int:net

Interoperability Network for the Energy Transition

Welcome to the int:net Final Conference!

18 September 2025

Viehscheid

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Interoperability Network for the Energy Transition

Welcome and Introduction

Univ.-Prof. Antonello Monti

Fraunhofer FIT
RWTH Aachen University

18 September 2025 – int:net Final Conference

09:00	• Welcome and introduction | Antonello Monti, Fraunhofer FIT/RWTH Aachen
09:15	• int:net as a whole and its role in the data space discussion | Antonello Monti, Fraunhofer FIT/RWTH Aachen
09:25	• Use cases to explore the scope | Maider Santos Mugica, Tecnalia
09:35	• Describing interoperability maturity | Gianluca Lipari, EPRI
09:45	• Testing systemic interoperability | Thomas Strasser, AIT Austrian Institute of Technology
09:55	• From standards to governance | René Kuchenbuch, OFFIS
10:05	• Involvement and collaboration | Kristin Petersen, B.A.U.M. Consult
10:15	• Coffee Break

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10:45	• Revisiting the definition of interoperability | Laia Guitart, E.DSO & Joep van Genuchten, EPRI
10:55	• From interoperability standards to interoperability profiles | Diana Jimenez, Trialog
11:15	• From data management to interoperable data spaces | Charukeshi Joglekar, Fraunhofer FIT & Nicolò Rossetto, EUI
11:35	• From component testing to systemic test approaches | Thomas Strasser, AIT & Sonia Jimenez, IDSA
11:55	• From technological interoperability to interoperability governance | Mona Marie Bielig, Seeburg Castle University
12:15	• Lunch buffet and networking

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13:15	• More than a dream: from int:net and EDSCP to INSIEME | Georg Hartner & Natalie Samovich, INISIEME Project
13:25	• Understanding potentials and hurdles of interoperability in practice | Diana Jimenez, Trialog & Carlos Ayon Mac Gregor, B.A.U.M. Consult
13:35	• EMINENT to assess maturity of interoperability communities | Joep van Genuchten, EPRI
13:45	• IntMAS to establish a continuous improvement process | Ludwig Karg, B.A.U.M. Consult together with Henry Keppler, EcoPlanet & Andreas Strasser, APG
14:10	• The int:net Compass | Laia Guitart, E.DSO & René Kuchenbuch, OFFIS
14:15	• From the int:net community to the Interoperability People and Project Connector (IntPPC) | Alphin Tom & Kristin Petersen, B.A.U.M. Consult
14:30	• Coffee Break

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15:00	• Introduction to the panel: appraisal and outlook by the EU Commission | Mark van Stiphout, DG ENER & Ludwig Karg, B.A.U.M. Consult
15:15	• Panel: The multi-faceted interoperability challenge: learnings, expectations and plans | Ludwig Karg, B.A.U.M. Consult
16:15	• Closing words | Antonello Monti, Fraunhofer FIT/ RWTH Aachen
	• Open exchange and networking

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Interoperability Network for the Energy Transition

Final Conference

18th September 2025

Univ.-Prof. Antonello Monti

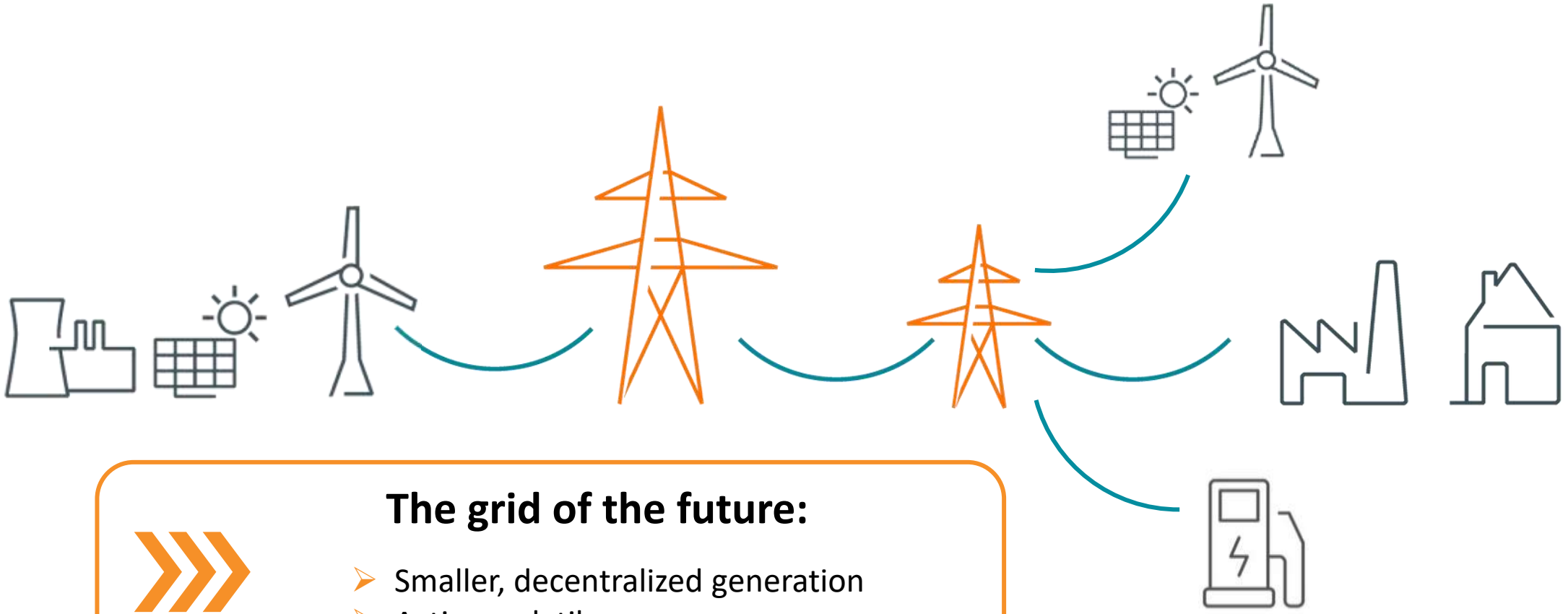
Fraunhofer FIT
RWTH Aachen University

Evolution of our grids

The grid of the past:

- Large, centralized generation
- Passive, predictable consumption

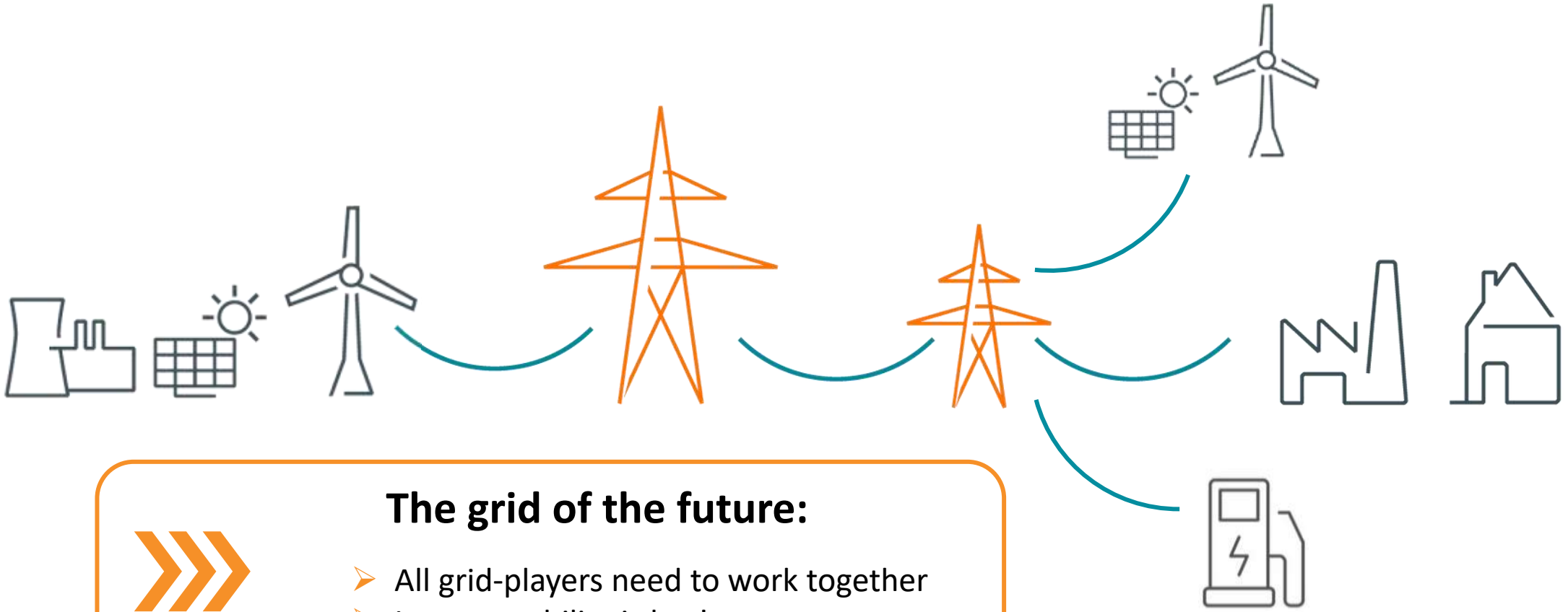
Evolution of our grids



The grid of the future:

- Smaller, decentralized generation
- Active, volatile prosumers

Evolution of our grids



The grid of the future:

- All grid-players need to work together
- Interoperability is key!

Results of int:net

Knowledge Base
- Initiaitves & Use cases
- IOP Testing Procedures & facilities
- Standardization overview

Tooling
- IOP Maturity Model EMINENT
- 6th SGAM-Layer concept
- Interoperability Compass
- Int:net project & people connector

Community
- Website with resources
- Platform with forums
- Community events (e.g. Connectathon)
- Lunch Talk events

int:net

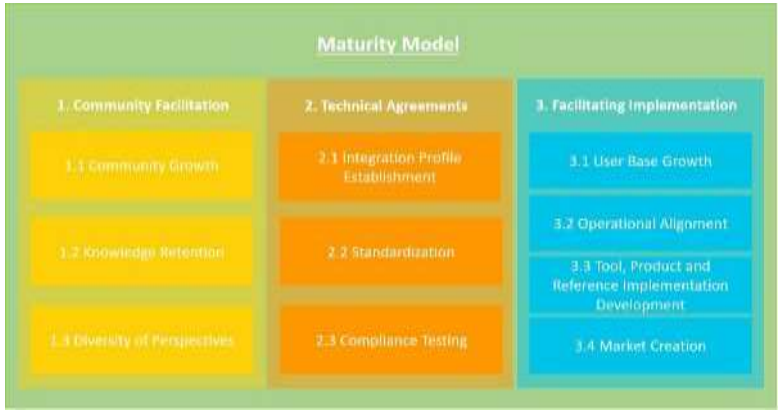
Labeling
- Continuous Improvement Process
- IntMAS
- EU registered label:

IntMAS approved organisation

EDSCP
- Cooperation between Dataspace Projects
- Blueprints and whitepapers
- Use Case Definitions

Exemplary Showcase

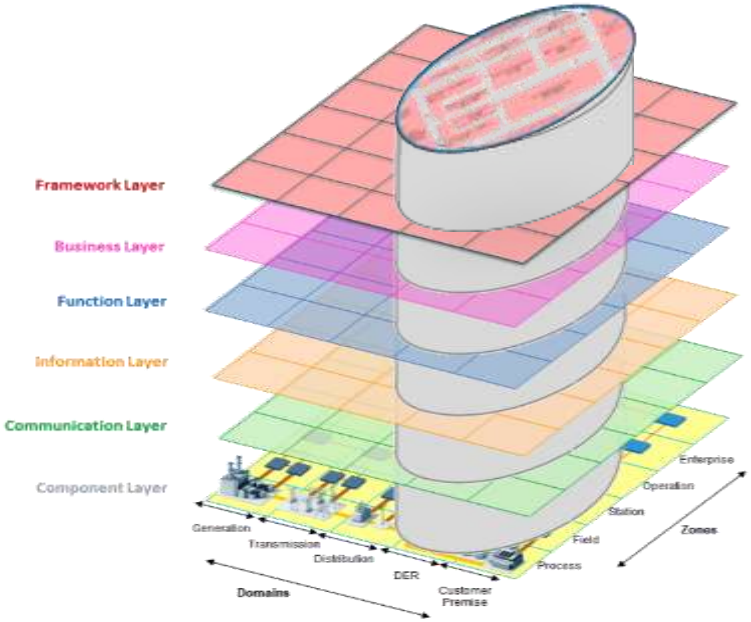
EMINENT



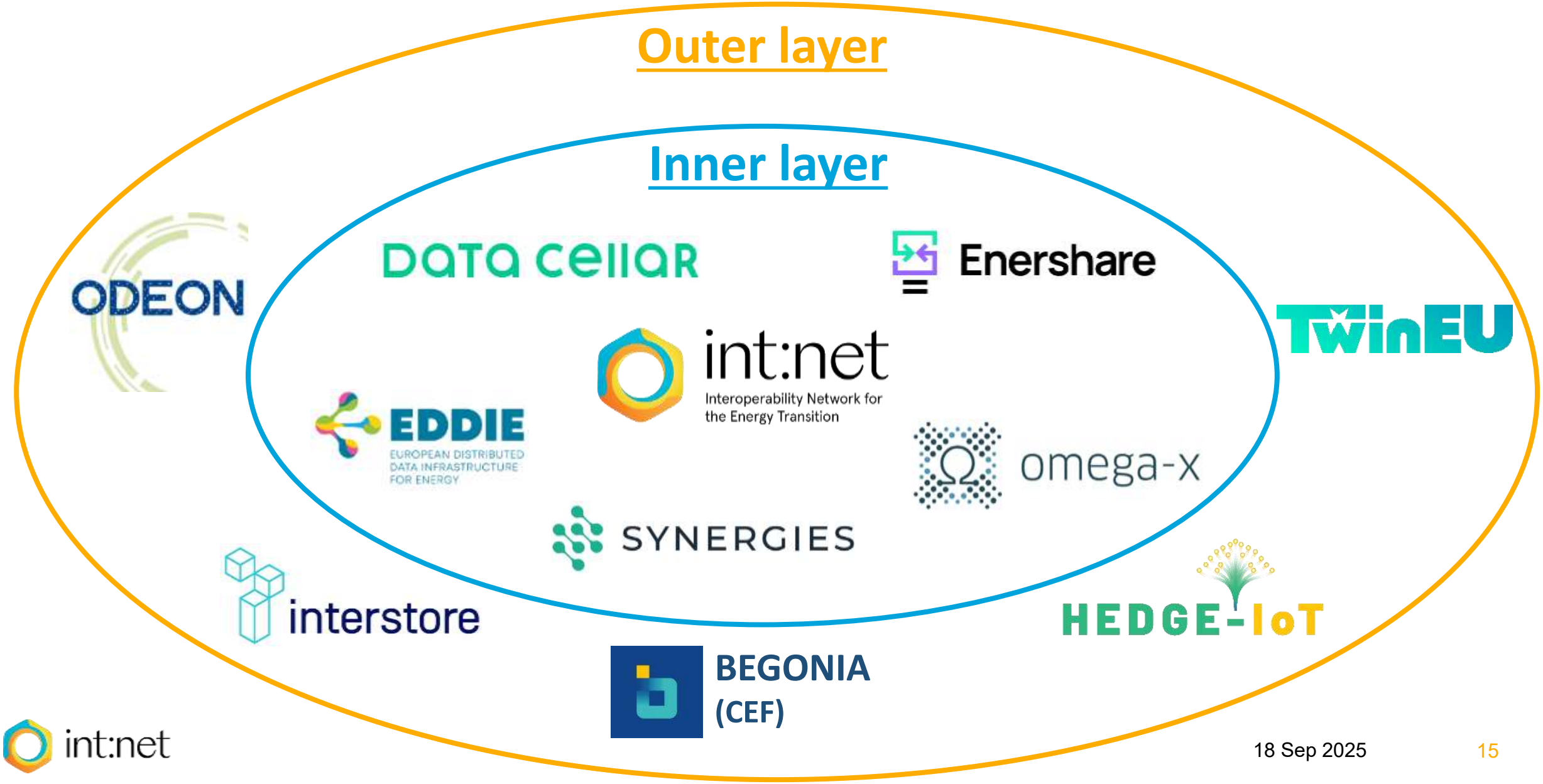
IOP compass

https://sgaaire.offis.de/iop-compass/

SGAM framework layer

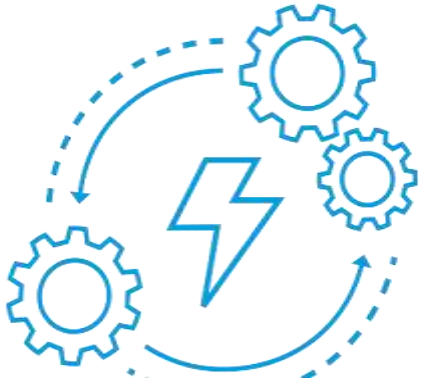


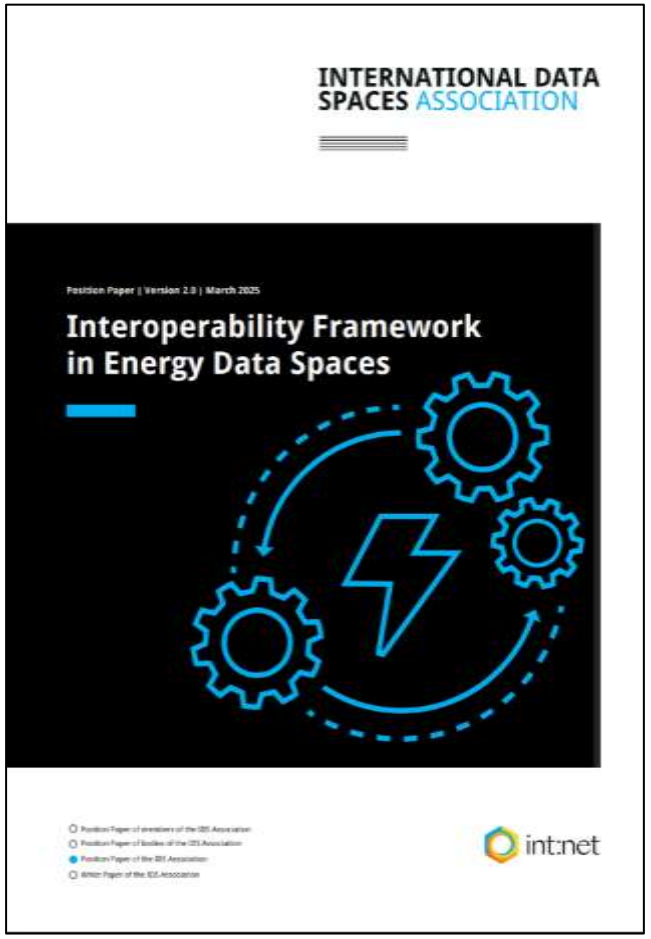
European Data Space Cluster Projects



Cluster Activities

CEEDS Business & System Use Cases





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Thank you for your attention.

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Use cases to explore the scope

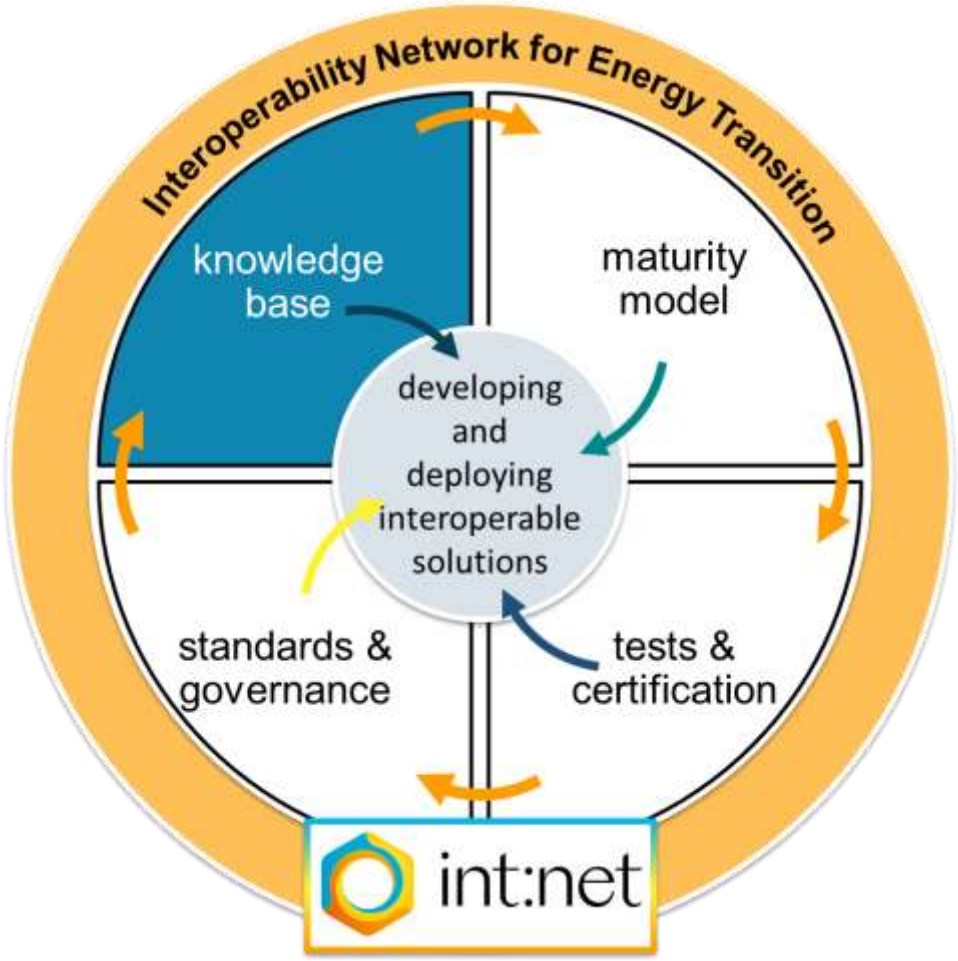
The making of int:net

Maider Santos Mugica, Tecnalia

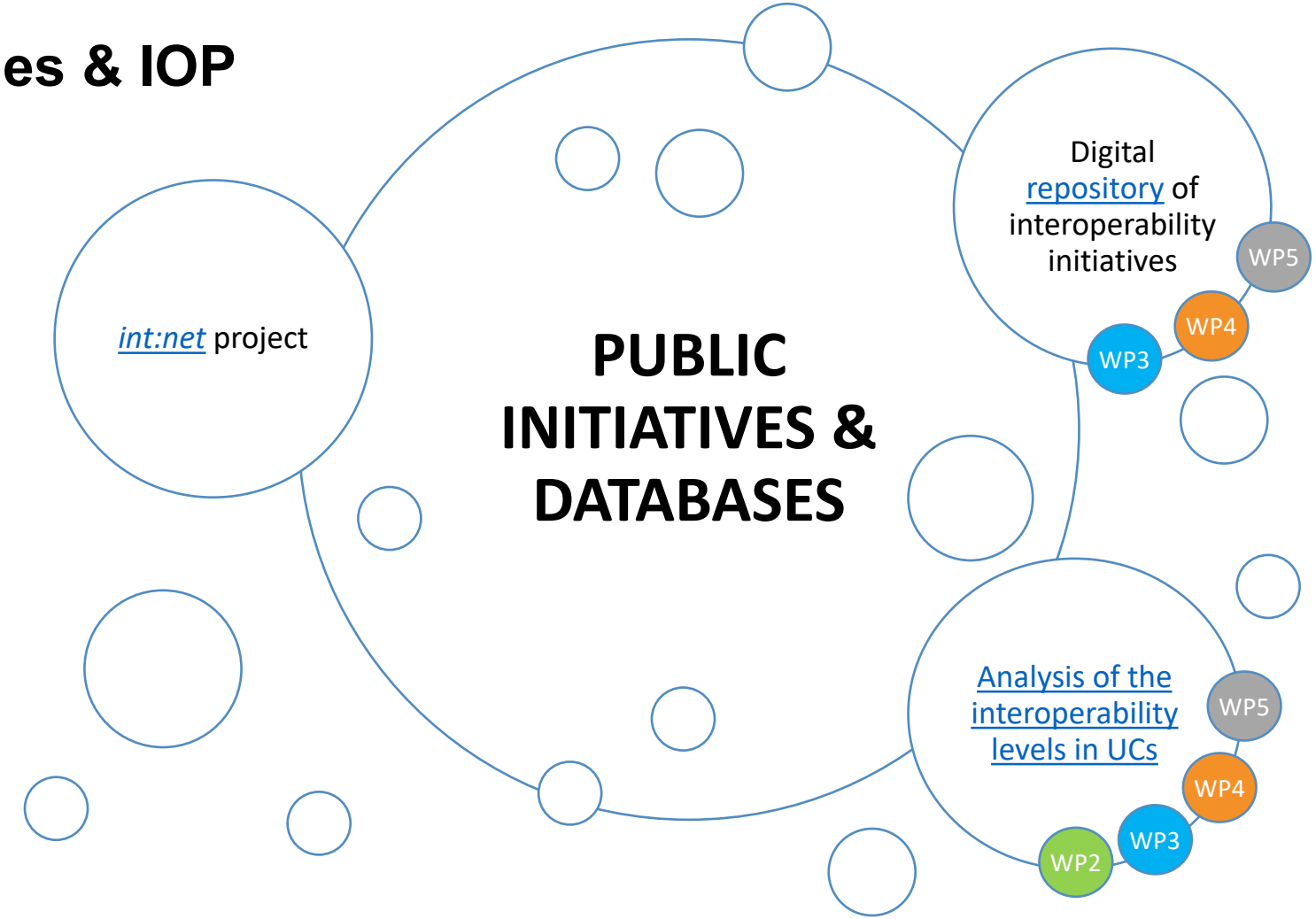
18 September 2025

Main contributions: knowledge base

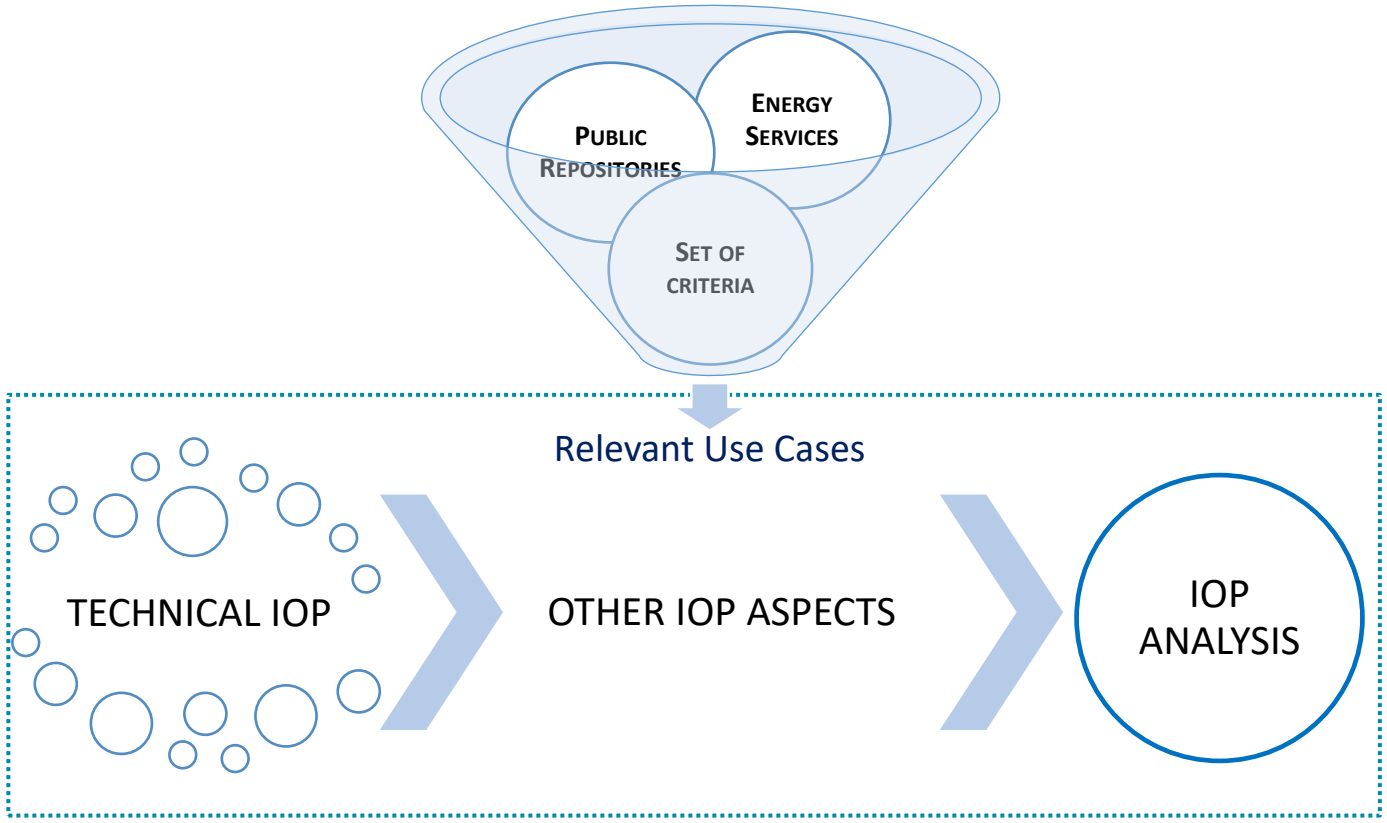
- Use Cases (UCs)
- Interoperability (IOP)



Public Use Cases & IOP



IOP Analysis



A **methodology** for the analysis of the **IOP in UCs** has been developed

Application of the interoperability methodology to a selection of **53 Use Cases**

Insight knowledge of Interoperability & Use Cases

IOP information included in the description **not completely covered / public**

Lack of consistency, rigour, knowledge in filling in the template

UC description at the beginning and **not updated**

Outcomes

Deliverables

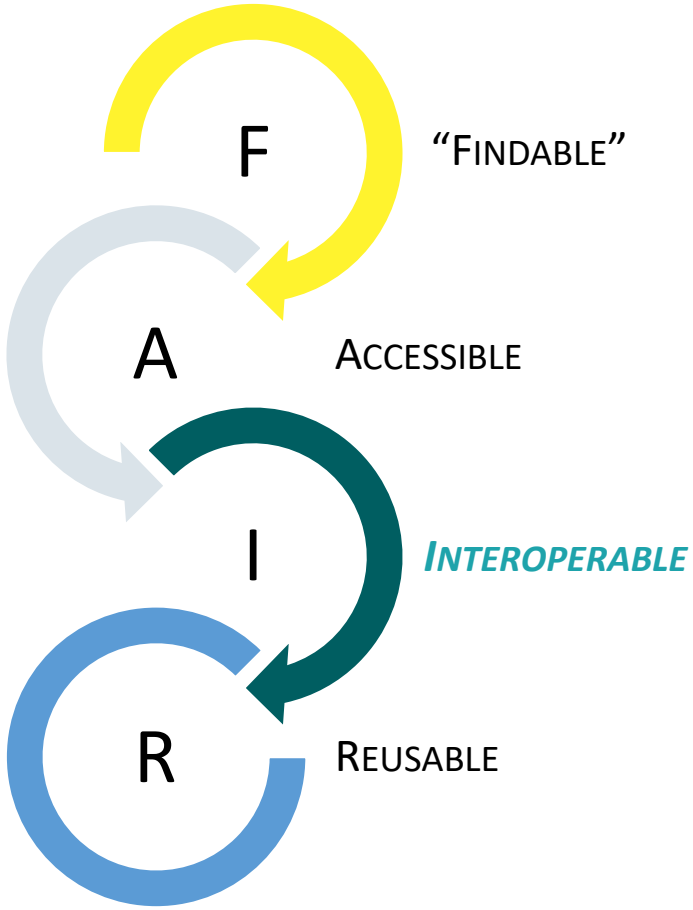
- ✓ *D1.1 Repository of interoperability initiatives (https://intnet.eu/images/resources/intnet_interoperability_initiatives-v1.1.zip)*
- ✓ *D1.2 Report on identified interoperability use cases, requirements and lifecycle process in the value chain and business models (https://intnet.eu/images/resources/D1.2%20Report%20on%20identified%20interoperability%20use%20cases%20requirements%20and%20lifecycle%20process%20in%20the%20value%20chain%20and%20business%20models.pdf)*

