who find and visit the website through social media platforms (e.g., X, LinkedIn).

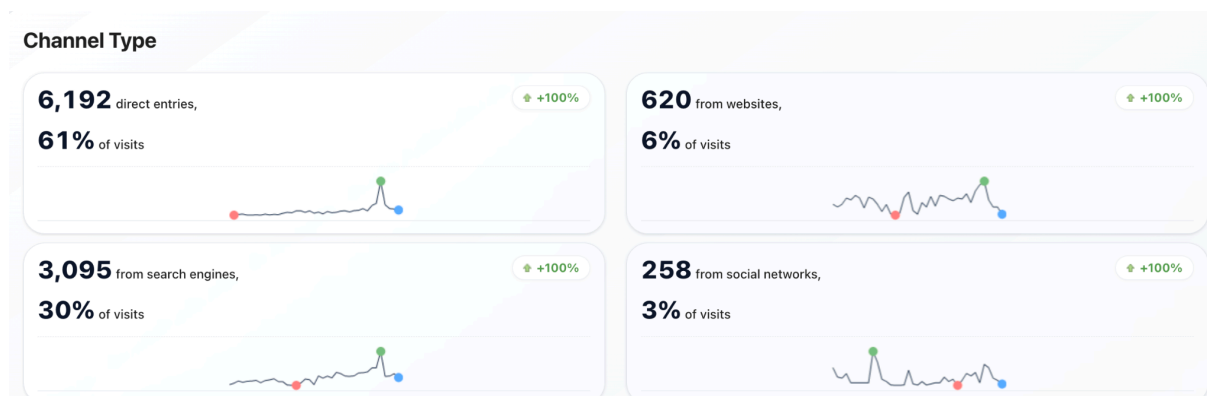


Figure 4: Visitor acquisition via different channels.

Measures undertaken to improve website traffic. In the final phase of the project we see a steady rise in the website visitors, peaking around November 2025, which was when TaRDIS was co-organising the Swarm Workshop with the cluster projects. A number of strategies were implemented through the communication activities in order to bring more traffic to the TaRDIS website.

1. Organic Search Traffic: Organic search accounted for 30% of the total traffic, the trend remained the same during the first reporting period (refer to Deliverable D8.3 [2]). The following measures were put in place to boost organic search traffic:

- Conducting thorough keyword research and incorporating relevant keywords into the website's content.
- Improving on-page Search Engine Optimisation (SEO) by optimising metadata (title tags, meta descriptions, header tags, etc.) and creating high-quality, informative content that engages visitors.
- Utilising internal and external links to improve site navigation and build a strong backlink profile.
- Regularly updating and maintaining the website to ensure optimal performance and user experience.

2. Social Media Presence: During the entire course of the project, social media contributed to only 3% of the total traffic. Despite regular postings on TaRDIS LinkedIn channel, and a sizable community on the platform, we noticed not a large influx of visitors on the website.

3. Referral Traffic: Referral traffic accounted for 6% of the total traffic. Following measures were incorporated to drive referral traffic.

- Established partnerships with relevant industry websites, blogs, or online communities.
- Engaged in guest posting on authoritative websites in the TaRDIS niche.
- Offered valuable resources, such as whitepapers and joint webinars, that were shared by other websites.

4. Direct Traffic: Direct traffic constituted the majority of the website's traffic, 61%. Following measures were incorporated into the communication activities:

- Ensuring that the website is easily accessible through clear navigation, fast loading times, and mobile-friendly design.
- Encouraging repeat visitors by offering valuable content.
- Keeping the website dynamic and updated with current technical advancements of the project.

All information and e-mails collected are protected under the General Data Protection Regulation (GDPR). Contact has been only made with people who have submitted inquiries. Similarly, the newsletters have been sent out only to individuals who have explicitly requested to receive them. Any subscriber can request for their e-mail address to be removed from the list. The website provides information on the data kept and how they are used in alignment with the GDPR under the privacy policy link (footer of the webpage).

Last but not least, TaRDIS opted for an environmentally responsible website hosting platform, which has been designed to be as energy efficient as possible to limit the unnecessary waste of resources. The web hosting provider, GreenGeeks, puts back three times the power consumed into the grid in the form of renewable energy.

2.1.2 Social Media Channels

TaRDIS established its presence on social media channels to regularly promote project activities and outputs while encouraging wider discussions on swarm computing research and development, as well as Artificial Intelligence (AI), Machine Learning (ML), programming languages, cloud, edge, Internet of Things (IoT), and distributed computing. The project has built a solid follower base on prominent social media channels, namely X and LinkedIn, which are linked to the project's website.

For most of the promotional posts, social media cards are created following the brand identity of the project (or of the event), and these social media cards are used for the promotion of project events, international days of relevance, newsletter announcements etc. Some examples of social media cards produced for TaRDIS project are shown in the following Figure.

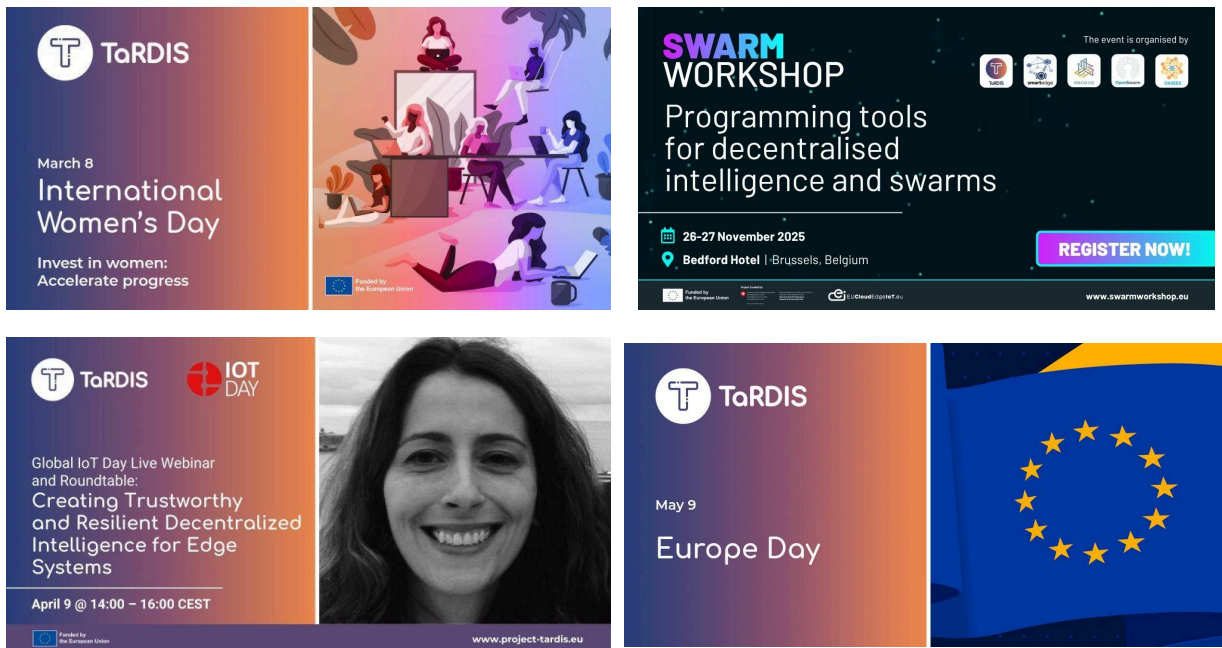


Figure 5: TaRDIS project social media cards.

2.1.2.1 X

TaRDIS uses X, as it is a very dynamic social network covering the news in real-time at a global level. To date, the TaRDIS X account (@TARDIS_EU) has attracted **239 followers**. The project follows 119 accounts, mostly projects, and initiatives in similar fields. The project’s X account is used predominantly to promote and disseminate project activities and developments but also to learn about and cross-share relevant and interesting events and initiatives and to establish meaningful connections with relevant stakeholders, including policy makers, industry, and the general public.

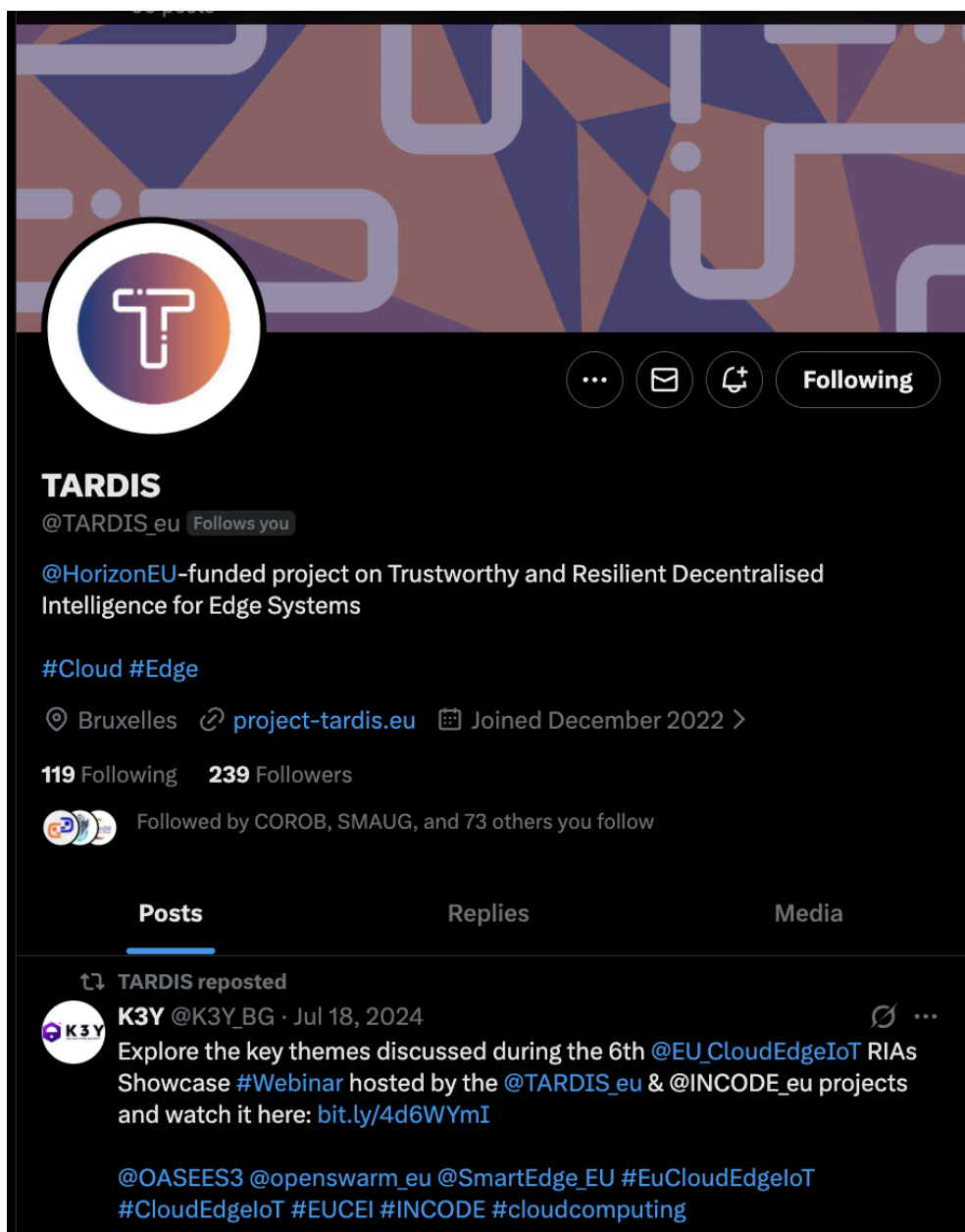


Figure 6: TaRDIS X Channel.

2.1.2.2 LinkedIn

LinkedIn, as one of the biggest business networks in the world (over 150 million users in more than 200 countries and territories), is a useful tool for TaRDIS. It allows the project to network with individuals and organisations within the industry and beyond, share relevant information about project activities, and stay up to date on the latest developments in the field. To date, the TaRDIS LinkedIn account (tardis-project) has attracted **543 followers**. Similar to X, the LinkedIn account is used to promote project activities and learn about and cross-share relevant events and activities. Figure 7 presents the project’s LinkedIn profile.

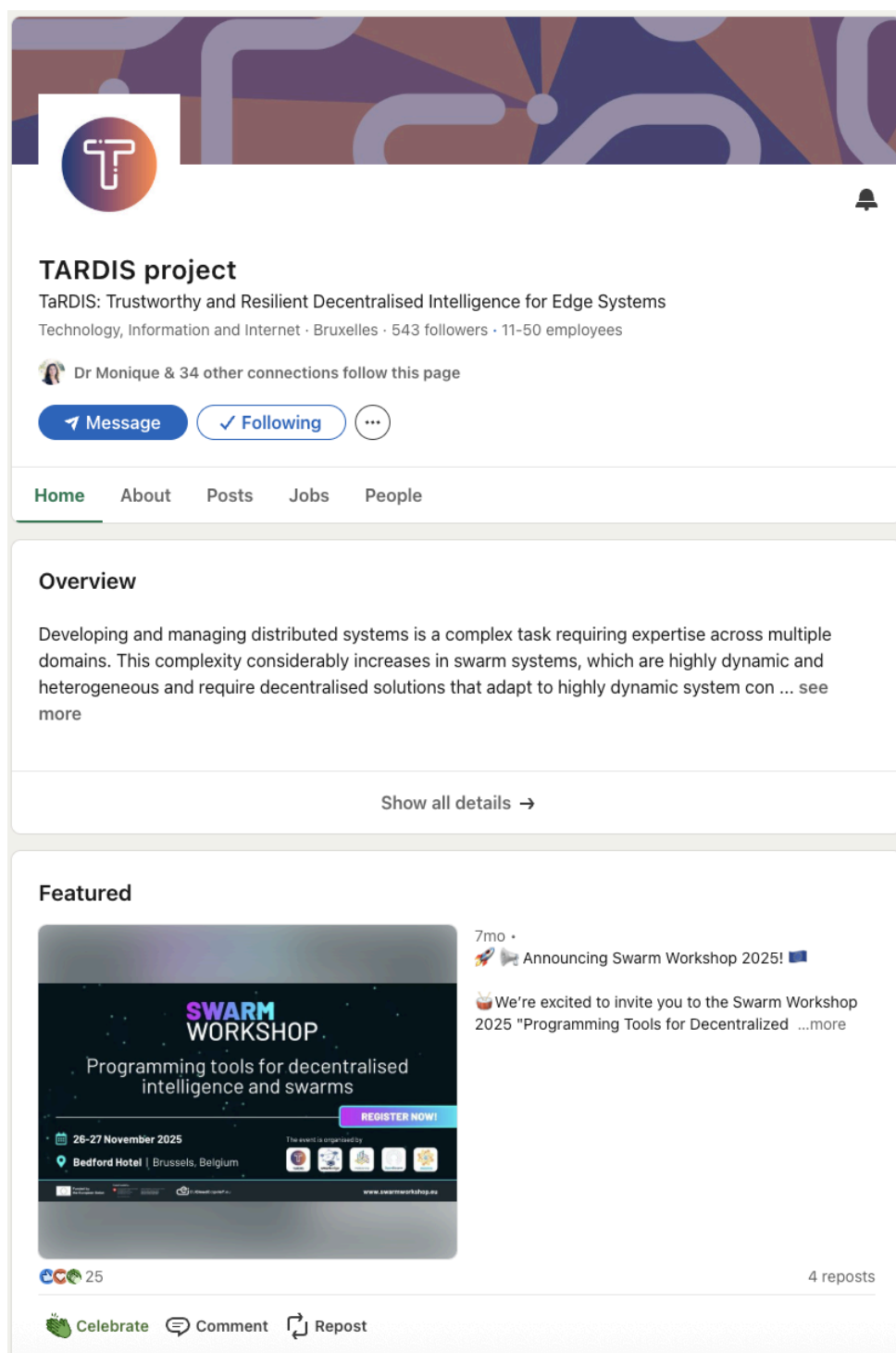


Figure 7: TaRDIS LinkedIn page.

2.1.3 News items, press releases

The TaRDIS consortium keeps the community and the general public informed about relevant activities, undertakings, and events by publishing news items and press releases. During the course of the project, **29 news items** and **1 press release** have been published on the project website. Figure 8 shows the news items published on the website.

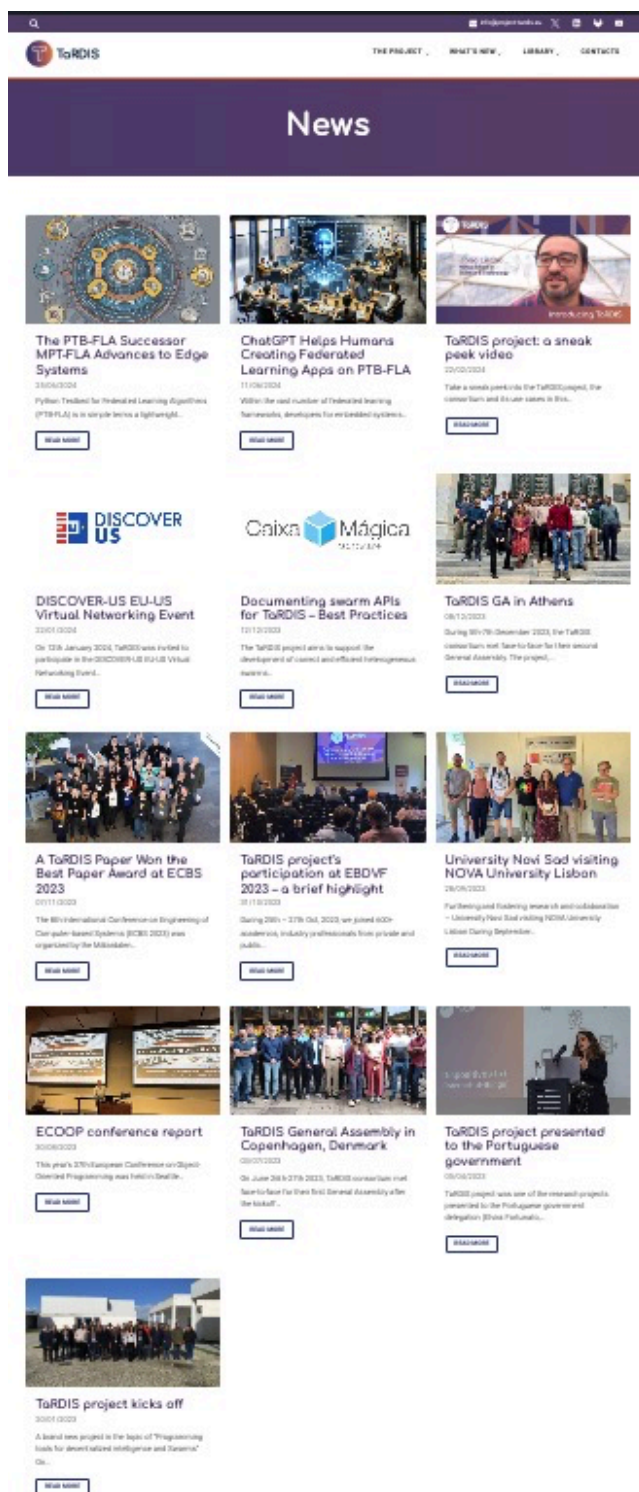


Figure 8: TaRDIS project News webpage.