Lists and Repositories

- ✓ *Repository of interoperability initiatives (https://intnet.eu/images/resources/intnet_interoperability_initiatives-v1.1.zip)*

Conclusions & Next Steps

- Is IOP enough?
  - Boost efficiency and effectiveness
  - Facilitate case reuse and adaptation
  - Enhance stakeholder collaboration
  - Reduce case development time
  - Traceability



The FAIR Guiding Principles for scientific data management and stewardship | Scientific Data (nature.com)

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Interoperability Network for the Energy Transition

Describing interoperability maturity

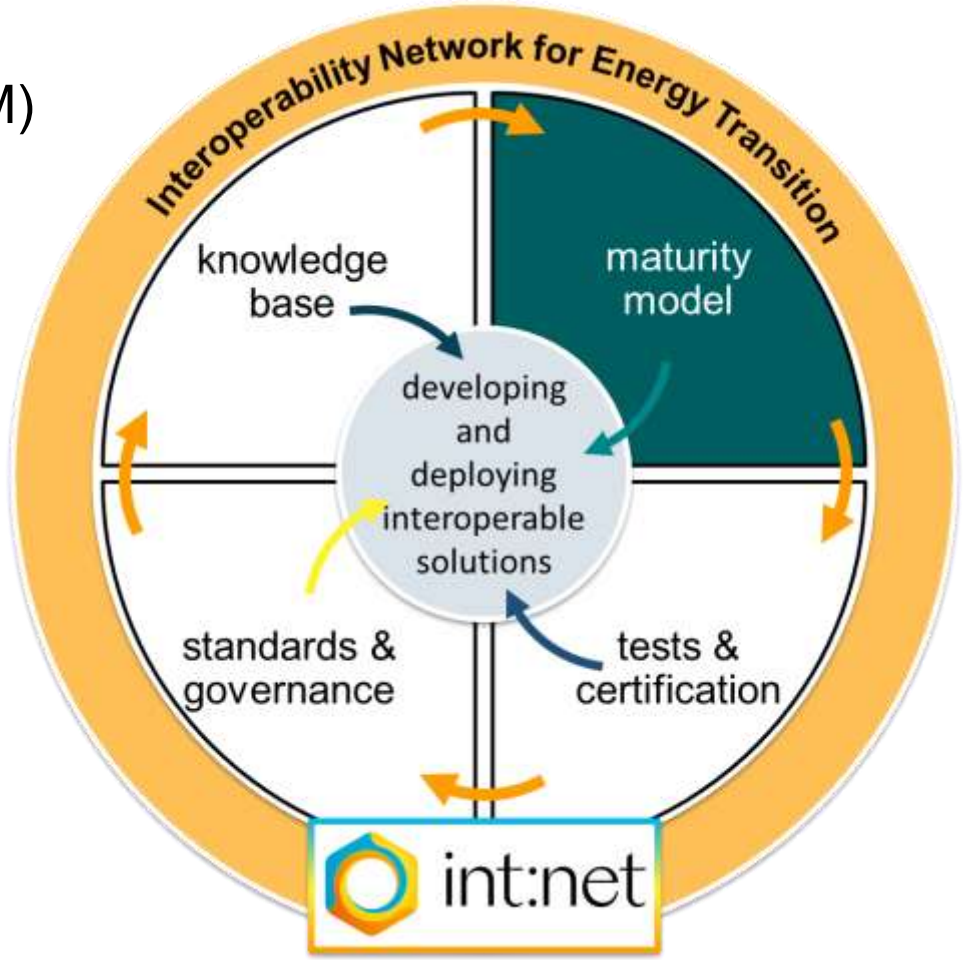
The making of int:net

Gianluca Lipari, EPRI

18 September 2025

Main contributions: EMINENT

- Interoperability Maturity Model (IMM)
- Capability Assessment Tool



Interoperability Maturity Model and assessment tool

- Understanding Interoperability Maturity requires proper modeling and understanding of “Interoperability Dimensions” to be measured
- Classic Interoperability Maturity Models measure and evaluate the technical aspects
- Capabilities that foster and support Interoperability within an organization or community are equally important
- We developed EMINENT to understand these capabilities and be able to assess them

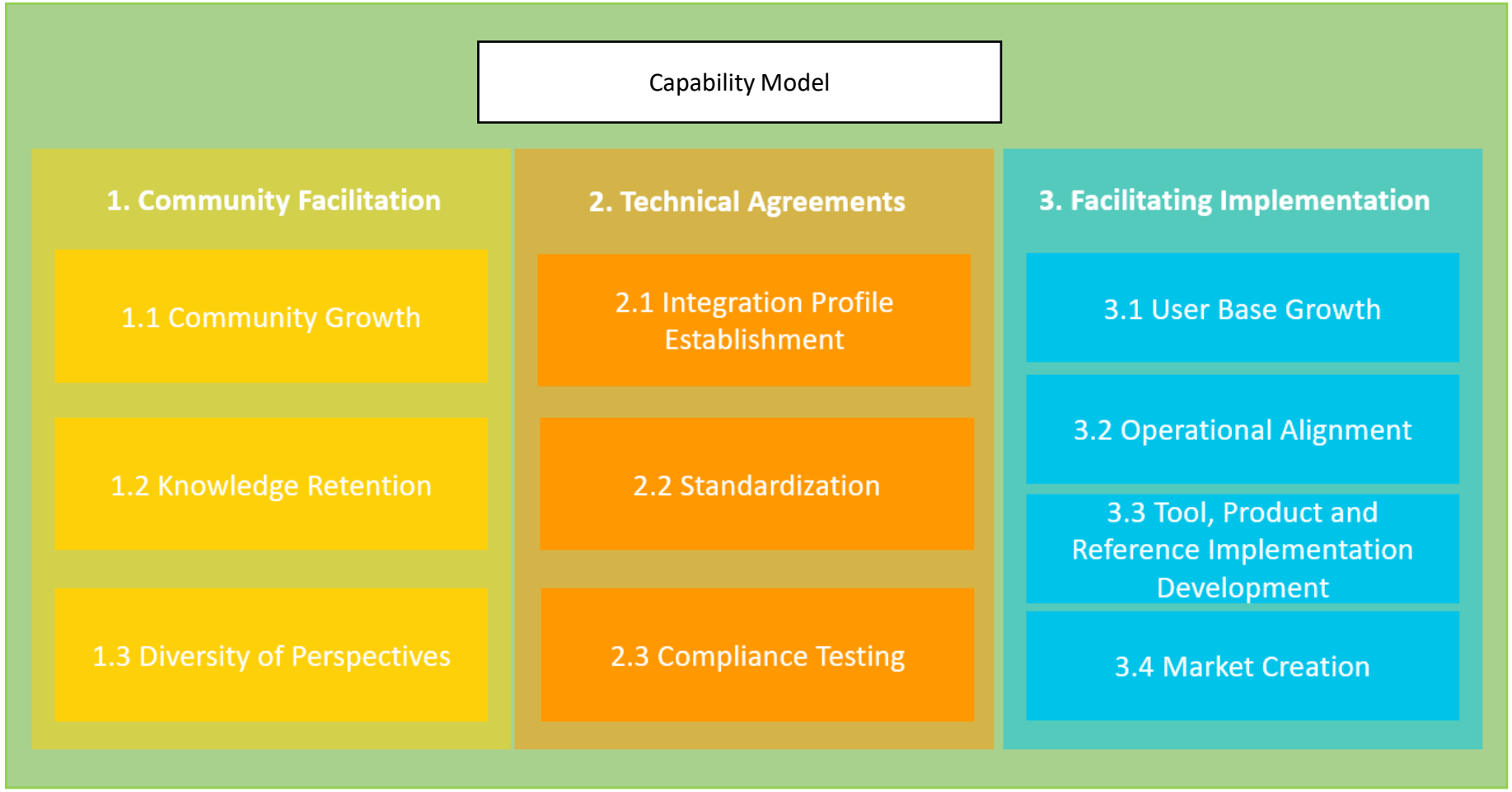
How can we get good at interoperability

Interoperability:

We know it when we see it

But how do we create it?

Capabilities



Dimensions of maturity

Dimension	Description
Process	The activities, procedures, and workflows an organization follows to achieve its goals, emphasizing documentation, standardization, efficiency, and continuous improvement.
People and organization	The human resources and the organizational structure, including leadership, talent management, employee engagement, and culture.
Information	The management, accessibility, and utilization of data and knowledge within an organization, encompassing data governance, quality, integration, security, and analytics.
Resources	The tangible and intangible resources necessary to deliver the capability; including grid assets, buildings, vehicles, money and intangible assets like intellectual property and brand reputation.

Maturity levels

Level 0:
There is no process for
Compliance testing

Maturity Model

maturity level > Dimension v	Level 0	Level 1	Level 2	Level 3	Level 4	Level 5
Process	Characteristic p0	Characteristic p1	Characteristic p2	Characteristic p2	Characteristic p3	Characteristic p5
People and organization	Characteristic po0	Characteristic po1	Characteristic po2	Characteristic po3	Characteristic po4	Characteristic po5
Information	Characteristic i0	Characteristic i1	Characteristic i2	Characteristic i3	Characteristic i4	Characteristic i5
Resources	Characteristic r0	Characteristic r1	Characteristic r2	Characteristic r3	Characteristic r4	Characteristic r5

Level 5:
Processes for Compliance Testing are continuously reviewed, benchmarked and improved resulting in industry-leading practices and results.

Outcomes

Deliverables

- ✓ *Deliverable D2.1 Interoperability Maturity Model Framework and Background*
- ✓ *Deliverable D2.2 IMM Assessment Tool, Users Guide and Example Applications*
- ✓ *Deliverable D2.3 Database and User Interface for Tracking Interoperability Maturity*

Lists and Repositories

- ✓ *EMINENT GitHub repository*

Publications

- ✓ *Interoperability Maturity Model - White Paper*

Conclusion

- By looking at interoperability through the lens of a capability, we can define how we can become better at creating interoperable solutions
- Looking at the capability model, there is a lot of overlap between the capabilities required for
  - Interoperability,
  - Standardisation,
  - Data spaces
  - Open source (software) development

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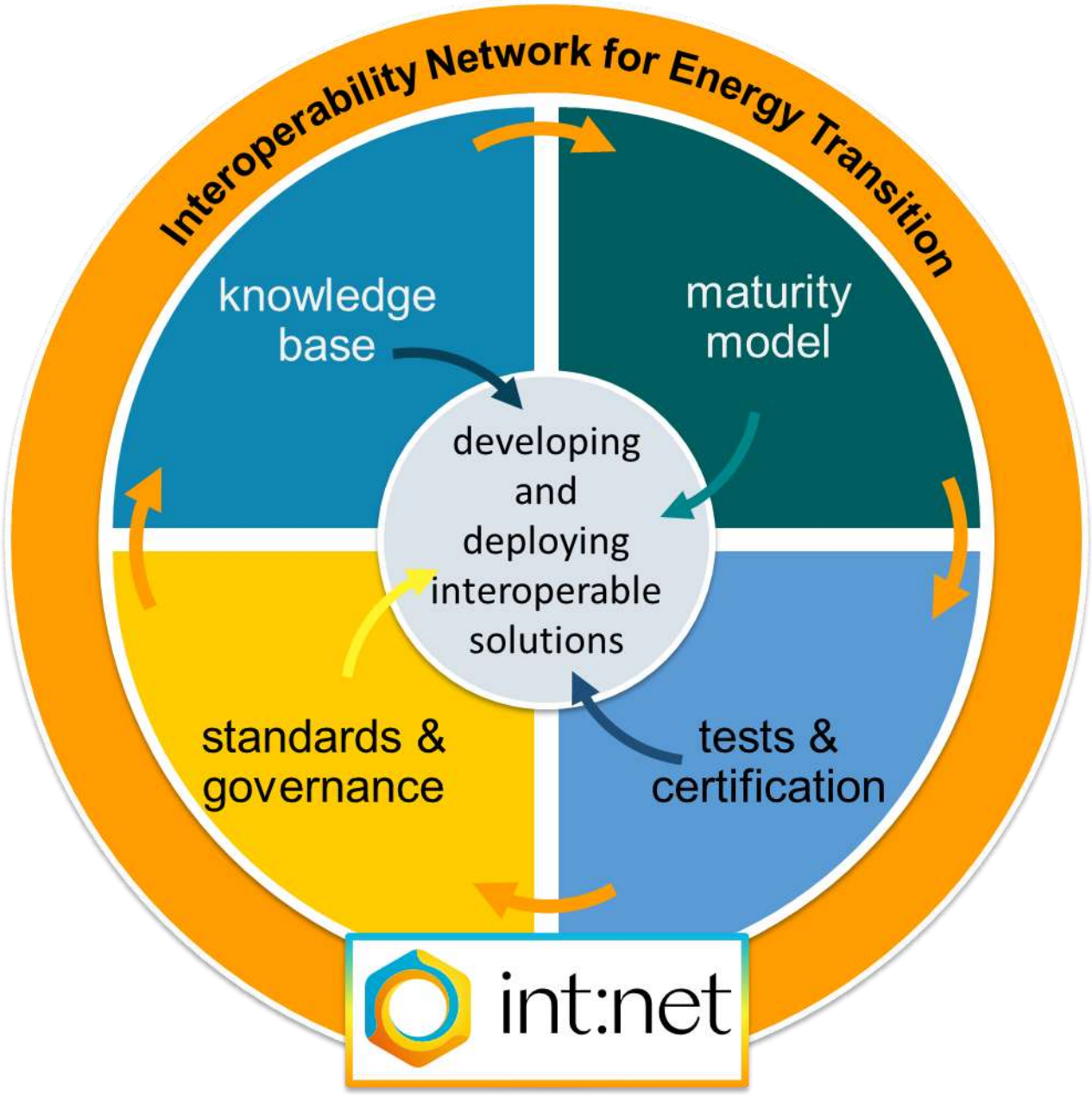
Testing systemic interoperability

The making of int:net

Thomas Strasser, AIT

18 September 2025

The int:net Vision



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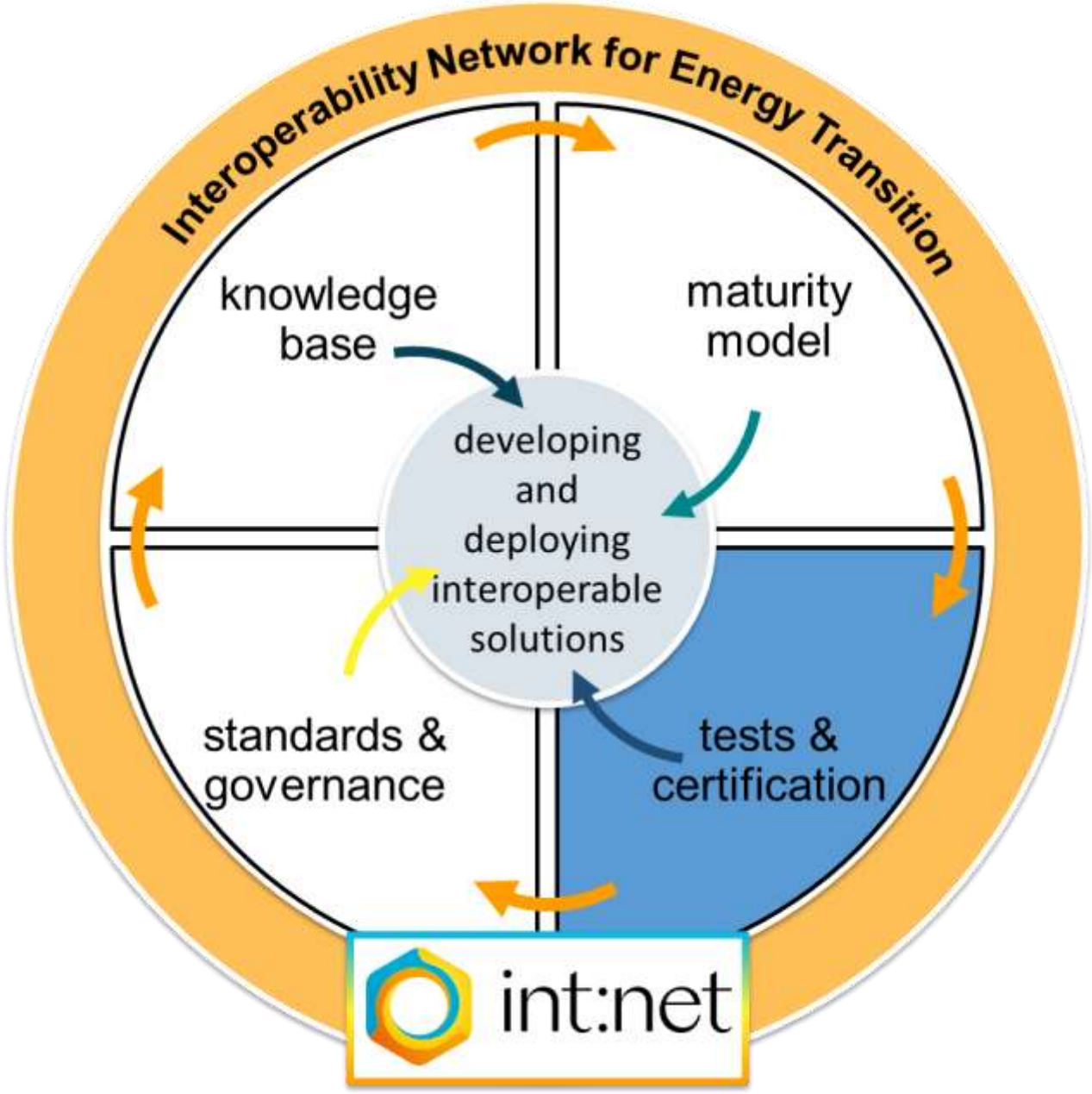
Testing systemic interoperability



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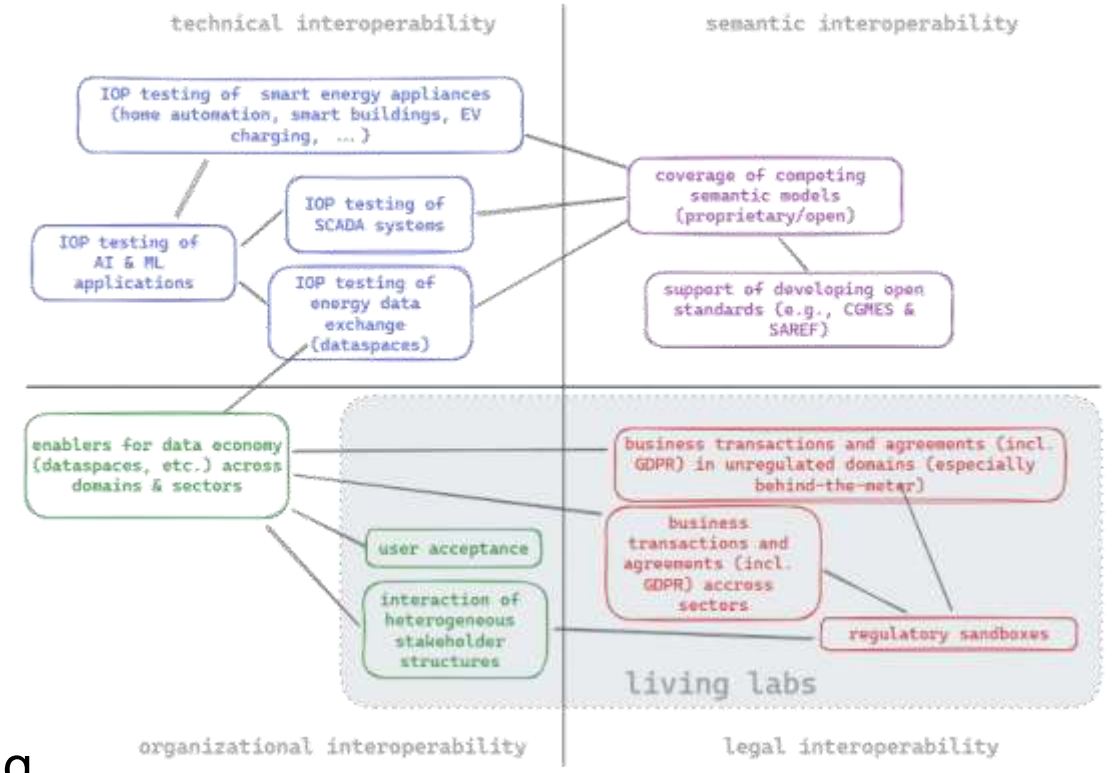
Interoperability (IOP) Testing Challenges

- Challenge
  - Convergence of many sectors with different standards, cultures and technical backgrounds
  - Single/multi-vendor devices, components should be able to inter-work on the system-level
- Status
  - Standards and experimental methods for testing the interoperability are partly missing
  - Standards do not guarantee interoperability, even if they promote it
- Solution
  - Introduction of a **comprehensive framework for interoperability testing,** including interoperability profiles, testing methods/procedures, and test facilities

Interoperability (IOP) Testing Challenges

- *Application*
  - → *"WHAT needs to be covered by IOP testing?"*
  - → Focus on applications (data exchange, IoT, etc.)
- *Testing Infrastructure*
  - → *"WHICH testing infrastructure (physical/ virtual) is required for IOP testing?"*
  - → Focus on implementation of IOP testing setups
- *Process(es)/Procedure(s)*
  - → *"HOW should IOP testing be done?"*
  - → Focus on specification and execution of IOP testing



Fragemented Landscape of Methodologies, Frameworks, and Tools

Methodologies

- JRC Smart Grid Interoperability Testing Methodology
- EU Code of Conduct for Energy Smart Appliances
- SMARTGRIDS Austria IES-Process (based on IHE)
- ERIGrid Holistic Test Description (HTD)

Frameworks and Tools

- Smart Grid Design of Interoperability Tests (SG-DoIT)
- Interoperability Test Bed (from EC DIGIT)
- IHE Gazelle Open-source Platform for Test Management
- ENTSO-E CGMES Conformity Assessment Framework
- NIST Framework and Roadmap for SG IOP Standards
- Leveraging IOP Maturity (int:net EMINENT)
- AIT Virtual Verification Laboratory Framework (AIT VLab)

Standards, guidelines, and Policies

- Integration of Quality (SQuaRE family – ISO/IEC 25000)
- Leveraging Use Cases in IOP Testing based on ISO/IEC 30194
- Leveraging Models for Privacy Engineering based on ISO/IEC 27564
- Leveraging Behavioural and Policy IOP based on ISO/IEC 21823

Other Approaches from the Literature

- Metamodel for IoT Testing
- Application of a Smart Grid Interoperability Testing Methodology in a Real-Time HIL Testing Environment
- Design of Experiments in the Methodology for IOP Testing
- EEBUS Living Lab Cologne, etc.

European Testing Facilities Landscape

- Heterogenous and scattered landscape,
  > 100 research laboratories and testing facilities
- Distributed all over Europe
- Focusing on different topics and activities
- Providing various services for stakeholders
- Some facilities focus on interoperability topics

→ *Creation of Interoperability Test Facility Inventory (incl. approach, methods, and tools)*

Source: JRC Smart Grid Laboratories Inventory Report 2022

Outcomes

Deliverables

- ✓ *Deliverable 3.1: Testing Concepts and Procedures Harmonisation Report*
- ✓ *Deliverable 3.2: Inventory of interoperability testing facilities*
- ✓ *Deliverable 3.3: Report on the integrated Pan-European community of testing facilities (upcoming)*

Lists and Repositories

- ✓ Interoperability Testing Approaches, Test Cases, and Test Facilities (IOP Focus Group (IFG) 4)
- ✓ CIM/CGMES IOP Report
- ✓ SV IOP Testing Report

Conclusions

- European test facilities play a pivotal role in advancing interoperability through
  - Standards adherence
  - Collaborative research and developments
  - Access to state-of-the-art testing facilities
  - Promotion of European-wide grid integration
- However, a harmonization and coordination of activities is necessary
  - Adoption of best practices (also from other domains/areas)

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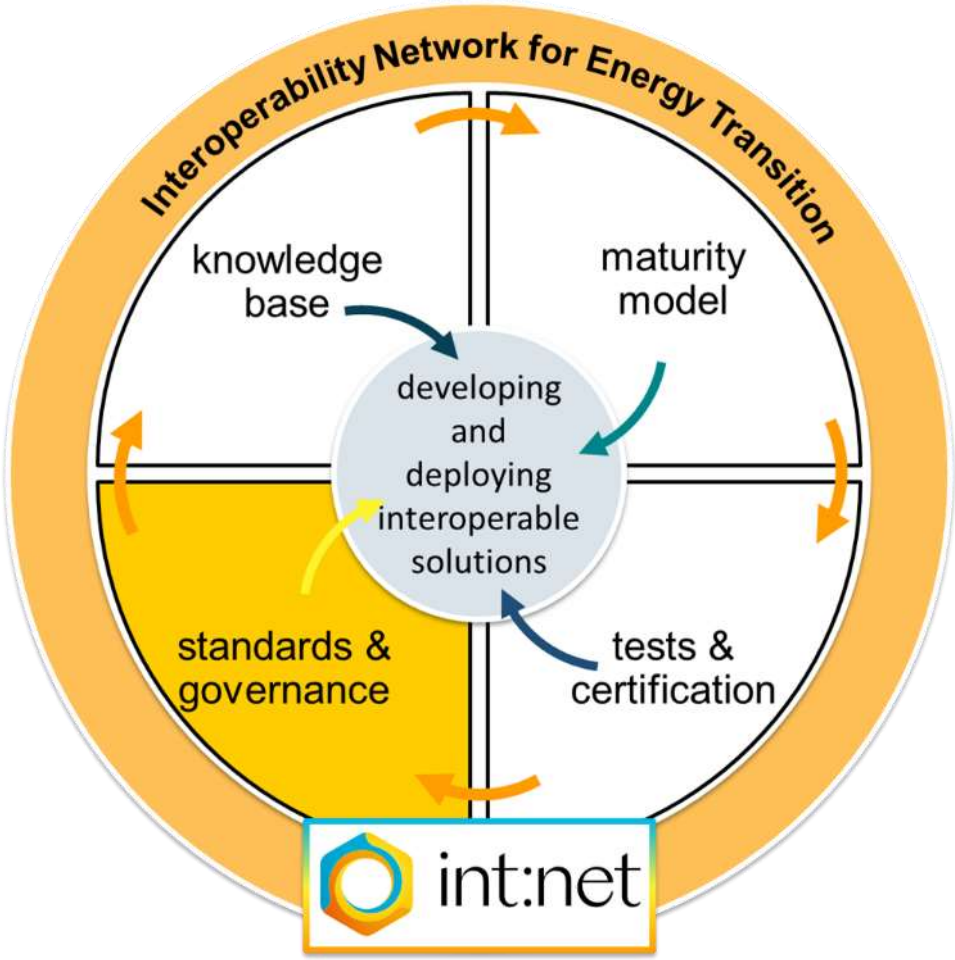
From standards to governance

The making of int:net

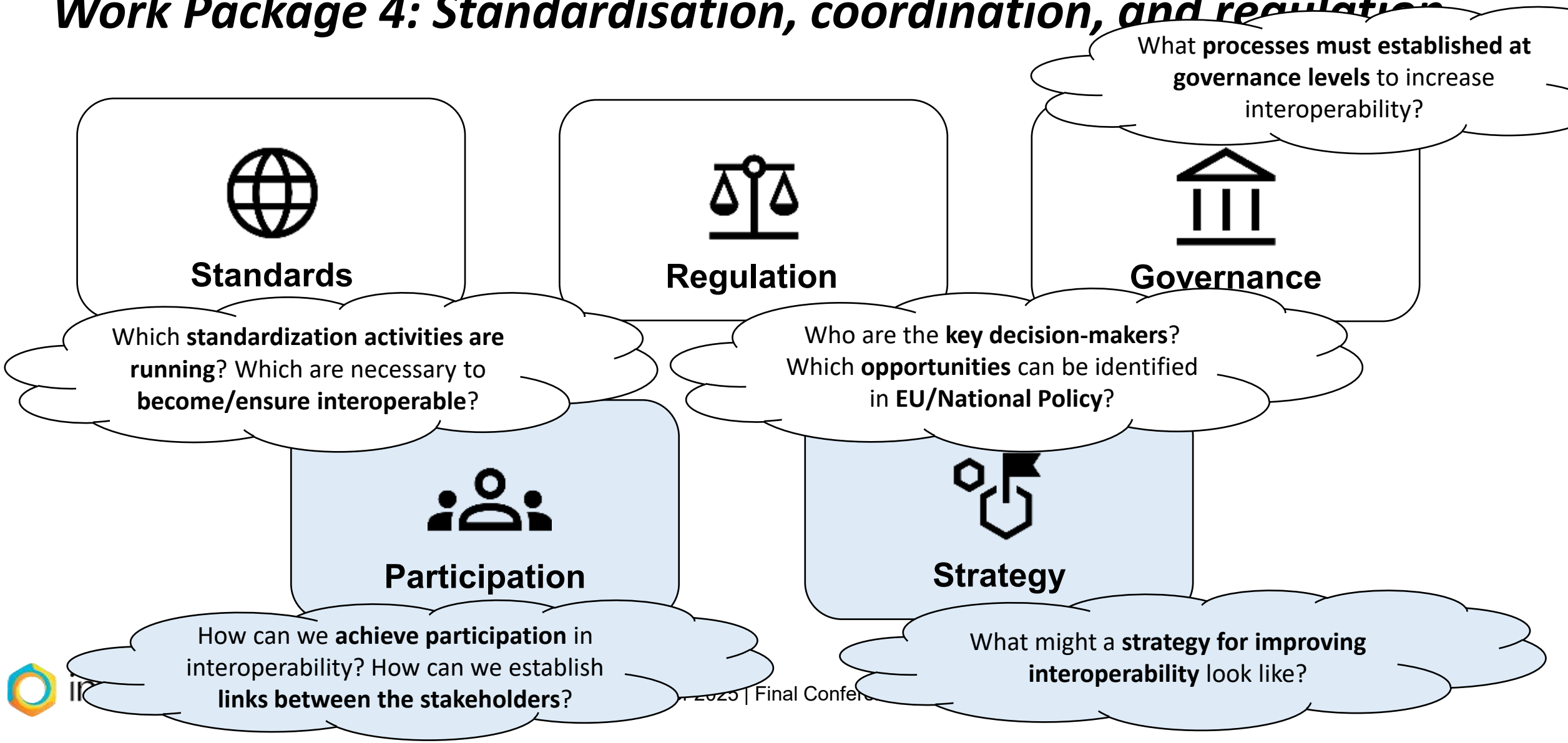
René Kuchenbuch, OFFIS

18 September 2025


Interoperability Network for Energy Transition
knowledge base
maturity model
developing and deploying interoperable solutions
standards & governance
tests & certification
int:net