2.1.4 Newsletters

The TaRDIS periodic newsletter is sent out twice a year, providing updates on the swarm computing topics, programming languages, cloud-edge-iot, AI/ML ecosystems as well as on the project activities, findings, demos and results. The project newsletters also contain information on the upcoming tasks, events, as well as any relevant news and announcements from individual project partners when relevant. A mailing list based on subscription has been created, giving the possibility to share the newsletter via mass mailing. A registration functionality allowing interested visitors to subscribe to the newsletter has been available on the project website since the beginning of the project. The design of each newsletter is aligned with the TaRDIS brand identity. The newsletter is also fully responsive to ensure its readability on any device. All newsletters issued are being uploaded to the website upon distribution to subscribers. During the course of the project, 6 editions of the newsletter have been sent out (see Figure 9).

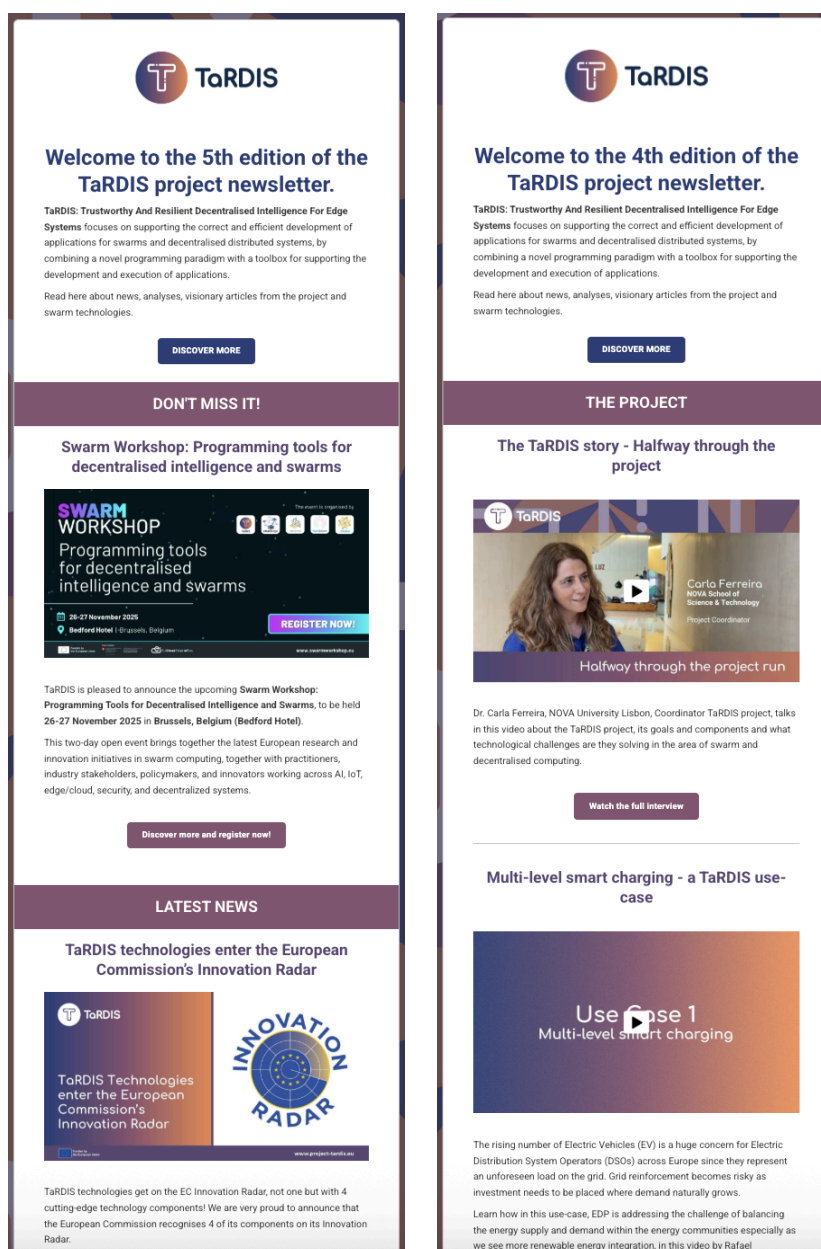


Figure 9: TaRDIS published newsletters.

2.1.5 Publications

The TaRDIS consortium is committed to bringing research results closer to the public and adheres to the Open Access guidelines set by the Horizon Europe work programme. All project partners are strong supporters of Open Access as it enables all interested parties to use published research results irrespectively of their location or income, boosting the transfer of knowledge between science, the economy, and society at large. The project has been very active in that sphere since its early stages. Table 1 below lists all the accepted and published papers stemming from TaRDIS in this reporting period.

Table 1: TaRDIS project scientific publications.

Title	Authors	Place of publication
Flocking to Mastodon: Tracking the Great Twitter Migration	He, Jiahui, Haris Bin Zia, Ignacio Castro, Aravindh Raman, Nishanth Sastry, and Gareth Tyson	IMC '23: Proceedings of the 2023 ACM on Internet Measurement Conference
Lightweight Inference by Neural Network Pruning: Accuracy, Time and Comparison	Ilias Paralikas, Sotiris Spantideas, Anastasios Giannopoulos & Panagiotis Trakadas	IFIP International Conference on Artificial Intelligence Applications and Innovations
Deep Reinforcement Learning for Smart Home Temperature Comfort in IoT-Edge Computing Systems	Marios Christopoulos, Sotirios Spantideas, Anastasios Giannopoulos and Panagiotis Trakadas	Co-located with the European Conference on Computer Systems (EuroSys)
COTS: Connected OpenAPI Test Synthesis for RESTful Applications	Christian Bartolo Burlò, Adrian Francalanza, Emilio Tuosto and Alceste Scalas.	COORDINATION 2024 - 26th International Conference on Coordination Models and Languages
Fair Join Pattern Matching for Actors	Philipp Haller, Ayman Hussein, Hernán Melgratti, Alceste Scalas, Emilio Tuosto	38th European Conference on Object-Oriented Programming (ECOOP 2024)
Fair Join Pattern Matching for Actors (Artifact)	Philipp Haller, Ayman Hussein, Hernán Melgratti, Alceste Scalas, Emilio Tuosto	38th European Conference on Object-Oriented Programming (ECOOP 2024)
Accountable Banking Transactions	Sebastian Mödersheim, Siyu Chen	Open Identity Summit 2024
Models for Storage in Database Backends	Edgard Schiebelbein, Saalik Hatia, Annette Bieniusa, Carla Ferreira, Gustavo Petri, Marc Shapiro	PaPoC '24: Proceedings of the 11th Workshop on Principles and Practice of Consistency for Distributed Data
A Language-Based Version Control System for Python	Luís Carvalho, João Costa Seco	38th European Conference on Object-Oriented Programming (ECOOP 2024)
Towards Formal Verification of Federated Learning Orchestration Protocols on Satellites	Miroslav Popović, Marko Popović, Miodrag Đukić, Ilija Bašičević	TELFOR 2024, Belgrade, Serbia

MicroPython Testbed for Federated Learning Algorithms	Miroslav Popović, Marko Popović, Ivan Kaštelan, Miodrag Đukić, Ilija Bašičević, Pavle Vasiljević	TELFOR 2024, Belgrade, Serbia
"FedShip: Federated Over-the-Air Learning for Communication Efficient and Privacy-Aware Smart Shipping in 6G Communications"	A. E. Giannopoulos, S. T. Spantideas, M. Zetas, N. Nomikos and P. Trakadas	IEEE Transactions on Intelligent Transportation Systems
"Distributed Gradient Clustering: Convergence and the Effect of Initialization"	Aleksandar Armacki, Himkant Sharma, Dragana Bajović, Dušan Jakovetić, Mrityunjoy Chakraborty, Soumya Kar	ACSSC 2024, Pacific Grove, CA, USA
Tackling heavy-tailed noise in distributed estimation: Asymptotic performance and tradeoffs	Dragana Bajović, Dušan Jakovetić, Soumya Kar, Manojlo Vuković	TELFOR 2024, Belgrade, Serbia
Configuration Management in the Distributed Cloud	Tamara Ranković, Ivana Kovačević, Veljko Maksimović, Goran Sladić, Miloš Simić	ICIST 2024, Kopaonik, Serbia
Token-based identity management in the distributed cloud	Ivana Kovačević, Tamara Ranković, Milan Stojkov, Miloš Simić	ICIST 2024, Kopaonik, Serbia
Polymorphic network structures allowing distributed clouds	Miloš Simić, Milan Stojkov, Tamara Ranković, Goran Sladić, Miroslav Zarić	ICIST 2024, Kopaonik, Serbia
Misconfiguration Prevention and Error Cause Detection for Distributed-Cloud Applications	Tamara Ranković, Filip Šiljić, Jovan Tomić, Goran Sladić, Miloš Simić	SISY 2024, Pula, Croatia
Data Overlay Mesh in Distributed Clouds Allowing Collaborative Applications	Miloš Simić, Jovana Dedeić, Milan Stojkov, Ivan Prokić	IEEE Access
Distributed Center-Based Clustering: A Unified Framework	Aleksandar Armacki, Dragana Bajović, Dušan Jakovetić, Soumya Kar	IEEE Transactions on Signal Processing
Minimization of the Training Makespan in Hybrid Federated Split Learning	Joana Tirana, Dimitra Tsigkari, George Iosifidis, Dimitris Chatzopoulos	IEEE Transactions on Mobile Computing
Parameterized Complexity of Caching in Networks	Robert Ganian, Fionn Mc Inerney, Dimitra Tsigkari	AAAI 2025
Correct orchestration of federated learning generic algorithms: Python translation to CSP and verification by PAT	Miodrag Đukić, Ivan Prokić, Miroslav Popović, Silvia Ghilezan, Marko Popović, Simona Prokić	International Journal on Software Tools for Technology Transfer
High-probability Convergence Bounds for Online Nonlinear Stochastic Gradient Descent under Heavy-tailed Noise	Aleksandar Armacki, Shuhua Yu, Pranay Sharma, Gauri Joshi, Dragana Bajović, Dušan Jakovetić, Soumya Kar	28th International Conference on Artificial Intelligence and Statistics (AISTATS) 2025
Federated Isolation Forest for Efficient Anomaly Detection on Edge IoT Systems	Pavle Vasiljević, Milica Matic, Miroslav Popović	2025 Zooming Innovation in Consumer Technologies International Conference (ZINC)

Translating Federated Learning Algorithms in Python into CSP Processes Using ChatGPT	Miroslav Popović, Marko Popović, Miodrag Đukić, Ilija Bašičević	48th ICT and Electronics Convention MIPRO 2025
Autonomous Price-Aware Energy Management System in Smart Homes via Actor-Critic Learning With Predictive Capabilities	S. T. Spantideas, A. E. Giannopoulos and P. Trakadas	IEEE Transactions on Automation Science and Engineering
ReDunT: Automatically Deriving Redundancy Relations for Pure Op-Based CRDTs	Dina Borrego, Afonso Vilalonga, Henrique Domingos, Nuno Pregoça, Elisa Gonzalez Boix, Carla Ferreira	12th Workshop on Principles and Practice of Consistency for Distributed Data (PaPoC '25)
Towards Local-First Distributed Property Graphs	Ayush Pandey, Stefania Dumbrava, Marc Shapiro, Carla Ferreira, Mário Pereira, Nuno Pregoça	12th Workshop on Principles and Practice of Consistency for Distributed Data (PaPoC '25)
Concurrency Contracts for Designing Highly Available Replicated Data Types	Kevin De Porre, Carla Ferreira, Elisa Gonzalez Boix	Software: Practice and Experience
Ensuring Convergence and Invariants Without Coordination	Dina Borrego, Nuno Pregoça, Elisa Gonzalez Boix, and Carla Ferreira	39th European Conference on Object-Oriented Programming (ECOOP 2025)
Iso-Recursive Multiparty Sessions and their Automated Verification	Marco Giunti, Nobuko Yoshida	34th European Symposium on Programming (ESOP 2025)
Grading call-by-push-value, explicitly and implicitly	Dylan McDermott	10th International Conference on Formal Structures for Computation and Deduction (FSCD 2025)
Pallas: A Data-Plane-Only Approach to Accurate Persistent Flow Detection on Programmable Switches in High-Speed Networks	Weihe Li, Beyza Bütün, Tianyue Chu, Marco Fiore, Paul Patras	IEEE ICNP 2025
Harmonia: A Swift and Accurate Approximate Data Structure for Real-Time Heavy Flow Detection in High-Speed Networks	Weihe Li, Tianyue Chu, Christos-Savvas Bouganis & Paul Patras	Advanced Data Mining and Applications (ADMA 2025)
Protocol-aware cloud gateway with adaptive rate control	Ivana Kovačević, Vasilije Milić, Isidora Knežević, Tamara Ranković, Milos Simić	International Conference on Software Engineering Advances (ICSEA 2025)
PSPSP: A Tool for Automated Verification of Stateful Protocols in Isabelle/HOL	Andreas Hess, Sebastian Mödersheim, Achim Brucker, and Anders Schlichtkrull	Journal of Computer Security (JCS)
A Structural Complexity Analysis of Hierarchical Task Network Planning	Cornelius Brand, Robert Ganian, Fionn Mc Inerney, and Simon Wietheger	Thirty-Fourth International Joint Conference on Artificial Intelligence (IJCAI 2025)
The Parameterized Complexity of Computing the VC-Dimension	Florent Foucaud, Harmender Gahlawat, Fionn Mc Inerney, and Prafullkumar Tale	Advances in Neural Information Processing Systems (NeurIPS 2025)
Decentralized reconfiguration management in distributed clouds	Milos Simić, Boris Lauš, Tamara Ranković	ICIST 2025, Kopaonik, Serbia

Monitoring the distributed cloud: Metric collection and aggregation	Tamara Ranković, Nemanja Pokornić, Aleksandar Pavlović, Miloš Simić	ICIST 2025, Kopaonik, Serbia
A monitoring system for collecting and aggregating metrics from distributed clouds	Tamara Ranković, Mateja Rilak, Janko Rakonjac, Miloš Simić	2025 IEEE 23rd Jubilee International Symposium on Intelligent Systems and Informatics (SISY)
Generic Algorithm for Universal TDM Communication Over Inter Satellite Links	Miroslav Popović, Marko Popović, Pavle Vasiljević, Ilija Bašičević	33rd Telecommunications Forum (TELFOR)
Formal Verification of a Generic Algorithm for TDM Communication Over Inter Satellite Links	Miroslav Popović, Marko Popović, Pavle Vasiljević, Miodrag Đukić	33rd Telecommunications Forum (TELFOR)
On Asynchronous Multiparty Session Types for Federated Learning	Prokić Ivan, Prokić Simona, Ghilezan Silvia, Scalas Alceste, Yoshida Nobuko	ICTAC 2025, Marrakesh, Morocco
Knowledge Distillation-Driven Federated Learning as a Service for Resource-Constrained Edge Intelligence	Filippo Vannella, Tianyue Chu, David Solans Noguero, Sotiris Spantideas	ANTS 2026, Darmstadt, Germany
D-Exit: A Decentralised Early Exit of Inference Framework for Swarm Systems	Sotirios Spantideas, Anastasios Giannopoulos, Anastasios Kaltakis, Nicholas Assimakis and Panagiotis Trakadas	IEEE DESSERT 2025
Denotational reasoning for asynchronous multiparty session types	Dylan McDermott, Nobuko Yoshida	Denotational reasoning for asynchronous multiparty session types

2.1.6 Project Videos

The TaRDIS project has a YouTube channel for its videos. **11 videos** have been published on the website, which includes project overview video, videos explaining the use-cases and several demos showcasing the technical outputs of the project. Figure 10 shows the videos page on the website.

Workshops, webinars and project's interviews.

Follows us and subscribe our [YouTube channel](#).

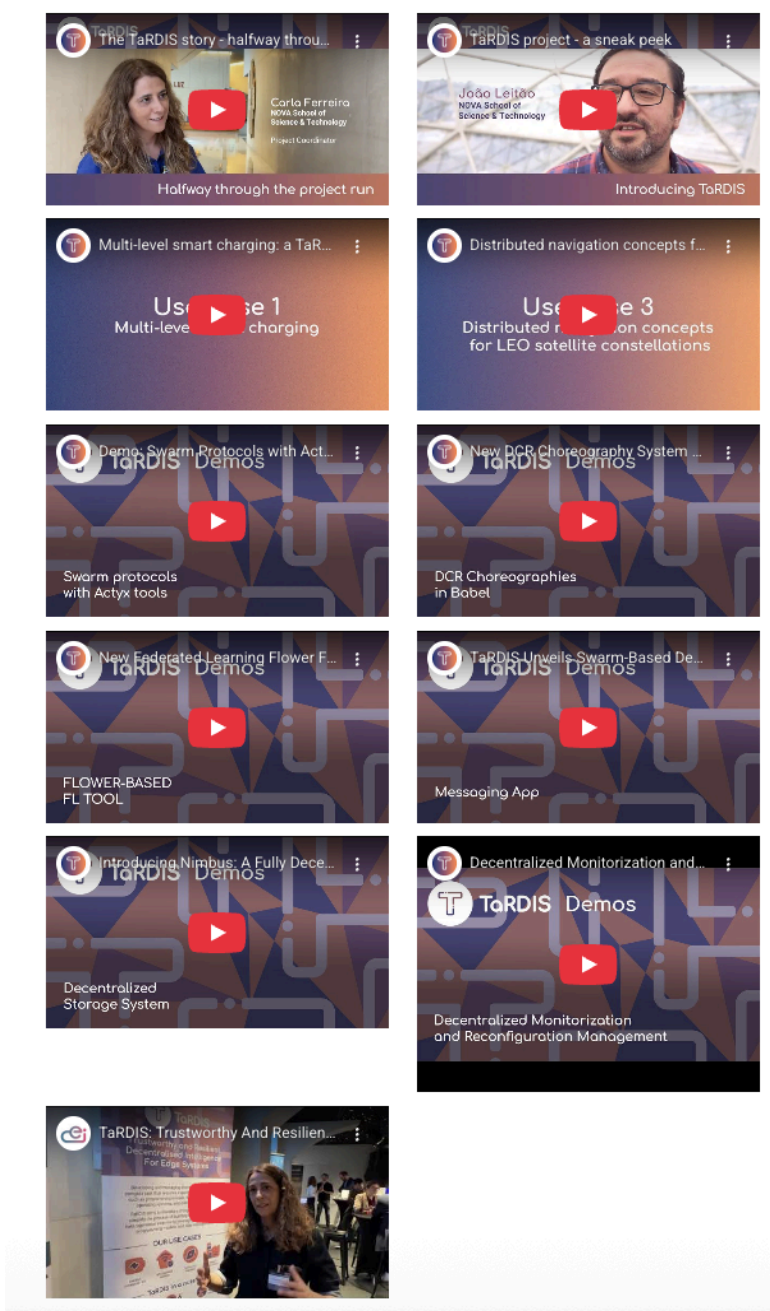


Figure 10: TaRDIS published videos on the website.

2.1.7 Digital and printed promotional materials

The TaRDIS project partners have participated in many events during the course of the project and have carried with them the different promotional materials that were produced. We have also participated in conferences with poster presentations. All promotional artefacts of the project have been published on the website (<https://project-tardis.eu/promo-materials/>). All promotional materials are printed as well as uploaded on the website.



Figure 11: TaRDIS project promo materials (demo flyers and rollup).



Figure 12: TaRDIS project promo materials (postcard).

2.1.8 Events

Event organisation and attendance are an important aspect of the TaRDIS' communication and dissemination strategy. Since the project kicked off in January 2023, TaRDIS coordinator and project partners have taken a very proactive step in raising awareness about the project in the European and global swarm computing and cloud-edge-IoT communities.

Table 2 provides further details on attended events for the reporting period.

Table 2: TaRDIS Events Overview.

N.	Name of the event	Type of event	Location and date	Focus/target stakeholders	URL	Planned presence	Partner involved
1	DISCOVER-US Workshop on Swarm computing	Workshop	24-26 June, Sabaudia, Italy	Academia, Industry, policy makers, EC	https://discover-us.eu/sabaudia/#/	Presentation	NOVA
2	COORDINATION 2024	Conference	Groningen, Netherlands, 17-21 June 2024	Academia	https://www.discotec.org/2024/coordination.html	Presentation	DTU
3	Open Identity Summit 2024	Workshop	Porto, Portugal, 20-21 June 2024	Academia, industry	https://easychair.org/cfp/oid2024	Presentation	DTU
4	Copenhagen Programming Languages Workshop - CoPLaWS 2024	Workshop	23 August 2024, Copenhagen, Denmark	Academia, industry	https://coplaws.github.io/2024	Presentations and participation	DTU
5	PLAID workshop	Workshop	16-20 Sept 2024, Vienna, Austria	Academia	https://conf.researchr.org/home/issta-ecoop-2024/plaid-2024	Workshop organiser	DTU, NOVA, Oxford, Actyx
6	Workshop on Cross-Domain Standardisation and Architecture for IoT and Edge Computing	Workshop	26-27 Nov. 2024, Brussels	EC, Industry, academia	https://instarstandards.org/events/workshop-cross-domain-standardisation-and-architecture-edge-computing	Presentation	TID
7	ESA NAVITEC conference	Conference	11-13 December 2024, Noordwijk, Netherlands	Academia, industry	https://atpi.eventsair.com/navitec-2024/	poster presentation, presentation	GMV
8	ETSI AI Conference - How Standardisation is Shaping the Future of AI	Conference	10-12 Feb 2025, Sophia Antipolis, France	Academia, industry	https://www.etsi.org/events/2451-etsi-ai-conference-2025	scientific poster	EDP, NKUA

9	EUROPEAN UTILITIES TELECOM COUNCIL - Standards and Spectrum Group	internal working group call	7th March 2025, 13:00 CET, online	Academia, industry		EDP usecase presentation	EDP
10	IoT Day 2025, Latest research in IoT supply chain security to ensure compliance with the Cyber Resilience Act (CRA)	Webinar	9 April 2025, 14:00 - 16:00, online	Academia, industry	https://dossproject.eu/iot-day-webinar-2025/	Presentation, panel	NOVA, Martel
11	16th Workshop on Programming Language Approaches to Concurrency and Communication-centric Software (PLACES 2025)	Workshop	4 May 2025, Hamilton, Canada	Academia, industry	https://places-workshop.github.io/2025/	Presentation	UOXF
12	ARIA Safeguarded AI, TA1.1 Creator Cohort: Kick-Off	Workshop	1-2 October 2024, Manchester, UK	Academia, industry		Discussions with Safeguarded AI researchers	UOXF
13	ARIA Safeguarded AI, TA1.1 Creator Workshop 2	Workshop	2-5 February 2025, York, UK	Academia, industry		Discussions with Safeguarded AI researchers	UOXF
14	ARIA Safeguarded AI, TA1.1 & TA3 Creator Workshop	Workshop	10-11 April 2025, Nottingham, UK	Academia, industry		Discussions with Safeguarded AI researchers and companies	UOXF
15	28th International Conference on Artificial Intelligence and Statistics (AISTATS) 2025	Conference	3 - 5 May 2025, Mai Khao, Thailand	Academia, industry	https://aistats.org/aistats2025/	Presentation	UNS

16	2025 Zooming Innovation in Consumer Technologies International Conference (ZINC)	Conference	28 - 29 May 2025, Novi Sad, Serbia	Academia, industry	https://www.gozinc.org/	Presentation	UNS
17	48th ICT and Electronics Convention MIPRO 2025	Conference	2 - 6 Jun 2025, Opatija, Croatia	Academia, industry	http://mipro.hr/	Presentation	UNS
18	Standardization activities in the cloud continuum. (Cognitive Computing Continuum Cluster)	Webinar	July 1 2025, Online	Academia, industry	https://cognets.eu/event/webinar-standardization-in-cc/	Attendance	TID
19	NexusForum2025 Summit	Conference	5-6 Nov 2025, Brussels	Academia, Industry, policy makers, EC	https://nexusforum.eu/	Presentation	NOVA, Martel
20	ADRA Forum 2025	Conference	23-24 Sept 2025, Stavanger, Norway	Academia, Industry, policy makers, EC	https://adrforum.eu/adrforum-agenda-2025	Panel participation	NOVA, CMS, Martel
21	Swarm Aware Workshop 2025	Conference	29 Sept - 2 Oct 2025, Porto	Academia, industry	https://swarmaware.github.io/	Workshop co-organiser	NOVA, Martel
22	Swarm workshop	Final event Swarm projects	26-27 Nov 2025, Brussels	Academia, Industry, policy makers, EC	https://swarmworkshop.eu/	Co-organiser	All partners
23	PLAID 2024	ECOOP Workshop	Sept 16, 2024	Academia, industry	https://conf.research.org/home/issta-ecoop-2024/plaid-2024	Workshop organiser	NOVA, DTU, UOXF, Actyx
24	PLF+PLAID 2025	ECOOP Workshop	July 3, 2025	Academia, industry	https://2025.ecoop.org/home/plf-plaid-2025	Workshop organiser	DTU, UNS, NOVA,

3 COLLABORATION AND LIAISONS WITH OTHER PROJECTS AND INITIATIVES

3.1 LIAISONS WITHIN THE EUCEI ECOSYSTEM

The EuCEI Continuum is an umbrella initiative that was brought to life by the OpenContinuum and the UnlockCEI projects to coordinate and support the European Cloud, Edge and IoT Continuum ecosystems. The goal is to unlock the potential of these transformative technologies by understanding the supply and demand value chains in Europe. It is currently managed by the Connectivity Standards Alliance (CSA) NexusForum.EU and CEI-Sphere.

As reported in D8.3 [2], TaRDIS' participation in the EuCEI community remains unchanged. TaRDIS participated in the events organised by the EuCEI initiative, (directly collaborating with the NexusForum project), contributed to the EuCEI monthly newsletter and participated in the monthly communication task force calls.

The EuCEI brings an inclusive vision supporting actionable recommendations and solutions for the next generation of Cloud-Edge-IoT for researchers, industry, and policymakers. Through effective partnerships, the initiative guides its stakeholders towards defining an integrated, open ecosystem built around open source, open standards, and the seamless and effective blending of cloud, IoT and edge.

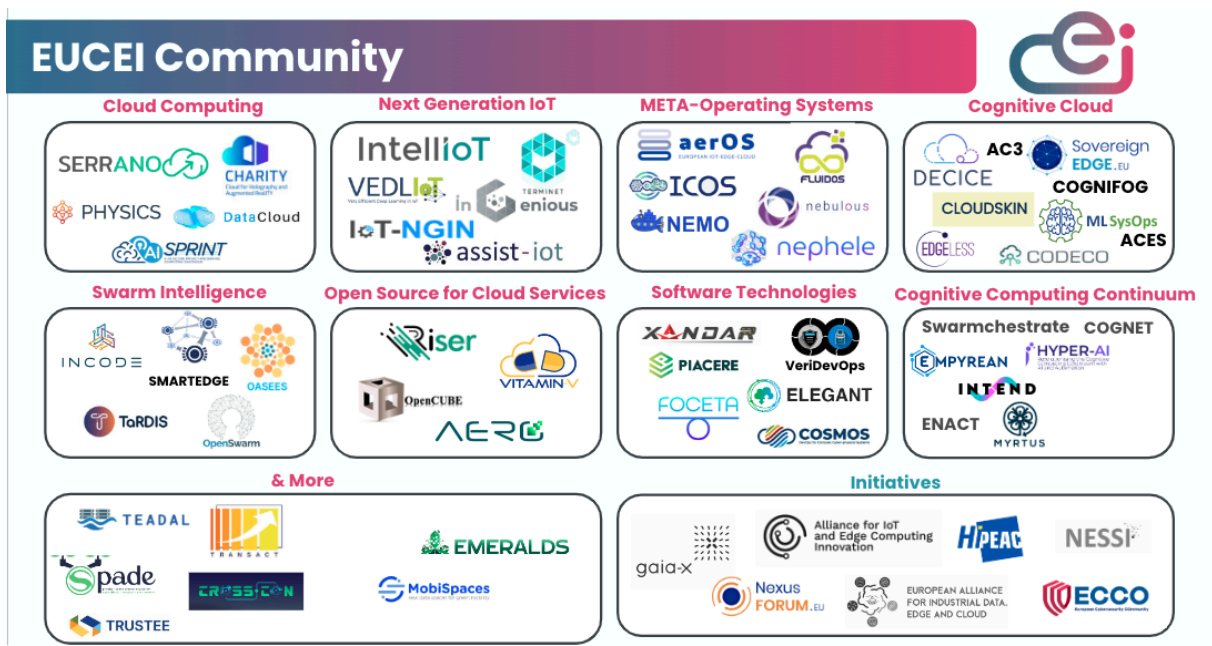


Figure 13: The EuCEI community.

3.2 LIAISONS AND EVENTS - RELEVANT INITIATIVES AND PROJECTS

TaRDIS has participated and co-organised several events and scientific workshops in collaboration with other projects from the Swarm computing cluster.

AI, Data and Robotics (ADR) Forum 2025. On September 23rd 2025, TaRDIS and P2CODE organised a technical panel on the topic “From Lab to EU Open Digital Markets: AI Swarm Programmability & Collaborative Rollouts” at **ADR Forum 2025**, that took place in Stavanger, Norway. This interactive workshop explored how AI paradigms, such as swarm intelligence, uses concrete use cases to drive collaborative, large-scale rollouts and strategically disseminate them via the EU’s open digital markets and the AI-on-Demand platform.

Participants explored how European open platforms such as AI-on-Demand and EU open digital markets can act as accelerators for collaborative innovation, transforming early-stage AI research into trusted and scalable digital services. Discussions focused on how to lower barriers to adoption, improve digital literacy, and embed governance-by-design principles to ensure compliance with the EU AI Act, especially in distributed and safety-critical contexts.



Figure 14: TaRDIS at ADR Forum 2025.

SwarmAware 2025 (Workshop at SRDS 2025). Between 29 October - 2 October 2025, TaRDIS, OASEES and P2CODE organised the SwarmAware 2025 Workshop, located at the SRDS 2025 Conference, in Porto. The organizing committee was led by Vrettos Moulos (ARHS Group, P2CODE), Carla Ferreira (NOVA University Lisbon, TaRDIS), and Akis Kourtis (NCSR Demokritos, OASEES), reflecting the close cooperation between the three

Horizon Europe initiatives focused on secure, intelligent, and dependable distributed systems. SwarmAware provided a forum to examine the emergence of swarm intelligence in edge-to-cloud systems, where large numbers of autonomous agents, from IoT sensors to drones and mobile robots, need to collaborate under uncertain real-world conditions. Discussions throughout the day highlighted both the promise of distributed decision-making and the engineering challenges it introduces in reliability, coordination, and security.

Swarm Workshop 2025. On 26-27 November 2025, all 5 projects of the Horizon Europe Swarm Computing cluster co-organised the Swarm Workshop 2025 in Brussels. The 2 day event gathered private and public organisations as well as individuals active in the European swarms community, that are also actively engaged in several related research domains, such as artificial intelligence, Information and Communications Technologies (ICT) security and connectivity, or working on topics acting in those domains, such as interoperability, open source and ICT standardisation.



Figure 15: Swarm Workshop banner

Apart from contributing to the overall development of the event's program, TaRDIS also led the design and graphic aspects of the event. We developed an independent brand and brand identity for the event, developed the website (<https://swarmworkshop.eu/>), templates, as well as provided and managed the registration platform. No new social media channels were established for the event, and all 5 projects (TaRDIS, OASEES, P2CODE, OpenSwarm, SmartEdge) contributed to the promotion and publicity of the event.

The detailed program with a list of demos are available on the official website of the event <https://swarmworkshop.eu/>.

The event gathered **147 registered participants**, ranging from academia, industries and research institutions. In Figure 16, we see the percentage of participants from each of the projects, as well as participation outside of the projects, which accounted for **over 35%** of the total participants.

Participation percentage

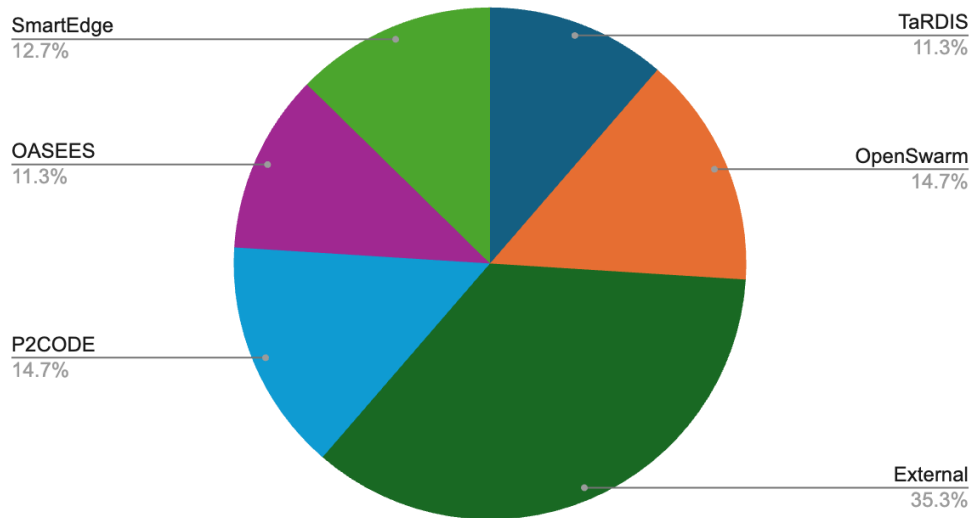


Figure 16: Participants distribution: across projects and external.

A detailed report on the event is captured in this [news item](#).



Figure 17: Some glimpses from the Swarm Workshop 2025.

4 IMPACT ASSESSMENT

4.1 DISSEMINATION AND COMMUNICATION KPIS

The following metrics, reported in Table 3 and updated from Deliverable D8.3 [2] in the final phase of the project, were used to monitor and assess the progress of the communication and dissemination activities and provide some measurable outcomes related to their impact created (as far as this is feasible from a quantitative point of view).

Table 3: Dissemination and Communication KPIS.

Tool/Activity	KPI	Target value	Value at M39
Website	Unique visitors average (yearly)	1500	10211 total visitors
Social media	Number of followers (by project end) on X Number of followers (by project end) on LinkedIn	≥ 1000 (both accounts)	X: 239 LinkedIn: 543
Promo materials	Number of flyers Number of posters/rollups	6 4	5 2
Videos	Number of published videos	≥ 6	11
Press releases	Number of press releases tailored to specific target groups	≥ 4	1
Newsletters	Number of newsletters sent out	6	6
Fairs, conferences & events	To diffuse results to the academic community and industry, receive feedback and discover scientific cooperation opportunities.	≥ 9	44
Demos		4 demos	5
Publications		≥ 30	76
Workshops		≥ 3	9

4.2 IMPACT CREATION DELIVERABLES AND MILESTONES

Table 4: List of deliverables for Work Package 8.

Number	Name	Lead partner	Dissemination level	Due date	Status at M18
D8.1	Dissemination and Communication Strategy and Plan	MARTEL	PU	M03	Submitted
D8.2	Exploitation and sustainability strategy and plan	CAIXA MAGICA	SEN	M18	Submitted
D8.3	Outreach activities mid-term report	TID	PU	M18	Submitted
D8.4	Exploitation and sustainability roadmap	CAIXA MAGICA	PU	M39	Pending
D8.5	Outreach activities final report	TID	PU	M39	Current document

5 STANDARDISATION, OPEN SOURCE, AND POLICIES CONTRIBUTIONS

This section presents the results of Task 8.2 on standardisation (Section 5.1), open-source activities (Section 5.2), and policy-related outreach (Section 5.3) over the full project duration (M1-M39). It builds on the baseline established in Deliverables D8.1 [1] and D8.3 [2] for the first project phase (M1-M18).

5.1 STANDARDISATION

This subsection consolidates the results of Task 8.2 on standardisation-related activities across the full project duration, building on the baseline mapping and internal survey reported in Deliverable D8.3 [2]. While the first phase of the project focused on identifying relevant standards, standardisation bodies, and partner practices, the second phase concentrated on consolidating standardisation-relevant results around concrete TaRDIS artefacts and use-cases.

In particular, the final phase focused on translating technical results into standards-relevant terms, analysing their alignment with existing standards, identifying potential gaps in the current standardisation landscape, and supporting targeted engagement in relevant standardisation fora. It also considered opportunities for follow-up beyond the project duration, given that standardisation cycles typically extend beyond the duration of the project.

5.1.1 Objectives and Strategy

The standardisation activities of Task 8.2 aimed to position the outcomes of TaRDIS within the broader landscape of relevant standards, reference architectures, and standardisation-oriented communities. In this context, standardisation was understood not only as a possible contribution to formal standards development, but also as a mechanism for improving interoperability, supporting market and community uptake, and facilitating dialogue with stakeholders beyond the consortium. More specifically, the standardisation dimension of TaRDIS pursued two main objectives:

1. **Identify applicable standards and standardisation potential of TaRDIS outcomes.** This includes mapping existing standards relevant to the technical work of the project, understanding where TaRDIS artefacts align with established practices, and identifying gaps or emerging needs that could inform standardisation activities.
2. **Use standardisation as a tool for dissemination, uptake and external relevance of the project results, and interaction with relevant market stakeholders.** This includes engaging with relevant standardisation and architecture-oriented communities, increasing the visibility of TaRDIS outcomes, and framing the project's technical results in a way that is understandable and useful to Standards Development Organisations (SDOs), implementers, industrial actors, and policy-related audiences.

To achieve these objectives, Task 8.2 followed a staged strategy across the project lifetime, including: (i) collecting key technical topics and relevant standards across the consortium; (ii) identifying the standardisation bodies and technical committees most relevant to TaRDIS technologies; (iii) guiding project partners on possible standardisation pathways, participation models and contribution formats; and (iv) coordinating participation in targeted events, networking sessions, and standardisation or policy relevant exchanges.