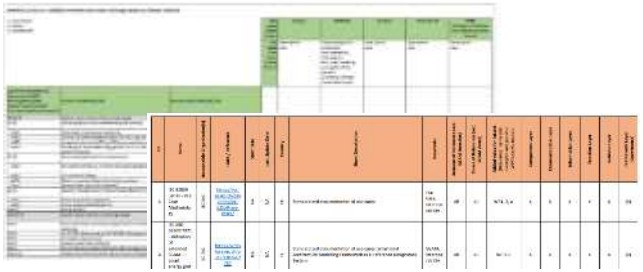
int:net

Work Package 4: Standardisation, coordination, and regulation

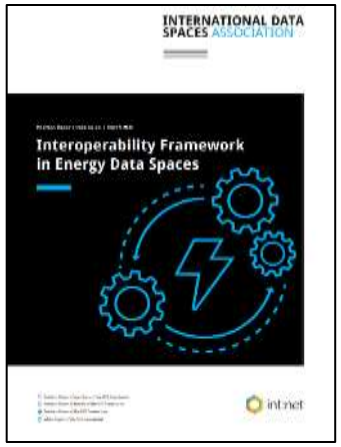


Timeline

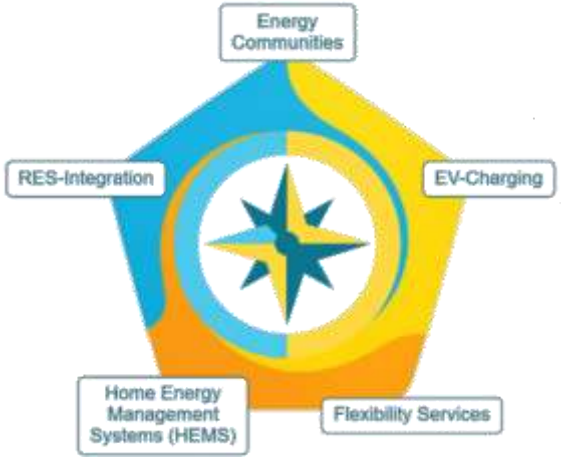
Standardization Workshops



Standardization Matrices and –Table



Interoperability Framework in Energy Data Spaces

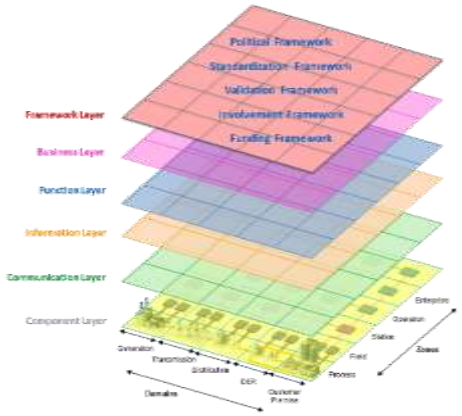


int:net Interoperability Compass

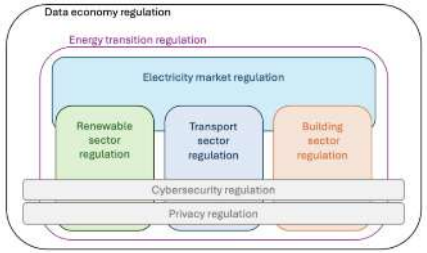
2022 **2023** **2024** **2025** **2026…**

Work Package 4: Kick-Off 23rd September 2022

6th SGAM „Framework“ Layer



Regulatory Framework



Analysis of Standards Environment for int:net

IHE Connectathon 2024 and 2025

Outcomes

Deliverables

- ✓ *Deliverable 4.1: Analysis of standards environment relevant for IntNET*
- ✓ *Deliverable 4.2: Analysis of the regulatory framework for IntNET*
- ✓ *Deliverable 4.3/4.4: Whitebook on engagement towards interoperability in governance (V1, V2)*

Platforms

- ✓ *IFG-2: Increasing Maturity in Interoperability*
- ✓ *IFG-3: The Interoperability Regulatory Landscape*
- ✓ *int:net Interoperability Compass (W.I.P)*
- ✓ *Smart Grid Assistive AI in Requirements Engineering (SGAAIRE)*

Lists and Repositories

- ✓ *Smart Grid Interoperability Standardization Whitepaper*
- ✓ *Evolution of Interoperability Standards*
- ✓ *Information Models Coordination and Governance: Standardisation Recommendations*
- ✓ *int:net Standardization Matrices*
- ✓ *int:net Standardization Overview*
- ✓ *VDE SPEC 90020 "Interoperability Maturity Model"*
- ✓ *…*

Conclusion

- **Work Package to support Standardization, Regulation and Governance issues**
  - Participation in Standardization & Working Groups
  - Collaboration e.g. in the development of Whitepapers

- **6th SGAM "Framework" Layer should address the *interoperability issues*, particularly in the regulation/governance related topics**

- **Further Inputs gathered to improve usage of the IEC 62559 Use Case-Methodology and SGAM Framework**
  - Usage of Standards and extending them (Tube-in-the-cube, standards analysis)
  - Development and Analysis of *Smart Grid Assistive AI in Requirements Engineering (SGAAIRE)*

No standard works in isolation; interoperability is built when we all engage!
Your contribution makes the difference.

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Interoperability Network for the Energy Transition

Involvement and collaboration

The making of int:net

Kristin Petersen, B.A.U.M. Consult

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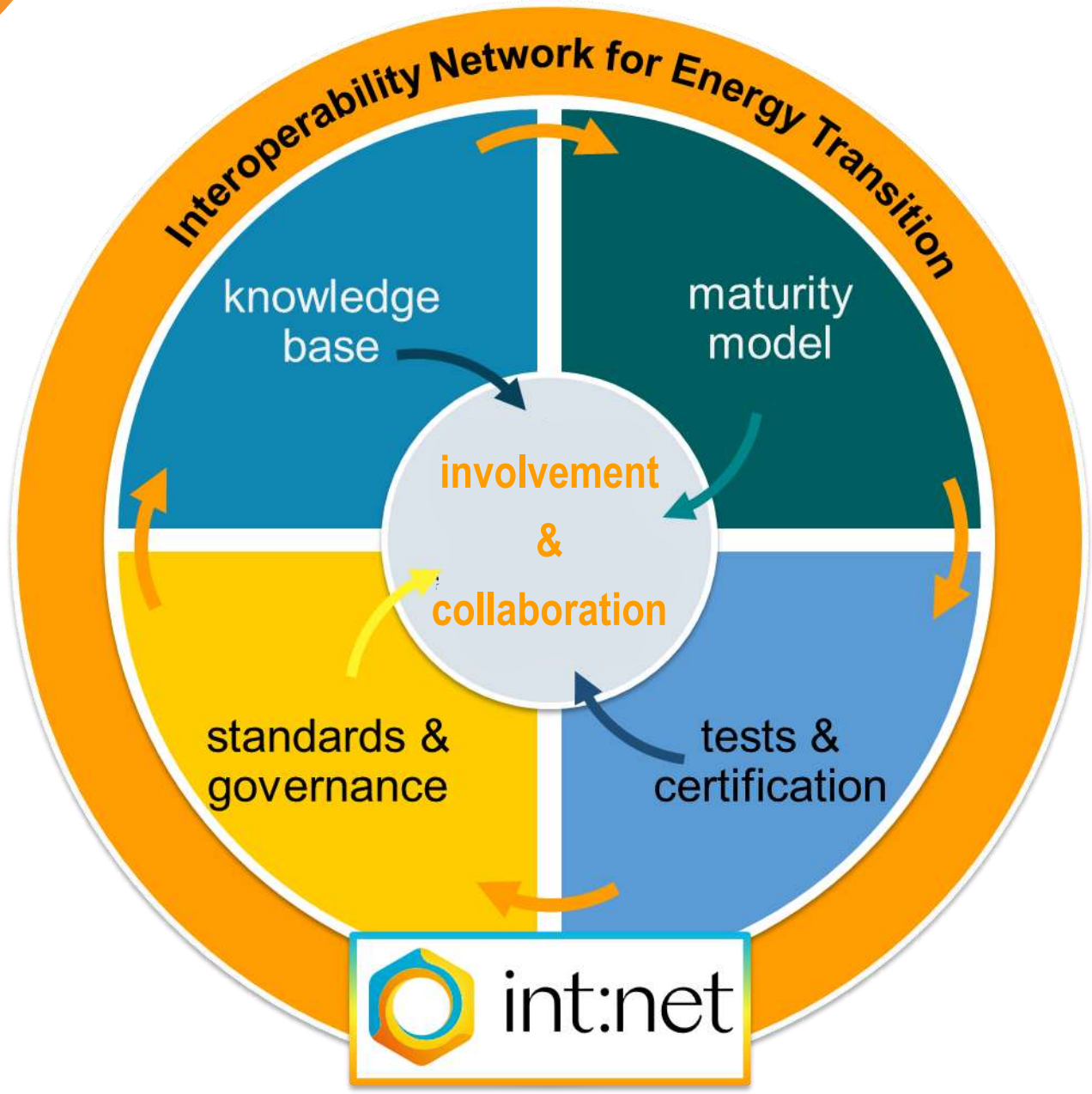
The int:net Vision



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Our Tasks

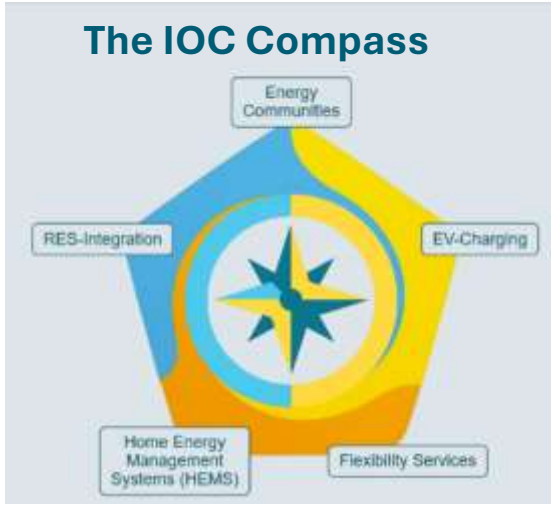
- *General communication and dissemination*
- *Organisation of capacity building and dissemination events*
- *Building a cross-sectoral network for interoperability*
- *Providing, moderating and operating a European interoperability network / ecosystem platform*
- *Starting establishment of a sustainable and self-sufficient, formal Interoperability Network for the Energy Transition*

General communication and dissemination

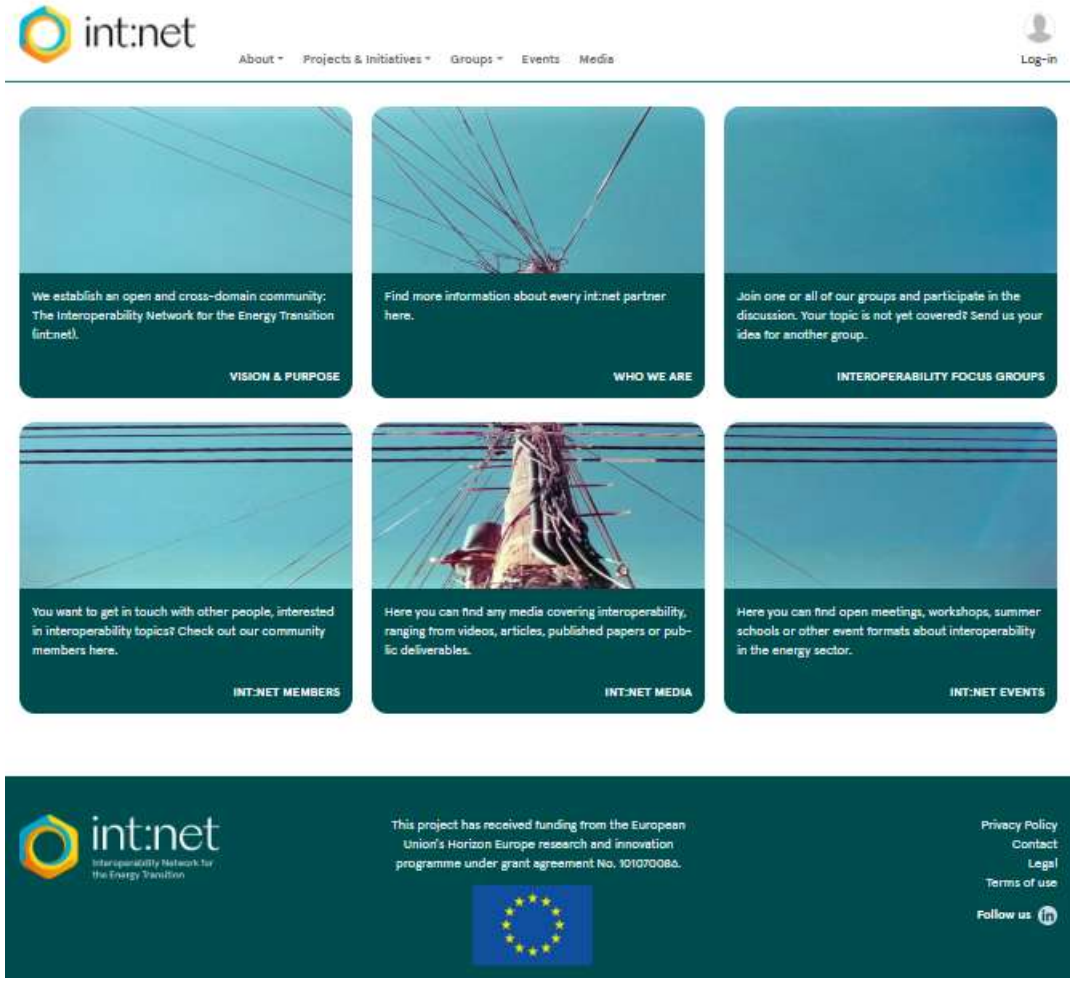
LinkedIn

Capacity building and dissemination events

- 14 talks 2024 - 2025
- > 350 participants

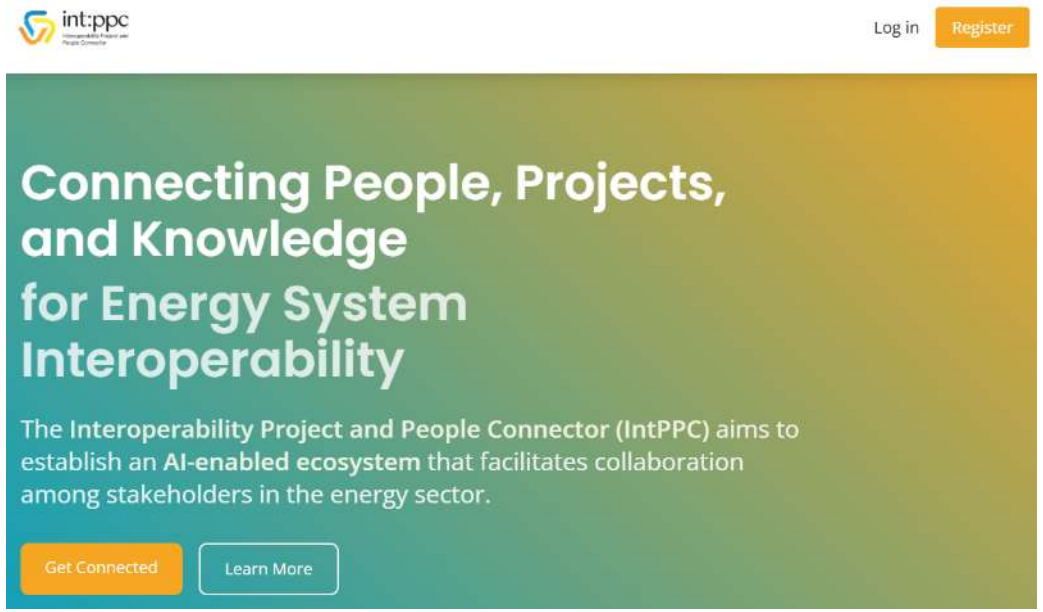


Building a cross-sectoral network for interoperability



- Open and cross-domain community
- More than 180 members
- Full access to focus groups, media repository with lunch talks etc.
- Interoperability Focus Groups (IFG)
  - IFG-1: "Interoperability Profiles in Data Spaces"
  - IFG-2: "Increasing Maturity in Interoperability"
  - IFG-3: "The Interoperability Regulatory Landscape"
  - IFG-4: "Interoperability Testing Approaches, Test Cases, and Test Facilities"
  - IFG-5: "Smart Grid related Use Cases and SGAM"

European interoperability network / ecosystem platform: From int:net community to IntPPC



AI-powered insights
Smart expert matching and knowledge discovery

Expert Circles
Focused collaboration spaces for innovation

Knowledge Hub
Curated repository with persistent DOIs

IntMAS Assessment
Evaluate and certify interoperability maturity

Who Benefits from IntPPC?

- Researchers and Academia
- Service Providers
- Standards Bodies
- Technology Vendors
- Regulators and Policy
- Consumer Organizations

Interoperability Network for the Energy Transition

IntMAS approved – The Label for Interoperability Management in energy relevant organisations

- ✓ Future-proof implementation of energy solutions
- ✓ Continuous improvement and cross-sector collaboration
- ✓ Trusted by partners and customers

Who is it for?

Technology providers, system operators, test labs, associations and more.

How does it work?

Guideline, templates, assessment tool, personal support and online certification

Outputs

Deliverables

- ✓ *D5.1 Updated plan for dissemination, exploitation and communication activities*
- ✓ *D5.2 Interim report on the status of the Interoperability Network for the Energy Transition*
- ✓ *D5.3 Final report on the status of the Interoperability Network for the Energy Transition and dissemination and communication activities due Oct 2025*
- ✓ *D5.4 Exploitation and long-term sustainability of IntNET due Oct 2025*

Platforms

- ✓ *IntMAS Workspace and Register – https:\\intmas.eu*
- ✓ *Int:net Community – https:\\community.intnet.eu*
- ✓ *int:ppc – Interoperability Project and People Connector – https://intppc.eu/*
- ✓ *Website - https://intnet.eu/*

- **Stay tuned!**
- **Follow us on LinkedIn.**

linkedin.com/company/int-net-project

Coffee Break

Please be back
at 10:45!

int:net

Interoperability Network for the Energy Transition

Interoperability

Revisiting a definition

Joep van Genuchten (EPRI Europe) | Laia Guitart (E.DSO)

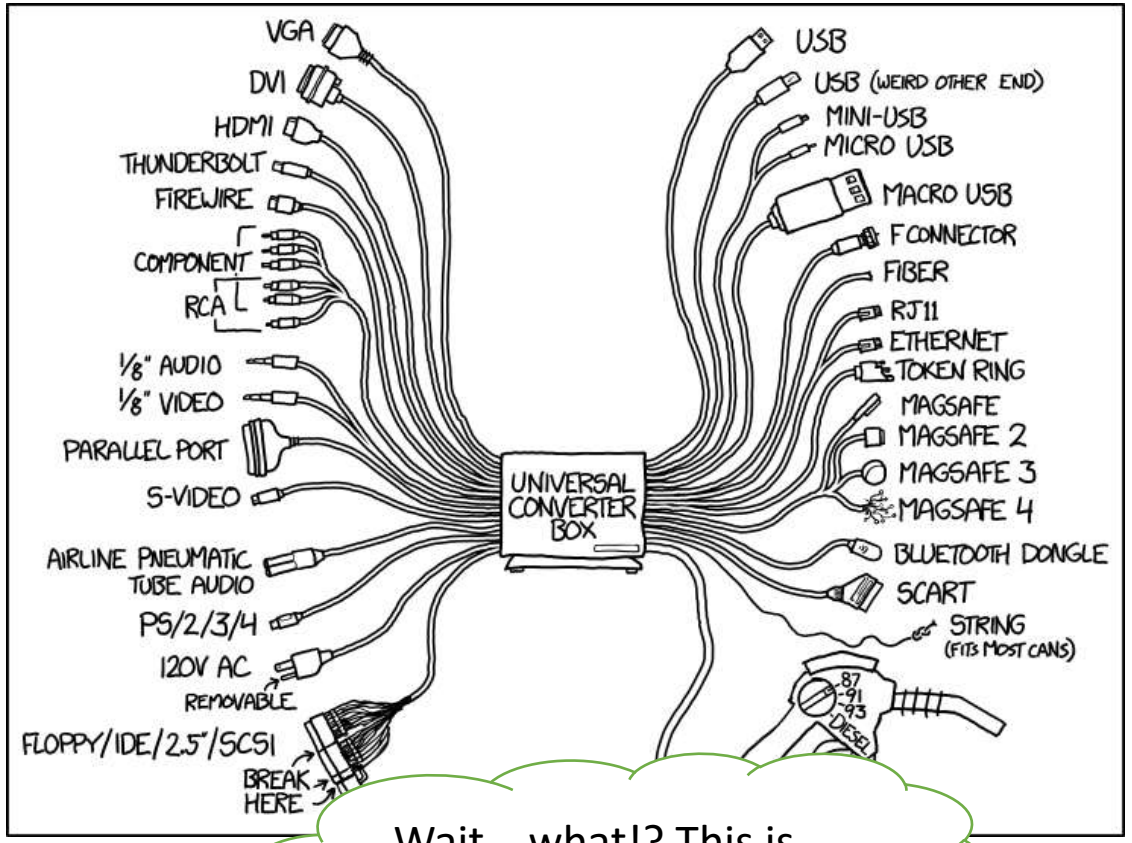
18 September 2025

Why revisit the definition of interoperability?

in·ter·op·er·a·bil·i·ty ˌin-tər-ˌä-p(ə-)rə-ˈbi-lə-tē

: ability of a system (such as a weapons system) to work with or use the parts or equipment of another system (Meriam Webster)

Interoperability: the degree to which two products, programs, etc. can be used together, or the quality of being able to be used together (Cambridge Dictionary)



Wait… what!? This is interoperability?

What we did

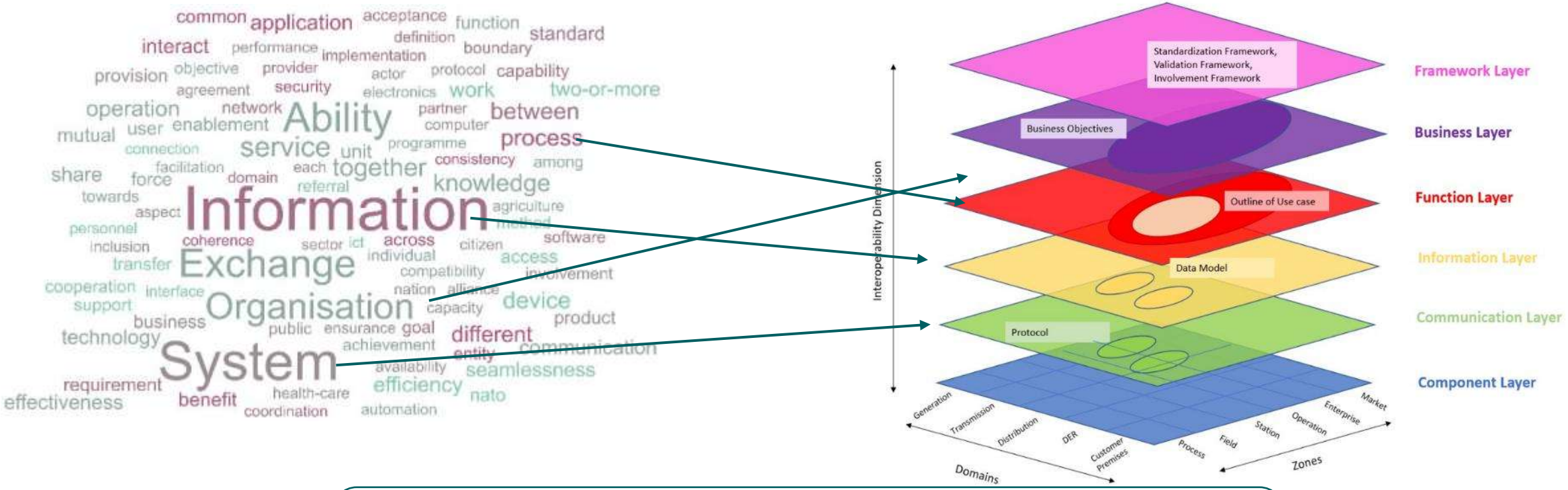
Computer (1949)

Maybe we don’t mean the same thing anymore when we say 'interoperability'

Concepts change over time, as what we need to describe changes

Computer (2025)

Can we uncover what we meant by interoperability



Definitions seem to emphasize 3 of the 6 layers:
interoperability goes beyond components and information

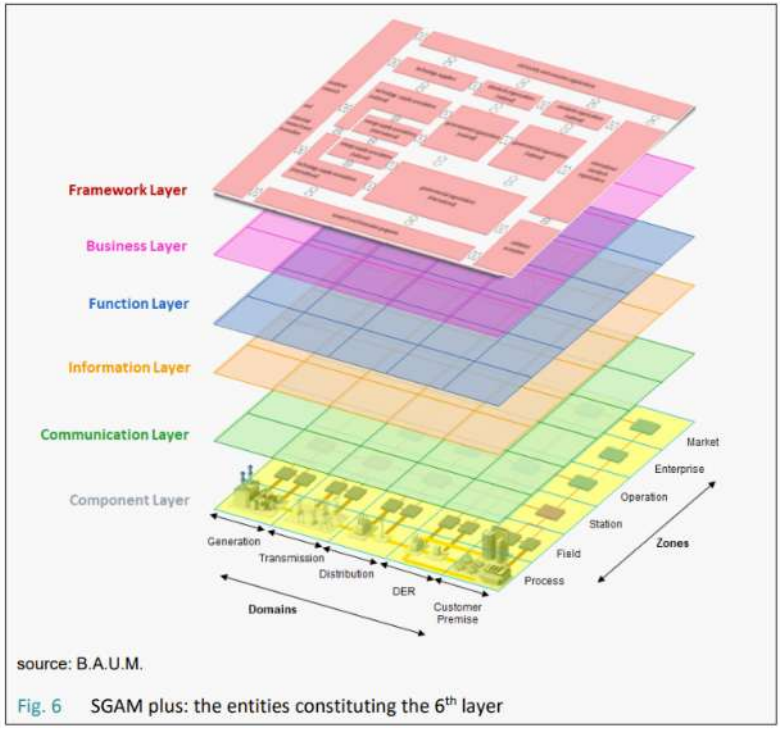
New definition.

"Interoperability refers to the ability of diverse systems, organisations, and individuals to work together seamlessly through shared understanding and mutual compatibility. It is an emergent property that arises from the continuous development and refinement of standards, collaboration among stakeholders, and the dissemination of knowledge across technical, organisational, and societal boundaries."

Open for peer review.
Please leave feedback

Implication of the new definition

1. Conceptual frameworks like the SGAM need to be expanded with an additional layer accounting for social and organizational interoperability.
   - Looking beyond the traditional definition of (technical) interoperability.
   - This new layer shall assess a broader set of interactions including governance and communities.
     - Need for communities needs to be accounted for in order to deliver the right polices.



source: B.A.U.M.

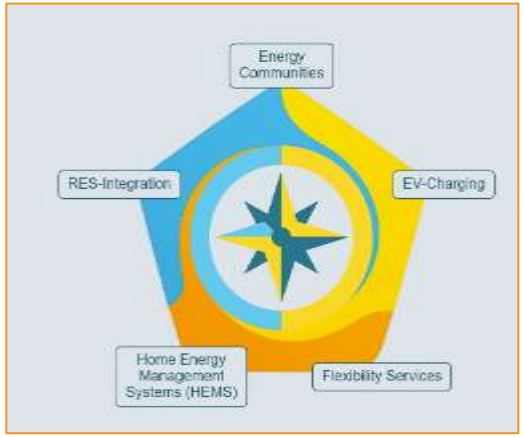
Fig. 6 SGAM plus: the entities constituting the 6th layer

Implication of the new definition

2. Interoperability literacy needs to be promoted.

Achieving interoperability requires not only technical alignment but also social buy in.

- Final users taking the right decisions may include training programs and creation of KS platforms/tools.

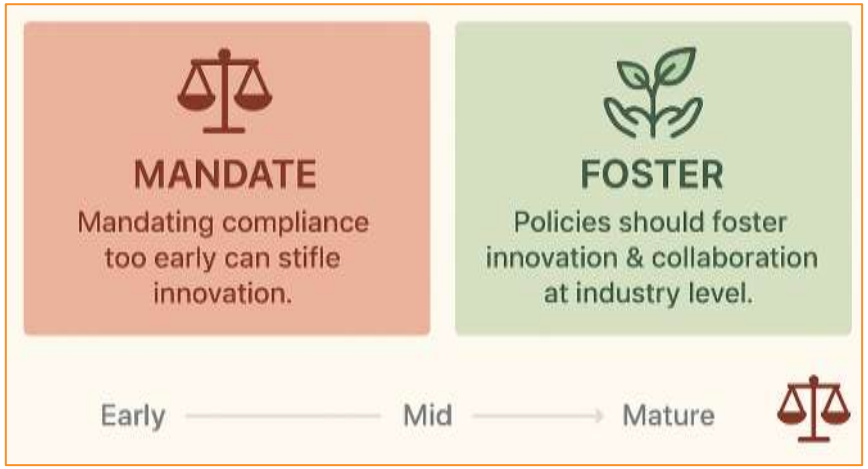


int:net Summer School on "Governance in Energy Interoperability"
23 Jun 2025 - 27 Jun 2025
Vienna, Austria

Implication of the new definition

3. We need the right policies: Mandate where appropriate, foster where possible.

- Mandating compliance can prevent innovation. Policies should foster innovation and collaboration.
- Only once a solution has proven to work mandating can be useful, to prevent a mandate vacuum.



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Thank you for your attention.

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Int:net Final Conference

Multi-faceted interoperability

From interoperability standards to interoperability profiles

Diana Jimenez – Antonio Kung | Trialog

18 September 2025

ISO/IEC JTC1/SC41 Hybrid webinar on IoT Standardization

Join us for a webinar hosted by ISO/IEC JTC 1/SC 41 (Internet of Things and Digital Twin), where we will explore key achievements related to the standardization of Internet of Things (IoT) technologies. The session will highlight recent progress, examine emerging trends, and present an overview of the future work program in relation to these technologies and some of their applications.

This hybrid event will take place both online and in person at the École de technologie supérieure in Montréal, Québec, Canada.

Share On Share Share

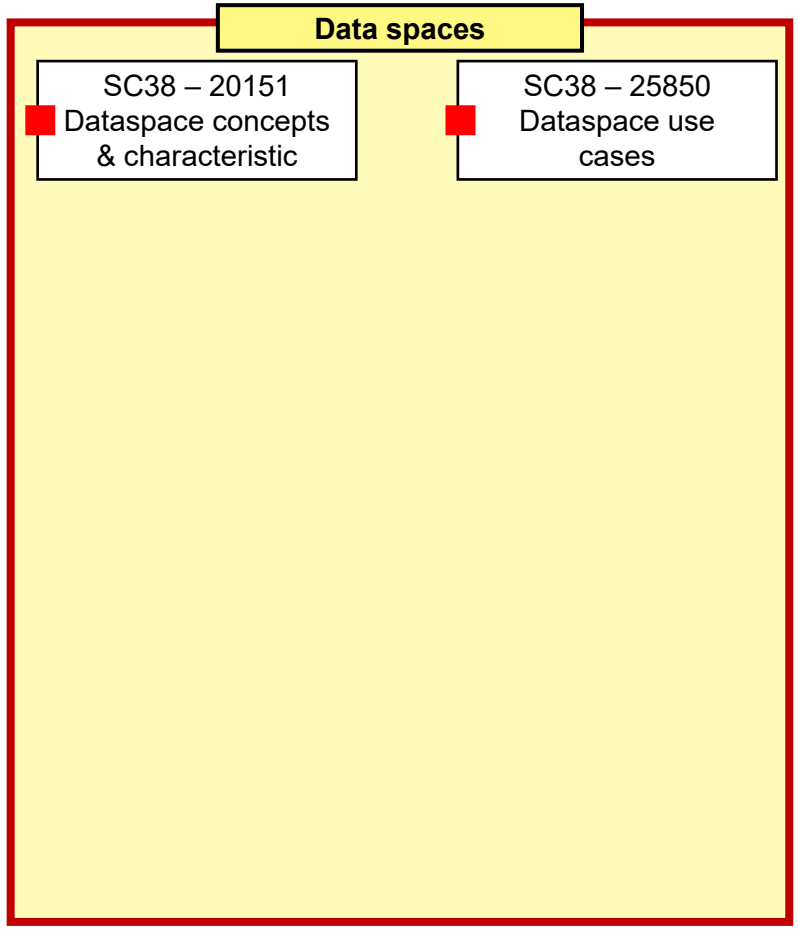
Date & Time

04 June 2025 (15:00 - 18:00 CEST)

Video recording

Video Link IEC members

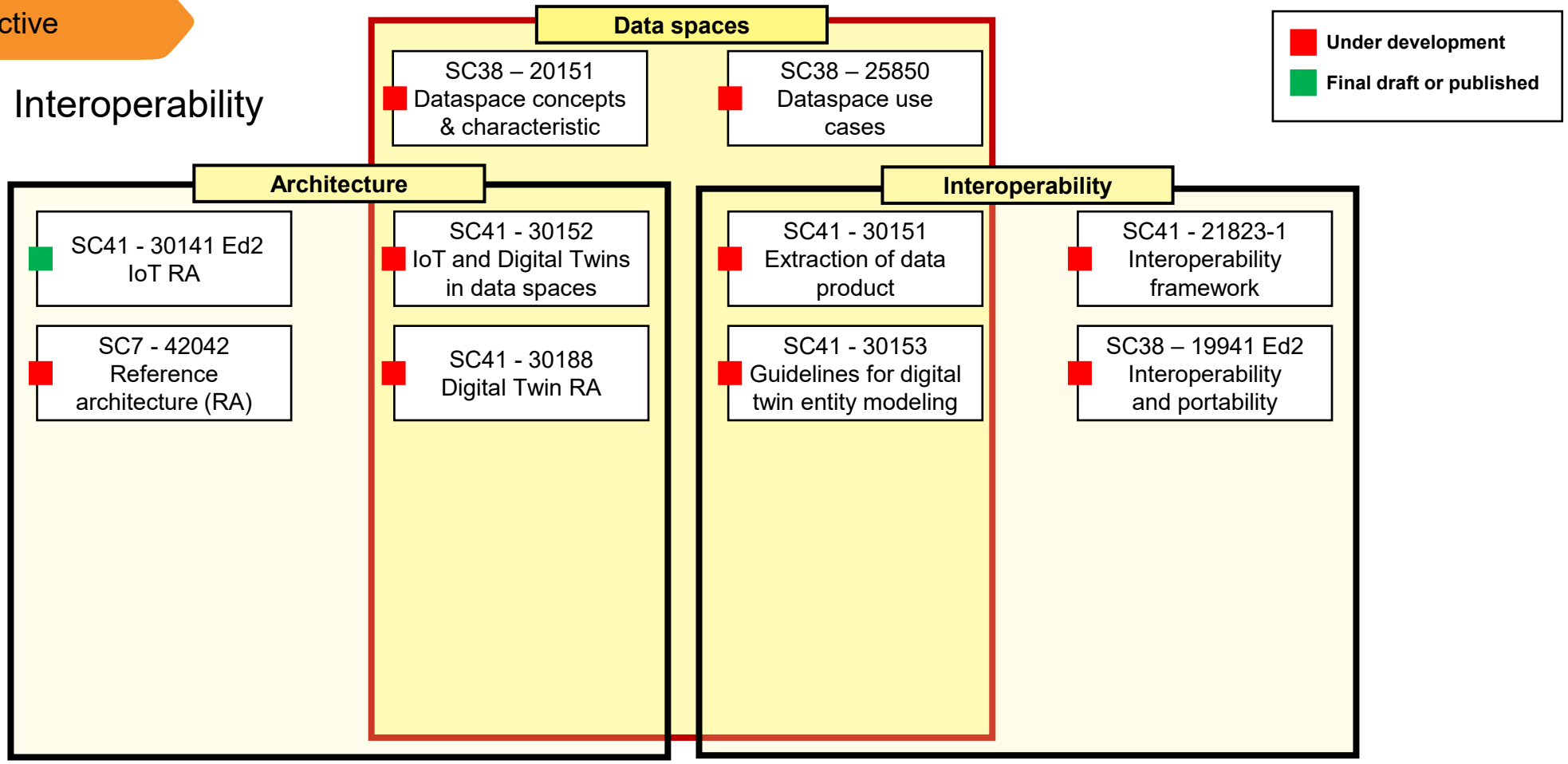
Dataspaces



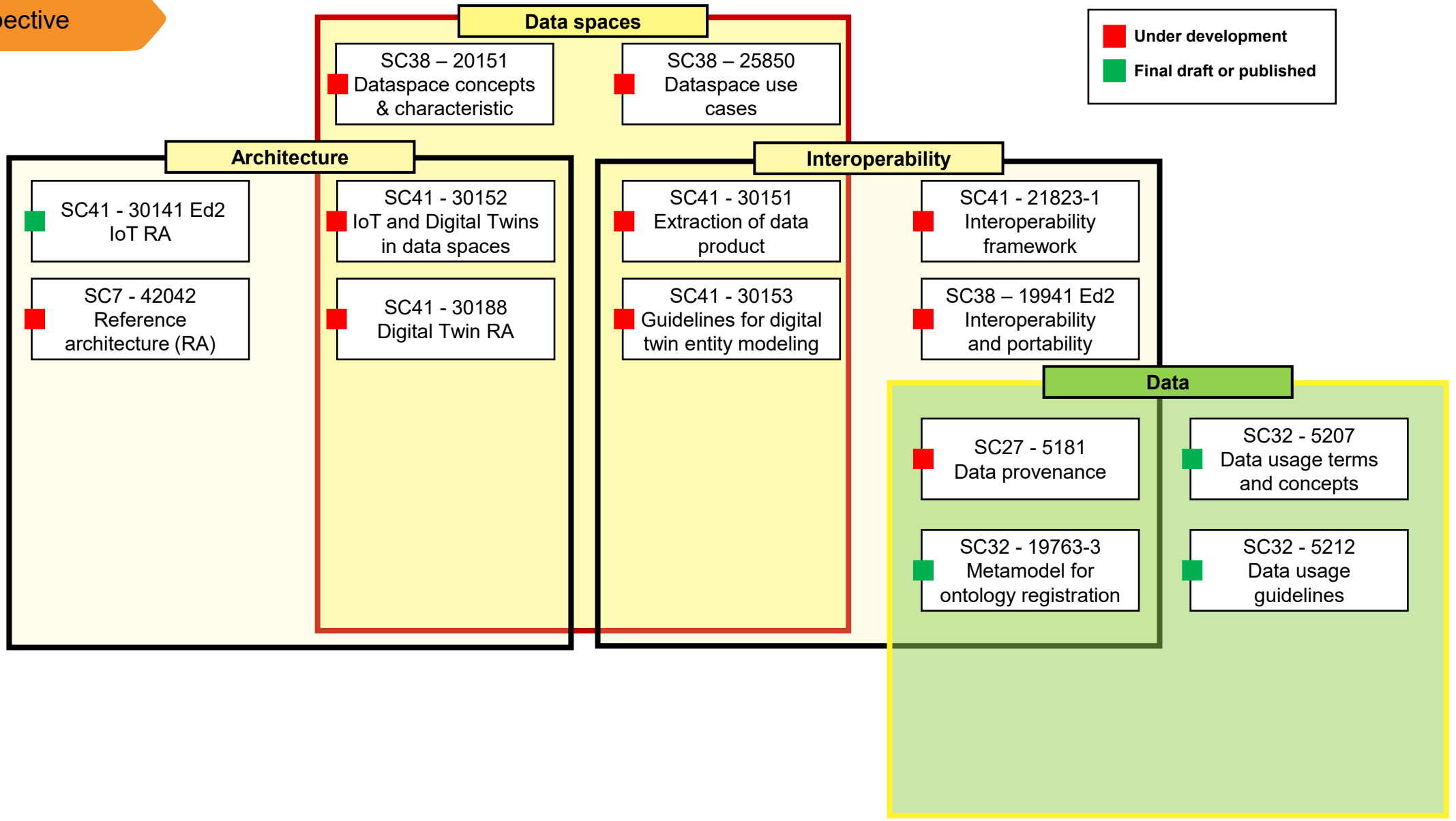
Under development

Final draft or published

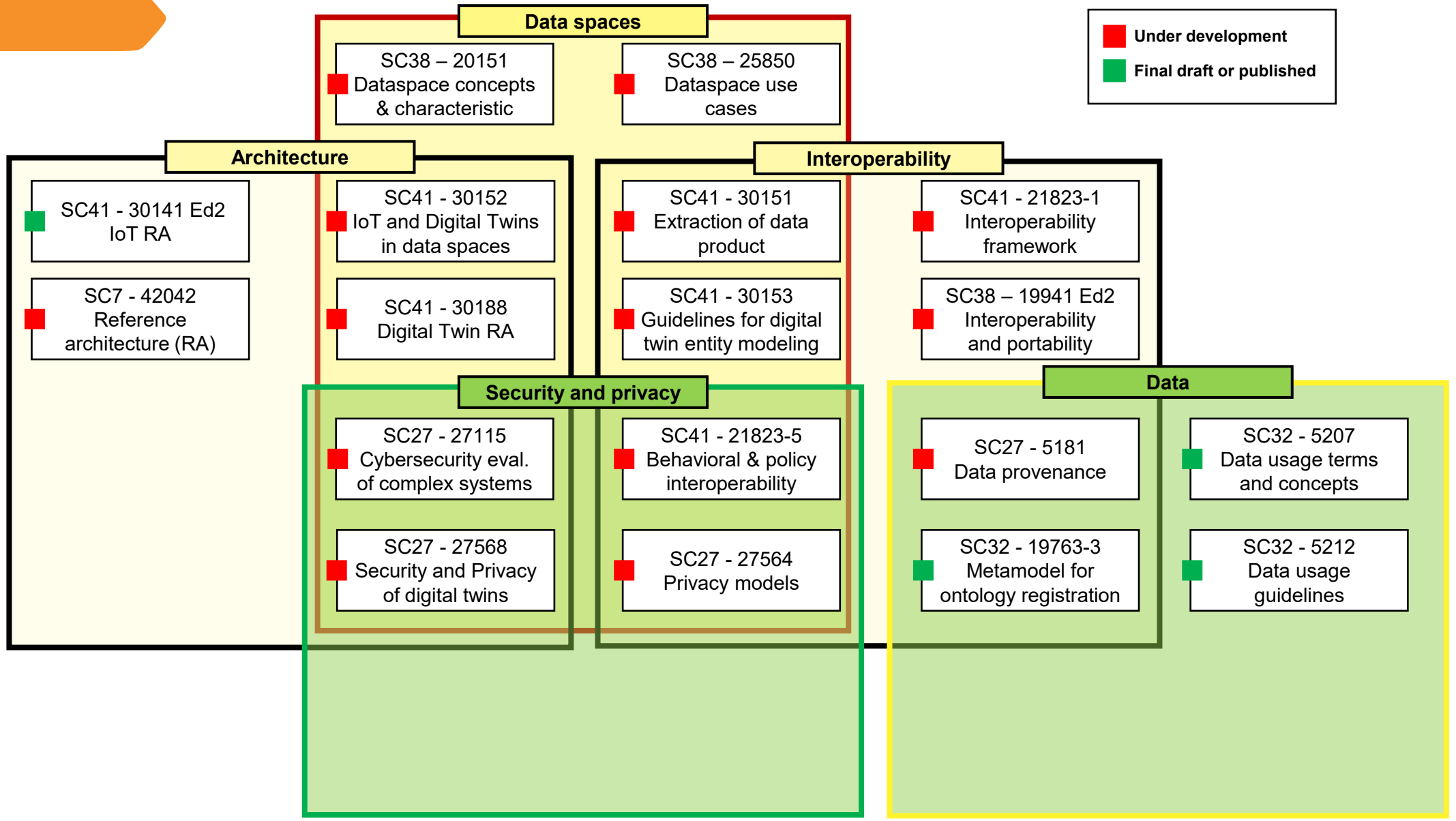
Architecture and Interoperability



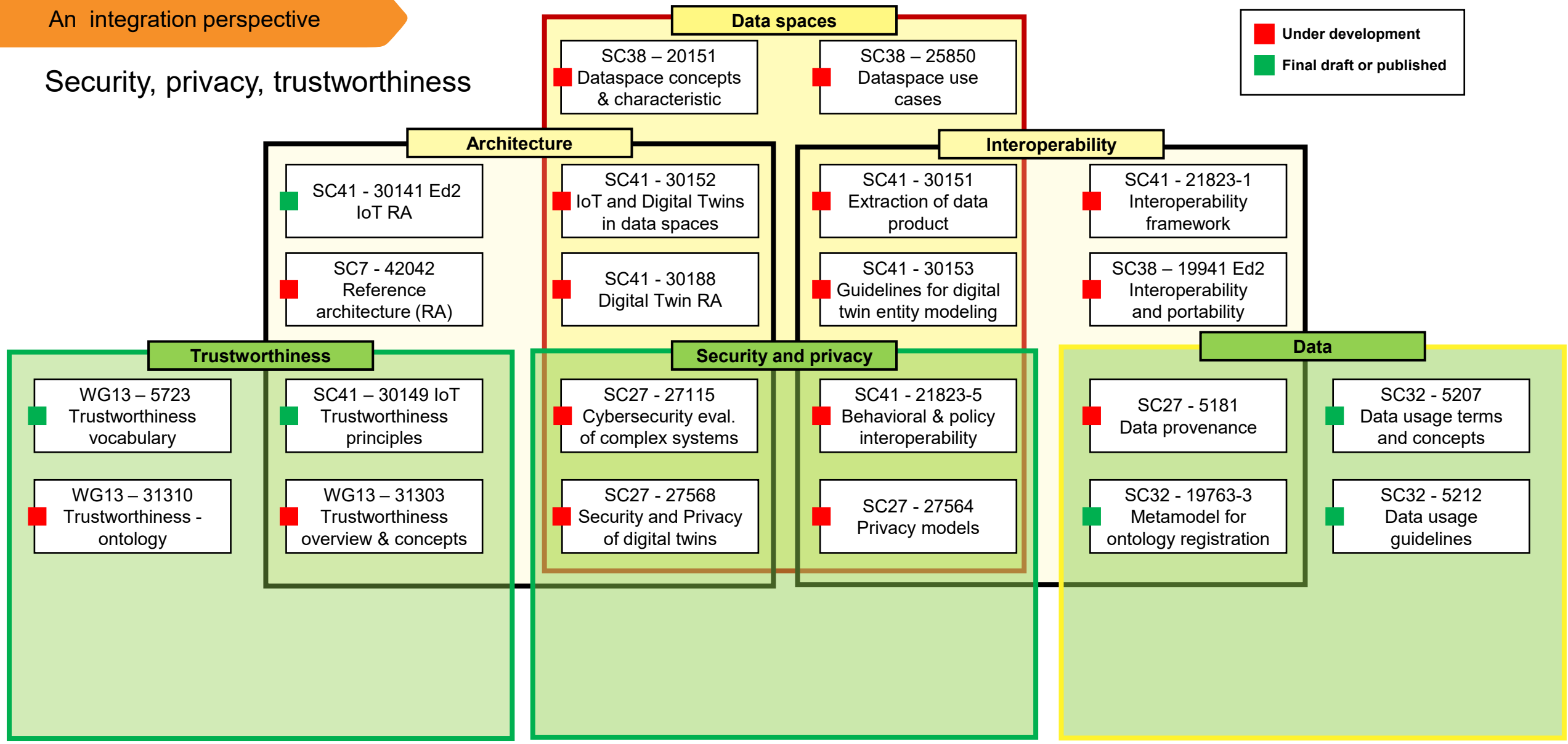
Data


Under development
Final draft or published
Data spaces
SC38 – 20151
Dataspace concepts & characteristic
SC38 – 25850
Dataspace use cases
Architecture
SC41 - 30141 Ed2
IoT RA
SC7 - 42042
Reference architecture (RA)
SC41 - 30152
IoT and Digital Twins in data spaces
SC41 - 30188
Digital Twin RA
Interoperability
SC41 - 30151
Extraction of data product
SC41 - 30153
Guidelines for digital twin entity modeling
SC41 - 21823-1
Interoperability framework
SC38 – 19941 Ed2
Interoperability and portability
Data
SC27 - 5181
Data provenance
SC32 - 19763-3
Metamodel for ontology registration
SC32 - 5207
Data usage terms and concepts
SC32 - 5212
Data usage guidelines

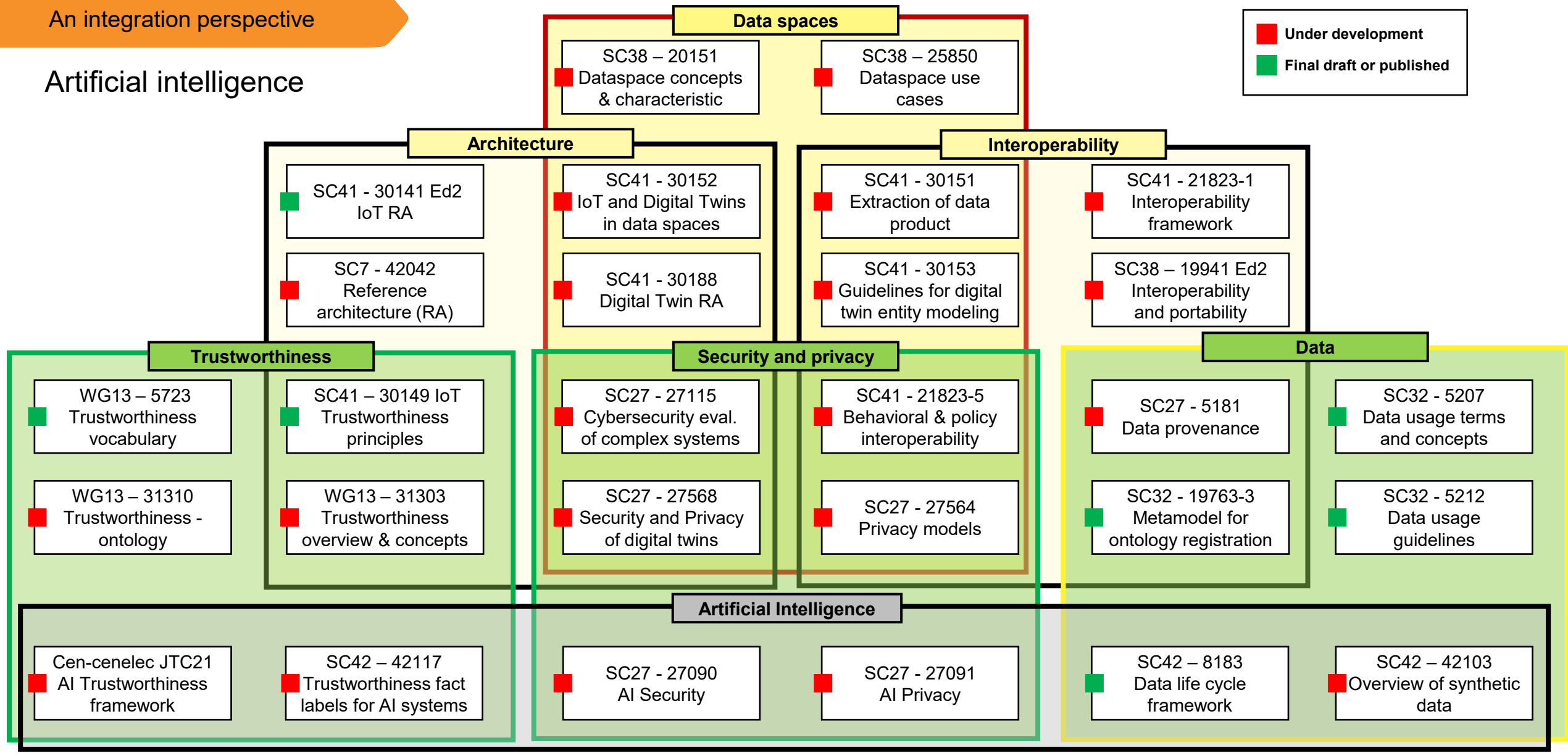
An integration perspective



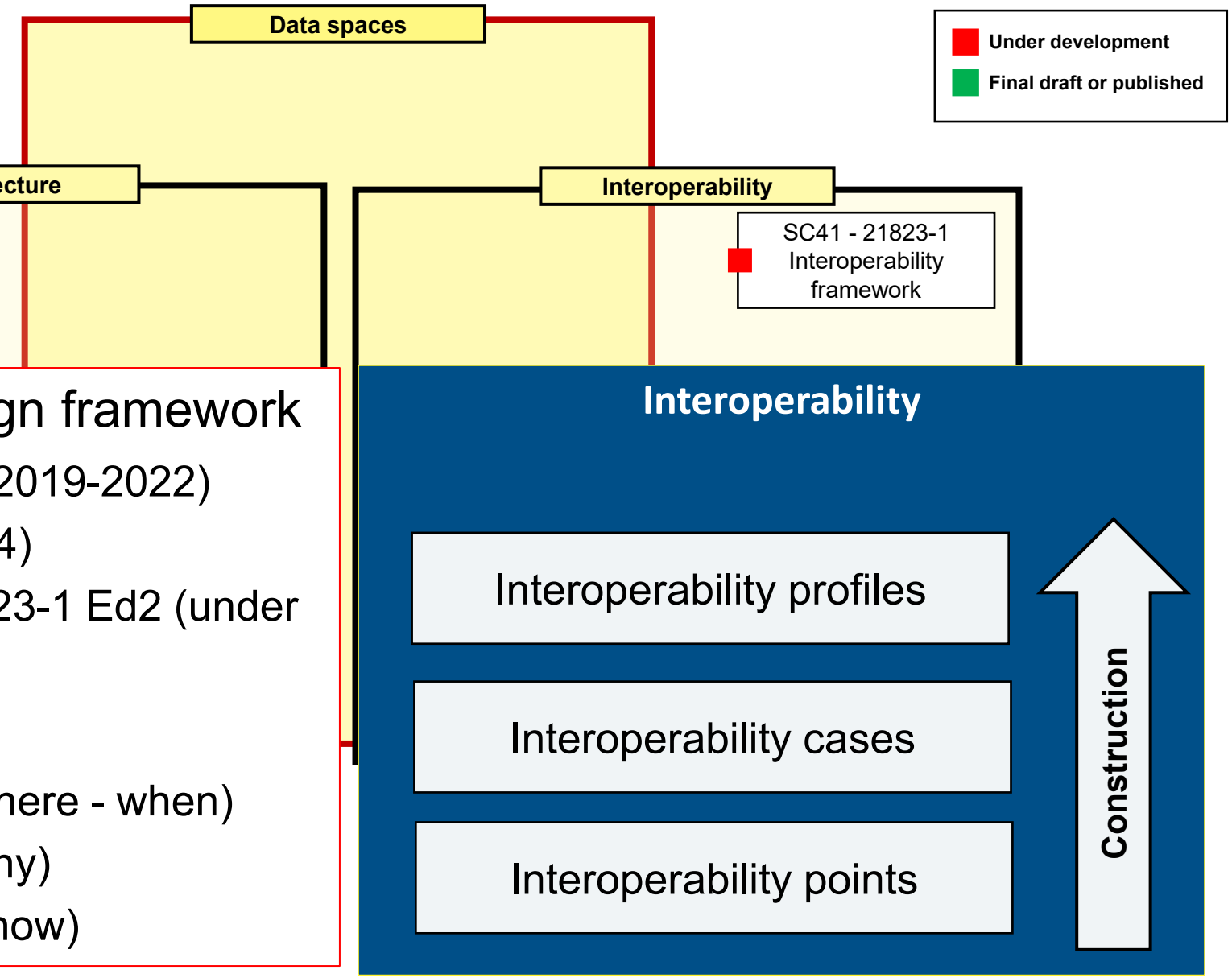
Security, privacy, trustworthiness



Artificial intelligence

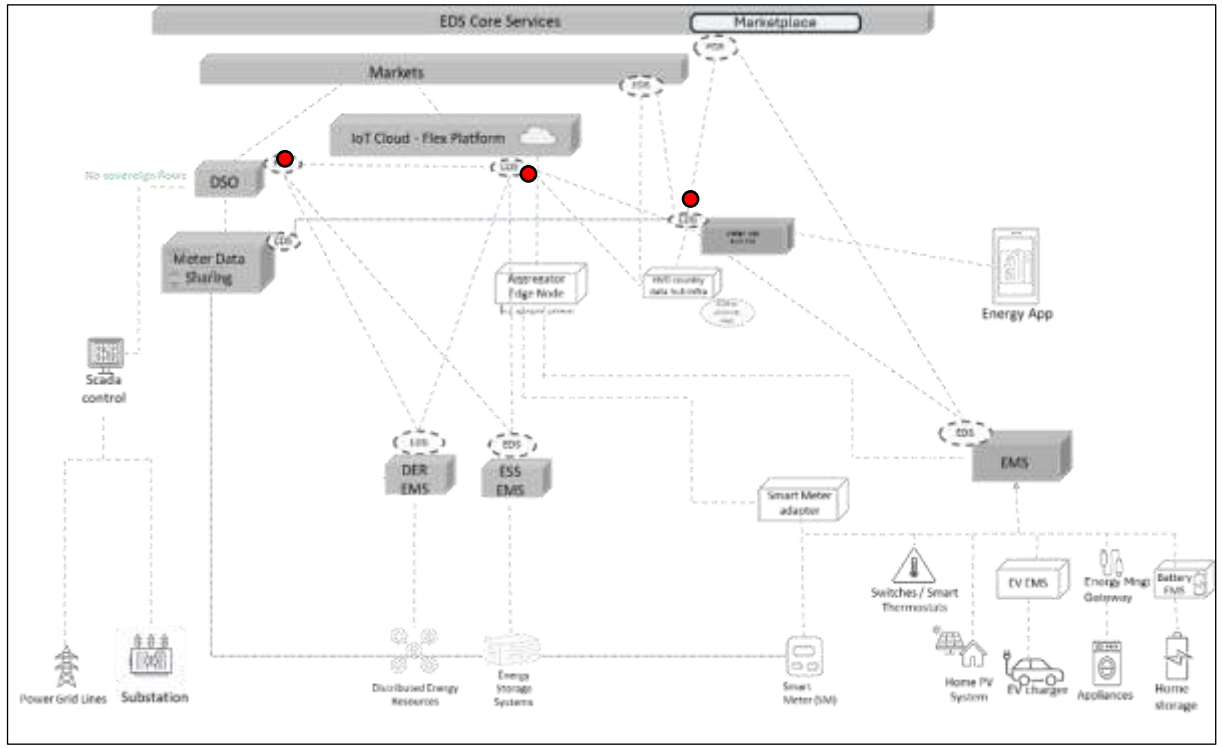


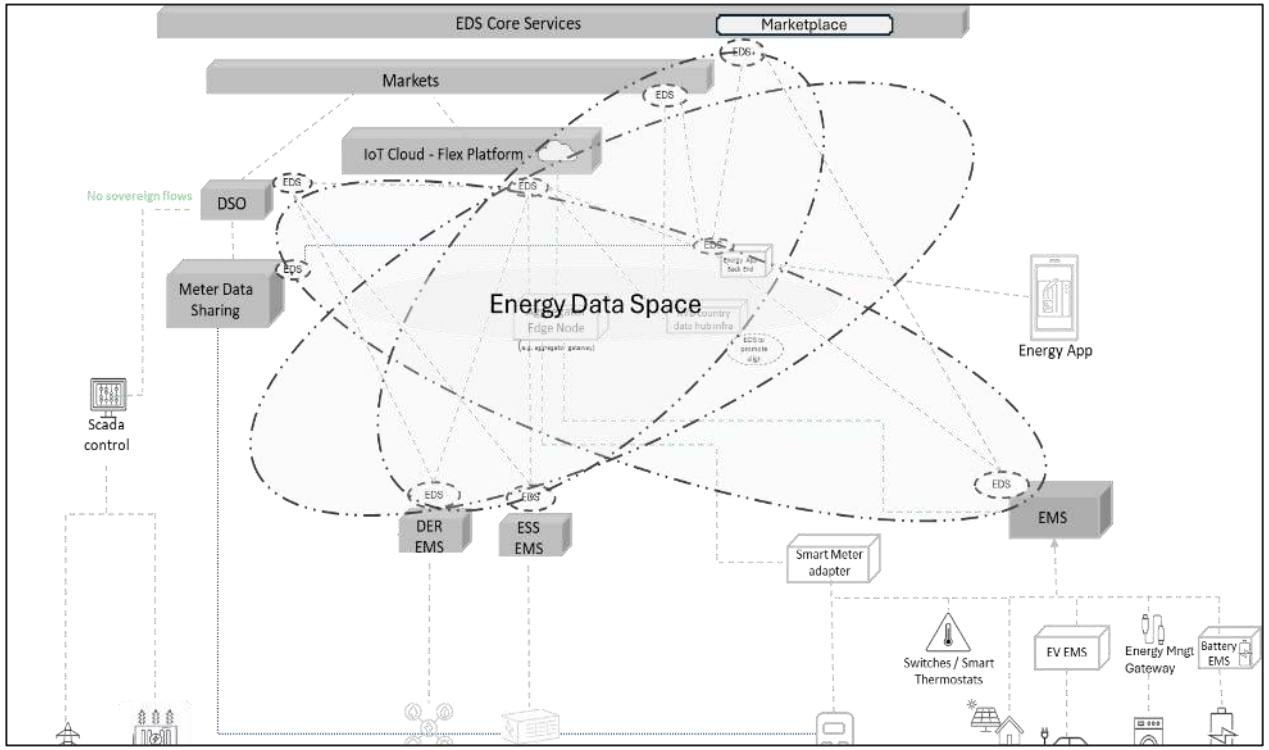
Where, when, why, how



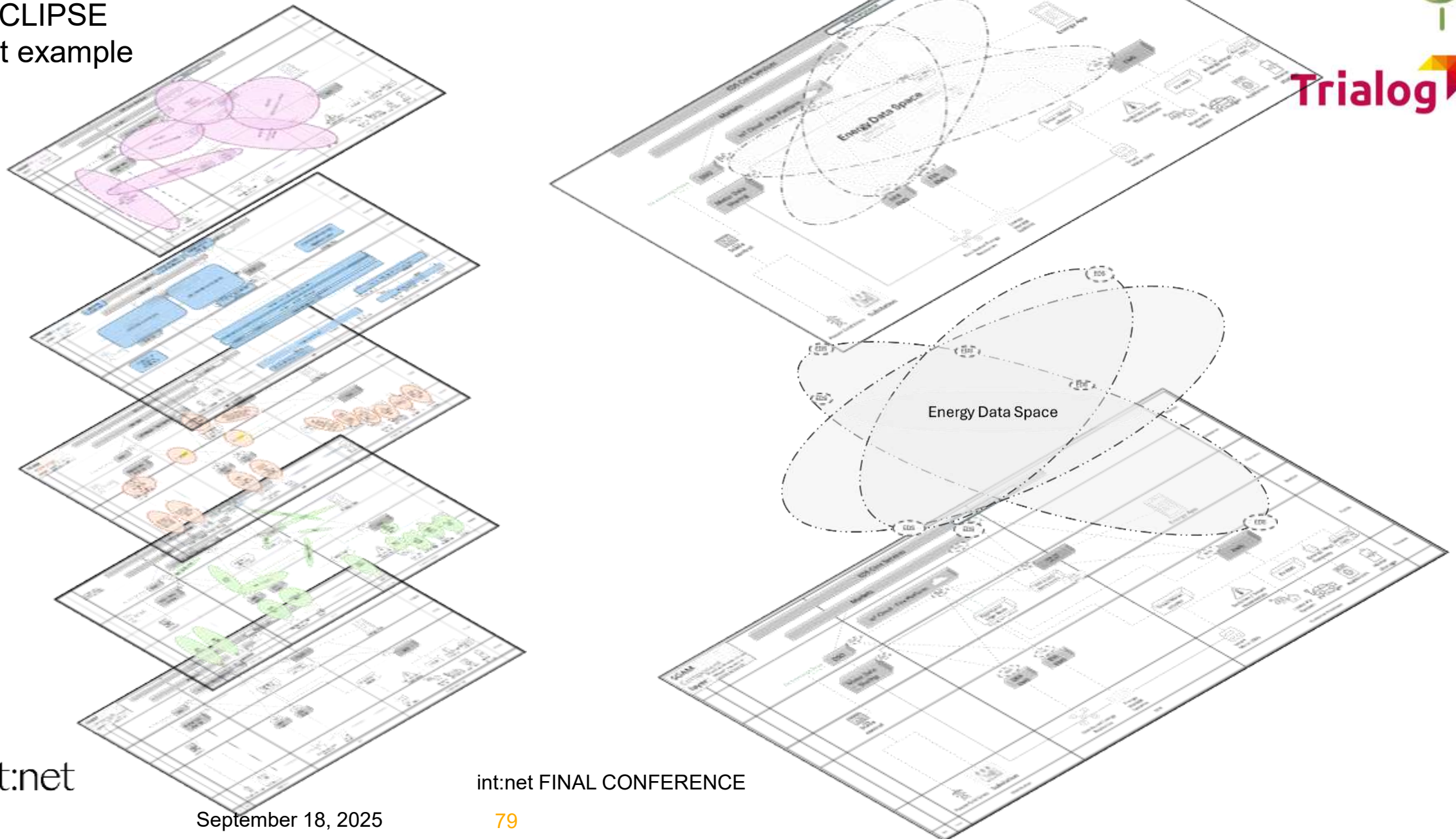
- Interoperability-by-design framework
  - Introduced in OpenDEI (2019-2022)
  - Published by AIOTI (2024)
  - Included in ISO/IEC 21823-1 Ed2 (under development)
- Construction process
  - Interoperability points (where - when)
  - Interoperability cases (why)
  - Interoperability profiles (how)