During the first phase of the project (M1-M18), emphasis was placed on surveying the standardisation landscape relevant to TaRDIS. This included collecting key technical topics from partners, identifying standards already adopted and monitored in the technical work packages, and mapping relevant standardisation bodies.

In the second phase of the project (M18-M39), the focus shifted from general mapping towards a more concrete standards-facing consolidation of TaRDIS outcomes. In particular, the work concentrated on: analysing how selected TaRDIS tools and use cases relate to existing standards, identifying gaps and opportunities relevant to standardisation, strengthening the connection between standardisation, open-source dissemination, and supporting external positioning through targeted engagement activities, including standards-related exchanges and contributions.

This approach was shaped by the M18 review recommendation, which called for a stronger pathway to standardisation, closer alignment with communities around open source, standards, and common architectures, and stronger support for the emergence of a European swarm developer community. Accordingly, in the second phase of the project, Task 8.2 focused on consolidating partner inputs, relating selected TaRDIS artefacts and use cases to existing standards, identifying gaps, and strengthening external positioning through targeted engagement activities, including standards-related exchanges and contributions.

5.1.2 Overview of Relevant Standards

To keep this final report self-contained, we recall a set of standardisation definitions and concepts. A more detailed overview of standards, SDOs, and standardisation procedures was already provided in Deliverable D8.3 [2]. In the present final deliverable, only the elements strictly necessary to contextualise TaRDIS standardisation activities are recalled.

A *standard* (French: *norme*, German: *Norm*) is a document that provides rules, guidelines or characteristics for activities or their results, for common and repeated use¹. Depending on the issuing body, such outputs may take the form of standards, international standards, technical specifications, technical reports, or guides/recommendations.

The standardisation landscape relevant to TaRDIS spans several SDOs active in ICT, networking, AI, ML, cybersecurity, and application areas. In particular, the bodies most relevant to TaRDIS include: ITU-T (International Telecommunication Union Telecommunication standardisation Sector), ISO (International Organization for standardisation) IEC (International Electrotechnical Commission), ETSI (European Telecommunications Standards Institute), IEEE-SA (Standards Association of the Institute of Electrical and Electronics Engineers, IETF (Internet Engineering Task Force), and W3C (World Wide Web Consortium) complemented by more specialised organisations such as CCSDS (Consultative Committee for Space Data Systems) and ECSS (European Cooperation for Space standardisation) for the satellite-related use case. Where relevant to the broader European standards landscape, CEN and CENELEC are also considered.

Their relevance stems from the technical scope of TaRDIS, which intersects with distributed systems, decentralized learning, communication protocols, trust and security mechanisms, orchestration, and software engineering practices. The logos of these SDOs are depicted in Figure 18 and the technical focus of several well-established SDOs in the ICT domain is summarised in Table 5.

¹ Retrieved from the official website of the European Committee for Standardisation (French: Comité Européen de Normalisation (CEN)): <https://www.cenelec.eu/european-standardisation/european-standards/types-of-deliverables/>



Figure 18: Logos of relevant TaRDIS SDOs.

Table 5: Technical scope of relevant TaRDIS SDOs.

Organisation	Technical Scope
ITU-T	Interoperable telecom specifications including architecture, services, protocols, addressing/numbering plans.
ISO	ICT architecture (Open System Interconnection (OSI) model), services, protocols including application layer protocols.
IEC	Electrotechnical standards, including connectors, electrical safety, and tests.
ETSI	Interoperable ICT specifications including architecture, services.
CEN	Household appliances, Intelligent Transportation and Mobility, Smart Grids and Smart Metering, Cybersecurity, Blockchains.
CENELEC	Electrotechnical standards, including connectors, switches, plugs, sockets, electrical installation, electrical safety and tests, electromagnetic compatibility, communication systems using the electricity supply lines, Smart Grids and Smart Metering,
IEEE	Electrical and Electronics: LANs, MANs (IEEE 802), Emerging technologies (AI, IoT, automotive, robotics, home automation).
IETF	All Internet-related specifications, including protocols, generic applications, addressing rules (IP, URL, etc.).
ECSS	Space systems engineering, software engineering, product assurance, and lifecycle processes for space missions and their associated ground equipment and facilities, including spacecraft, launchers, payloads, experiments, and related support segments
CCSDS	Communications and data systems standards for spaceflight, including space communications protocols, data handling, interoperability, and cross-support for governmental and commercial space missions.

In Deliverable D8.3 [2] the typical lifecycle of a standard was presented, we refer the reader to this document for a comprehensive explanation. Given the time horizon of TaRDIS compared to the longer lifecycle of formal standardisation processes, the role of Task 8.2 was not limited to the potential submission of standards contributions but included monitoring relevant SDO activities, identifying standards applicable to TaRDIS artefacts, and translating project outcomes into standards-facing language that can support future follow-up beyond the duration of the project.

The next subsections present the internal consortium survey strategy and its main results.

5.1.3 Conducted Survey

The collection of data on standardisation efforts relevant to TaRDIS was carried out within Task 8.2 and was reported in D8.3 [2]. During the final phase of the project, this material was updated and consolidated to reflect the latest partner inputs, the evolution of the technical work, and the increased maturity of the TaRDIS toolbox and use intersections concerning relevant standards and standardisation activities.

In order to obtain a comprehensive and structured view of how standardisation intersects with the project's technical activities, a survey was conducted among partners involved in technical work packages and tasks, namely WPs 2 to 7. The survey collected information per work package, per task, and per partner, focusing on four key aspects:

- i. **Key topics, technologies, and research areas** addressed by each partner in the context of the project;
- ii. **Standards already used** for the implementation of each task;
- iii. **Standards planned to be used or monitored** as the technical work evolved;
- iv. **Existing involvement in standardisation bodies/committees**, including memberships, working group participation, and related activities.

The survey was implemented through a structured Excel template circulated across the consortium, ensuring uniformity and comparability of inputs across work packages. The completed templates were returned and centrally consolidated within Task 8.2. In the second part of the project, the collected material was updated where relevant in order to support the final analysis reported in this deliverable.

Figures 19-21 illustrate the structured templates of the conducted survey: Figure 19 presents the table for collecting key topics and keywords; Figure 20 summarises the standards partners currently use or plan to use; Figure 21 captures partners' involvement in SDOs, including memberships and working group participation.

	A	B	C
1	Dear Partner,		
2	In order to organize the standardization activities within the TaRDIS project (Task 8.2), we kindly ask you to fill in the following.		
3			
4	Partner's Name:		
5	Description of the Basic Role of the Partner (e.g., WP2 leader and Task 7.1 leader):		
6	Contact information (name of the person/team , email address) for standardization activities within your organization: (This information will not be made publicly available)		
7			
8			
9	Table 1: Please state as a list the key topics you will be involved in during your participation in the project per Task.		
10	Note: For your convenience, the information of the WP and the Task Name have been drawn from the agreement and can be selected from the available dropdown menus. One organization can insert more than one lines, since they may be involved in many WPs Tasks Topics. In blue below you may find an example on how to fill the table.		
11	e.g., WP6: Data Management and Distribution Primitives	e.g., Task 6.1: Decentralised membership and communication primitives	e.g., secure communications, peer-to-peer communications, data management, ...
12	WP Title	Task Name	Key Topics/Keywords (at least 5)
13			
14	<div style="border: 1px solid #ccc; padding: 2px;"> WP2: Definition of heterogeneous swarms WP3: Programming Abstractions for the Cloud-Edge Continuum WP4: Programming Logic and Analysis Framework WP5: Decentralised Machine Learning WP6: Data Management and Distribution Primitives WP7: Implementation and Evaluation </div>		

Figure 19: Template for collection of key topics/keywords.

Table 2: For each of the topics that you have identified in Table 1, please indicate the standards you are a)already using (top) and b)planning to investigate/use (bottom).			
Note: In blue below you may find an example and a list of some standards issuing organizations that may provide standards related to the project. A dropdown menu is available to fill in the relevant project task.			
e.g., IEEE, ISO, ETSI, UL standards, IEC, ...	e.g., ISO/IEC 29151:2017	e.g., Information technology -- Security techniques -- Code of practice for personally identifiable information protection	e.g., Task 6.1: Decentralised membership and communication primitives
Related Standard Issuing Organization	Related Standard Identifier	Related Standard Title	Related TaRDIS Task
Standards you are currently using and are related to TaRDIS			
Standards you are planning to investigate on their relevance to TaRDIS			

Figure 20: Template for collection of related standards.

Table 3: Do you personally or your organization take part in any standardization activity?			
If yes, please provide the details (e.g. Standardization Organization Title of committee or standard Type of participation Status of effort). If no, leave blank. In blue below you may find an example.			
<i>e.g., ISO</i>	<i>e.g., ISO 27032</i>	<i>e.g., Contributor</i>	<i>e.g., Contribution in the definition of swarm based on the findings of WP2</i>
Standardization Organization	Title of committee or standard	Type of participation	Status of effort related to TaRDIS (if any)

Figure 21: Template for collection of partners’ involvement in standardisation activities and bodies.

The results derived from this survey provided the baseline for identifying the standardisation areas most relevant to TaRDIS. In the final phase of the project, this material was revisited and consolidated in light of the increased maturity of the toolbox, the refinement of the use cases, and the clearer understanding of the technical artefacts produced by the consortium. This also enabled a transition from broad standards mapping to a more targeted analysis of concrete TaRDIS tools and use cases, as presented in the following subsections.

5.1.4 Standards Survey Results

The standardisation survey provided two complementary outputs: (i) a consolidated view of the technical themes emerging across the consortium, and (ii) an updated inventory of the technical standards and technical recommendations relevant to the TaRDIS technical work.

The first output concerns the technical focus of the project. Based on the updated partner inputs, the most recurrent themes include “requirements, implementation, learning, analysis, verification, protocols, and specification”, confirming that the TaRDIS technical work is strongly implementation-driven and closely linked to concrete use cases and engineering concerns. From a standardisation perspective, this is relevant, as it shows that the project’s interaction with standards is connected to practical questions of interoperability, software engineering, trust, and deployment.

The second output of the survey concerns the standards landscape itself. Partners were asked to report both standards already applied/aligned in their tasks and standards identified as relevant reference points for alignment, assessment, or monitoring. This resulted in a consolidated inventory covering 22 unique standards, technical recommendations or relevant standardisation documents (e.g. IETF drafts) .

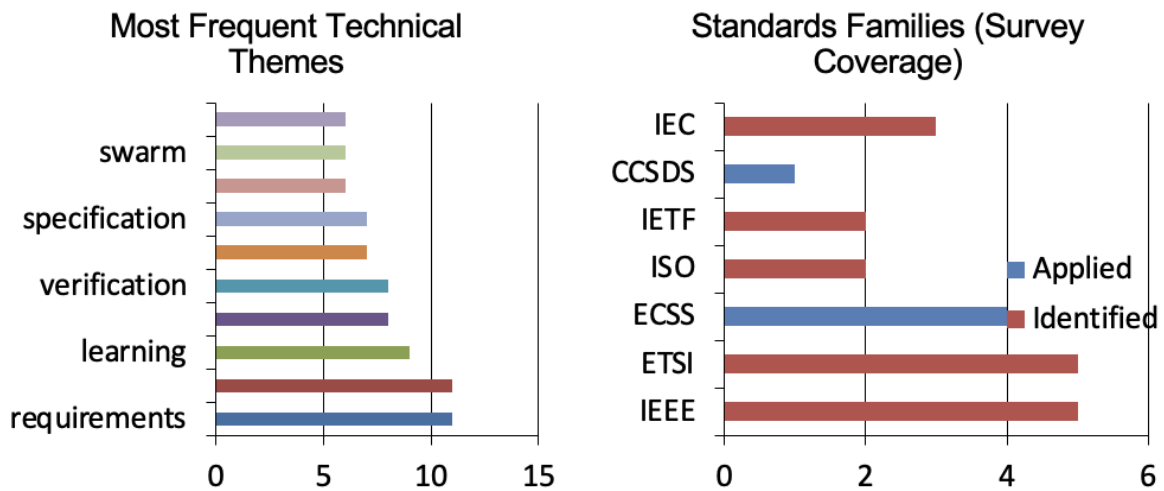


Figure 22: Updated partner survey results: recurring technical themes and standards families relevant to TaRDIS.

The collected standards span a broad range of domains directly aligned with the TaRDIS technology portfolio. These include Federated Learning (FL) and collaborative ML, network automation and orchestration, identity and security frameworks, industrial and communication network security, device interoperability, neural-network compression, and space communication and satellite-swarm related standards. Taken together, the survey confirms that TaRDIS sits at the intersection of several mature standardisation ecosystems, rather than within a single narrowly defined domain.

The inventory is summarised in Table 6 which lists standards identified by partners as relevant to the project and therefore important reference points for alignment and assessment. The resulting landscape is structured around standard families with strong relevance to TaRDIS outcomes, notably IEEE-SA, ETSI, ISO/IEC, IETF, IEC, CCSDS, and ECSS. The survey highlights a concentration of standards-related relevance around three areas: (i) **distributed learning and AI-related frameworks**, (ii) **protocols, security, and interoperability**, especially through IETF, IEC, and related references; and (iii) **space system validation and software assurance**, especially through CCSDS and ECSS for the satellite swarm use case.

Table 6: Collection of Standards and recommendations relevant to TaRDIS.

Standard Issuing Organisation	Standard Identifier	Standard Title	Related TaRDIS task
P4 Language Consortium / Linux Foundation	P4	P4 Language Specification, P4 Runtime Specification	Task 4.1
IEEE Standards Association	IEEE 2785-2023	IEEE Standard for Architectural Framework and General Requirements for Smart Home Systems	Task 7.3
IEEE Standards Association	IEEE 3652.1-2020	IEEE Guide for Architectural Framework and Application of	Task 5.1

		Federated Machine Learning	
IEEE Standards Association	IEEE 2986-2023	IEEE Recommended Practice for Privacy and Security for Federated Machine Learning	Task 5.1
IEEE Standards Association	IEEE 1903.1-2017	IEEE Standard for Content Delivery Protocols of Next Generation Service Overlay Network	Task 6.1
IEEE Standards Association	P2958	Standard for a Decentralized Identity and Access Management Framework for Internet of Things	Task 6.1
ETSI	ETSI TR 104 031	Securing Artificial Intelligence (SAI); Collaborative Artificial Intelligence	Task 6.1, Task 7.3
ETSI	ETSI GS ZSM 012	Zero-touch Network and Service Management (ZSM); Enablers for Artificial Intelligence-based Network and Service Automation	Task 6.1
ETSI	ETSI TS 128 105	5G; Management and orchestration; AI/ML management	Task 7.3
ETSI	ETSI EN 301 575	Environmental Engineering (EE); Measurement methods for energy consumption of Customer Premises Equipment (CPE)	Task 7.3
ETSI	ETSI ES 202 336-1	Environmental Engineering (EE); Monitoring and control interface for infrastructure equipment	Task 7.3
ISO	ISO/IEC 30118-5:2021	Open Connectivity Foundation (OCF) Specification, Part 5: OCF device specification	Task 6.1
ISO	ISO/IEC 15938-17:2024	Compression of neural networks for multimedia content description and analysis	Task 5.1
IETF	RFC 5280	Internet X.509 Public Key Infrastructure Certificate and Certificate Revocation List (CRL) Profile	Task 6.1

IETF	draft-ietf-suit-mud-08	Strong Assertions of IoT Network Access Requirements	Task 6.1
IEC	IEC 62443-3-3:2013	Industrial communication networks - Network and system security - Part 3-3: System security requirements and security levels	Task 2.2
IEC	IEC 61907:2009	Communication network dependability engineering	Task 2.3
IEC	IEC 62559-2	Use case methodology - Part 2: Definition of the templates for use cases, actor list and requirements list	Task 2.2
CCSDS	CCSDS 133.0-B-1	Space Packet Protocol	Task 7.3, Task 7.4
ECSS	ECSS-E-ST-70-41	Packet Utilization Standard	Task 7.3, Task 7.4
ECSS	ECSS-E-ST-40C	Software development	Task 7.3, Task 7.4, Task 7.5
ECSS	ECSS-Q-ST-80C	Software product assurance	Task 7.3, Task 7.4, Task 7.5
ECSS	ECSS-E-HB-40-02A	Space Engineering Machine Learning Handbook	Task 7.3, Task 7.4, Task 7.5

More precisely, the collected standards cover a broad range of domains aligned with TaRDIS work, including:

- Federated and collaborative machine learning (e.g., IEEE 3652.1-2020, IEEE 2986-2023, ETSI TR 104 031, ISO/IEC 15938-17:2024);
- Network automation, orchestration, and distributed service frameworks (e.g., ETSI GS ZSM 012, ETSI TS 128 105, IEEE 1903.1-2017);
- Identity, trust, and security frameworks (e.g., RFC 5280, IEEE P2958, draft-ietf-suit-mud-08);
- Industrial and communication network security and dependability (e.g., IEC 62443-3-3:2013, IEC 61907:2009);
- Use-case engineering and requirements methodologies (e.g., IEC 62559-2);
- Device interoperability (e.g., ISO/IEC 30118-5:2021);
- Smart home and application-oriented architectural frameworks (e.g., IEEE 2785-2023);
- Space communication, software assurance, and satellite-swarm related engineering (e.g., CCSDS 133.0-B-1, ECSS-E-ST-70-41, ECSS-E-ST-40C, ECSS-Q-ST-80C, ECSS-E-HB-40-02A).

This consolidated mapping provided a clear understanding of the breadth of standardisation activities within the consortium and was instrumental for moving towards targeted involvement in M18-M39. This survey provided a broad mapping of relevant standards across WPs, the final project phase focused on translating concrete TaRDIS artefacts and use-case requirements into *standards-facing* elements: (i) where TaRDIS aligns with existing standards (interfaces, assumptions, engineering practices), and (ii) where gaps remain and follow-up contributions could be pursued. The next subsection consolidates these alignment and gaps inputs collected from use-case and tool owners.