The ECLIPSE project example

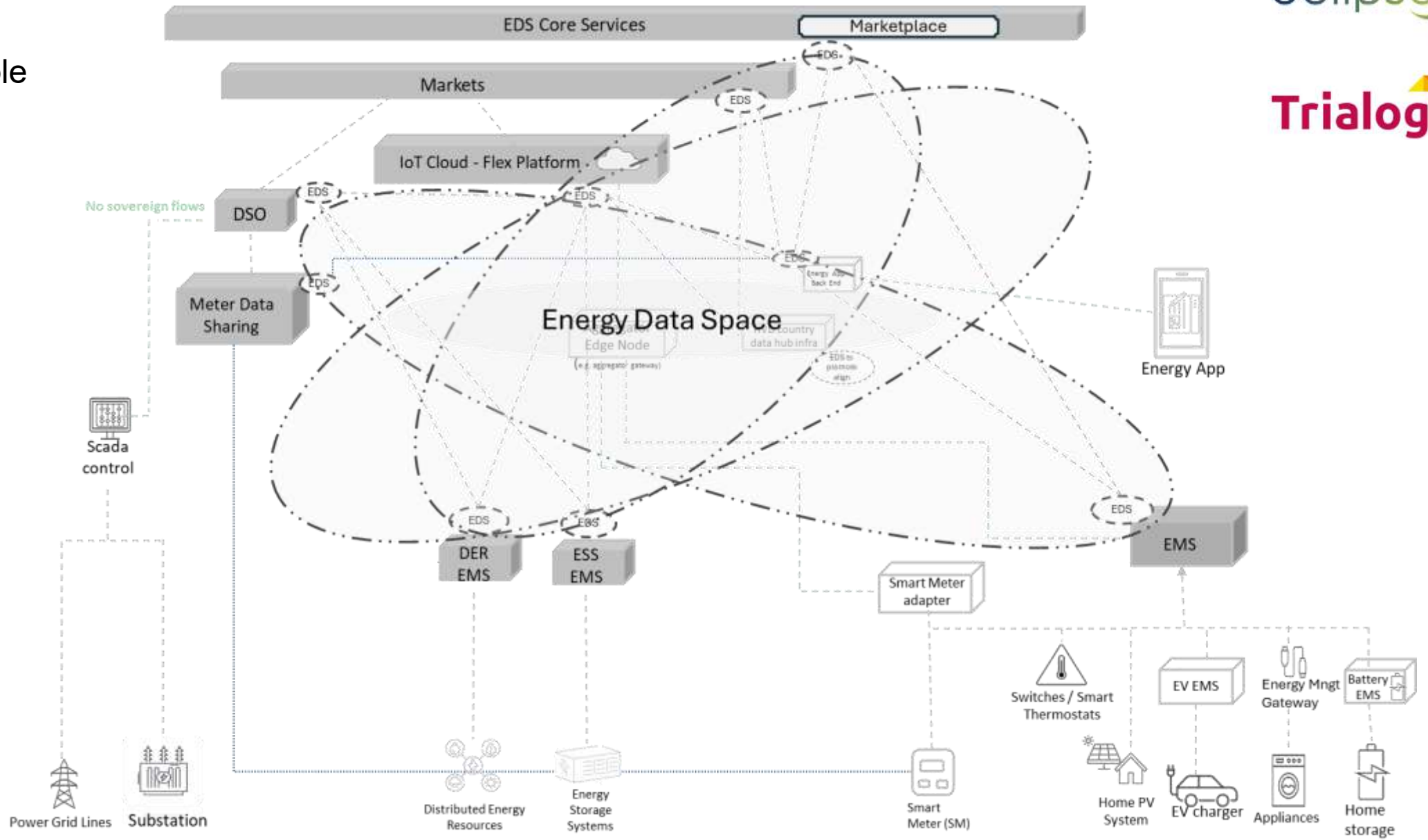




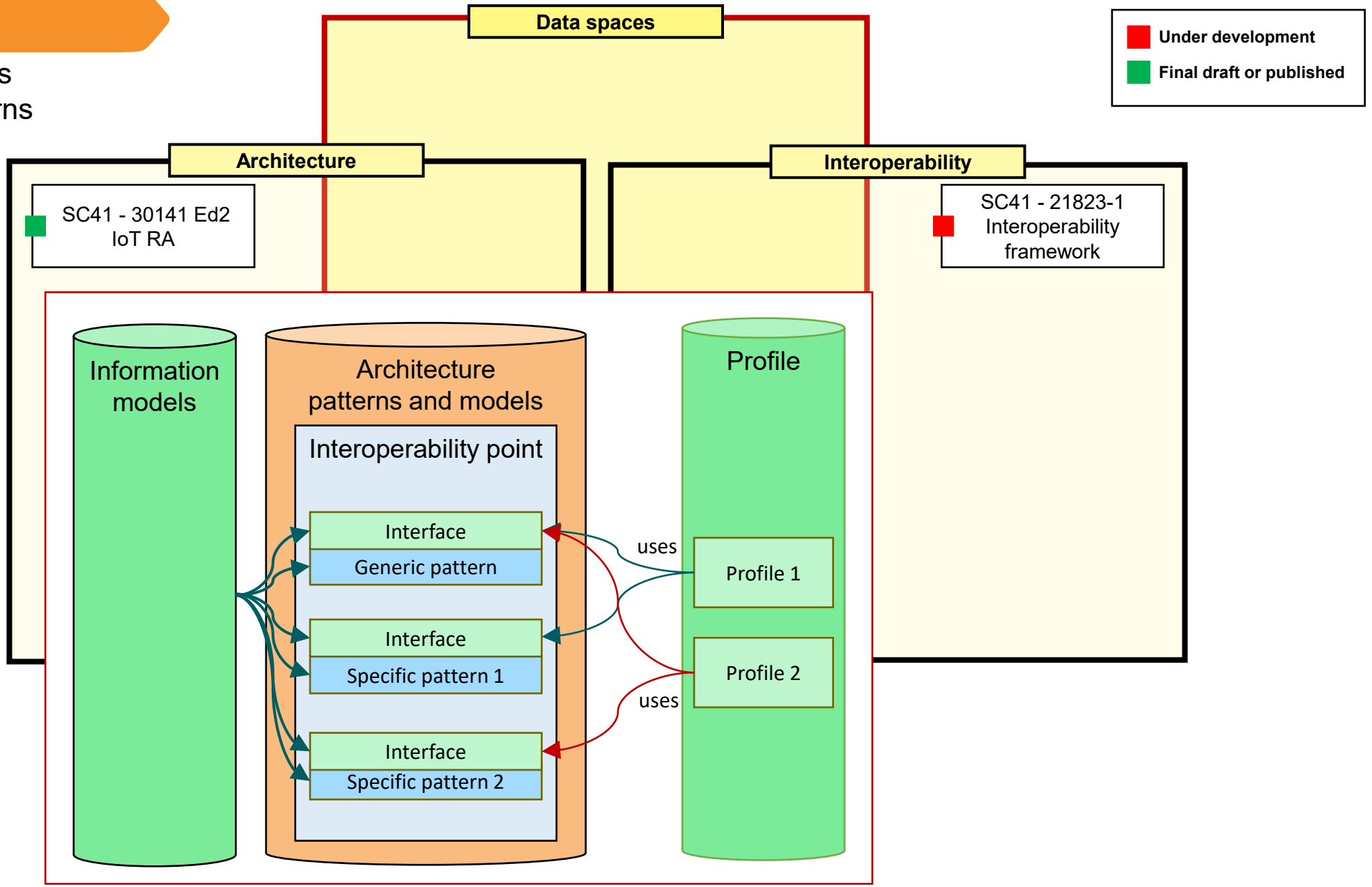
The ECLIPSE project example



The ECLIPSE project example

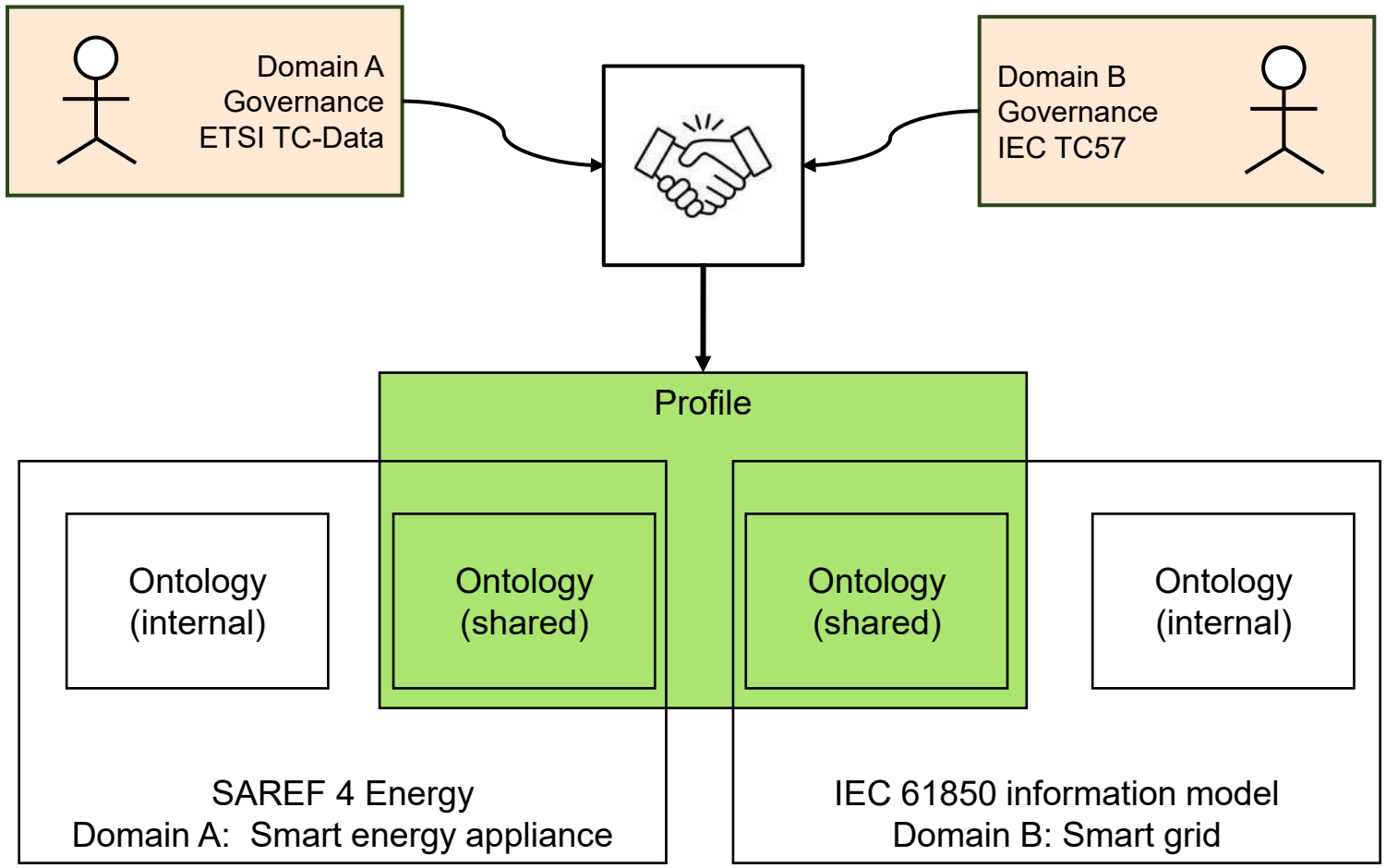


Information models
Architecture patterns



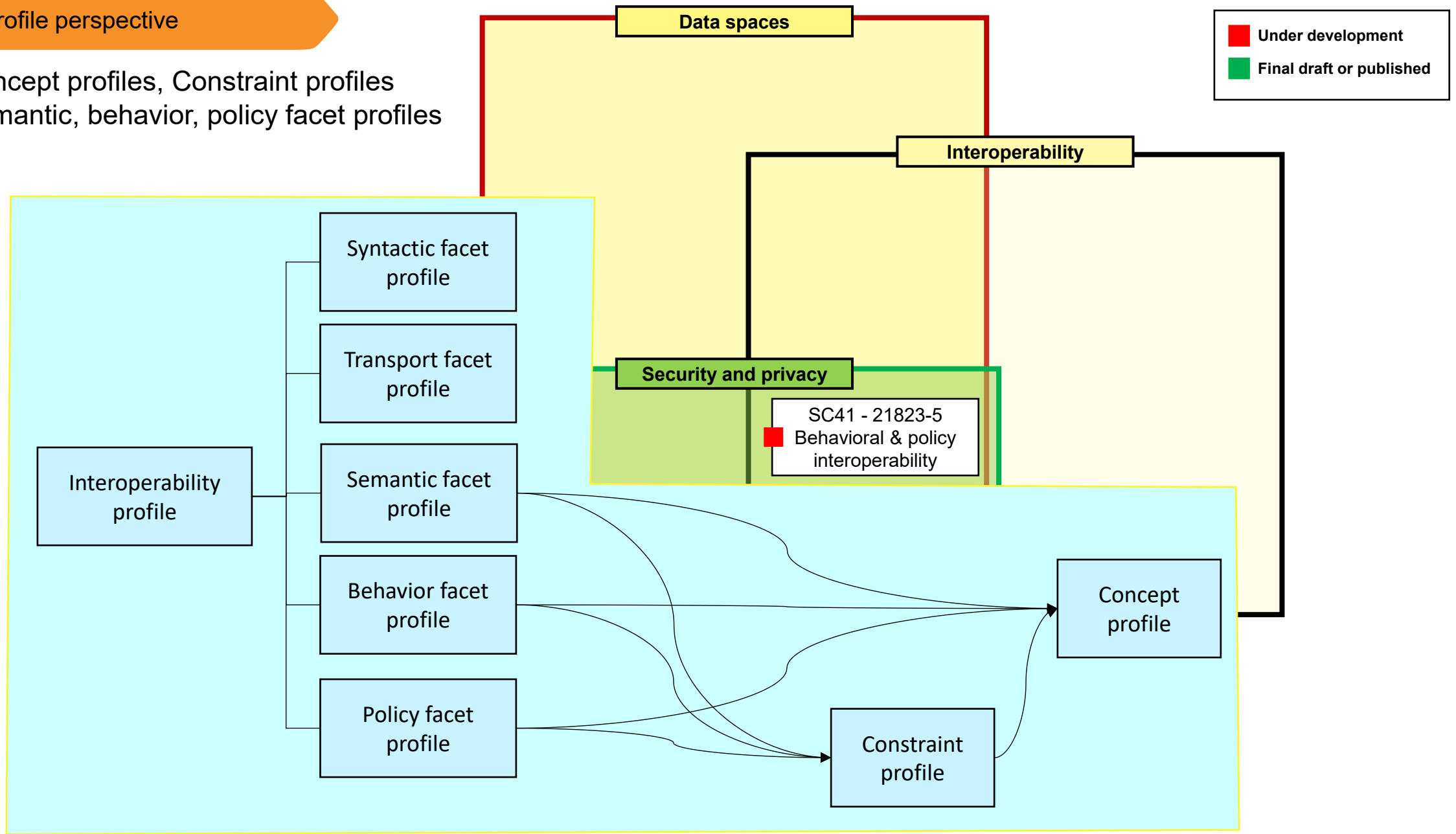
Information model governance

Source
- AIOTI Report: Towards semantic interoperability standards based on ontologies (Oct 2019) DOI 10.13140/RG.2.2.26825.29282
- ISO/IEC 21823-3 IoT semantic interoperability (Sept 2021)



A profile perspective

Concept profiles, Constraint profiles
Semantic, behavior, policy facet profiles



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Thank you for your attention.

Diana Jimenez, Antonio Kung, Trialog

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Interoperability Network for the Energy Transition

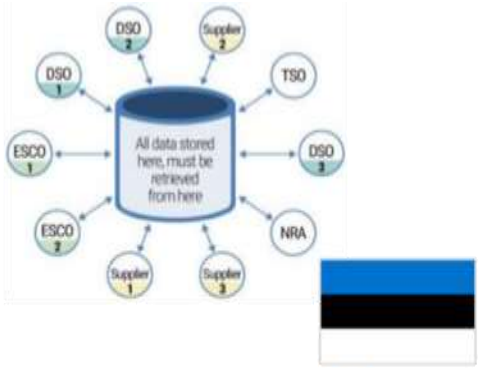
From data management to interoperable data spaces

Charukeshi Joglekar | Fraunhofer FIT

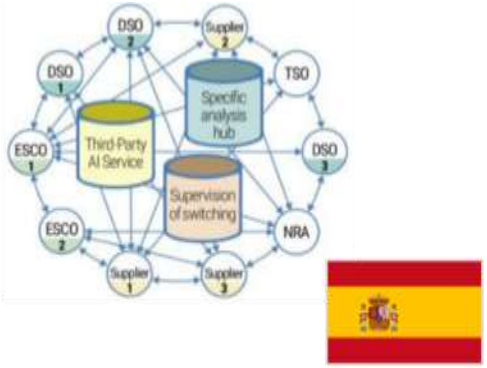
Nicolò Rossetto | EUI-FSR

18 September 2025

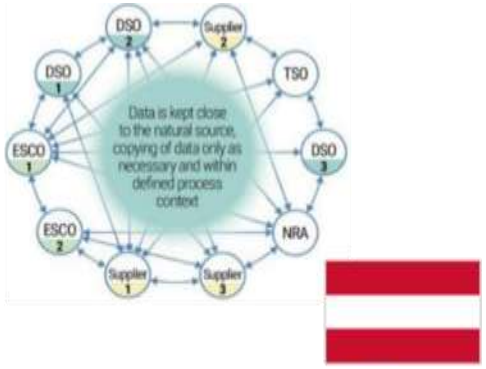
Pursuing interoperable data management models for metering & consumption data



Centralized model



Hybrid model



Decentralized model

- No attempt to impose a specific DMM for consumer data at the EU level
- Art. 23 Electricity Directive defines a set of rights & duties which apply "independently of the DMM applied in each MS"
- Art. 24 Electricity Directive mandates the EC to adopt "interoperability requirements and non-discriminatory and transparent procedures for data access by means of implementing acts"

A role model to facilitate interoperability...

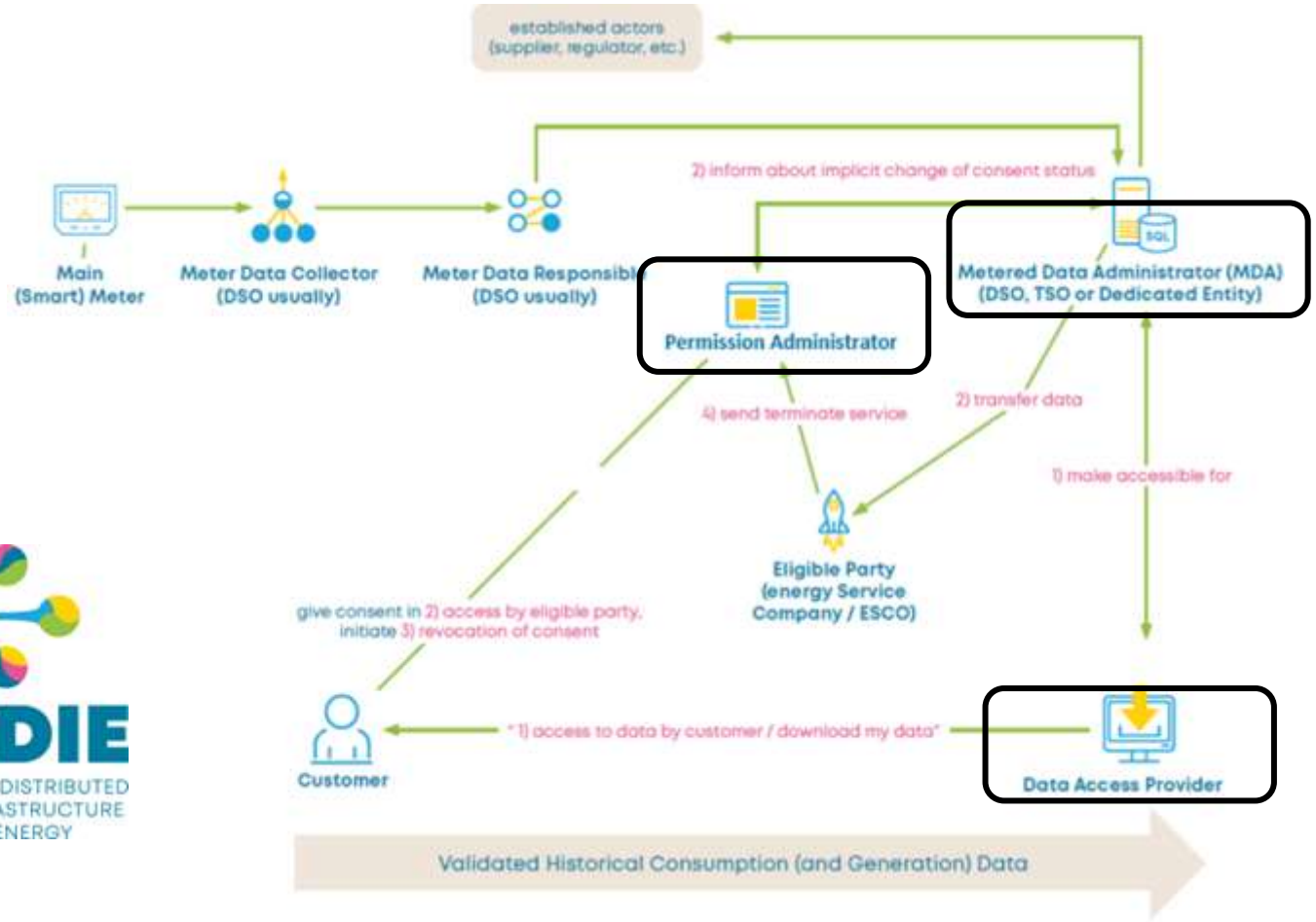
L 154/10 EN Official Journal of the European Union 15.6.2023

COMMISSION IMPLEMENTING REGULATION (EU) 2023/1162

of 6 June 2023

on interoperability requirements and non-discriminatory and transparent procedures for access to metering and consumption data

(Text with EEA relevance)



EDDIE
EUROPEAN DISTRIBUTED DATA INFRASTRUCTURE FOR ENERGY

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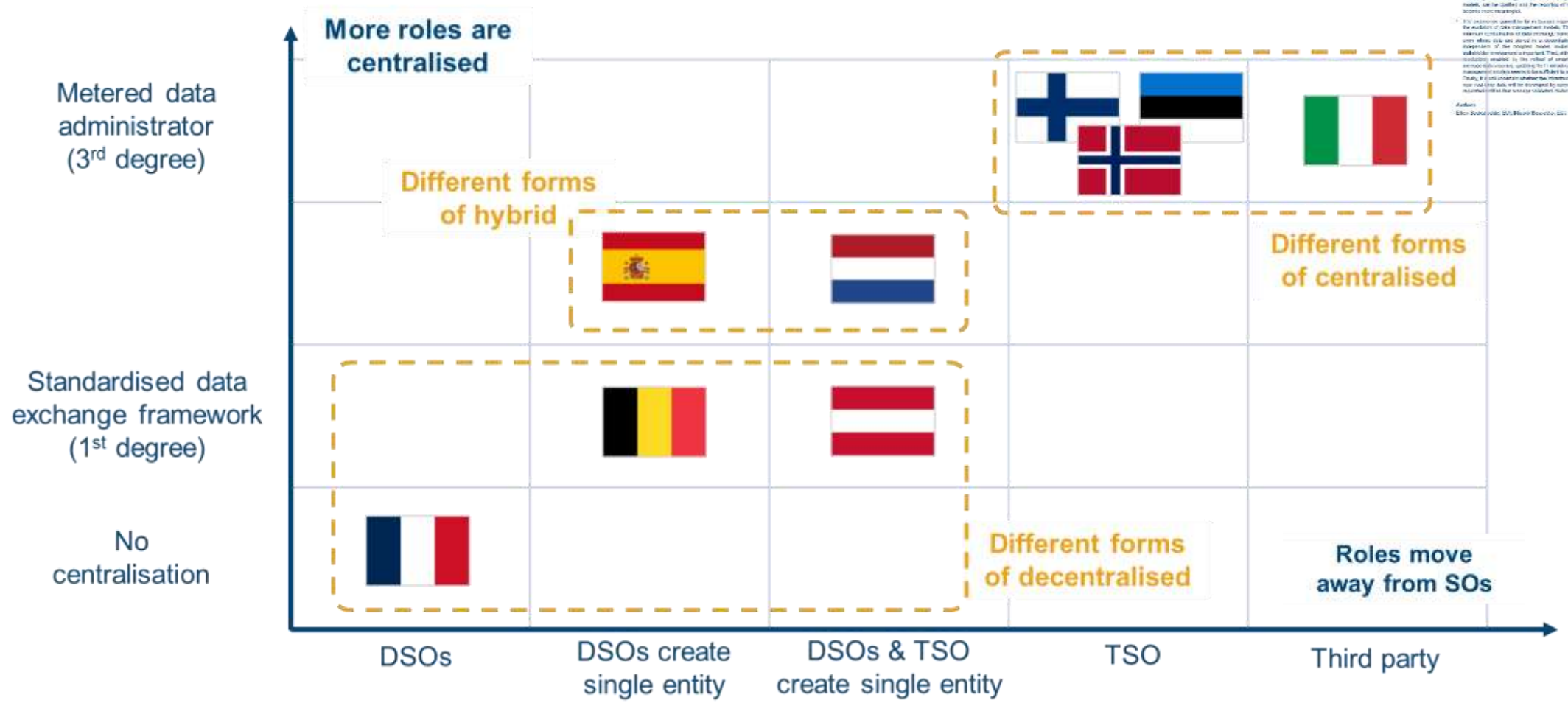
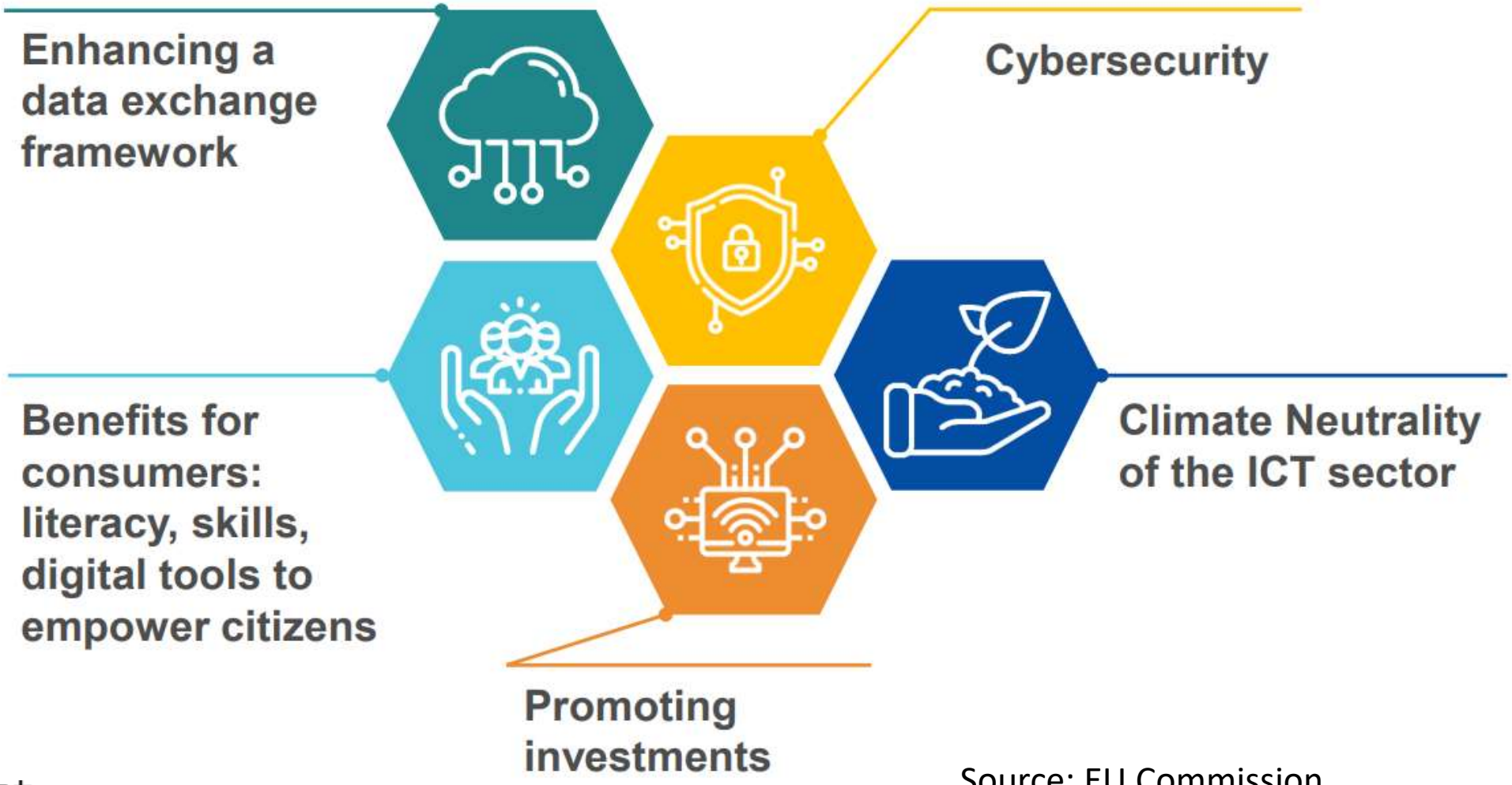
...and distinguish better national solutions



Four reflections on the evolution of DMMs for metering & consumption data

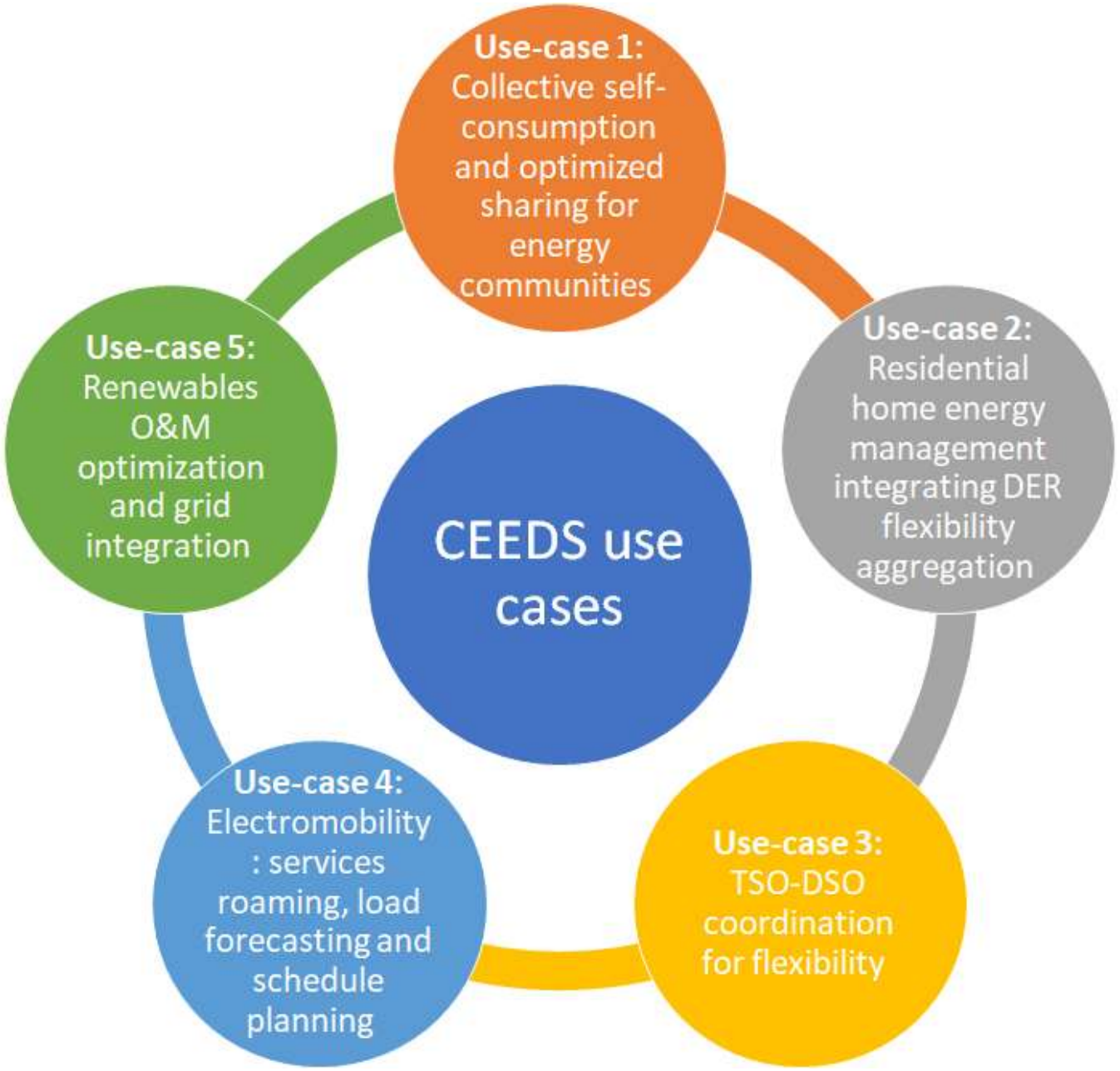
Reflection 1 Trend towards a minimum centralisation of data exchange frameworks	Reflection 2 Inclusive governance and stakeholder involvement are considered important	Reflection 3 DMMs must deal with growing data volumes (e.g., 15 min resolution)	Reflection 4 Use of near real-time data is still limited but interest is growing
Greater centralisation of roles is assessed at a national level in terms of cost-efficiency, consumer centricity, data integrity and security, and agility	Both ad-hoc and systematic stakeholder involvement are being implemented, but the optimal level of formalisation and stakeholder control remains an open question	Updating the IT infrastructures of existing data management models seems to be sufficient to address this challenge	It is not yet clear who will be responsible for the management of near real-time data and the development of the relevant data access and sharing infrastructure

Digitalisation of Energy Action Plan



Source: EU Commission

Business Use Cases for the CEEDS



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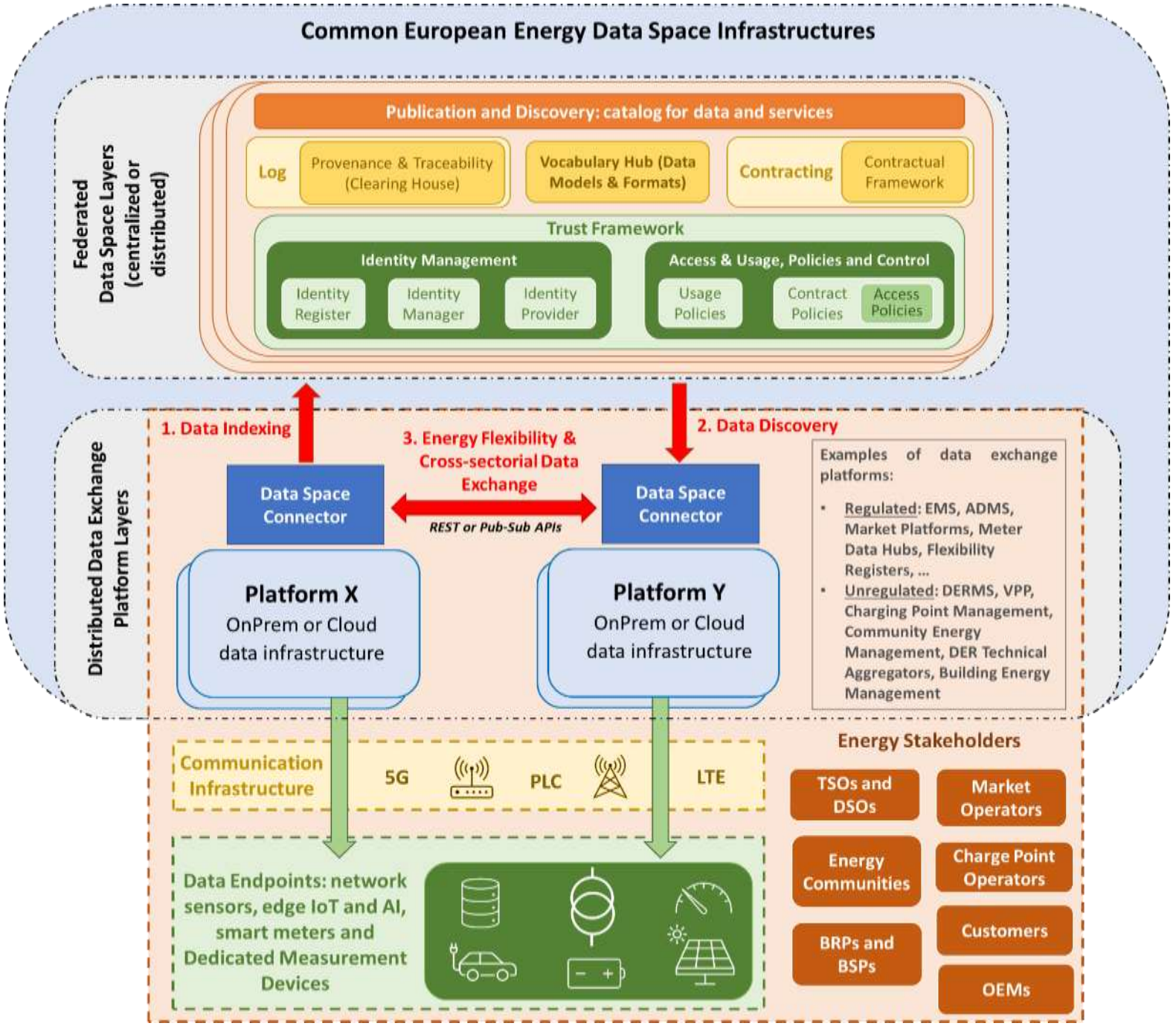
CEEDS Reference Architecture



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European Interoperability Framework

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Interoperability Network for the Energy Transition

Thank you for your attention.

Charukeshi Joglekar (Fraunhofer FIT) and Nicolò Rossetto (EUI-FSR)
int:net final event
18 September 29025
Brussels

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Interoperability Network for the Energy Transition

Int:net Final Conference

From component testing to systemic test approaches

Sonia Jimenez | IDSA

Thomas Strasser | AIT

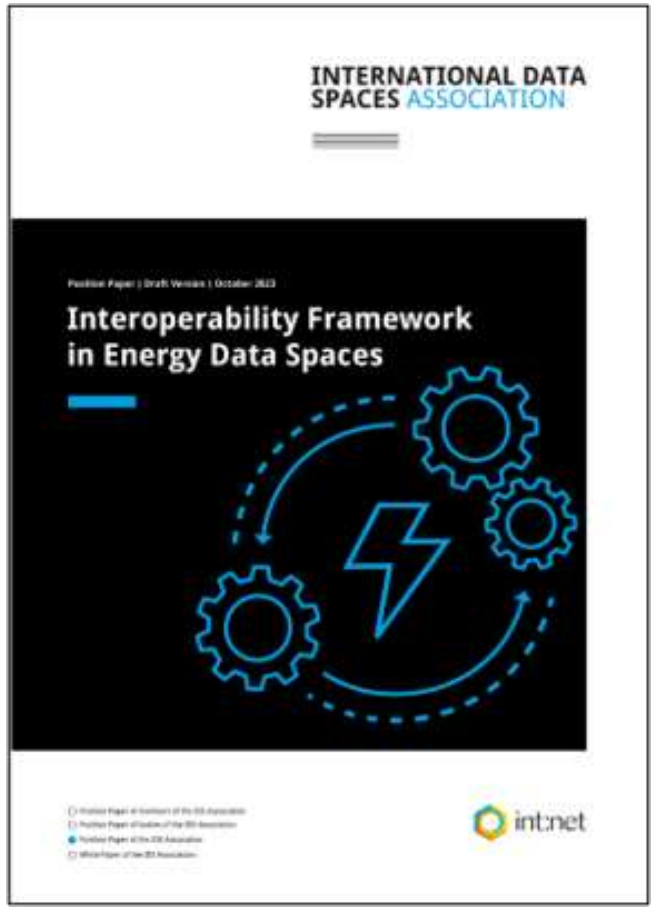
18 September 2025

Lessons Learned

Realisation of 5 CEEDS Use Cases

Insights from the CEEDS 5 system use cases

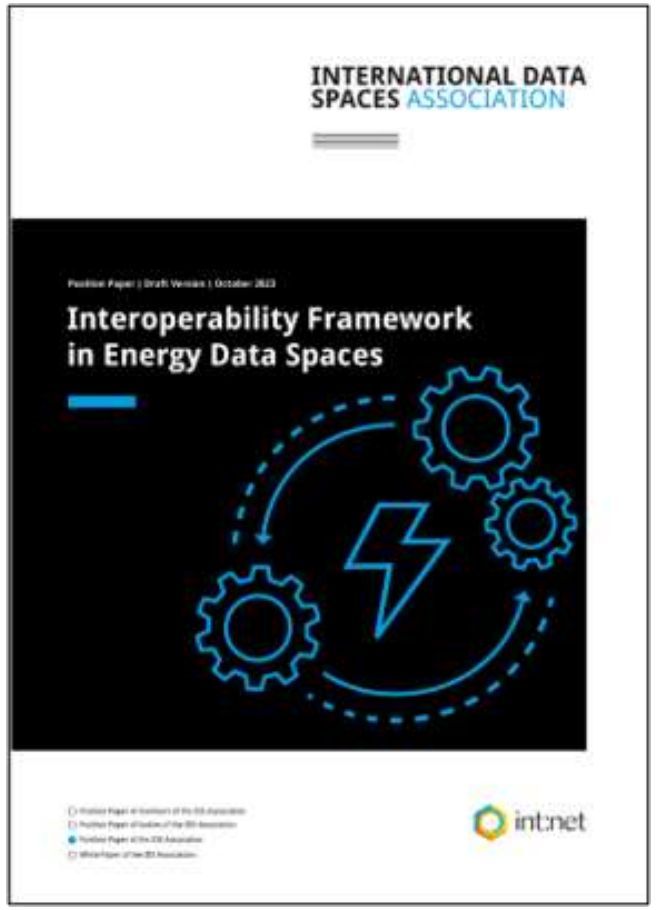
- Energy cluster projects **defined 5 system use cases** aimed at achieving **inter-data space interoperability:**
  - **SUC1 - Onboarding** (process to generate, and check credentials to access an ecosystem)
  - **SUC2 - Data Discovery** and push into the catalogue
  - **SUC3 - Contracting** (selecting a dataset and/or service to purchase it).
  - **SUC4 - Data Exchange** and interoperability
  - **SUC5 – Semantic** interoperability



Insights from the CEEDS 5 system use cases

- Energy cluster projects **defined 5 system use cases** aimed at achieving **inter-data space interoperability:**

System Use Case	Projects
SUC1 - Onboarding (process to generate, and check credentials to access an ecosystem)	Enershare, omega-x
SUC2 - Data Discovery and push into the catalogue	DATA CELLAR, omega-x
SUC3 - Contracting (selecting a dataset and/or service to purchase it)	DATA CELLAR, omega-x
SUC4 - Data Exchange and interoperability	SYNERGIES, EDDIE
SUC5 – Semantic interoperability	All projects

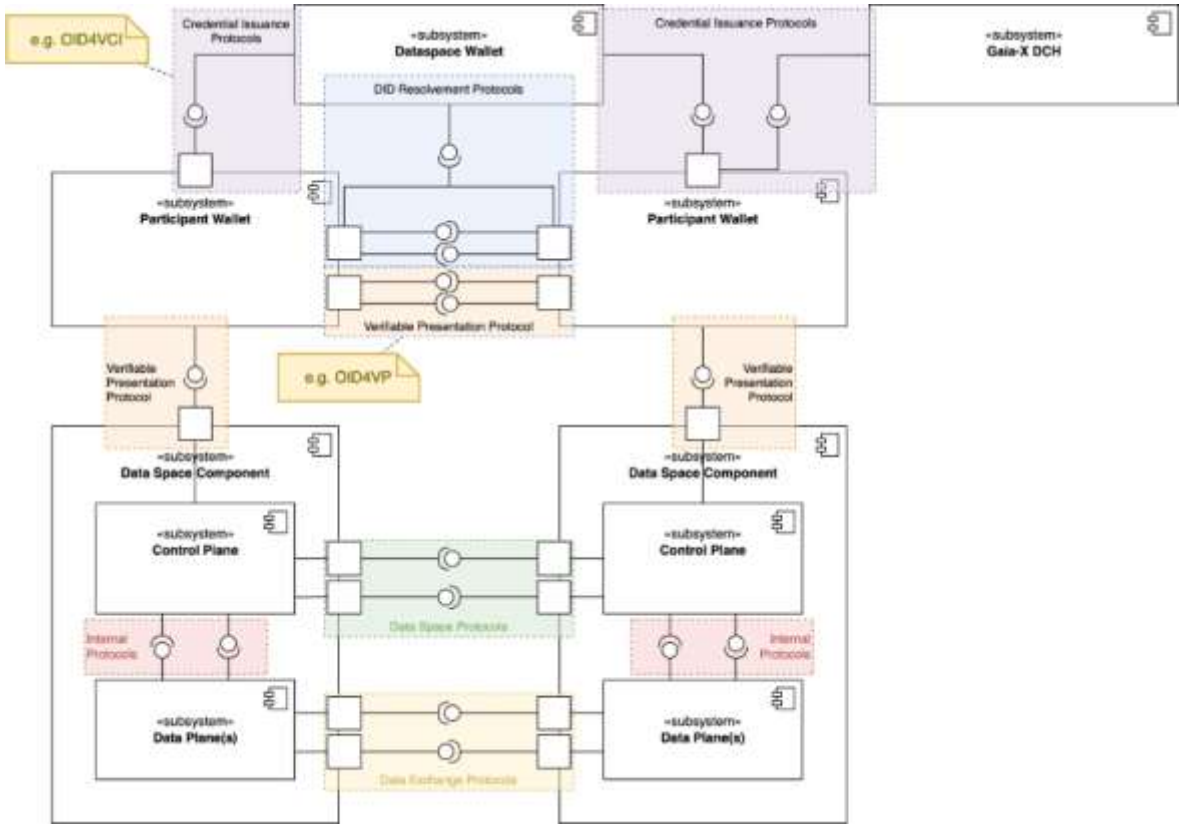


SUC1: Onboarding

- **Interoperable Credential Recognition**:
  Participants can enroll in a Data Space and obtain a Verifiable Credential (VC) recognized across multiple Data Spaces, provided the VC issuer is accepted and trusted.

- **Standardized Credential Issuance:** The OpenID for Verifiable Credential Issuing (OID4VCI) standard ensures consistent, interoperable credential issuance and management, fostering trust and scalability.

- **Flexible Verification Methods:** Accepted verification methods, including DID Web and DID Key, provide robust and flexible mechanisms for validating credentials across interconnected Data Spaces.



SUC1: Onboarding – Challenges & Recommendations

Challenges

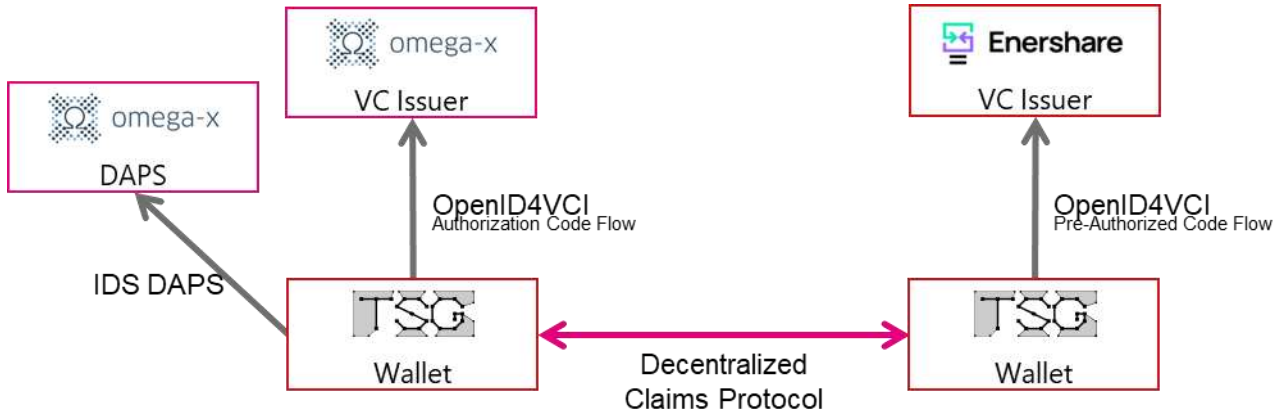
- **Protocol Interpretation and Feature Selection:** A key challenge in Test 1 was aligning on the OID4VCI protocol implementation, particularly the differing approaches of OMEGA-X (Authorization Code Flow) and ENERSHARE (Pre-Authorized Code Flow). This was resolved by both parties agreeing to use the Authorization Code Flow.
- **Metadata Synchronization:** Challenges related to metadata were resolved efficiently during synchronization sessions.
- **Credential Trust Frameworks:** Ensuring that credentials and their associated trust frameworks are synchronized is essential to maintaining their value across different data spaces.
- **Interoperability Between Connectors:** Full interoperability between the connectors (SUC4) remains a significant challenge and requires ongoing collaboration

Recommentations

- **Validity of Current Agreements:** The technical agreements made between OMEGA-X and ENERSHARE remain valid for future technical implementations.
- **Flexible Protocol Selection:** Future credential issuance may involve selecting the appropriate protocol at the moment of issuance, as implementations are expected to support multiple protocols.
- **Efficient Presentation Protocols:** For presenting credentials, efficiency in protocol selection is critical. Implementations might restrict available protocols in scenarios requiring optimal performance.

SUC1: Onboarding - Results

- The ENERSHARE and OMEGA-X projects have successfully demonstrated SUC1:
  - A Verifiable Credential (VC) is generated by the OMEGA-X issuer for an ENESHARE participant using the OID4VCI protocol.
  - ENERSHARE participant stores the credential in a wallet integrated with the connector and presented to another ENERSHARE participant using OpenID for Verifiable Presentation Protocol (OID4VP). The generated credential is successfully accepted the same as the credentials generated by the ENERSHARE VC issuer.



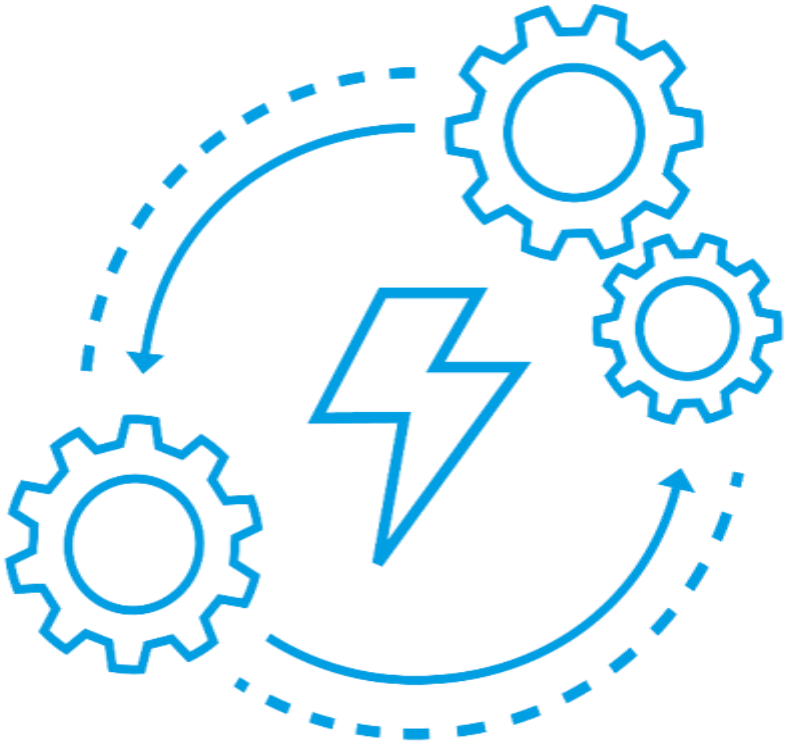
Key Learnings & Next Steps

Key Learnings:

- Component tests prove feasibility; systemic integration is harder.
- Semantic alignment, and flexible protocols are recurring needs.
- Cross-project collaboration accelerates convergence.

Next Steps:

- Develop pan-European standards for onboarding, contracts, metadata.
- Establish governance for semantic models.
- Pilot real-life deployments to validate at scale.
- Foster cross-sector integration (energy, mobility, buildings).



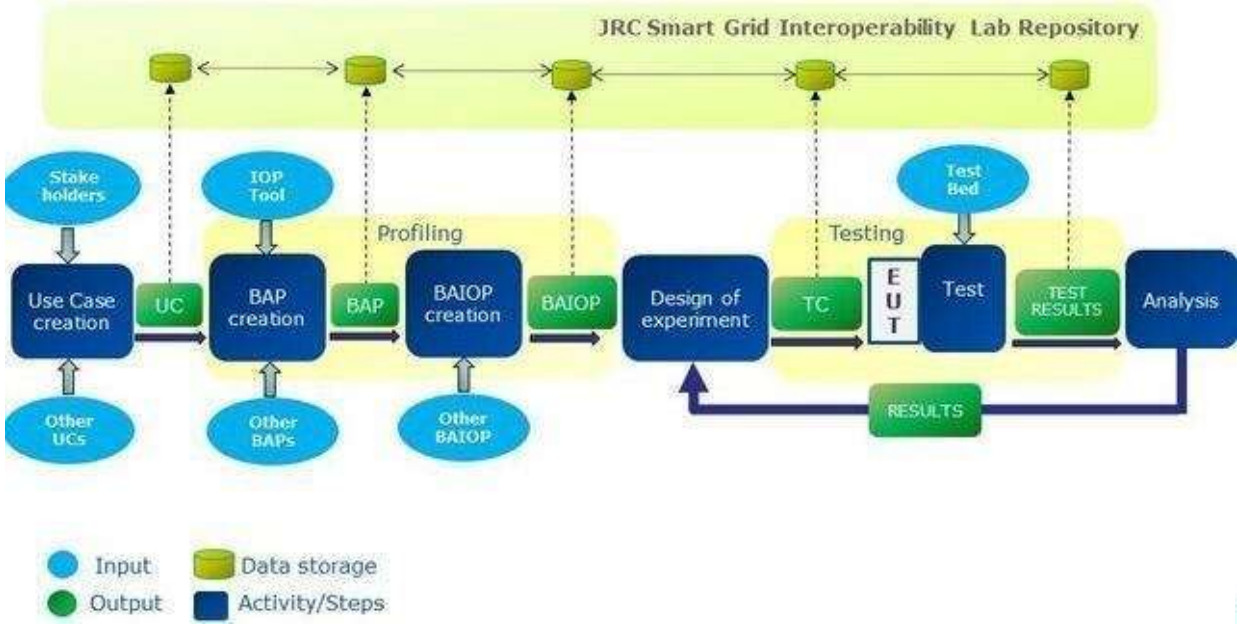
Future Approach

Systematic and Community-driven

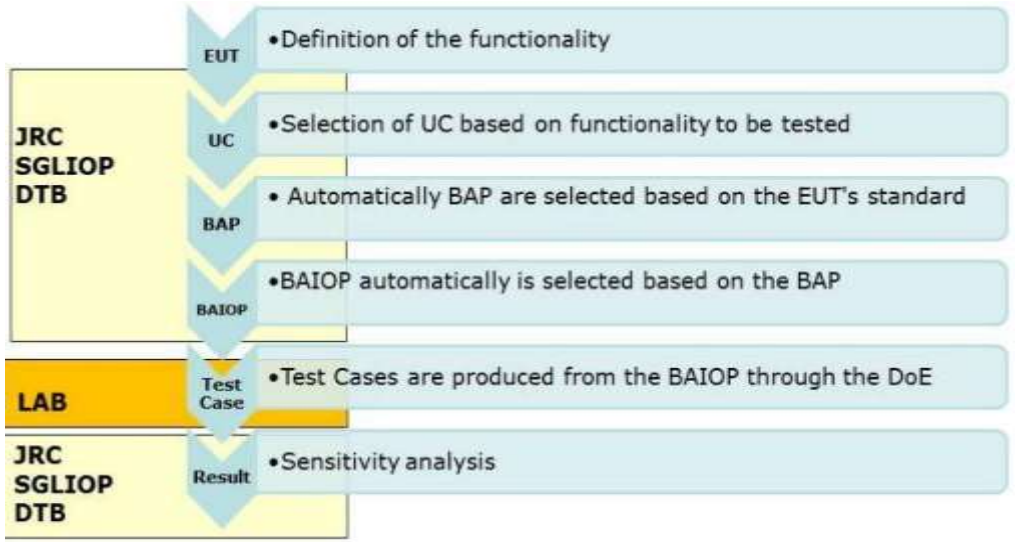
Best Practicies – System-Level Interoperabiliy Testing

- Example: JRC Smart Grid Interoperability Testing Methodology and Laboratory
  - Provision of tools, methods, and testing facilities