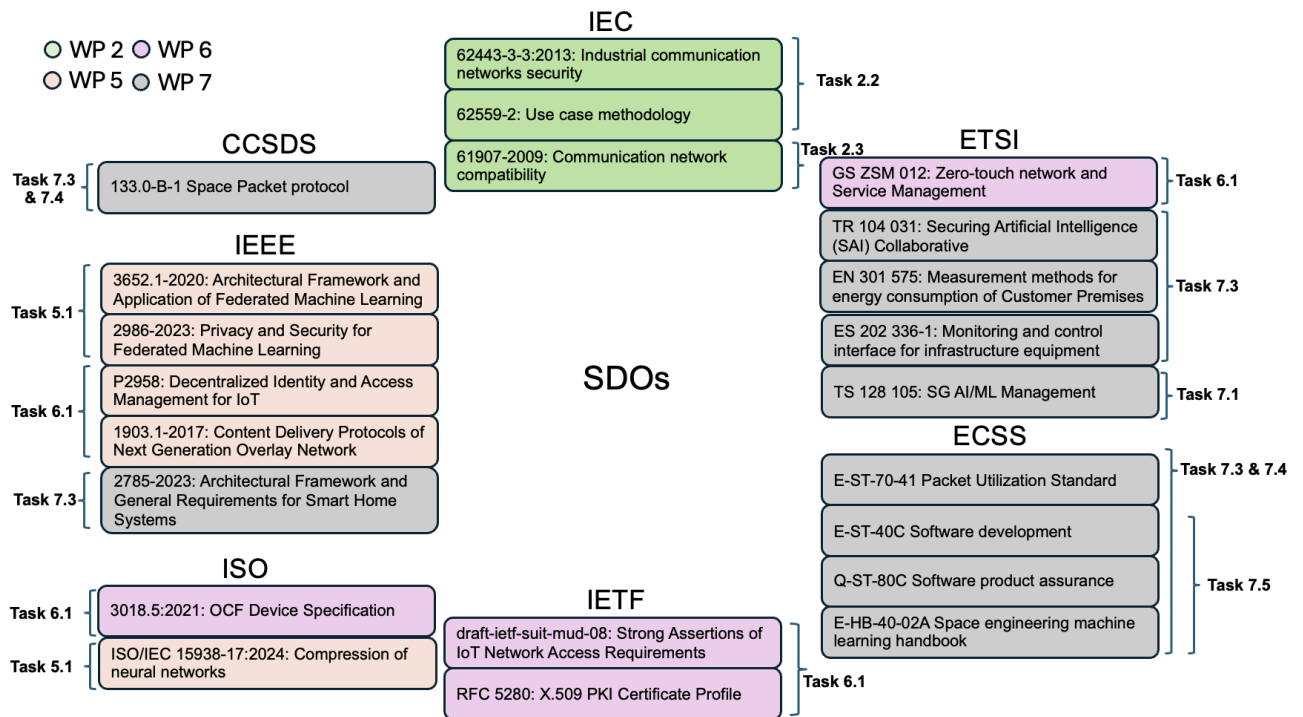


Figure 23: Schematic representation of standards and technical recommendations relevant to the project.

5.1.5 Standards Alignment and Gaps

The survey results presented in the previous subsection provide the baseline mapping of standards relevant to TaRDIS. In the final phase, Task 8.2 placed greater emphasis on analysing how concrete TaRDIS artefacts and use cases relate to this standard landscape in practice. The objective of this analysis was twofold: first, to identify where selected tools and use cases are aligned with existing standards, recommendations, and engineering practices; and second, to identify gaps and opportunities in areas where existing standards do not yet fully address the challenges raised by decentralised intelligence, federated learning, and swarm-oriented systems.

Table 7 summarises the main alignment points and identifies gaps for a selected set of representative TaRDIS tools and use cases. The cases discussed below were chosen because they illustrate distinct standardisation-relevant challenges across the TaRDIS portfolio, including federated learning, decentralised coordination, software assurance, and space-system interoperability.

Table 7: Collection of alignment and gaps identified in the current TaRDIS standard landscape.

Tool/Use-case	Partner	Relevant Standards	Main alignment Points	Main identified gaps
Distributed navigation concepts for LEO satellite constellations	GMV	CCSDS 133.0-B-1; ECSS-E-ST-70-4 1; ECSS-E-ST-40C; ECSS-Q-ST-80C; ECSS-E-HB-40-0 2A	Space communication interfaces, software engineering, and software assurance for satellite systems	Autonomous swarm-level coordination, distributed on-board decision making, and V&V of cooperative algorithms
Privacy-preserving learning through decentralized training in smart homes	TID	IEEE 3652.1-2020; IEEE 2784-2020; IEEE 2986-2023; ETSI TR 104 031; ETSI TS 103 645; ISO/IEC 29192; ISO/IEC 15938-17:2024	Privacy-aware distributed learning across heterogeneous smart-home, edge, and cloud environments; interoperability, security, and efficient deployment on resource-constrained devices	Lack of standard treatment for cross-domain privacy enforcement, dynamic privacy-budget management, heterogeneous device orchestration, real-time privacy-preserving inference
Multi-level grid balancing in decentralized energy communities	EDP	IEC 62559-2:2015; Directive (EU) 2018/2001; Directive (EU) 2019/944; Commission Delegated Regulation (EU) 2024/1366	Structured use-case and requirements modelling; alignment with the EU framework for energy communities and electricity-market participation; cybersecurity and secure information-exchange considerations for distributed coordination	Lack of standardised mechanisms for cross-community trust and privacy enforcement, privacy-preserving coordination of fine-grained energy data, interoperable decentralized workflow and event models, and capability/performance profiles for heterogeneous assets
Resilient decentralized workflow orchestration in smart manufacturing	UNIWA	IEEE 802.3 / 802.11; IEEE 802.1 TSN; IEC 62264; IEC 62541; IEC 62443; ISO 3691-4; ISO	Decentralized shop-floor coordination aligned with industrial interoperability, cybersecurity,	Lack of standardised patterns for peer-to-peer workflow orchestration, resilient recovery after network partitions, cryptographic trust

		22400; ISO 23247; ISO/IEC 27001; ISO/IEC 23894	safety, KPI, and digital-twin frameworks	re-establishment in offline industrial swarms, and domain-specific guidance for AI-driven operational decision support
PTB-FLA	UNS	IEEE 3652.1-2020; ETSI TR 104 031	Privacy-aware federated learning framework with structured development workflow	Lack of standardised programming models and correct-by-construction development workflows for federated learning
Flower-based FL tool	UNS	IEEE 3652.1-2020; IEEE 2986-2023; IEEE 3187-2024	Privacy-by-design, scalable orchestration, and trustworthy federated learning principles	Limited interoperability across FL frameworks and insufficient standard treatment of trust and attestation
FEDRA	NKUA	IEEE 3652.1-2020; ETSI TR 104 031	Decentralised peer-to-peer federated learning architecture	No standard treatment of fully decentralised FL and dynamic peer churn
PRUNING	NKUA	ISO/IEC 15938-17:2024	Lightweight model compression and efficient resource use	Trade-off between compression effectiveness, accuracy, and latency not yet standardised

5.1.5.1 Distributed navigation concepts for LEO satellite constellations

This use case addresses distributed Orbit Determination and Time Synchronization (ODTS) in LEO satellite constellations, where autonomous nodes exchange measurements and timing information through inter-satellite links. From a standardisation perspective, it is relevant because it combines space communication interfaces, software engineering, software assurance and emerging questions related to autonomy and machine learning in space systems.

The most relevant standards are CCSDS 133.0-B-1 and several ECSS documents, notably ECSS-E-ST-70-41, ECSS-E-ST-40C, ECSS-Q-ST-80C and ECSS-E-HB-40-02A. These standards are relevant because they address packet-based communication for space missions, packet utilisation and interoperability between on-board and ground systems, software engineering lifecycle practices, software assurance, and the emerging treatment of machine learning in space engineering.

The main alignment points lie in four areas:

1. Communication interfaces and message handling are aligned with established space communication conventions.
2. The software development process is aligned with recognised software engineering practices.
3. Reliability and robustness considerations are connected to existing software assurance frameworks.
4. The use case highlights the growing relevance of machine learning and autonomy in space systems.

At the same time, the analysis reveals several important gaps. Existing ECSS standards provide strong guidance on conventional software development and assurance, but do not yet fully address distributed autonomous decision-making across constellations, verification and validation of cooperative on-board algorithms spanning multiple spacecraft, or graceful degradation and fault containment at swarm level. In addition, while recent ECSS material acknowledges the relevance of machine learning in space systems, the standard treatment of on-board ML in mission-critical and safety-sensitive contexts remains at an early stage.

5.1.5.2 Privacy-preserving learning in smart homes

This use case addresses privacy-preserving collaborative learning across heterogeneous smart-home devices, edge nodes, and cloud-based orchestration services. Its standardisation relevance lies in the fact that it combines federated and split learning with smart-home interoperability, resource-constrained devices, and privacy-by-design requirements in a highly distributed environment.

The most relevant references are IEEE 3652.1-2020, IEEE 2784-2020, IEEE 2986-2023, ETSI TR 104 031, ETSI TS 103 645, ISO/IEC 29192, and ISO/IEC 15938-17:2024. These standards are relevant because they address federated learning architectures, privacy and security recommendations, smart-home system interoperability, cybersecurity requirements for consumer IoT, lightweight cryptography for constrained devices, and neural-network compression techniques for efficient deployment.

The main alignment points lie in four areas. First, the use case is aligned with current federated learning architectural guidance through the use of local data retention, exchange of model updates instead of raw data, and privacy-preserving coordination mechanisms. Second, it is aligned with smart-home interoperability and device-integration concerns, since it assumes heterogeneous devices operating within a common distributed environment. Third, it is consistent with existing security and trust requirements for connected devices and communication channels, especially in relation to consumer IoT security and lightweight cryptographic protection. Fourth, it reflects current standardisation work on efficient deployment of AI models in resource-constrained settings, including model compression and bandwidth-aware update exchange.

At the same time, the analysis reveals several important gaps. Existing standards provide useful guidance for privacy-preserving federated learning within bounded architectures, but they do not yet fully address privacy enforcement across multiple administrative domains or service-provider boundaries in smart-home ecosystems.

In addition, current references recommend differential privacy and secure aggregation, but do not provide standardised approaches for dynamic privacy-budget management in

long-running or continual learning settings. A further gap concerns the orchestration of highly heterogeneous devices with very different computation, memory, and connectivity capabilities, especially in scenarios combining simple IoT sensors, mobile devices, and edge helpers. Finally, existing standards remain much stronger on training-time privacy than on real-time privacy-preserving inference, where latency, local decision-making, and privacy guarantees must be balanced in operational smart-home applications.

5.1.5.3 Multi-level grid balancing in decentralized energy communities

This use case addresses distributed coordination and balancing across grid, community, and household levels in energy communities composed of heterogeneous assets such as smart meters, photovoltaic systems, batteries, EV chargers, and flexible loads. From a standardisation perspective, it is relevant because it combines decentralised coordination, near-real-time operation, cybersecurity, interoperability, and privacy-sensitive data handling in a sector shaped by both technical and regulatory constraints.

The most relevant reference in terms of standardisation is IEC 62559-2:2015, which provides a structured methodology for defining use cases, actors, and requirements. In addition, the use case is situated within a broader European regulatory framework defined by Directive (EU) 2018/2001, Directive (EU) 2019/944, and Commission Delegated Regulation (EU) 2024/1366. These regulatory instruments are relevant because they define the legal framework for renewable and citizen energy communities, electricity-market participation, and cybersecurity requirements in the electricity sector.

The main alignment points concern three areas. First, the use case is aligned with established structured use-case engineering practices through IEC 62559-2. Second, it is consistent with the broader European regulatory framework promoting decentralised participation in energy generation, consumption, storage, and flexibility services. Third, it reflects the growing importance of cybersecurity, secure information exchange, and operational resilience in distributed electricity environments.

At the same time, the analysis reveals several important gaps. Existing standards and regulations do not yet define comprehensive technical mechanisms for enforcing trust, privacy, and access-control policies across multiple energy communities and administrative domains. They also provide limited guidance on privacy-preserving coordination of fine-grained household and market data in distributed balancing workflows.

In addition, current references remain stronger on documentation, governance, and sectoral obligations than on interoperable machine-readable workflow and event models for decentralised swarm-based coordination. Finally, the standard treatment of heterogeneous asset capabilities, real-time responsiveness, resilience, and verifiable performance guarantees in decentralised balancing remains underdeveloped.

5.1.5.4 Resilient decentralized workflow orchestration in smart manufacturing

This use case addresses decentralized coordination of production workflows, transport operations, and real-time monitoring across heterogeneous shop-floor systems. From a standardisation perspective, it is relevant because it combines industrial interoperability, cybersecurity, networking, transport safety, and data-driven operational optimisation in a resilient distributed manufacturing environment.

The most relevant references are IEEE 802.3 and IEEE 802.11 for wired and wireless communication, IEEE 802.1 TSN for deterministic networking, IEC 62264 for enterprise-control system integration, IEC 62541 for OPC UA-based interoperability, IEC

62443 for industrial cybersecurity, ISO 3691-4 for the safety of driverless industrial trucks, ISO 22400 for manufacturing KPIs, ISO 23247 for digital-twin concepts in manufacturing, ISO/IEC 27001 for information security management, and ISO/IEC 23894 for AI risk management. These standards are relevant because they address the integration of enterprise and shop-floor systems, exposure of asset and workflow state, secure communication in industrial automation and control systems, transport safety, auditable performance measurement, and responsible deployment of AI-based functions.

The main alignment points lie in five areas. Communication performance is supported by established industrial networking standards. Interoperability with enterprise and shop-floor systems is aligned with IEC 62264 and IEC 62541. Security and trust are connected to IEC 62443 and ISO/IEC 27001. Transport coordination is constrained by the safety requirements applicable to AGVs and similar systems. Finally, the use case is consistent with current standardisation work on KPI extraction, digital-twin representations, and AI risk management in manufacturing environments.

At the same time, the analysis reveals several important gaps. Existing standards provide strong support for interoperability, cybersecurity, and safety in industrial systems, but they do not yet define common patterns for peer-to-peer event-sourced workflow orchestration across heterogeneous shop-floor nodes.

They also provide limited guidance on deterministic recovery and synchronization after temporary network partitions in decentralized production settings. In addition, practical treatment of cryptographic key rollover and trust re-establishment in partitioned industrial environments remains limited. Finally, while AI governance standards address lifecycle and risk-management concerns, more domain-specific guidance is still needed for ML-based task allocation, logistics coordination, and anomaly detection in smart-manufacturing workflows.

5.1.5.5 PTB-FLA

PTB-FLA is a framework for developing federated learning algorithms with an emphasis on correct-by-construction design and developer-facing abstractions. Its standardisation relevance lies in the fact that it exposes a layer that is largely missing from current FL standards: explicit programming models and structured development workflows.

The most relevant references are IEEE 3652.1-2020 and ETSI TR 104 031, both of which address architectural, privacy and coordination aspects of federated learning and collaborative AI. The main alignment point is that PTB-FLA supports privacy-aware and structured federated learning development in a way that is conceptually consistent with current architectural and security-oriented standardisation work.

The main identified gaps are twofold. First, current FL standards do not define standardised programming-model abstractions or execution models for distributed training and coordination. Second, they provide little guidance on correct-by-construction development and the use of reusable verified algorithmic components. In this respect, PTB-FLA points to a possible need for standardisation at the level of developer-facing abstractions, and correctness-oriented workflows.

5.1.5.6 Flower-Based Federated Learning Tool

The Flower-based FL tool provides a swarm-compatible federated learning component supporting data preparation, model training, inference and evaluation, including deployment on real edge-device clients. Its standardisation relevance lies in the fact that it connects

privacy-preserving federated learning with practical deployment, orchestration and trustworthy lifecycle concerns.

The most relevant standards are IEEE 3652.1-2020, IEEE 2986-2023 and IEEE 3187-2024, which address federated learning architectures, privacy and security, and trustworthy federated learning. The main alignment points concern privacy-by-design, scalable orchestration and trustworthy federated learning principles, especially through the use of local data retention, exchange of model updates instead of raw data, and deployment on heterogeneous edge devices.

The main identified gaps concern interoperability across federated learning frameworks and toolchains, as well as the limited standard treatment of trust, attestation and adversarial resilience in large-scale heterogeneous FL deployments.

5.1.5.7 Fedra

FEDRA is a decentralised peer-to-peer FL framework designed to avoid central points of control and support dynamic participation of nodes within a swarm-like environment. From a standardisation perspective, it is relevant because it pushes beyond the assumptions of many current FL architectures, which remain partly centralised.

The main relevant references are IEEE 3652.1-2020 and ETSI TR 104 031, both of which provide architectural and security-oriented guidance for federated learning systems. The main alignment point is that FEDRA remains consistent with privacy- and security-oriented architectural goals while extending them into a more decentralised peer-to-peer setting. The main identified gaps concern the lack of standard treatment of fully decentralised federated learning, including the absence of common approaches for peer churn, dynamic topologies and coordination in wireless or heterogeneous environments.

5.1.5.8 Pruning

The Pruning tool provides lightweight versions of deep neural networks by reducing parameters and improving inference efficiency. Its main standards relevance lies in the area of neural-network compression for resource-constrained devices.

The most relevant reference is ISO/IEC 15938-17:2024, which addresses neural network coding and compression methods. The main alignment point is the focus on lightweight model compression and efficient resource use. The main identified gap concerns the absence of more standardised treatment of the trade-off between model compression, inference accuracy and latency in practical deployment settings.

5.1.6 Participation in Standardisation-Related Activities and Communities

Based on the survey results and the relevance of identified standards carried out during the first half of the project (M1-M18), Task 8.2 assessed which SDOs represent the most strategic opportunities for TaRDIS. The main candidates were: IEEE-SA, ETSI, ISO, IEC, and IETF, as well as CCSDS and ECSS.

During the second half of the project (M18-M39), Task 8.2 moved from mapping and surveying activities towards targeted engagement with relevant standardisation communities. This engagement took place at several levels, including continuous monitoring of SDO activities, participation in cluster-level standardisation discussions, presence in selected international events, and concrete interactions with fora relevant to distributed systems, interoperability, automation and the cloud-edge-IoT continuum.

5.1.6.1 IETF

The IETF ecosystem was particularly relevant to TaRDIS for Internet architectures, decentralised systems and protocol-oriented technical discussions. The IETF makes voluntary standards that are often adopted by Internet users, network operators, etc. IETF mainly operates through mailing lists and meetings, from which NOVA and TID project members are subscribed and monitor relevant activities.

Among around 500 mailing lists/working groups operated under the umbrella of IETF², some working groups of interest are, in the Internet Area: Networking WG “IPv6 over Networks of Resource-constrained Nodes”, and in the Security Area, “Authentication and Authorization for Constrained Environments”, and “Lightweight Authenticated Key Exchange, Transport Layer Security”. Within Task 8.2, IETF-related engagement was especially important because it offered a recognised external forum in which TaRDIS-related architectural concepts could be expressed in a structured and reviewable form.

In this context, a relevant result connected to Task 8.2 is the Internet-Draft “A Generic Framework for Building Dynamic Decentralized Systems (GFDS)” [4], registered in the IETF Datatracker. The draft is currently listed as an active Internet-Draft and describes a generic framework for building and managing dynamic heterogeneous decentralised systems, combining a reference architecture and an execution model with higher-level abstractions for developers and system designers. The draft has clear relevance to the standardisation task, because it expresses TaRDIS-related technical ideas in a structured format suitable for external technical discussion within a recognised Internet standards environment.

The draft is also relevant from a standardisation perspective because it moves beyond an internal description of technical results and translates them into a form that can be discussed, reviewed, and iterated in a wider community concerned with decentralisation and Internet-related system design.

In this sense, the Internet-Draft can be regarded as a standardisation-facing project output: a concrete artefact through which architectural concepts, execution assumptions, and design choices can be exposed to external scrutiny and progressively refined. The fact that the draft is framed around a reference architecture and execution model is particularly relevant since these are precisely the kinds of elements through which research results can interact with standardisation-oriented fora.