Methodology in general

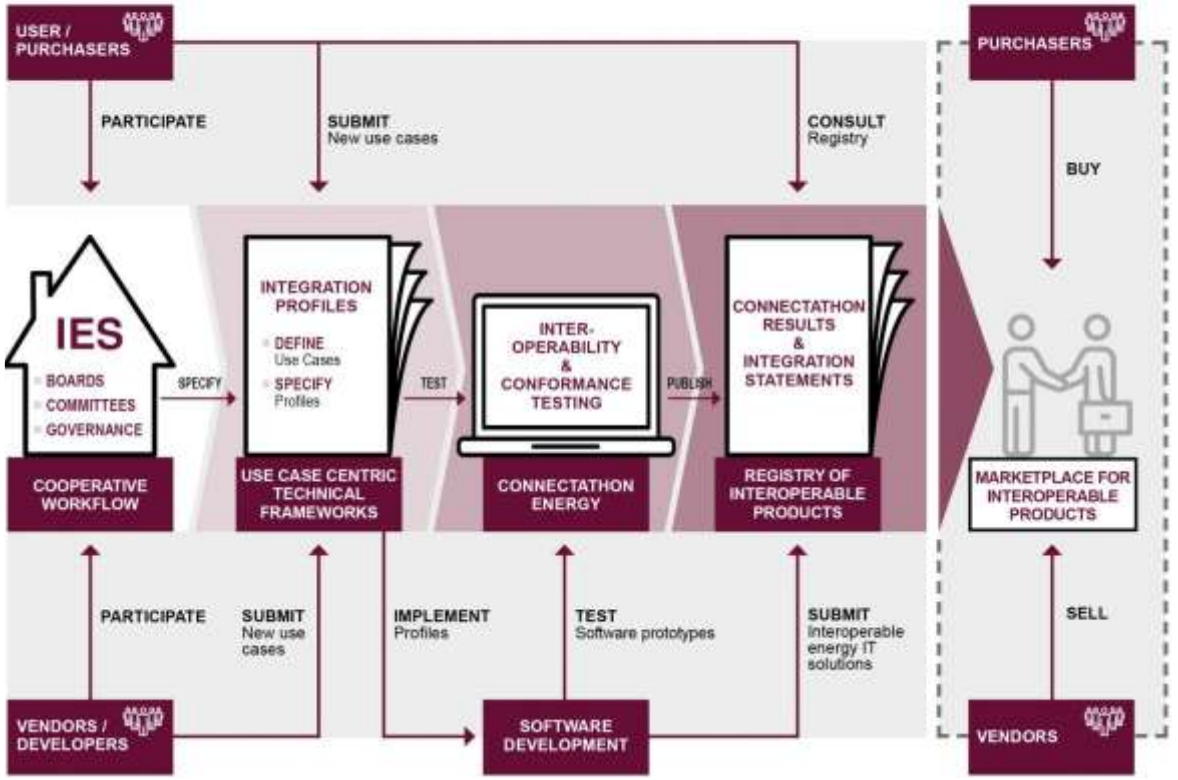


Methodology mapped to test facility



Best Practicies – System-Level Interoperabiliy Testing

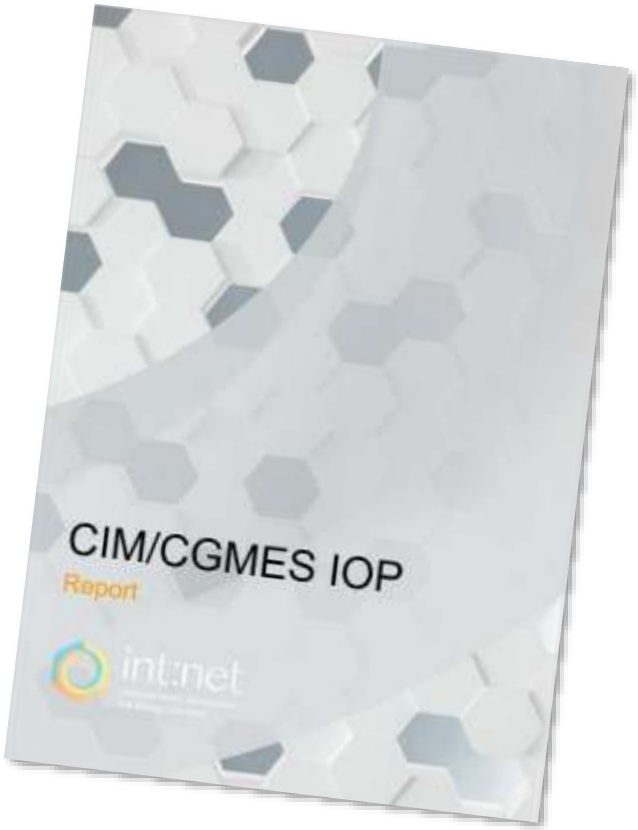
- Example: Connectathons
  - SMARTGRIDS Austria IES-Process (based on the IHE approach from the healthcare sector)
  - Process chain and tools for testing technological integration
  - Usage of Integration Profiles and Technical Framework
  - Organisation of test events (connecthatons)
  - Community involvement



Source: SMARTGRIDS Austria

Best Practicies – System-Level Interoperabiliy Testing

- Example: ENTSO-E Testing Events
  Harmonization of CIM/CGMES v3 ENTSO-E grid model exchange approach
  - Outcomes
    - IOP participants recognize the importance of CGMES v3
    - Several issues have been identified for improvements
  - Lessons learned and suggestions
    - Wider dissemination and exploitation of CGMES v3 necessary
    - Development of a stable interoperability framework related to conformity assessments
    - Communication between vendors, standardisation activities and TSO/DSO organisations need improvement
    - Improvements regarding boundary, reference data, manifest, and new serializations necessary



Next Steps

- Follow best practices, establish testing community
- Organise regular events (e.g., connectathons every year)
- Sharing of experiences and results will improve collaboration and trust
- Award successful institutions with a label (“int:net approved”)

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Interoperability Network for the Energy Transition

Thank you for your attention.

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Interoperability Network for the Energy Transition

From Technological Interoperability to Interoperability Governance

The Role of Society and Networks

Dr. Mona M. Bielig | Seeburg Castle University

18 September 2025

Beyond technical perspectives

- Interoperability is not just about machines working together - it’s about people, systems, and institutions collaborating effectively
- Interoperability governance = designing for alignment across societal, technical, and institutional domains

The societal dimension

- Technical progress and the technical potential for interoperability does not directly translate to societal acceptance

→A rollout of a new technology can simply fail because people reject to install it

Examples & Research

- Idea: Technology given to social housing tenants for free and they can keep the savings
- **BUT:** Baseline uptake rates were only around ca. 60%
- **RESEARCH:** People who got social norm information were much more likely to get the technology installed

Examples & Research

- **PROBLEM:** India faces a wave of protests and activism against Smart Meters across the country

- **RESEARCH:** Large-Scale Field Study & additional online experiment with participants from Delhi, Jaipur and Jodhpur showed: **Trust in the organization is they key factor for adoption**

Mass protest in Vijayawada against smart power meters and tariff hikes

The protesters accused the government of betraying public trust by imposing ₹15,485 crore worth of adjustment charges within a year of coming to power, despite promises to reduce electricity costs

Updated - July 04, 2025 06:35 pm IST - VIJAYAWADA:

THE HINDU BUREAU

READ LATER PRINT

The CPI(M) activists staging a protest against smart meters in front of the CPDCL office in Vijayawada on Friday. | Photo Credit: G.N. Rao

Beyond technical perspectives

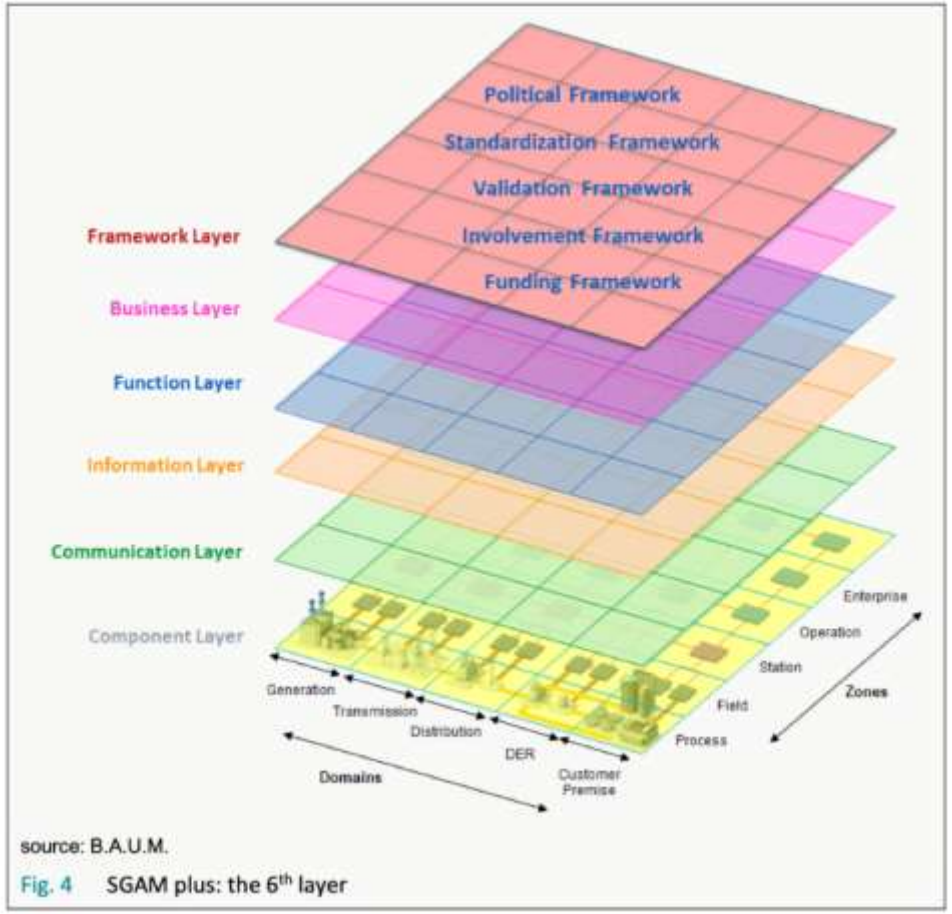
- Societal acceptance is key for Interoperability
- It *not* just about machines working together - it's about people, systems, and institutions collaborating effectively
- Interoperability governance = designing for alignment across societal, technical, and institutional domains

Systemic Governance – We need all dimensions

- Interoperability governance is only possible when all spheres collaborate:
  - Government can decide, but needs legitimacy.
  - Technology alone can’t solve social resistance.
  - Academia is needed for foresight but it needs strategic funding.

„The future energy system will be way more complex.“

How do we navigate this complexity?
→ SGAM Layer 6



source: B.A.U.M.

Fig. 4 SGAM plus: the 6th layer

Systemic Governance – We need all dimensions

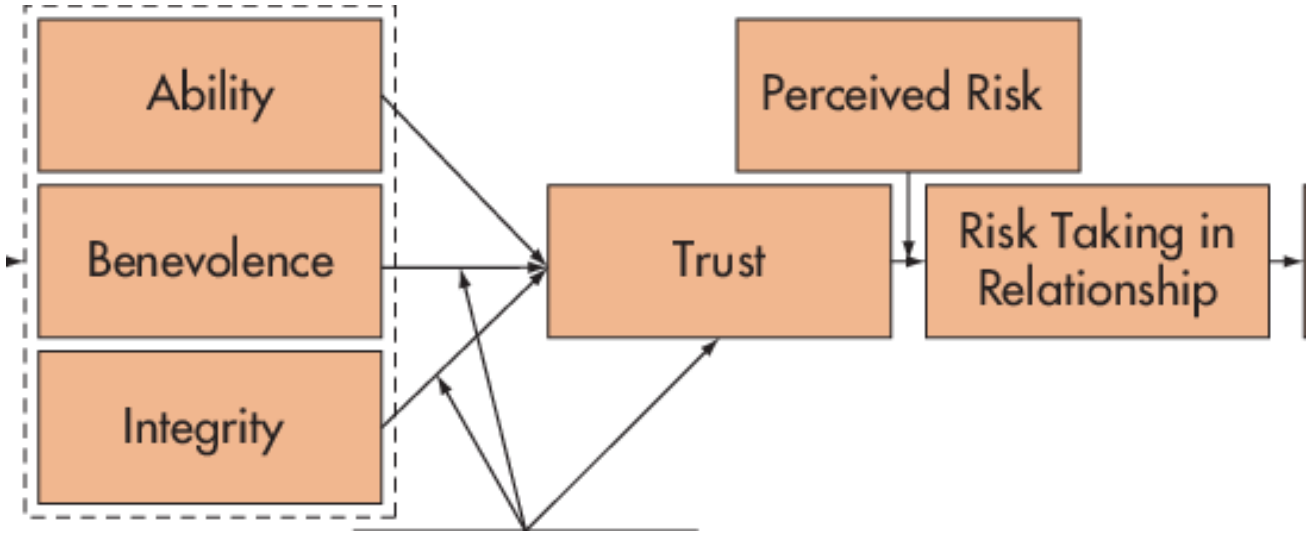
- Role of norms and networks:
  - Norms: What do others do? What is socially acceptable?
  - Networks: Who do I trust? Who do I act with?

- “Networks” = webs of cooperation among actors (civil society, academia, NGOs, municipalities, SMEs) → not just tech networks, but **relational infrastructures**

- **Interoperability of a broad range of stakeholder groups**

Systemic Governance – Coordination, Trust, Communication

- Systemic governance and networks require coordination, trust, and accessible communication
- What do we know about trust and coordination in organizations?



Summary - The Role of Society and Networks

- **Interoperability governance goes beyond technology**
  - It requires active societal engagement — machines can be interoperable, but systems fail without human and organizational alignment.
  - Governance = Coordination + Trust-building + Communication

- **Trust, governance and networks are essential**
  - Trust in technology and institutions (e.g., smart meters) influences adoption.
  - Networks (between actors like citizens, municipalities, academia) enable collaboration and legitimacy.
  - Governance and frameworks to enable interoperability between multiple stakeholders is needed and should be formally defined → e.g. SGAM Layer 6

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Thank you for your attention.

Lunch Time!

Enjoy the break and please be back at 13:15!

Int:net consortium please be back at 13:05h for a photo!

INSIEME

TOGETHER TOWARDS THE COMMON EUROPEAN ENERGY DATA SPACE

MORE THAN A DREAM: FROM INT:NET AND EDSCP TO INSIEME

CONTACT: N.SAMOVICH@ENERCOUTIM.EU

GEORG.HARTNER@EDDIE.ENERGY

This work has been co-funded by the European Union's Digital Europe Programme under grant agreement No. 101194952.

2022-2025 DEVELOPMENT AND TESTING OF DATA SPACE CONCEPTS

INSIEME

EDDIE
EUROPEAN DISTRIBUTED DATA INFRASTRUCTURE FOR ENERGY

mffbas

Enershare

eclipse

ENEDIS

datadis

ENERGINET

omega-x

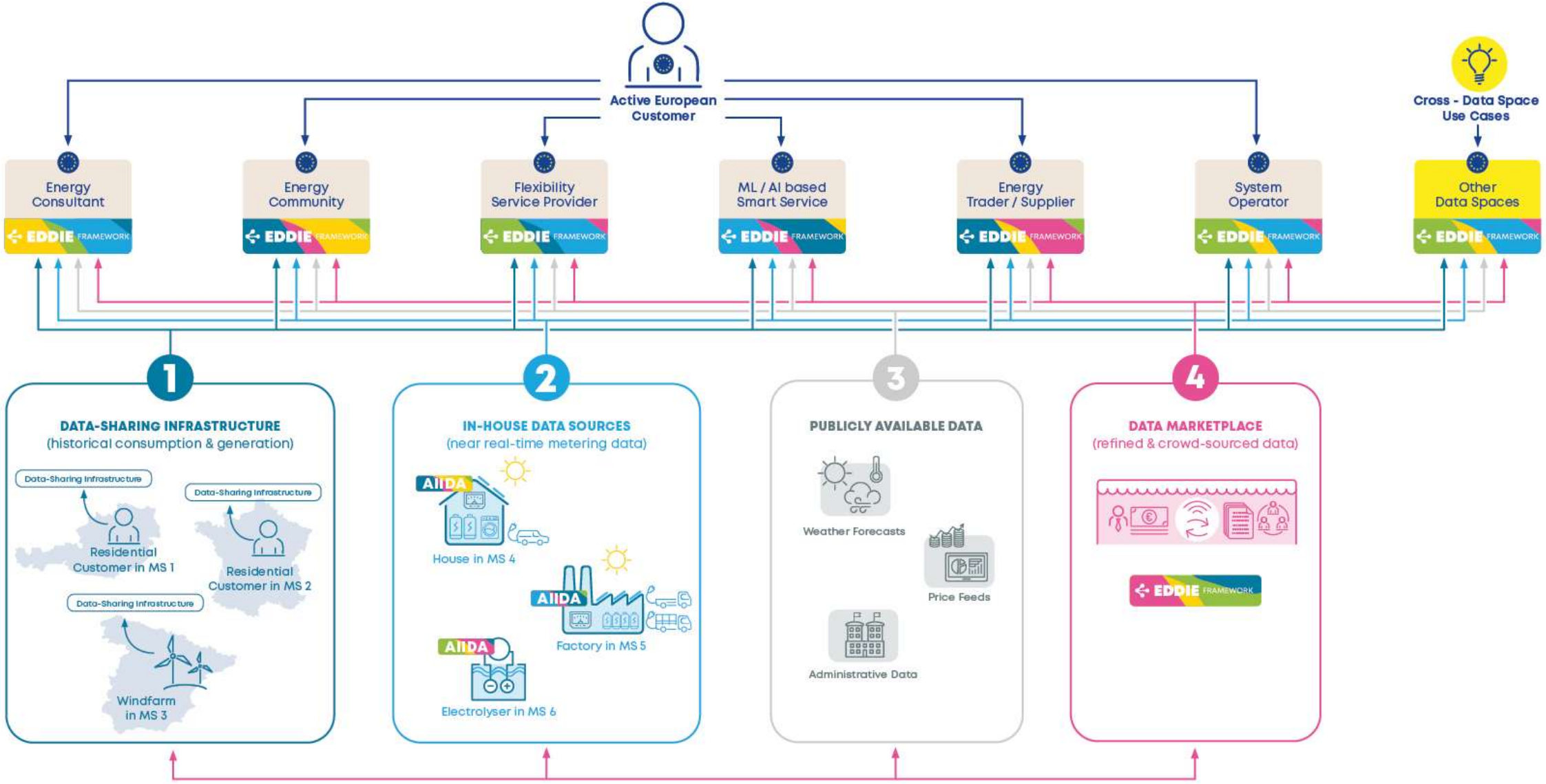
SYNERGIES

ONENET
one network for Europe

DATA CELLAR

EDA energie wirtschaftlicher datenaustausch

PROJECT EDDIE – WRITE ONCE, RUN ANYWHERE



INSIEME

UNIVERSITY OF APPLIED SCIENCES UPPER AUSTRIA

Start: April 1st 2025

End: March 2028

Establishing a CEEDS by the sector for the sector

54 European Partners co-operating closely with European workstreams

16 Mio. EUR Budget

(8 Mio. EUR European co-funding out of Digital Europe Programme)

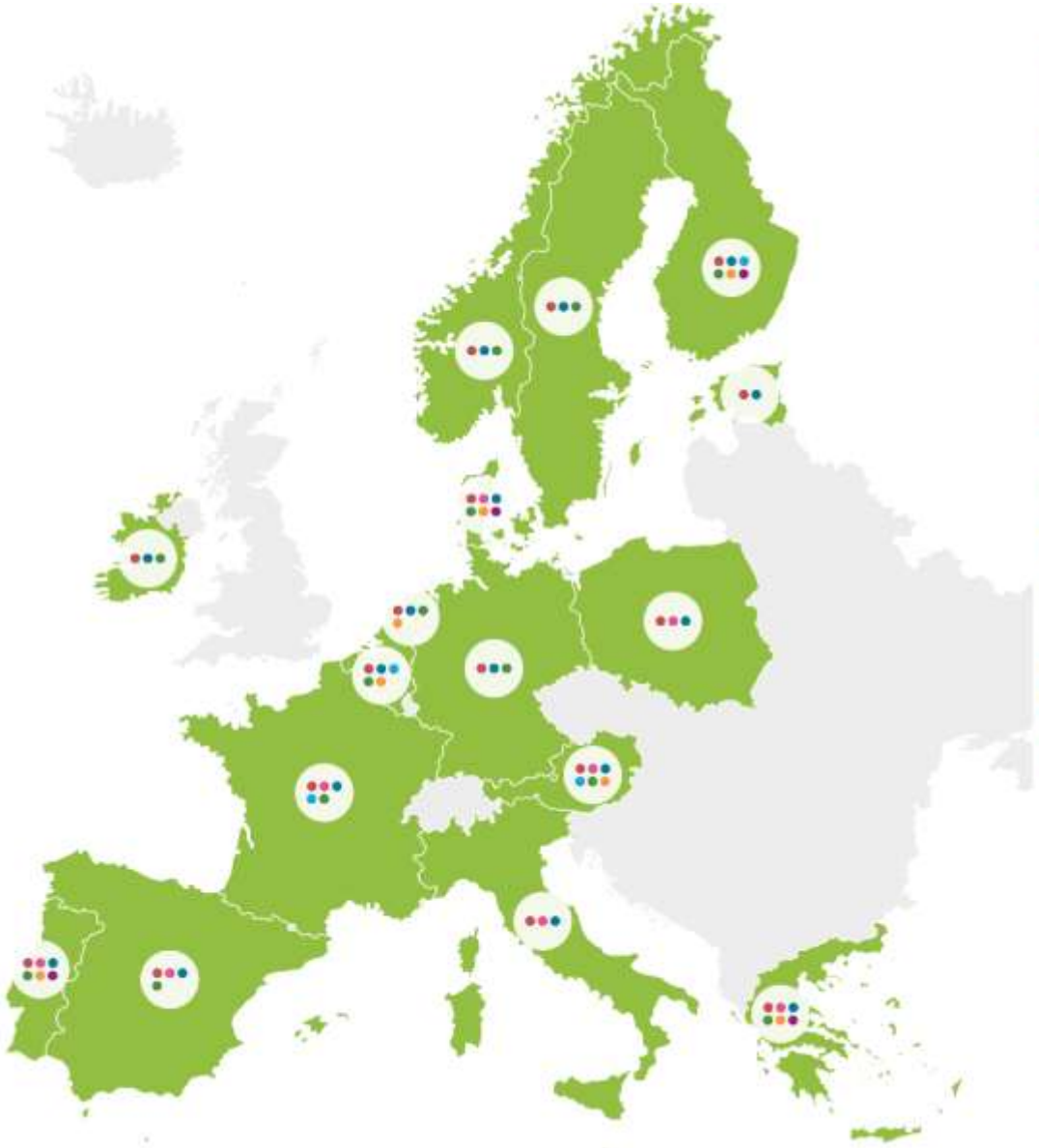
Piloting highest-priority twin transition challenges directly using the CEEDS

Deploy use cases in 15 EU countries

INSIEME Consortium

- Coordinator
- Research & Innovation
- Infrastructure Operator
- Industry Association
- New Market Actor
- Consulting
- Solution Provider

1. University of Applied Sciences Upper Austria (FHOOE) FH OO FORSCHUNGS & ENTWICKLUNGS GMBH (FHOOE)
2. ENEDIS
3. EUROPEAN RENEWABLE ENERGIES FEDERATION (EREF)
4. ETRA INVESTIGACION Y DESARROLLO SA
5. DIGITALAGRIDS
6. ENERCOUTIM - ASSOCIACAO EMPRESARIALDE ENERGIA SOLAR DE ALCOUTIM
7. DANMARKS TEKNISKE UNIVERSITET
8. CENTER DANMARK DRIFT APS
9. RISE RESEARCH INSTITUTES OF SWEDEN AB
10. ENGINEERING - INGEGNERIA INFORMATICA SPA
11. ARETI S.P.A.
12. EDA ENERGIEWIRTSCHAFTLICHER DATENAUSTAUSCH GMBH
13. VLAAMSE INSTELLING VOOR TECHNOLOGISCH ONDERZOEK N.V.
14. CUERVA ENERGIA SLU
15. FRAUNHOFER GESELLSCHAFT ZUR FÖRDERUNG DER ANGEWANDTEN FORSCHUNG EV.
16. UNIVERSITAT WIEN
17. COPENHAGEN BUSINESS SCHOOL
18. EUROPEAN UNIVERSITY INSTITUTE
19. EUROPEAN DISTRIBUTION SYSTEM OPERATORS FOR SMART GRIDS
20. ALLIANDER NV
21. Expert Modeller
22. SUITE5 DATA INTELLIGENCE SOLUTIONS LIMITED
23. AUSTRIAN POWER GRID AG
24. TAURON DYSTRYBUCJA SPOLKA AKCYJNA
25. Operator Klastra Energii Sp. z o.o.
26. EnliteAI GMBH
27. ADAION SMART GRID SOLUTIONS SL
28. Luxembourg National Data Service (PNED GIE)
29. VOLVO TECHNOLOGY AB
30. STATISTISKA CENTRALBYRAN
31. STATENS ENERGIMYNDIGHET
32. VATTENFALL ELDISTRIBUTION AB
33. R8 Technologies OÜ
34. ETHNIKON METSOVION POLYTECHNION
35. IRON ANONYMI ETAIREIA ENERGEIAKON YPIRESION - HERON SOCIETE ANONYME ENERGY SERVICES
36. ORGANISMOS TILEPIKOINONION TIS ELLADOS OTE AE
37. REN - REDE ELECTRICA NACIONAL SA
38. INESC TEC - INSTITUTO DE ENGENHARIADE SISTEMAS E COMPUTADORES, TECNOLOGIA E CIENCIA
39. COOPERATIVE ELECTRICA DO VALE DESTE CRL
40. ENERGIENETZE STEIERMARK GMBH
41. NETZ NIEDEROSTERREICH GMBH
42. backbone.one GmbH
43. COMERCIAL VALLESANA DE SUMINISTROS SA
44. ASOCIACION DE EMPRESAS DE ENERGIA ELECTRICA
45. SMART ENERGY EUROPE
46. RENAULT TRUCKS SAS
47. ENEXI GMBH
48. ENFOR AS
49. STATNETT SF
50. EWII A/S
51. RTE RESEAU DE TRANSPORT D'ELECTRICITE
52. ENERGINET
53. ELIA TRANSMISSION BELGIUM
54. TREFOR EL-NET A/S
55. Litgrid
56. Vattenfall AB R&D



INSIEME Coverage & Use Cases

1. Energy Efficiency and Flexibility Management
2. Collective Self-Consumption
3. Grid Flexibility Services
4. Electromobility
5. Renewables Integration
6. Networks and Integration Planning
7. Smart Sector Integration

Flexible Connection Agreement – Pilot Bene Büromöbel

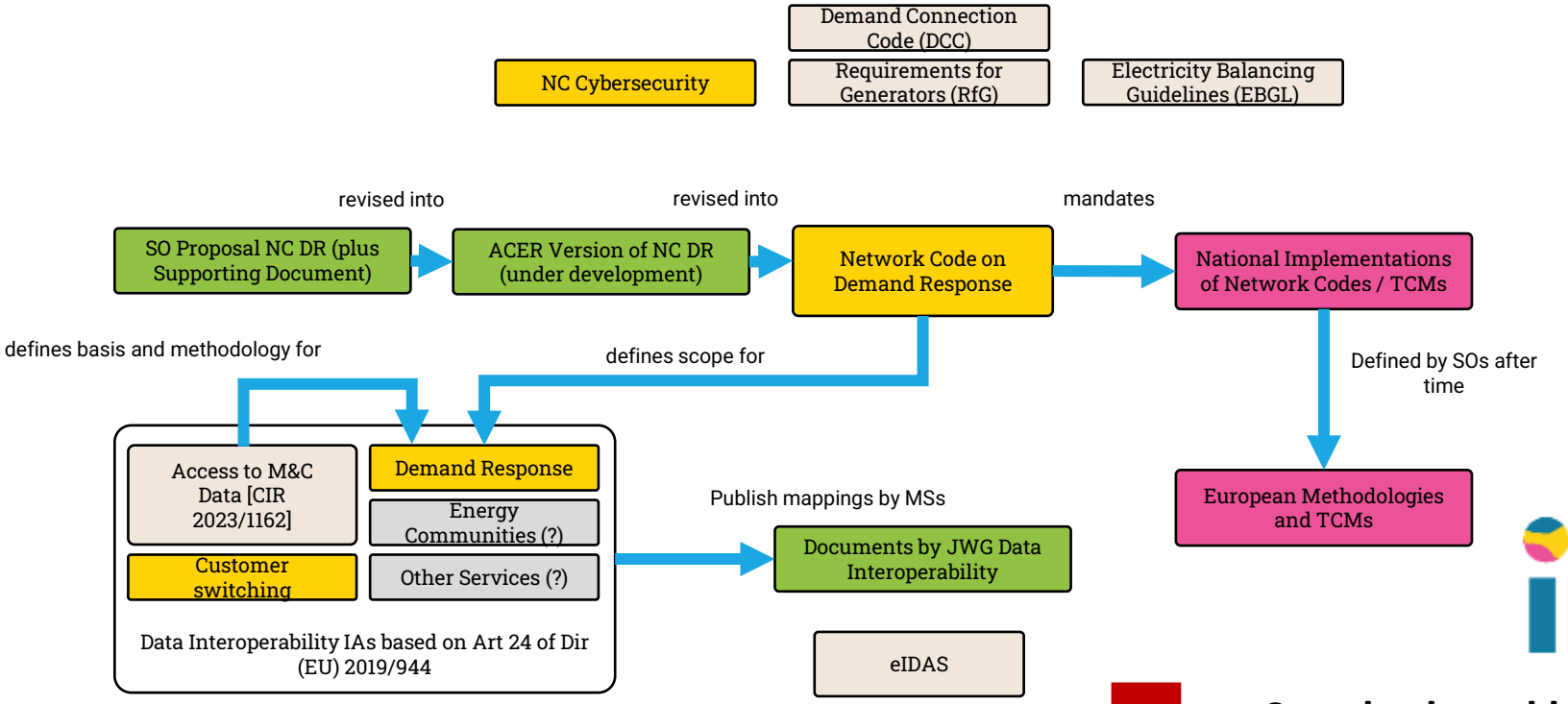
- Congested area due to high voltages in the medium voltage level
- Maximum installed power for new generation plants to avoid further congestions: 250kVA
- Bene Büromöbel PV affected by limitations
- Congestions mainly caused by water power plants
- Low simultaneities between PV and water power
- Bene has the opportunity for flexible connection aggrement
- Allow more PV grid injection in times with low water generation

- https://bene.com

bene
INSPIRIERENDE BÜROS. SEIT 1790.