² <https://datatracker.ietf.org/wg/>


Datatracker Groups Documents Meetings Other tilippo.vannella
Report a bug Document search

A Generic Framework for Building Dynamic Decentralized Systems (GFDS)

draft-jesus-gfds-02

Status
Email expansions
History

Versions: 00 01 02



Document	Type	Active Internet-Draft (individual)
	Authors	Diogo Jesus , João Leitão
	Last updated	2026-02-24
	RFC stream	(None)
	Intended RFC status	(None)
	Formats	txt html xml htmlized pdf biblatex bitum
Stream	Stream state	(No stream defined)
	Consensus boilerplate	Unknown
	RFC Editor Note	(None)
IESG	IESG state	I-D Exists
	Telechat date	(None)
	Responsible AD	(None)
	Send notices to	(None)

Email authors
IPR
References
Referenced by
Nits
Search email archive
Track

Workgroup: Network Working Group

Internet-Draft: draft-jesus-gfds-02

Published: 23 February 2026

Intended Status: Standards Track

Expires: 27 August 2026

Authors: D. Jesus, J. Leitão
TaRDIS, TaRDIS

Table of Contents

1. Overview
 - 1.1. Document Structure
2. Conventions and Definitions
3. Protocol Anatomy
 - 3.1. Protocol Initialization
 - 3.2. Handlers
 - 3.2.1. Timer-Handlers
 - 3.2.2. Inter-Protocol Handlers
 - 3.2.3. Discovery Handlers
 - 3.2.4. Configuration Handlers
 - 3.2.5. Resource Handlers
 - 3.2.6. Communication Handlers
 - 3.3. Procedures
 - 3.4. Example
4. Architecture
 - 4.1. Protocols
 - 4.2. Event Manager
 - 4.2.1. Inter Protocol Interaction
 - 4.2.2. Communication and Configuration
 - 4.2.3. Timer Manager

A Generic Framework for Building Dynamic Decentralized Systems (GFDS)

Abstract

Building and managing highly dynamic and heterogeneous decentralized systems can prove to be quite challenging due to the great complexity and scale of such environments. This document specifies a Generic Framework for Building Dynamic Decentralized Systems (GFDS), which composes a reference architecture and execution model for developing and managing these systems, while providing high-level abstractions to users.

Status of This Memo

This Internet-Draft is submitted in full conformance with the provisions of BCP 78 and BCP 79.

Internet-Drafts are working documents of the Internet Engineering Task Force (IETF). Note that other groups may also distribute working documents as Internet-Drafts. The list of current Internet-Drafts is at <https://datatracker.ietf.org/drafts/current/>.

Internet-Drafts are draft documents valid for a maximum of six months and may be updated, replaced, or obsoleted by other documents at any time. It is inappropriate to use Internet-Drafts as reference material or to cite them other than as "work in progress."

Figure 24: IETF Internet-Draft “A Generic Framework for Building Dynamic Decentralized Systems (GFDS)” [4].

In the final phase of the project, this work was presented at IETF 124 within the Decentralization of the Internet Research Group (DINRG) session by NOVA. According to the feedback reported by the presenter, the session provided useful comments from the chair and audience members, and also enabled follow-up discussions with attendees interested in the topic. This participation is relevant to Task 8.2 because it gave TaRDIS-related work visibility in an external technical forum dedicated to decentralisation, while also providing practical exposure to the IETF process of discussion and iteration around Internet-Drafts and related research outputs.



Figure 25: Presentation of the Internet-Draft GFDS at IETF 124, delivered within the DINRG session.

5.1.6.2 ETSI

ETSI was considered particularly relevant to TaRDIS because several project themes intersect with ETSI work on automation, AI-enabled management, environmental engineering and infrastructure-related aspects of digital systems. Three consortium partners are ETSI members: DTU, NKUA, and TID³. Within Task 8.2, ETSI was considered particularly relevant because several TaRDIS themes intersect with ETSI work on automation, which made ETSI a realistic and accessible point of reference for standards-facing engagement.

Among the many ETSI technical bodies, three were identified as especially relevant to TaRDIS. First, ETSI ISG ZSM (Zero-touch Network and Service Management) is directly relevant to TaRDIS because it focuses on end-to-end automation of network and service management and explicitly promotes alignment with other standardisation bodies and open-source initiatives. Second, ETSI TC EE (Environmental Engineering) is relevant because it addresses the environmental and infrastructural aspects of ICT equipment and networks, including power, eco-design, and equipment engineering. Third, ETSI TC ATTM (Access, Terminals, Transmission and Multiplexing) is relevant because it covers access, terminals, transmission, multiplexing, cabling, installations, and signal processing aspects, and therefore provides a useful point of reference for infrastructure- and deployment-oriented TaRDIS topics. Finally, the recently established ETSI TC DATA is also relevant, as it addresses data-related aspects of digital infrastructures and services, including data interoperability, management and exchange, which are increasingly important in distributed and AI-enabled systems such as those explored in TaRDIS.

³ <https://www.etsi.org/membership/members>

Poster Title: Collaborative Intelligence Sharing in Energy Communities via Federated Learning

Poster Overview:

- ML applications inside an Energy Community
- Prediction of Energy Demands and Energy Generation
- Dynamic Energy Management algorithm boosting the consumption of local renewable energy
- Federated Learning to share intelligence among smart homes, maintaining data privacy

Presented by: Luis Pisco / EDP CNET and Sotiris Spantideas / NKUA

What you will learn:

- Use the predictive capabilities of ML models to determine the energy management strategy of an Energy Community consisting of multiple smart homes
- Leverage Deep Reinforcement Learning (DRL) models to dynamically control the loads of a smart home, targeting to maximize the utilization of local renewable energy
- Utilize Federated Learning for these ML models inside an Energy Community to share the distilled intelligence among the smart homes without exposing private information

Figure 26: TaRDIS poster on “Collaborative Intelligence Sharing in Energy Communities via Federated Learning,” presented at ETSI AI conference.

A concrete example is provided by the TaRDIS-related poster “**Collaborative Intelligence Sharing in Energy Communities via Federated Learning**”, which connected project work on federated learning, smart homes, and energy communities with ETSI-related standardisation directions. In the abstract accompanying the poster, **ETSI TC EE** and **ETSI TC ATTM** were identified as relevant technical committees, while **ETSI ES 202 336-1** and **ETSI EN 301 575** were highlighted as related standards. These standards are directly concerned with the monitoring and control interface for infrastructure equipment and with methods for measuring the energy consumption of customer premises equipment, respectively, making them relevant to the energy-management and infrastructure dimension of the use case.

Taken together, these elements show that ETSI was relevant to TaRDIS at several levels: as a standards body already accessible through consortium membership; as a source of technical groups aligned with TaRDIS themes such as automation, environmental engineering, and infrastructure; and as an external framework within which selected project results could be positioned and discussed. In this sense, the ETSI-related work of Task 8.2 goes beyond general monitoring and contributes to connecting TaRDIS artefacts and use cases with concrete standardisation-oriented communities and reference standards

5.1.6.3 Participation in Other Standardisation Events and Communities

TaRDIS also participated in the webinar “**Standardisation Activities in the Cognitive Computing Continuum**”, organised in the context of the **Cognitive Computing Continuum cluster**. The webinar brought together several Horizon Europe projects working on

cloud-edge-IoT, AI, and swarm-related technologies, and focused on the standardisation potential of their technical artefacts, including interoperability, certification, open standards, and common architectural approaches.

More broadly, TaRDIS was also involved in other ecosystem- and standardisation-oriented activities, including the **Swarm Workshop** (see Section 3.2 for more details) and related community events, which contributed to placing the project within wider European discussions on decentralised intelligence, reusable technical assets, and emerging digital infrastructures. In these settings, standardisation-relevant aspects such as interoperability, reusable architectures and common technical approaches of the various projects involved were discussed.

Participation in these events is relevant to Task 8.2 because it situates TaRDIS within a broader European discussion on standardisation in distributed and cognitive computing infrastructures and is aligned to M18 review recommendation to improve alignment with related communities around standards and common architectures.

5.1.7 Conclusions and Reflections

In the first reporting period (M1-M18), Task 8.2 defined a set of next steps centred on identifying relevant SDOs and standards, analysing how TaRDIS outcomes could align with or influence them, and guiding partners in navigating standardisation processes. During the second half of the project (M18-M39), these objectives were advanced, leading to a clearer understanding of the standardisation ecosystem surrounding TaRDIS technologies and to concrete targeted engagement activities.

The consortium continued to collect and refine information on standards and SDOs relevant to the cloud-edge-IoT continuum, distributed intelligence, federated learning, security, and swarm-based communication. This strengthened the initial mapping and validated the prioritisation of SDOs such as ETSI, IEEE-SA, ISO/IEC, CCSDS/ECSS, and in particular IETF for protocol and identity-related aspects.

Task 8.2 also investigated how TaRDIS outcomes relate to ongoing standardisation efforts, identifying areas where existing standards could support implementation (e.g., secure onboarding, ML management, identity frameworks) and areas where TaRDIS introduces novel requirements, especially in swarm intelligence and decentralised coordination. These findings informed interactions with external groups and provided the basis for discussions on potential future contributions.

A noteworthy result was the active participation in standardisation-oriented events, including the Cognitive Computing Continuum Cluster webinar on standardisation and the contribution made to the extension and discussion of an IETF Internet-Draft relevant to secure, distributed IoT/swarm deployments. These activities provided a practical avenue to expose TaRDIS use cases, gather expert feedback, and position the project within relevant communities.

Throughout M18-M39, Task 8.2 continued to **guide partners on standardisation processes**, disseminating information on relevant working groups, contribution mechanisms, and opportunities for engagement. During the project, the consortium strengthened its internal capability to address standardisation topics and prepared a clearer foundation for future follow-up. The final phase of the project transformed the initial exploratory steps into tangible engagements, improved awareness, and concrete interactions with major SDOs, laying the groundwork for further evolution of TaRDIS-related topics beyond the project duration.

5.2 OPEN SOURCE

Regarding the open source dimension of the project, Task 8.2 pursued two complementary objectives. First, it aimed to support the availability of TaRDIS software as an open-source interoperable and extensible toolbox that can be accessed, reused and further developed beyond the consortium. Second, it aimed to ensure that these results are visible and understandable to communities beyond the immediate technical partners, including policymakers and other external stakeholders.

In order to achieve these objectives, the strategy was defined as follows:

1. Collection of TaRDIS-related repositories and partners' practices, including developer platforms⁴ of choice, licences, distribution methods.
2. Consultation and discussions within the consortium to support collective decisions and greater alignment on open source practices.
3. Organized repository-level and project-level information on access and distribution of the TaRDIS toolbox, in order to increase discoverability.

5.2.1 Continuity from Deliverable D8.3

Open source and the availability of software artefacts constituted an important element of the TaRDIS outreach and impact strategy. As described in Deliverable D8.3 [2], Task 8.2 aimed to ensure that the tools developed within the TaRDIS project become available as an interoperable and extensible toolbox that can be reused by the research community, developers, and policymakers.

At the mid-term stage of the project, the consortium focused on mapping existing practices and collecting information on repositories, development platforms, licensing choices and distribution methods used by project partners. This effort was carried out through a structured internal survey and a collection of TaRDIS-related repositories maintained by consortium members. This assessment showed that the project had already generated a substantial software base across several technical work packages, while open-source publication and licensing practices remained fragmented.

Importantly, the M18 review recommendation (R3) explicitly identified open source and licensing as areas requiring greater convergence and recommended that the consortium move towards viable solutions. The present deliverable addresses directly that recommendation by

- (i) updating the TaRDIS repository collection to include tools developed during the second part of the project;
- (ii) reflecting the outcome of consultations with partners regarding the current status of open-source publication, licensing and distribution; and
- (iii) presenting the TaRDIS Open Source and Distribution Manifesto as a consortium-level position on the licences, distribution channels and availability of the TaRDIS toolbox.

⁴ Also referred as collaborative or distributed version control platform/site.

5.2.2 Consolidation of Partner Practices and Data Collection Method

Building on the methodology established in Deliverable D8.3 [2], the consortium continued the structured collection of information related to TaRDIS software artefacts during the final stage of the project. This activity was carried out through an updated Excel-based template completed by project partners. For completeness and continuity, the templates used for data collection are reproduced in Figures 27-28.

<p>Dear Partner, In order to organize the efforts on open-source policies within the TaRDIS project (Task 8.2), we kindly ask you to fill in the following tables (first and second tab).</p>		
<p>Partner's Name:</p>		
<p>Description of the Basic Role of the Partner (e.g., WP2 leader and Task 7.1 leader):</p>		
<p>Please report on the use of developer platforms in the context of TaRDIS</p>		
<p>Name of the developer platform(s)/version control system(s) you are using in the context of TaRDIS (e.g., GitHub, GitLab, ...)</p>	<p>Describe in 1-2 phrases the reasons for which you chose this platform (e.g., ease of use, premium subscription provided by my organization)</p>	<p>Report on any previous experience with this platform (e.g., I have been using it since 2 years ago, Used it in previous EU projects)</p>

Figure 27: Template for the collection of information on developer platforms and version control systems used by TaRDIS partners.

Please provide information on the repositories related to TaRDIS, *one line per repository*						
Related TaRDIS tool(s) / use-case baseline (e.g., TID's baseline implementation)	Type of licence used (e.g., Creative Commons, MIT, ...)	Maturity level of code (select from the dropdown menu)	Is the code publicly available? (select Yes/No)	If the code is publicly available, has it been used/mentioned/cited by a third party (i.e., outside of the TaRDIS consortium)?	If the code is publicly available, is TaRDIS mentioned/acknowledged in this repository?	Comments possibly related to previous entries (e.g., explain why the tool/baseline is not open source)

Figure 28: Template for the collection of information on TaRDIS software repositories.

The collected information covered two main aspects:

- 1) the development platforms and version control systems used by partners, and
- 2) the repositories associated with the development of TaRDIS software components.

This structured data collection enabled a consistent overview of partner practices and provided the basis for the consolidation and alignment efforts presented in the following subsections.

5.2.3 Development Platforms and Repositories

The updated collection identified **53 repository entries** associated with TaRDIS software artefacts. These repositories span multiple technical work packages and include components related to distributed protocols, swarm programming frameworks, verification tools, storage systems, use-case-oriented implementations, and developer-facing tools.

The results confirm that the TaRDIS consortium relies primarily on distributed version control systems, with **Git-based platforms** constituting the main infrastructure for the development and hosting of TaRDIS software components. Most reported repositories are hosted on **GitLab**, while the remainder are hosted on **GitHub**.

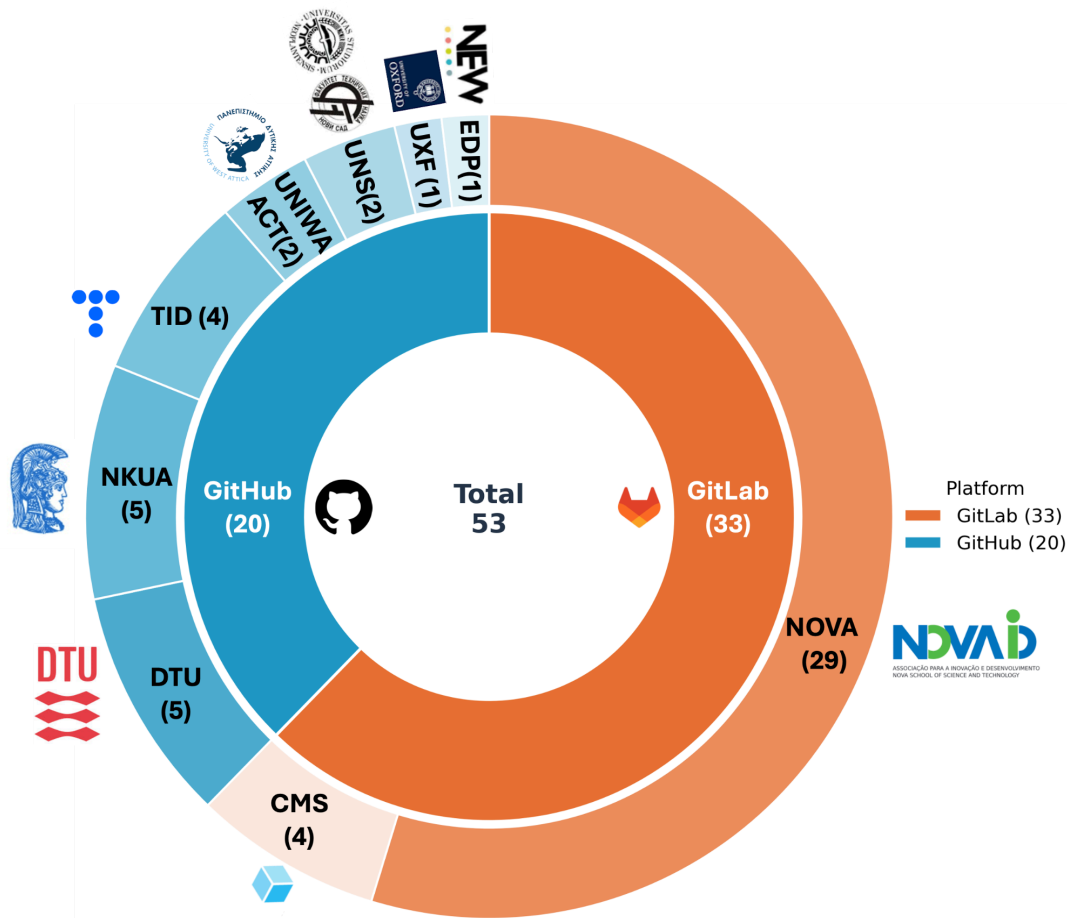


Figure 29: Distribution of reported TaRDIS repository entries by hosting platform. Of the 53 reported repository entries, 33 are hosted on GitLab, 20 are hosted on GitHub.

The consortium therefore recognises Git-based collaborative repositories as the **default infrastructure for the development and dissemination of TaRDIS software artefacts**.

The updated survey also confirms that the development of the TaRDIS toolbox is distributed across several partners. At the level of reported repository entries, **NOVA reports 29 entries, DTU and NKUA 5 each, CMS and TID 4 each, UNS and UNIWA/ACT 2 each, and EDP, UOXF 1 each (see Figure 29)**. This distribution reflects both the central role of some partners in the development of generic toolbox components and the contribution of several partners through tool-specific or use-case specific repositories.

Within TaRDIS, repositories are typically maintained by the partners responsible for the development of the corresponding software components. These repositories are often linked to scientific publications or technical reports produced within the project. In addition, the project website provides links to collections of TaRDIS-related repositories, improving the discoverability of the toolbox components.

The survey also collected information on the reasons underlying platform selection. The most frequently reported factors were **ease of use**, **institutional support or subscription availability**, and the fact that the selected platform was already well established within the relevant technical community. Additional reasons mentioned by partners included reliability, previous familiarity, open-source availability, and no-cost access (see Figure 30).

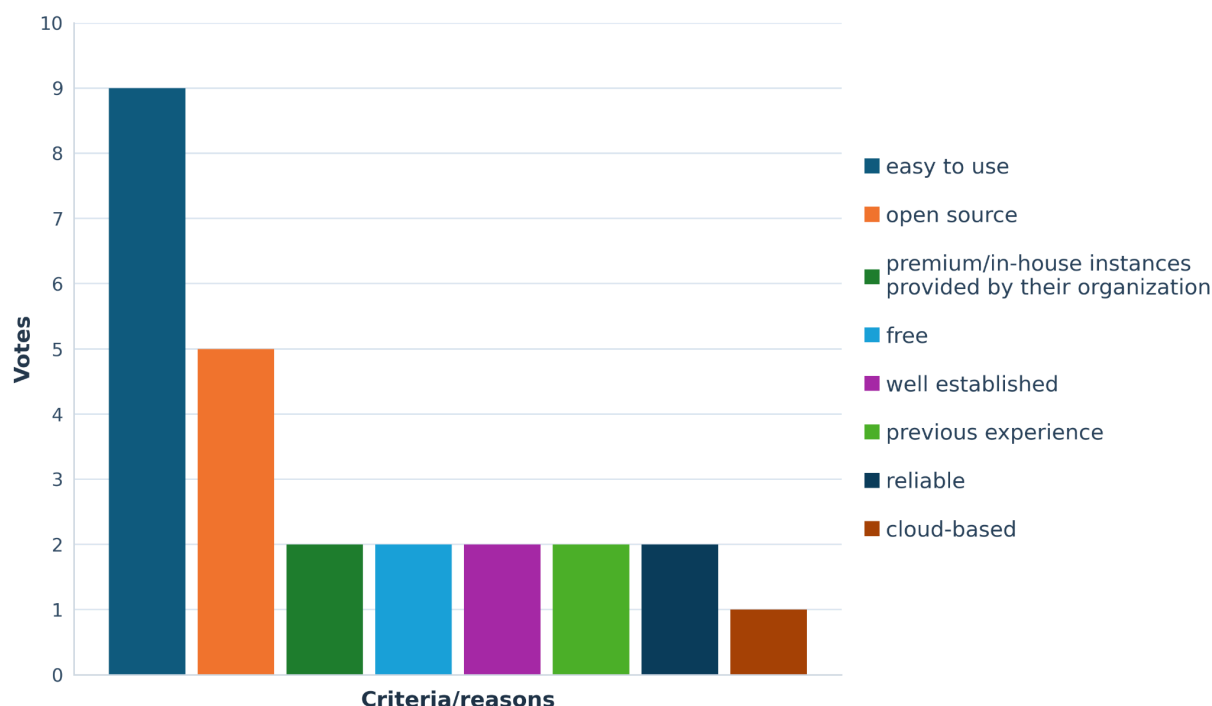
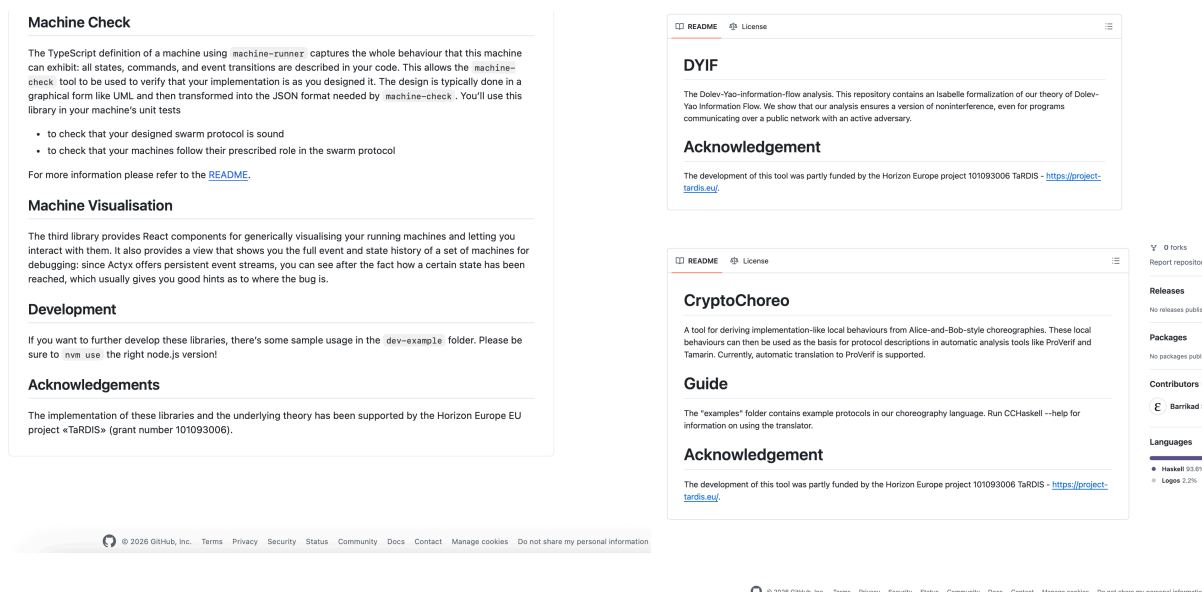


Figure 30: Most common reasons for choosing a developer platform according to the updated internal survey. Categories are not mutually exclusive; a single response may contribute to more than one category.

Overall, the updated consultation indicates that development infrastructure in TaRDIS is guided by a limited number of consistent principles: the use of standard collaborative version control systems, preference for platforms already familiar to the target development community, maintenance of repository-level metadata and documentation, and, where appropriate, public visibility in support of discoverability and uptake.

The survey further examined whether the repositories acknowledge TaRDIS as the originating project. According to the information reported by partners, all repositories that are publicly available include an acknowledgement of the project (see Figure 31) either in the repository itself and/or in linked publications. In addition, **10+ of the collected repositories** were reported as having already been **used, cited, or mentioned by third parties** outside the consortium.



Machine Check

The TypeScript definition of a machine using `machine-runner` captures the whole behaviour that this machine can exhibit: all states, commands, and event transitions are described in your code. This allows the `machine-check` tool to be used to verify that your implementation is as you designed it. The design is typically done in a graphical form like UML and then transformed into the JSON format needed by `machine-check`. You'll use this library in your machine's unit tests

- to check that your designed swarm protocol is sound
- to check that your machines follow their prescribed role in the swarm protocol

For more information please refer to the [README](#).

Machine Visualisation

The third library provides React components for generically visualising your running machines and letting you interact with them. It also provides a view that shows you the full event and state history of a set of machines for debugging; since Actyx offers persistent event streams, you can see after the fact how a certain state has been reached, which usually gives you good hints as to where the bug is.

Development

If you want to further develop these libraries, there's some sample usage in the `dev-example` folder. Please be sure to `npm use` the right `node.js` version!

Acknowledgements

The implementation of these libraries and the underlying theory has been supported by the Horizon Europe EU project «TaRDIS» (grant number 101093006).

DYIF

The Dolev-Yao-information-flow analysis. This repository contains an Isabelle formalization of our theory of Dolev-Yao Information Flow. We show that our analysis ensures a version of noninterference, even for programs communicating over a public network with an active adversary.

Acknowledgement

The development of this tool was partly funded by the Horizon Europe project 101093006 TaRDIS - <https://project-tardis.eu/>

CryptoChoreo

A tool for deriving implementation-like local behaviours from Alice-and-Bob-style choreographies. These local behaviours can then be used as the basis for protocol descriptions in automatic analysis tools like ProVerif and Tamara. Currently, automatic translation to ProVerif is supported.

Guide

The "examples" folder contains example protocols in our choreography language. Run `CCHaskell --help` for information on using the translator.

Acknowledgement

The development of this tool was partly funded by the Horizon Europe project 101093006 TaRDIS - <https://project-tardis.eu/>

Figure 31: Examples of TaRDIS related repositories README and their acknowledgement.

5.2.4 Distribution and Availability of the TaRDIS toolbox

The distribution and availability of the TaRDIS toolbox are important factors in ensuring the accessibility, usability and practical reuse of the project's outcomes. In the context of TaRDIS, distribution refers to the ways in which software artefacts are packaged, documented and made accessible to end users so that they can be installed, configured, integrated and reused with reasonable effort.

The updated repository inventory confirms that the TaRDIS toolbox is not a single monolithic software package. Rather, it is a collection of heterogeneous components including reusable protocol and middleware implementations, storage and data-replication components, developer-facing tools, verification-related artefacts, and use-case-oriented implementations. For this reason, a single distribution mechanism is neither realistic nor desirable. In this respect, relevant considerations include simplicity for both users and developers, transferability across environments, and the discoverability of the resulting software artefacts.

In line with the analysis already introduced in D8.3 [2], and confirmed by the updated repository inventory, three broad categories of software artefacts can be distinguished.

First, some components correspond to **software libraries or frameworks** that are integrated directly into applications during development. This includes, for example, distributed protocols, programming frameworks, and middleware components such as Babel. These artefacts are most appropriately distributed through public repositories and, where technically relevant, through language-specific package ecosystems or release assets, which simplify versioning, updates and reuse.

Second, some components correspond to **software systems or services** that operate as building blocks with their own execution lifecycle, independently from the applications that use them. This category includes, for example, storage-oriented components such as **Arboreal** or **PotionDB**. These artefacts benefit from distribution approaches based on binaries, containers, installation scripts or deployment-oriented documentation that reduce the effort required to install and configure them in practice.

Third, some components correspond to **developer-oriented tools**, including IDE support, workflow-related tools, verification-related software, and other supporting utilities. These artefacts may require packaged releases, installers, or environment-specific distribution methods adapted to the operating systems and development environments of their target users.

The consortium therefore adopts the position that public repositories should remain the primary entry point for access to TaRDIS software, while additional distribution mechanisms should be used whenever they reduce the effort required by external developers to install, configure and reuse the toolbox components. In other words, distribution should follow the nature of the artefact and the needs of its intended users, rather than imposing a single packaging model across the entire toolbox. Beyond packaging choices, the final-stage work in Task 8.2 also focused on improving the organisation and navigability of TaRDIS software artefacts at project level.

At the same time, the consortium considers that availability alone is not sufficient if potential users cannot easily identify, navigate and understand the relevant artefacts. For this reason, publicly released software artefacts should, where feasible, be linked through the project website and through a centralised TaRDIS toolbox landing page or repository collection. This improves visibility, ease of navigation and consistency of project branding, while also supporting the discoverability of the project's software results beyond the consortium.

In practical terms, this organisational effort was reflected in the use of the **project website** and a dedicated **repository collection** as central access points to TaRDIS software artefacts. By linking publicly available repositories through a common entry point, the project improved the visibility of toolbox components, facilitated navigation across repositories maintained by different partners, and strengthened the overall consistency of project branding and presentation. Moreover, TaRDIS' website contains a link to a collection of repositories on GitLab dedicated to the TaRDIS toolbox (see Figure 32).

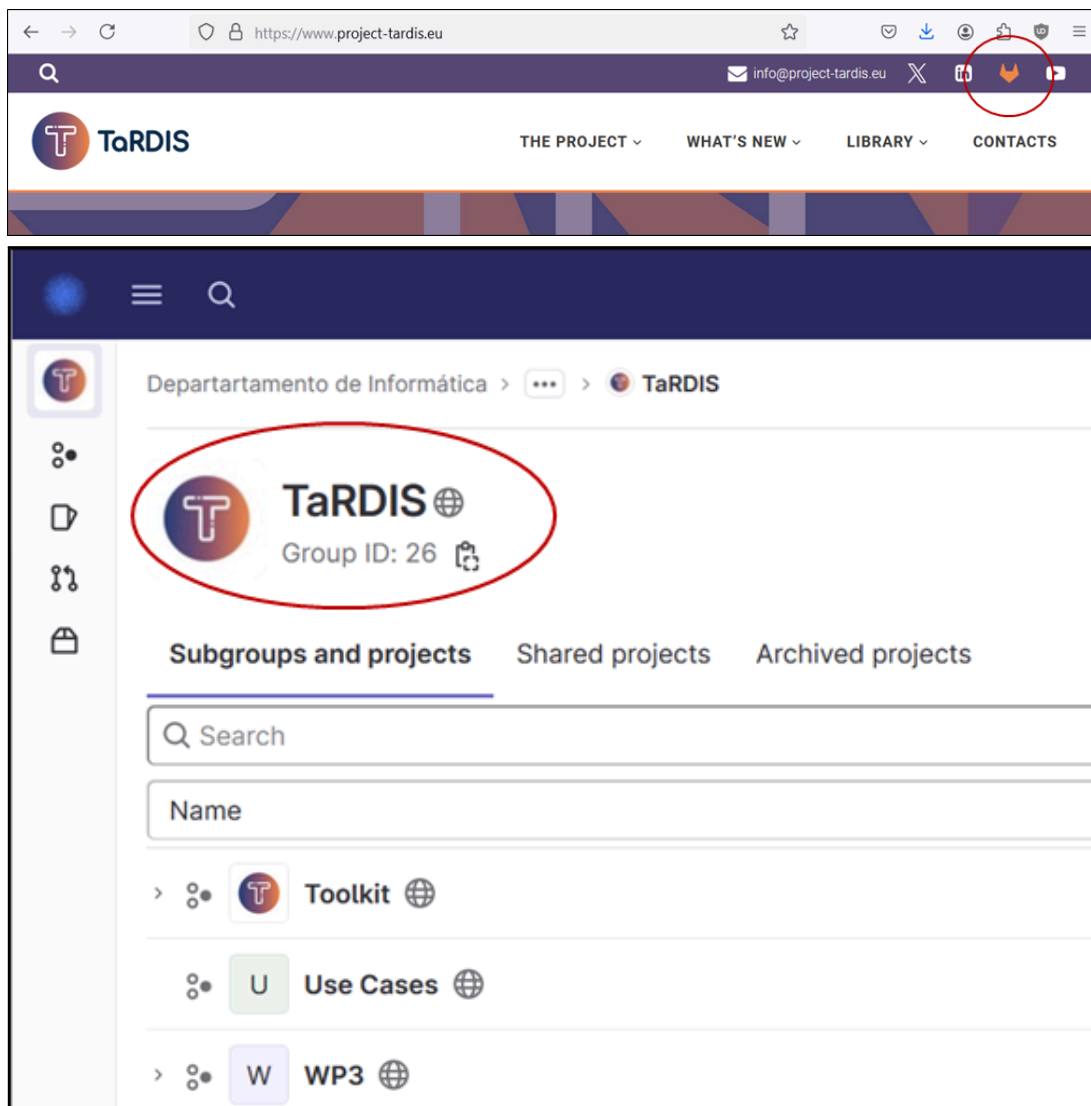


Figure 32: Link to the collection of repositories on GitLab at TaRDIS' homepage, entry point to TaRDIS related repositories.

In addition to the repository collection, the TaRDIS project provides a dedicated Wiki that serves as a centralized documentation and navigation hub for the TaRDIS toolbox. Beyond offering an overview of the programming model and the available tools and APIs, the Wiki also documents the TaRDIS IDE and provides recipe-based guidance describing how TaRDIS libraries, tools and the IDE can be combined in concrete use-case scenarios.

In particular, it contributes to structuring and presenting several tools and supporting artefacts developed in the context of WP3. By complementing the distributed repository landscape with structured, accessible and use-oriented documentation, the Wiki improves the discoverability, usability and reusability of TaRDIS results for developers, researchers and other external stakeholders.

Home



Welcome to the TaRDIS toolbox wiki! The TaRDIS toolbox for distributed programming simplifies the development of decentralised, heterogeneous swarm applications deployed in diverse settings. This wiki provides comprehensive information on the TaRDIS toolbox, including the programming model, APIs, and use case applications.



Trustworthy And Resilient Decentralised Intelligence For Edge Systems. Horizon Europe project no. 101093006.

Overview

The TaRDIS project proposes an event-driven programming model and toolbox allowing application programmers to take advantage of various facilities (communication, verification, machine learning, monitoring and reconfiguration) helping them develop safe and reliable distributed swarm applications. Such facilities are made available through the "TaRDIS Runtime" — which provides various higher-level APIs and abstractions over lower-level libraries and services; moreover, the project proposes a dedicated IDE support to simplify the programmers' tasks. Please see the [TaRDIS Programming Model](#) for a detailed account of the overall approach.

Tools and APIs

A [complete list of all TaRDIS tools and APIs](#) with links to their respective Wiki pages is given below. A curated list of the tools and APIs offered by the TaRDIS toolbox is given in [TaRDIS Tools and APIs](#).

IDE

With integrated support for TaRDIS tools, the IDE simplifies the development of TaRDIS applications. Please see the [TaRDIS IDE GitLab repository](#) for more information.

Figure 33: Screenshots from the TaRDIS Wiki. The Wiki serves as a centralised entry point to the TaRDIS toolbox by consolidating documentation on the programming model, tools and APIs, the TaRDIS IDE, and recipe-based guidance for concrete use cases, thereby improving the discoverability and usability of results developed in WP3.

Accordingly, the consortium considers that the availability of the TaRDIS toolbox should be understood in practical as well as technical terms. TaRDIS software artefacts should not only be publicly accessible online, but should also be organised, documented and connected through common entry points that allow third parties to discover, understand and reuse them as parts of a coherent toolbox rather than as isolated repositories.

5.2.5 Licensing Principles

Open-source licensing is a central element of software dissemination and reuse, as it defines the legal conditions under which software can be used, modified, and redistributed. In the context of TaRDIS, clear licensing is important both from an openness and visibility perspective, by making explicit that project outputs are intended for reuse, and from a legal perspective, by clarifying rights, obligations, liability limitations, and intellectual property conditions for both developers and users.

The repository survey conducted within the consortium confirms that multiple open-source licences are currently used across TaRDIS-related repositories. The most frequently observed licences include the **MIT**, **Apache 2.0**, **GNU General Public License v3.0 (GPL-3.0)**, and the **Eclipse Public License v2.0 (EPL v2.0)**. These licences fall into two widely recognised categories: **permissive licences** and **copyleft licences**.

The licence inventory shows a clear predominance of permissive licensing within the project. Among the repository entries that already declare a concrete licence, **MIT** is by far the most frequent, followed by **Apache 2.0**, **EPL v2.0**, and **GPL-3.0**, as illustrated in Figure 34. This pattern is consistent with common research software practice, where permissive licences are often preferred in order to maximise reuse, interoperability and uptake, while copyleft licences are used more selectively.

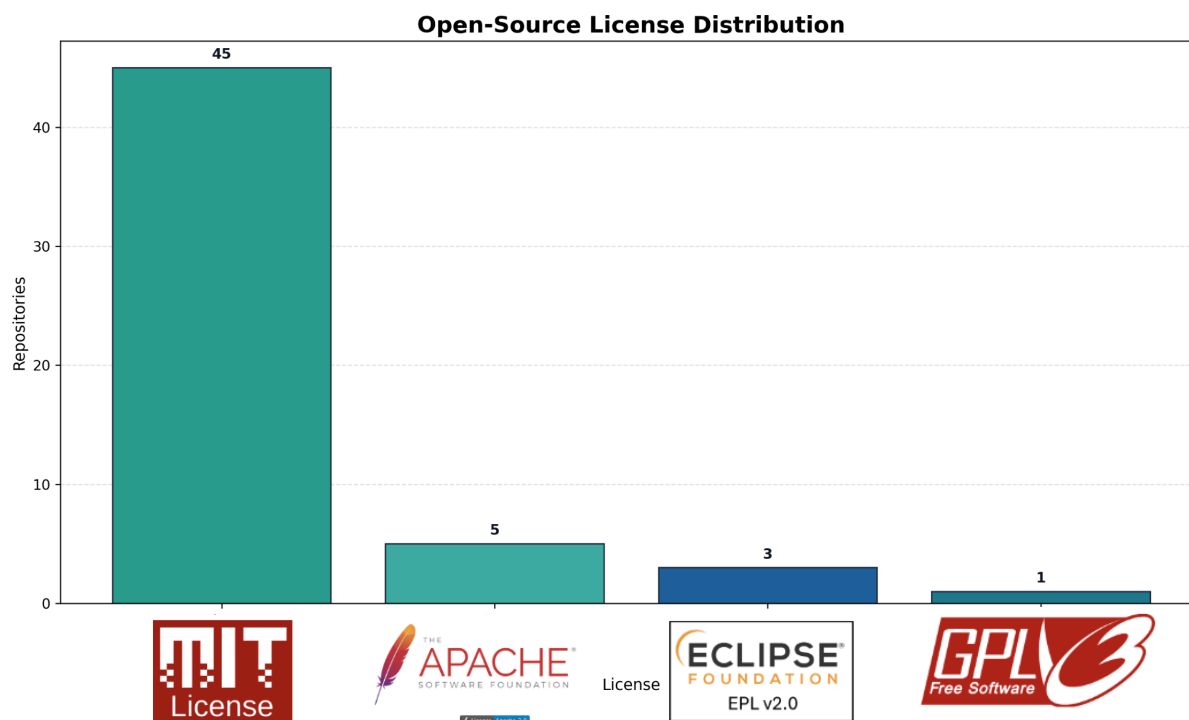


Figure 34: License distribution across TaRDIS repository.

Given the diversity of software components developed within the TaRDIS project, the consortium does not impose a single mandatory licence for all toolbox elements. The TaRDIS toolbox includes heterogeneous artefacts with different technical roles, dependencies, maturity levels and intended reuse scenarios, and a uniform licensing approach would therefore not be appropriate. Instead, partners retain the flexibility to select the most suitable licence for their components, taking into account:

- the technical nature of the software component,
- compatibility with existing open source ecosystems,
- institutional intellectual property policies,
- potential integration with external software frameworks.

At the same time, the consortium converged on a common set of licensing principles.

First, every publicly released TaRDIS software artefact includes an explicit licence file in the repository root and should also mention the selected licence in the repository README. Public visibility without a licence is not sufficient to make a repository reusable under open-source conditions.

Second, the consortium does not impose a single mandatory licence for all TaRDIS software components, because the repository inventory demonstrates that the toolbox contains software of different technical nature, maturity and reuse scenarios. A single licence for all components would therefore not be appropriate.

Third, the consortium recommends a default preference for permissive licences, notably **MIT** or **Apache 2.0**, for reusable libraries, frameworks, middleware components and similar software artefacts whenever there are no partner-specific constraints preventing this choice. This recommendation is grounded both in the observed licence distribution in the project and in the objective of maximising uptake and interoperability of the TaRDIS toolbox.

Fourth, the consortium recognises that **copyleft licences**, notably **GPL-3.0** or **EPL v2.0**, may be appropriate in cases where reciprocity obligations, ecosystem compatibility, or partner-specific strategic considerations justify such a choice.

Fifth, for non-code artefacts such as documentation, tutorials or dissemination-oriented materials, the consortium recommends that partners use an explicit and suitable reuse licence where relevant, for example **CC BY 4.0** for documentation material intended for broad circulation, provided that this is compatible with partner policy and the nature of the artefact.

In this way, the consortium addresses the M18 review recommendation not by forcing an artificial uniformity, but by converging on a viable and evidence-based policy: explicit licensing is mandatory for public release; permissive licensing is the recommended default; and deviations from that default remain possible when technically or legally justified.

5.2.6 TaRDIS Open Source and Distribution Manifesto

The findings presented above allowed the consortium to move from mapping and partner-level practices towards a more explicit common policy framework for the public availability, licensing, and discoverability of TaRDIS software artefacts. Based on the updated repository inventory, the consultation of partners, and the follow-up discussions conducted in Task 8.2 on the open-source status of TaRDIS software artefacts, the consortium adopts the following **TaRDIS Open Source and Distribution Manifesto**.

Openness by default for public project software. Whenever legally and technically feasible, TaRDIS software intended for public release should be made available under recognised open-source conditions in order to maximise transparency, reuse, reproducibility and long-term value of the software artefacts produced by the project.

Explicit licensing required for public release. Every publicly released TaRDIS repository should contain a clear licence file and a corresponding statement in the README. Public visibility without an explicit licence does not provide sufficient legal clarity for reuse. The TaRDIS toolbox contains heterogeneous artefacts with different technical roles, dependencies and intended reuse scenarios. For this reason, the consortium does not impose a single licence across all components.

Permissive licensing is the recommended default. Where there are no specific legal, technical or strategic constraints, the consortium recommends a default preference for permissive licences (e.g., MIT, Apache 2.0), for reusable libraries, frameworks and similar software artefacts.

Copyright remains a valid option when justified. GPL-3.0, EPL v2.0 or comparable licences may be appropriate where reciprocity obligations, ecosystem compatibility or partner-specific exploitation considerations support such a choice.

Distribution should follow the nature of the artefact. Reusable libraries should be distributed through public repositories and release assets where appropriate; service-like components should be accompanied by binaries, containers, scripts or deployment documentation; and developer-facing tools should be packaged in ways that reduce adoption effort for external users.

Discoverability is part of openness. TaRDIS software should therefore be discoverable through the project website, curated repository collections or equivalent entry points, and repository-level documentation that explains purpose, dependencies, installation and usage. In this context, the TaRDIS Wiki plays an important supporting role by providing a central documentation hub, including guidance on the TaRDIS IDE and recipe-based descriptions showing how tools and libraries can be combined in concrete use-case scenarios.

Repository hygiene is part of the consortium policy. Public-facing repositories should include, at a minimum, a README, a licence statement, project acknowledgement where appropriate, installation or usage guidance, and sufficient metadata to clarify the scope and status of the artefact.

Partner ownership is preserved within a common framework. Each software component remains under the responsibility of the partner or partners that develop and maintain it. However, these decisions should be taken within the common policy framework described in this manifesto and should support the broader project objective of presenting TaRDIS as a coherent, accessible and reusable toolbox.

Post-project availability should be considered from the release stage. Whenever feasible, publicly released TaRDIS software should remain accessible after the end of the project, and release practices should therefore take sustainability and future reuse into account from the outset.

5.3 POLICY ENGAGEMENT AND ECOSYSTEM OUTREACH

Task 8.2 also supported outreach towards stakeholders and interested parties through dedicated events and broader ecosystem engagement. This policy-facing dimension should be understood in a broad sense: not only as direct interaction with policy actors, but also as participation in the wider set of initiatives, events and communities in which future discussions on governance, interoperability, standards, openness, and responsible technology deployment are shaped.

As discussed in [5], an analytical framework for policymaking can have an impact on several major dimensions of society and technology, including the wellbeing of individuals and society, trade and economic activity, environmental sustainability, geopolitical strategies, and technological development, including system design, data use, and governance. In the context of rapidly evolving AI and distributed digital infrastructures, questions related to governance, interoperability, openness, and responsible technology deployment are becoming increasingly relevant.

Given the relevance of TaRDIS to distributed learning, swarm intelligence, and AI-enabled systems, Task 8.2 considered the broader policy and ecosystem dimension of the project. The objective was to maintain links with the wider communities in which policy-relevant discussions on distributed intelligence, edge systems, interoperability, open standards, and digital infrastructures are taking place. This includes interactions with researchers, developers, standardisation communities, and initiatives that operate close to research-policy interfaces.

Participation of TaRDIS in international workshops, networking events and research exchanges contributed to maintaining links with relevant stakeholders, including researchers, developers, policy advisers and regulators. Such interactions are important for identifying emerging technological trends, understanding regulatory developments, and ensuring that the research conducted within the project remains aligned with broader societal and policy priorities.

In this respect, TaRDIS engaged with broader European community-building and standardisation-oriented activities. In particular, participation in EuCEI Cloud-Edge-Continuum (CEC) events and in the Workshop on Cross-Domain Standardisation and Architecture for IoT and Edge Computing was especially relevant. These fora explicitly address Europe's role in international standardisation, the need for coordination across projects and sectors, and the development of common approaches for emerging digital infrastructures. Such activities connect project-level technical work with wider debates on interoperability, common architectures, open standards, and Europe's digital strategic positioning.

Furthermore, TaRDIS was represented in several international networking and ecosystem-building activities (see Table 3, Section 4.1 for a comprehensive list of these activities). A particularly relevant example is the interaction with the **DISCOVER-US** initiative⁵, whose purpose is to strengthen long-term collaboration between Europe and the United States around the computing continuum, distributed computing, and swarm intelligence, including through networking and brokerage opportunities. These exchanges are relevant not only from a scientific perspective, but also from a policy perspective, since they contribute to aligning research agendas and discussing broader strategic priorities around emerging distributed intelligence technologies.

⁵ <https://discover-us.eu/>

In addition, the consortium co-organised the Swarm Workshop: Programming tools for decentralised intelligence and swarms, together with other Horizon-funded projects. These types of events are highly relevant to the broader policy and ecosystem dimension of TaRDIS, because it contributes to building the European community around swarm programming tools, decentralised intelligence, and reusable technical assets. This point is also consistent with the M18 review recommendation to foster a European swarm developer community.

Taken together, these activities show that the policy-related dimension of Task 8.2 should be understood broadly: direct interaction with policy actors, but also as participation in the ecosystem of initiatives, events, and communities where future policy, standardisation, and strategic technology discussions are shaped. In this sense, dissemination, standardisation, open-source coordination, community building, and policy-facing engagement are closely interconnected. Through this coordination, TaRDIS aimed to ensure that its outcomes contribute not only to scientific progress, but also to the wider technological and societal discussions surrounding distributed intelligence systems.

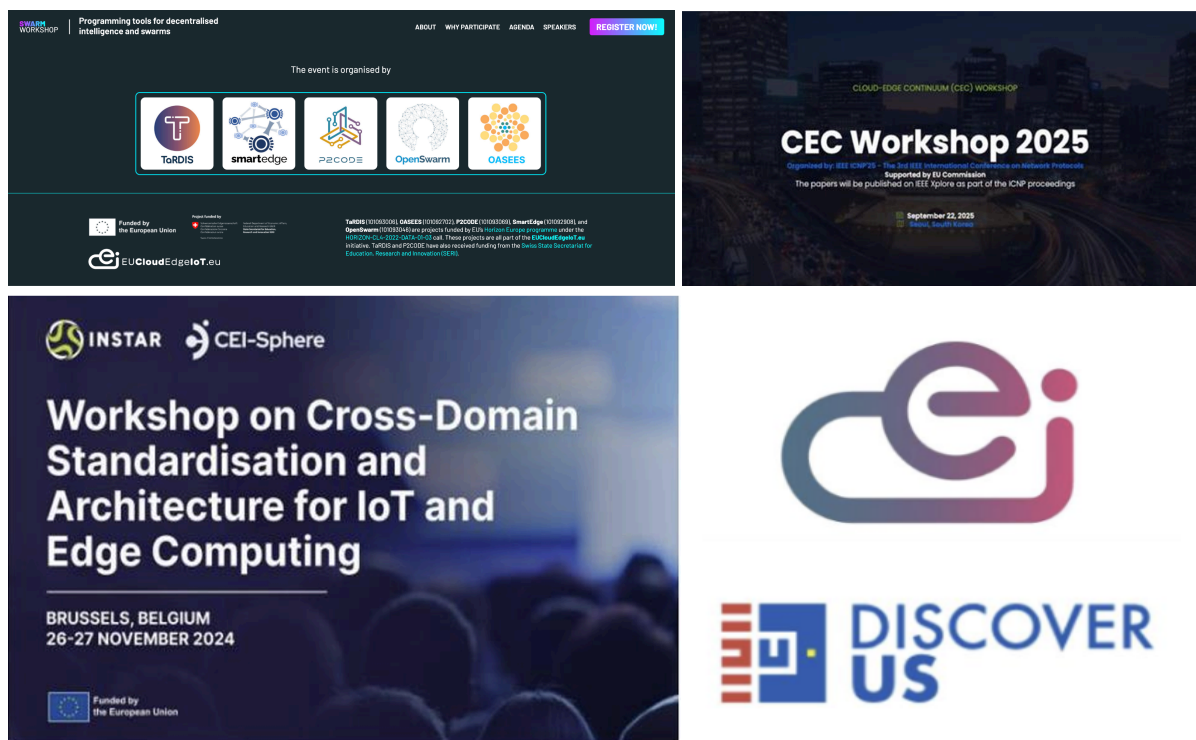


Figure 35: Representative policy, ecosystem, and standardisation-related events and initiatives in which TaRDIS participated or contributed during the project.

5.4 Conclusions and Perspectives

Building on the mapping and analysis conducted in Deliverable D8.3 [2], Task 8.2 continued to consolidate the standardisation, open-source, distribution, and policy dimensions of TaRDIS results. Over the course of the project, this work contributed to a more coherent framework for the identification of standardisation-relevant outcomes, the organisation and public availability of TaRDIS software artefacts, the clarification of licensing and distribution practices, and the positioning of project results within broader ecosystem and policy-oriented discussions. Several perspectives remain relevant for the continuation and long-term impact of this work.

With regard to standardisation, Task 8.2 moved beyond the initial mapping of relevant standards and standardisation bodies towards a more concrete analysis of how TaRDIS artefacts and use cases relate to existing standards, recommendations, and engineering practices. This work consolidated partner inputs, identified the principal standards families connected to TaRDIS technologies, and highlighted standardisation gaps in areas such as decentralised federated learning, swarm-level coordination, verification of distributed autonomous behaviour, and interoperability across emerging distributed intelligence systems. TaRDIS also strengthened its positioning through interactions with relevant communities and fora, including ETSI, IETF and cluster-related activities, as well as through the preparation and presentation of the Internet-Draft “A Generic Framework for Building Dynamic Decentralized Systems (GFDS)”. In this way, Task 8.2 not only mapped the standardisation landscape, but also translated TaRDIS results into a clearer standards-facing perspective and increased their visibility beyond the consortium.

The continued maintenance and evolution of TaRDIS software artefacts will be important for ensuring the sustainability of the project’s outcomes. As several repositories correspond to research prototypes or evolving frameworks, further development by consortium partners or by external contributors may enhance their robustness, maturity and applicability. The use of widely adopted collaborative platforms such as GitHub and GitLab supports this process by enabling community contributions, issue tracking and transparent development workflows.

The open-source ecosystem surrounding distributed learning, swarm intelligence and distributed systems continues to evolve rapidly. Future research projects and collaborations may build upon software components produced in TaRDIS, particularly in areas such as distributed coordination protocols, adaptive swarm behaviour and verification tools for distributed systems. By ensuring that the TaRDIS toolbox remains accessible through public repositories, common entry points and clearly documented licensing terms, the consortium increases the potential for reuse and further development by the broader research and developer community.

The activities carried out in Task 8.2 demonstrate that open-source coordination cannot be treated in isolation from dissemination, standardisation, ecosystem engagement, and exploitation. The work undertaken in this task highlights the importance of integrating these dimensions within collaborative research projects, especially where software artefacts are expected to contribute not only to scientific results, but also to wider technological uptake, alignment with emerging standards, and community building.

Finally, the broader policy and ecosystem engagement pursued during the project suggests that TaRDIS outcomes may also contribute to future discussions on the governance and responsible deployment of distributed artificial intelligence systems. As distributed learning infrastructures, edge systems and swarm-based applications become increasingly relevant, questions related to interoperability, transparency, reproducibility, and openness are likely to gain further importance in both research and policy contexts.

6 CONCLUSIONS

The TaRDIS project has made substantial progress in its impact-creation activities across communication, dissemination, standardisation, open-source coordination, and policy-facing engagement. Throughout the project duration, the consortium worked to promote the visibility of TaRDIS results, engage relevant stakeholders, and support the adoption and further development of the concepts, tools, and approaches developed within the project.

To achieve this, the consortium implemented a broad set of communication and outreach activities, including participation in external events, the organisation of workshops, webinars, and demonstrations, the publication of news items and newsletters, the preparation of promotional materials, and the dissemination of scientific results through journals, conferences, and technical reports. These activities contributed to increasing awareness of TaRDIS within the research community and among relevant stakeholders in the wider cloud-edge-IoT and decentralised computing landscape.

Beyond dissemination in a narrow sense, the project also strengthened its positioning in relation to standardisation. Building on the baseline established in D8.3 [2], the consortium consolidated its understanding of the standards landscape relevant to TaRDIS outcomes, identified alignment points and gaps for selected artefacts and use cases, and engaged with relevant standardisation-oriented communities and fora.

The project strengthened the visibility, accessibility, and discoverability of its software artefacts through the collection and consolidation of repository practices across partners, with a clear licensing approach, and the organisation of common entry points to the TaRDIS toolbox. The adoption of the TaRDIS Open Source and Distribution Manifesto further contributed to a more coherent project-level framework for licensing, repository hygiene, and practical reuse of toolbox components beyond the project lifetime.

In addition, TaRDIS engaged with broader policy and ecosystem discussions through participation in European and international initiatives, events, and community-building activities related to interoperability, digital infrastructures, distributed intelligence, and swarm-oriented systems. These activities helped position project outcomes within wider technical and strategic discussions and reinforced the links between dissemination, standardisation, open-source coordination, and long-term impact.

Taken together, the activities reported in this deliverable show that TaRDIS has not only generated research results, but also strengthened the basis for their visibility, accessibility, reuse, and continued relevance beyond the formal end of the project, while contributing to the European landscape around swarm programming, decentralised intelligence, and distributed digital infrastructures and preparing the ground for further technical, community, and standardisation-oriented follow-up.

REFERENCES

- [1] TaRDIS Consortium. (2023). “Dissemination and communication strategy and plan” (Deliverable D8.1). TaRDIS Project.
- [2] TaRDIS Consortium. (2024). “Outreach activities mid-term report” (Deliverable D8.3). TaRDIS Project.
- [3] Abdelkafi, N., Bekkers, R., Bolla, R., Rodriguez-Ascaso, A. and Wetterwald, M., Understanding ICT standardisation - principles and practice (ETSI), 2021.
- [4] Jesus, D., & Leitão, J. (2026, February 24). *A Generic Framework for Building Dynamic Decentralized Systems (GFDS)* (draft-jesus-gfds-02, Internet-Draft). Internet Engineering Task Force.
- [5] International Science Council, A guide for policy-makers: Evaluating rapidly developing technologies including AI, large language models and beyond, Paris, France, International Science Council, 2024