NÖ Netz
EVN Gruppe

INSIEME COMES AT THE RIGHT POINT IN TIME



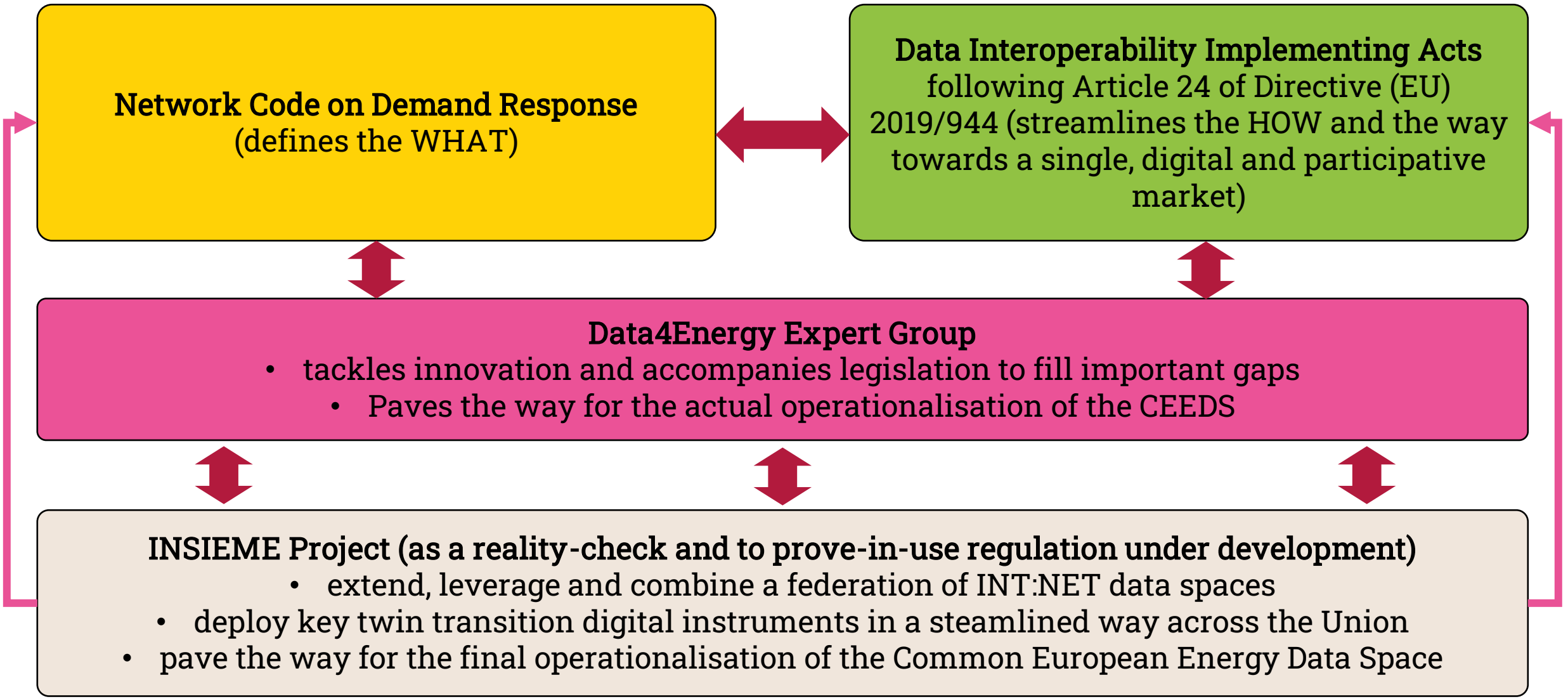
Standards and best practices needed <u>BEFORE</u>

Energy Data Space Cluster Projects
until Q2/2026

Establishment of Regulatory Basis for Flexibilisation
until Q1/2026

Implementation and national transposition of digital infrastructure
until 2030

INSIEME AS A REALITY-CHECK AND SANITY GATE



INSIEME

TOGETHER TOWARDS THE COMMON EUROPEAN ENERGY DATA SPACE

EU DATA SPACES

Overview

This work has been co-funded by the European Union's Digital Europe Programme under grant agreement No. 101194952.

17.09.2025

EU DATA SPACES

Domain	Initiative	Business Model	Sustainability Strategy	Key Stakeholders & Operators
Mobility	European Mobility Data Space (EMDS) & PrepDSpace4Mobility	Hybrid public co-funding + federation fees	Based on Governance and interoperability reuse	EC, CSA consortia, transport authorities
Mobility	Mobility Data Space (Germany, EU-linked)	Membership and transaction fees	Operator entity with partner network	German Mobility Data Space Association
Automotive/Manufacturing	Catena-X	Association membership and certified providers	Association and app providers ecosystem	BMW, Mercedes, Bosch, SAP, T-Systems
Manufacturing	Manufacturing-X	Public-private, marketplace model	Industry run spaces, aligned with Data Act	German government, industry associations
Energy	ENERSHARE	Towards federation services monetisation	Blueprint reused by DSOs/retailers	ENERSHARE consortium (DSOs, research)
Energy	OMEGA-X, EDDIE, DATA CELLAR, SYNERGIES	Mixed; service layers and components	Clustered blueprints	Cluster consortia
Smart Communities	DS4SSCC	DEP co-funding; local operator nodes	Marketplace for components, city coalitions	City alliances, EC
Health	EHDS	Public infra coupled with regulated access services	National hubs and EU services	EC, National Ministries, Hubs
Finance	EFDS	Data access and services fees	Industry governance, regulatory alignment	Financial institutions, EC
Agriculture	AgriDataSpace → CEADS	Ag-tech platforms, co-ops, marketplace	Governance based	CEADS consortium (farmers, tech)
Environment/Green Deal	GREAT, SAGE, AD4GD	Public core and commercial services apps	Services reuse	Green Deal DS consortiums
Media	TEMS	Consortium B2B services, licensing	Interoperable toolis, industry consortium	EBU, media partners
Skills	DS4Skills → DS4Skills-GO	Public private, API/service fees	Industry, educational institutions partners	DS4Skills consortium
Cultural Heritage	CEDS Cultural Heritage (Europeana)	Public core and facilitation of licensing/curation services	Europeana coordination and continuity	Europeana, cultural institutes
Language/AI	Language Data Space	Transaction model, procurement base	Industry participation	CELT, ELE projects
Tourism	DATES → DEPLOYTOUR	Destination/SME services; analytics	Sector governance and standalone use cases	DEPLOYTOUR consortium
Public Administration	PPDS	Public platform; analytics and other services	Harmonised schemas, APIs	EC, national authorities

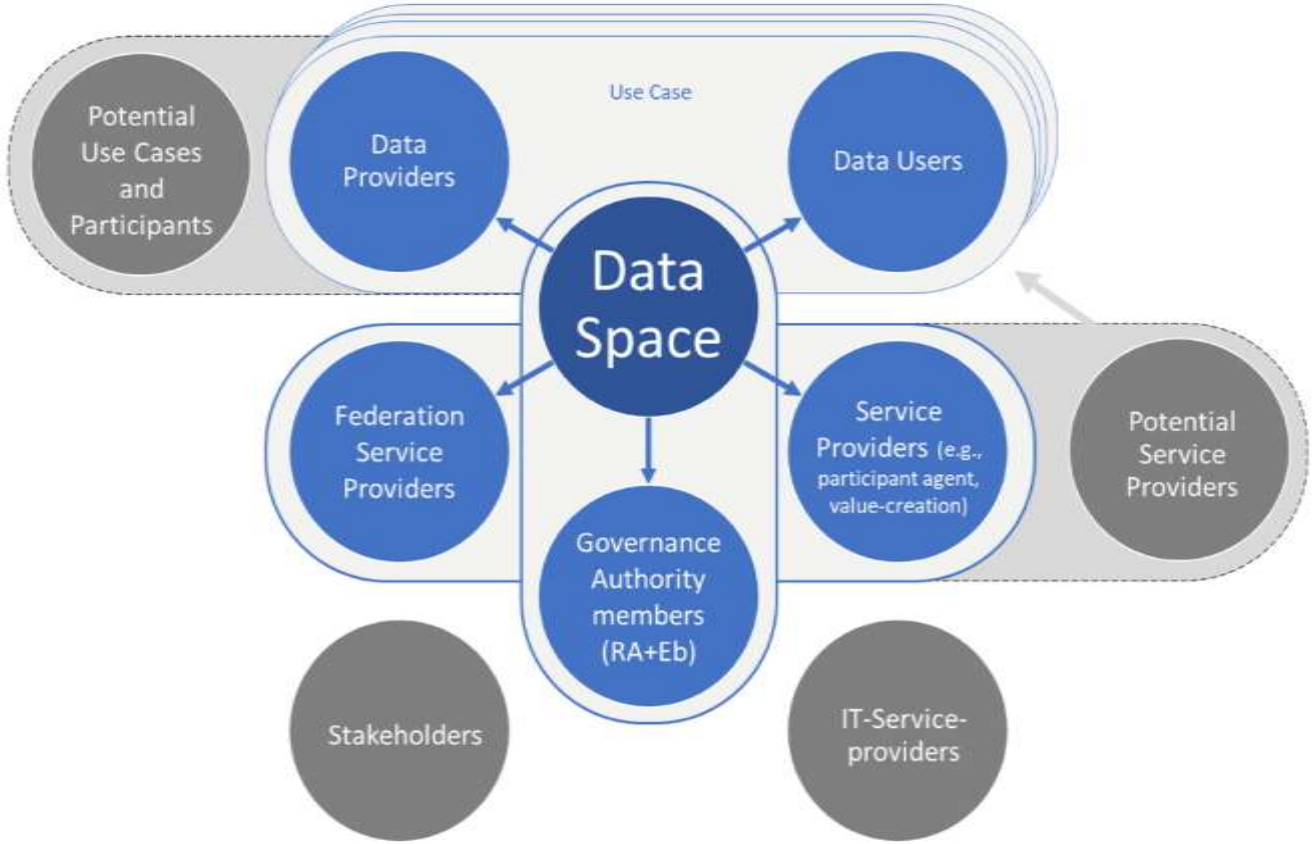


Figure 1: Actor overview as background for data space business model development

Multi-Sided Business Model

A business model is said to be multi-sided if an organization serves different segments, and those segments also interact. An example is Airbnb, where apartments are offered to travellers. This is also referred to as a 'platform business model'.

A data space differs in two important ways from a platform business model: In order to establish sovereignty and avoid undesired 'winner-takes-all' effects, control of the sharing of data essentially lies with the data owner and the infrastructure is distributed.

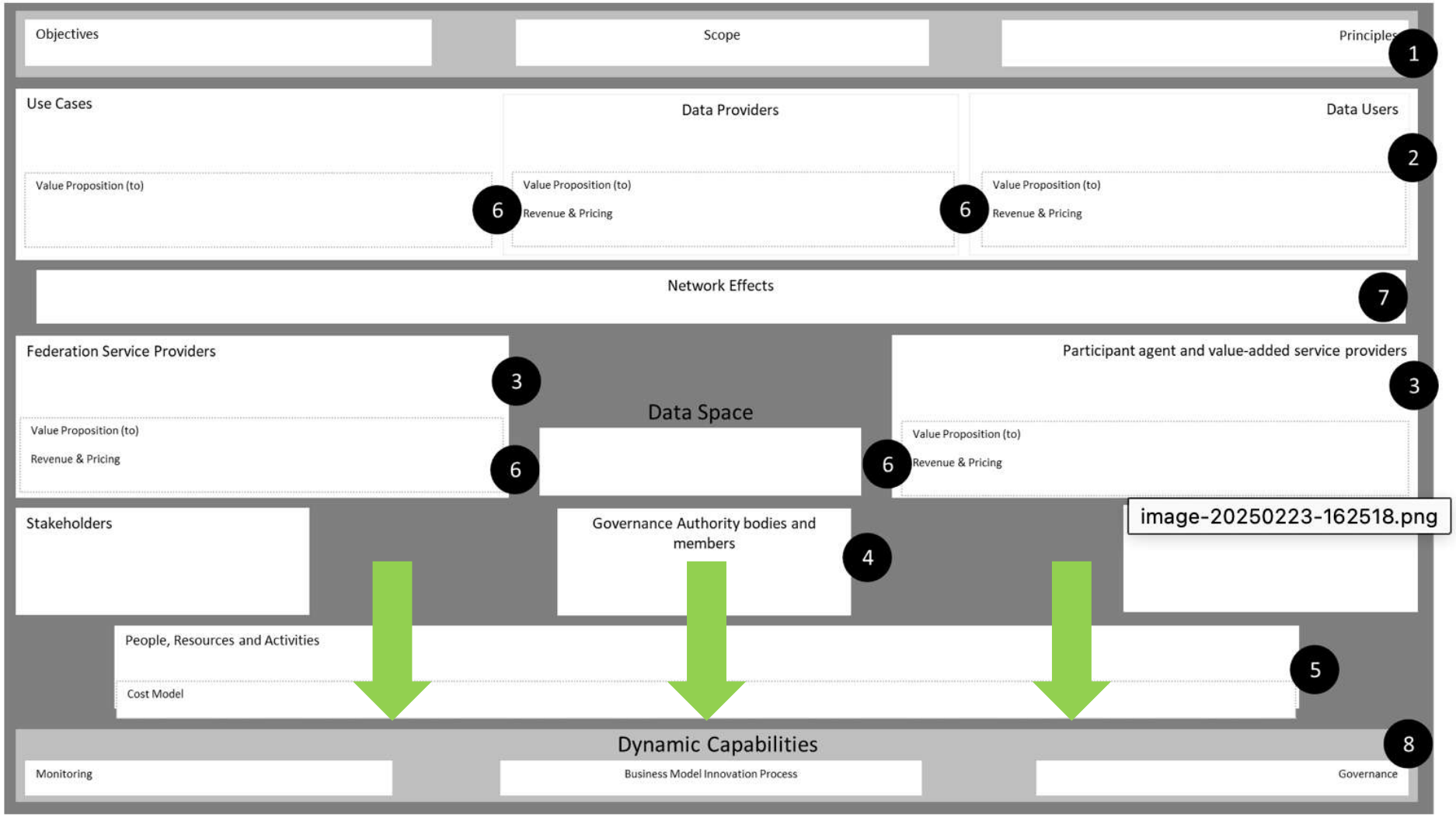


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Figure 2. Business Model Design Tool for Data Spaces

INSIEME

TOGETHER TOWARDS
THE COMMON EUROPEAN
ENERGY DATA SPACE

CONTACT

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int:net

Interoperability Network for the Energy Transition

Int:net Final Conference

Making it happen

Diana Jimenez | Trialog

Carlos Ayon Mac Gregor | B.A.U.M.

18 September 2025

int:net
Interoperability Network for the Energy Transition

Understanding potentials and hurdles of interoperability in practice

Introduction to the newly developed ontology constraints tester

Diana Jimenez | Trialog

18 September 2025

The interoperability challenge

"Smart appliances are key to the energy transition —

but what happens if a dishwasher from brand A can't 'talk' properly with a home energy manager from brand B?"

Objective: Support engineers to verify/ensure/validate the interoperability compliance of data exchange for various systems with ontologies (e.g., SAREF).

Context:

- Started in INT:NET project to be continued in Hedge-IoT project.
- Based on the JRC for ESA CoC methodology interoperability test method and needs
- Built on **SAREF ontology** (ETSI SAREF) but extensible to any ontology

Why this tool matters now

Ontology = Single Source Of Trust (SSOT)

"Without a neutral, ontology-driven tester, each company reinvents its own method, slowing down adoption and increasing costs"

Motivation drivers

- **Energy transition** → more renewables, need for flexibility
- **Rapid digitalization** → more machine-to-machine data exchange
- **Cost optimization** → testing interoperability early saves money for manufacturers
- **Regulatory push** → GDPR, AI Act (GDPR, AI Act)

1st identified: verify compliance with the Code of Conduct for Smart Home Appliances (CoC-ESA) established by the European Commission's JRC and DG ENER.

Challenges we target

- How to verify semantic + behavioural (next) interoperability in practice?
- How to help engineers integrate ontologies without reinventing the wheel?

Use cases – Making it concrete

- **Energy Smart Appliances (ESA)** defined in CoC:
  - “Products that provide energy flexibility through machine-to-machine communication.”
- **Domains**:
  - Home appliances (washing machines, dryers, dishwashers)
  - HVAC + water heating
- **5 key use cases defined by JRC CoC**:
  - **Flexible start:** → **Verifying the order of messages between Customer Energy Manager ↔ Appliance** 
  - Limitation of power consumption
  - Manual operation
  - Monitoring of power consumption
  - Incentive-based consumption management
- **Manufacturers who sign CoC commit to**:
  - Launch at least one ESA model per year
  - Ensure interoperability via SAREF & SAREF4ENERInform consumers about available use cases

What we've built so far

"Until now, standards stayed on paper. With ODC-Tester, they become testable, verifiable, and actionable"

During int:net lifetime

Peer Reviewed Publication

- Full paper accepted at the 6th **K**nowledge **G**raphs & **S**emantic **W**eb **C**onference 2024
- Methodology, dataset design & validation results publicly documented

Synthetic-Dataset

- Generated from the JRC CoC "Flexible Start" use case
- Four JSON/RDF packs (1 fully compliant + 3 seeded-error variants)
- 100% detection (accuracy & robustness) in compliance tests

Working Prototype

- Django-based web UI for dataset upload & SHACL validation
- Automated PDF report generator using ReportLab
- rdflib + pySHACL Library fully integrated with Ontology Engine

Open Research Artifacts

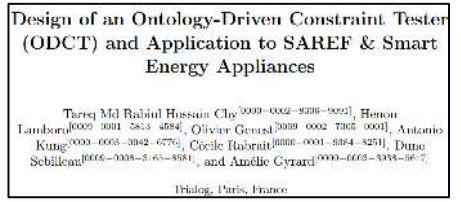
- Datasets, SHACL shapes & validation outputs available on Zenodo

Int:net → **Semantic testing** (1st proof of concept achieved);

ODCT tool presented at the JRC CoC ESA plenary (18 Sept 2024);

Int:net (Deliverable D3.1)

TRL 3


Design of an Ontology-Driven Constraint Tester (ODCT) and Application to SAREF & Smart Energy Appliances

Tarisq Md Rabiul Hussain Chy, Henon Lambord, Olivier Genest, Antonio Kung, Cécile Rabrait, Dune Sebilleau, and Amélie Cyrard

Trialog, Paris, France

Next steps: From int:net and beyond

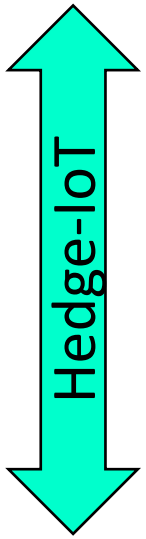
"Next version = not just checking messages, but verifying full conversations between systems"

- Current situation:
  - JRC's **Code of Conduct (CoC ESA)** already defines use cases and requires compliance.
  - BUT: It mainly checks **semantic correctness** (the data format), not **behavior** (the sequence of actions).
  - Result: integration delays, hidden costs, and missed energy flexibility opportunities.

Latest achievements connection with Next Steps:

- Now aligned with **ISO/IEC 21823-5** (link) and **EEBUS Spine WG** (EEBUS)

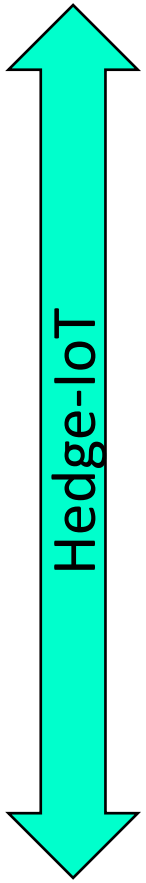
TRL 2



Next steps: Behavioural testing

"Semantic validation is like checking if two people speak the same language. Behavioral testing is making sure they can actually have a meaningful conversation"

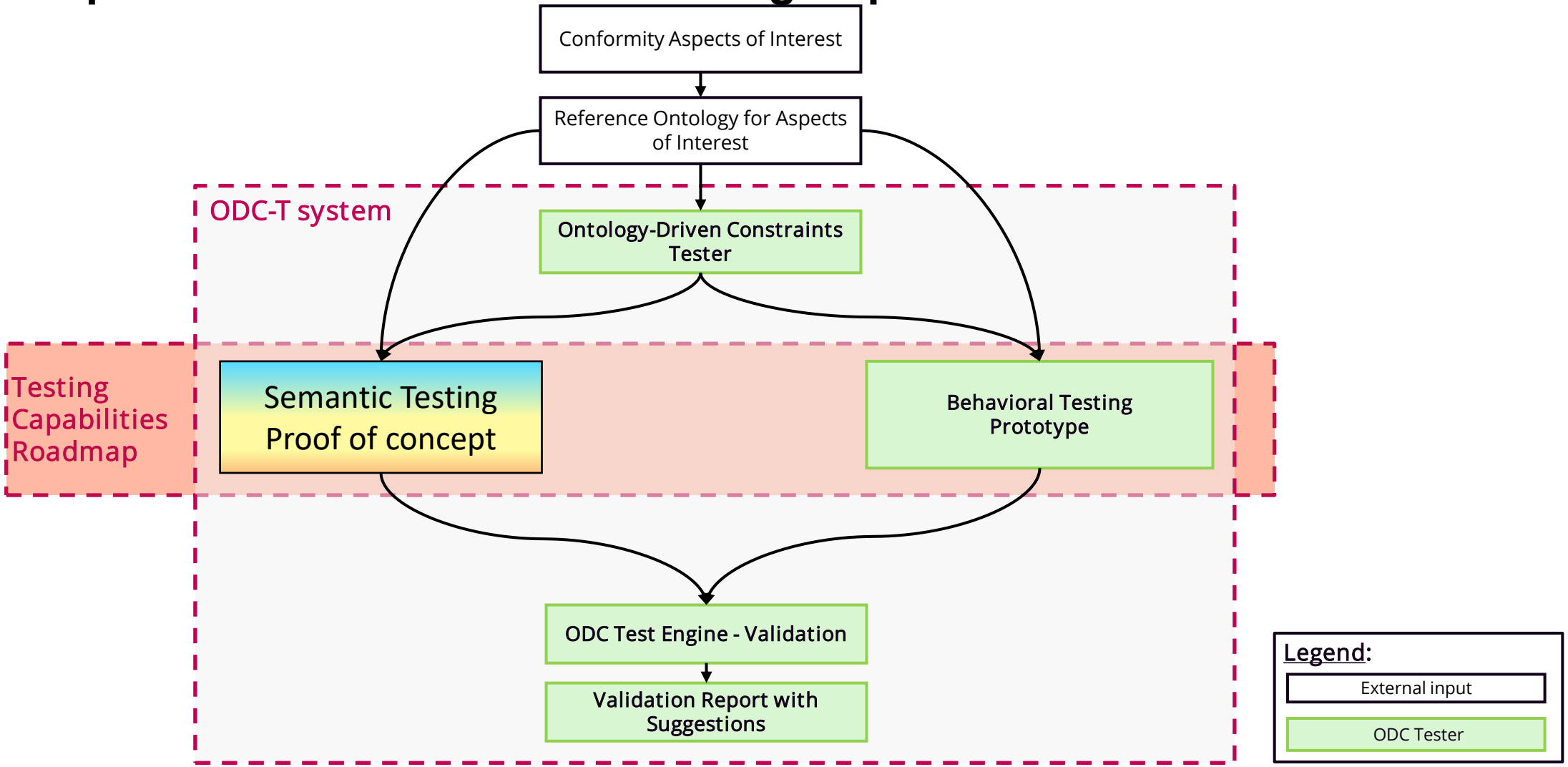
- Transition from prototype → production-ready tool
- Roadmap:
  - Select methodology for behavioural testing
  - Prototype & test behavioural architecture
  - Extend validation with real manufacturer data (as soon as available)
  - Continue contributions: JRC CoC Phase 2, ISO/IEC 21823-5, EEBUS Spine WG
  - Internal validation with project partners



- Outlook:

Potential beyond energy: IoT ecosystems, mobility, healthcare devices

Next steps: ODC-Tester – Overall Testing Capabilities



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Q&A: Understanding potentials and hurdles of interoperability in practice

Introduction to the newly developed ontology constraints tester

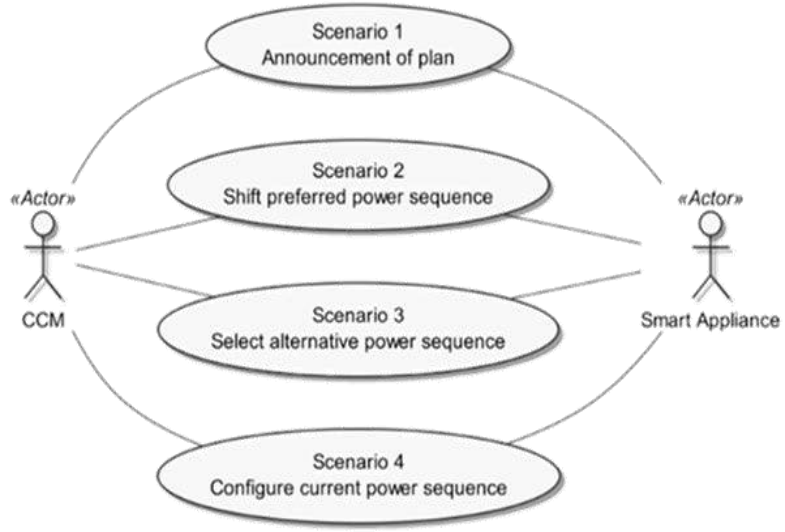
Diana Jimenez | Trialog

Carlos Ayon Mac Gregor | B.A.U.M.

18 September 2025

What is behavioral testing?

- ISO/IEC 21823-5 definition:
  - "**Interoperability so that the actual result achieves the expected outcome**."
- Focus on dynamic behaviour:
  - State transitions
  - Timing/synchronization
  - Policy rules
- Technique: Given–When–Then + state machines



View of the different scenarios for the Flexible Start use case of the JRC's CoC

Actions

- **Target use case:** CoC-ESA - **"Flexible Start" (Scenario 3)**
- **Standards & ecosystem:** participation in **EEBUS SPINE IoT WG**; alignment with **JRC CoC**,
- **ISO/IEC 21823-5** and **EN 50631-3-1**
- **Expected deliverables:** conformance reports and **reusable test templates** for manufacturers

What is behavioural testing?

Behavioral Testing (definition)

- From ISO/IEC 21823-5: *"Interoperability so that the actual result achieves the expected outcome."*
- Focuses on **dynamic behavior** → state transitions, timing, and policy rules over time.
- Validates *how* a system behaves during operation, not just *what* data it provides.

User Story: Dishwasher Schedule Management
Narrative: As a user I want to be able to set a preferred dishwasher cycle schedule. So that I can have the dishwasher run when it's most convenient for me, taking into account electricity tariffs or personal preference.

Scenario 1: Dishwasher Accepts Preferred Schedule
Given the dishwasher has an initial preferred sequence P1 (21:00-22:30) and a pre-condition for requests to be sent before 21:00,
When I send a request to start the dishwasher cycle,
Then the dishwasher accepts the request, transitions to State P2 (waiting), starts the cycle at 23:00 (±1 min), and ensures the dishwasher cycle finishes by 00:30.

Scenario 2: Dishwasher Rejects Out-of-Window Request
Given the dishwasher has an initial preferred sequence P1 (21:00-22:30) and a pre-condition for requests to be sent before 21:00,
When I send a request that does not meet the pre-condition (e.g., after 21:00),
Then the dishwasher rejects the request.

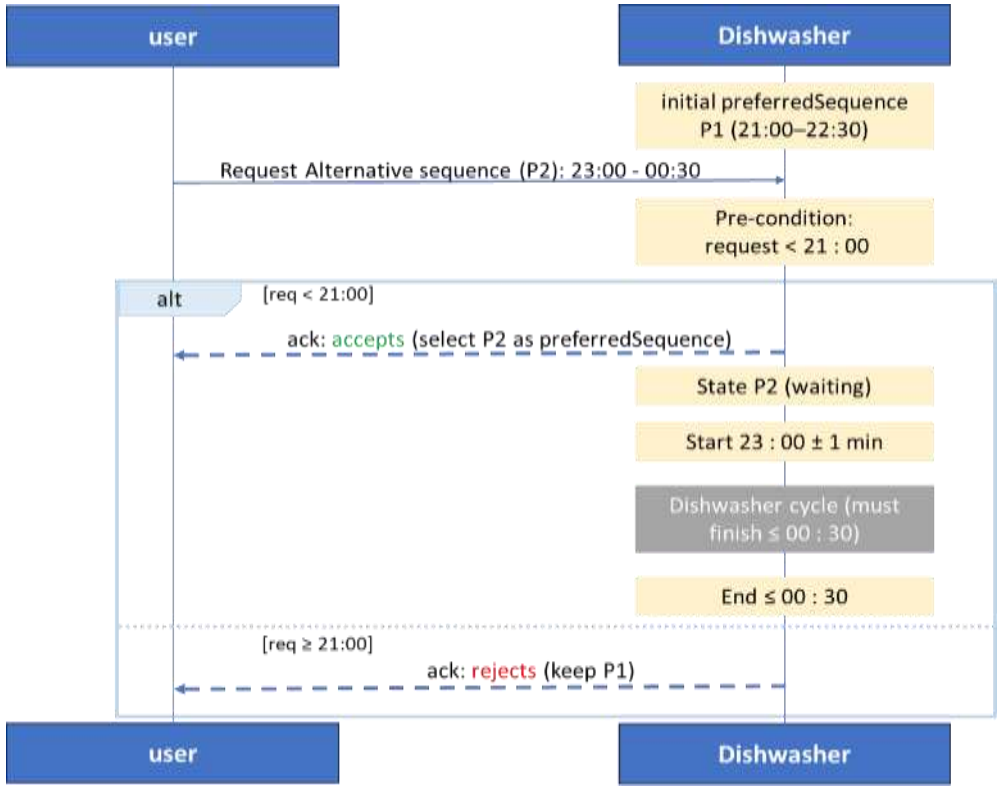


Figure: Dishwasher (Select Alternative Power Sequence) Sequence diagram

⚠ *Disclaimer: This example scenario is a simplified example used for demonstration purposes. Actual appliance behavior, requirements, or timing constraints may vary.*

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Thank you for your attention.

Diana Jimenez | Trialog
Carlos Ayon Mac Gregor | B.A.U.M.

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Interoperability Network for the Energy Transition

EMINENT

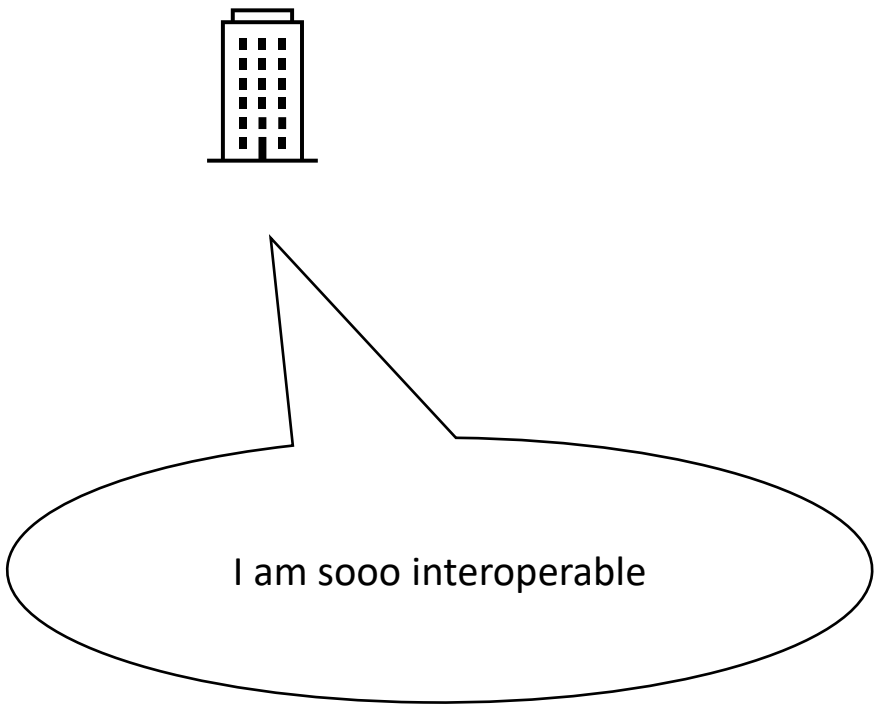
Measuring interoperability maturity

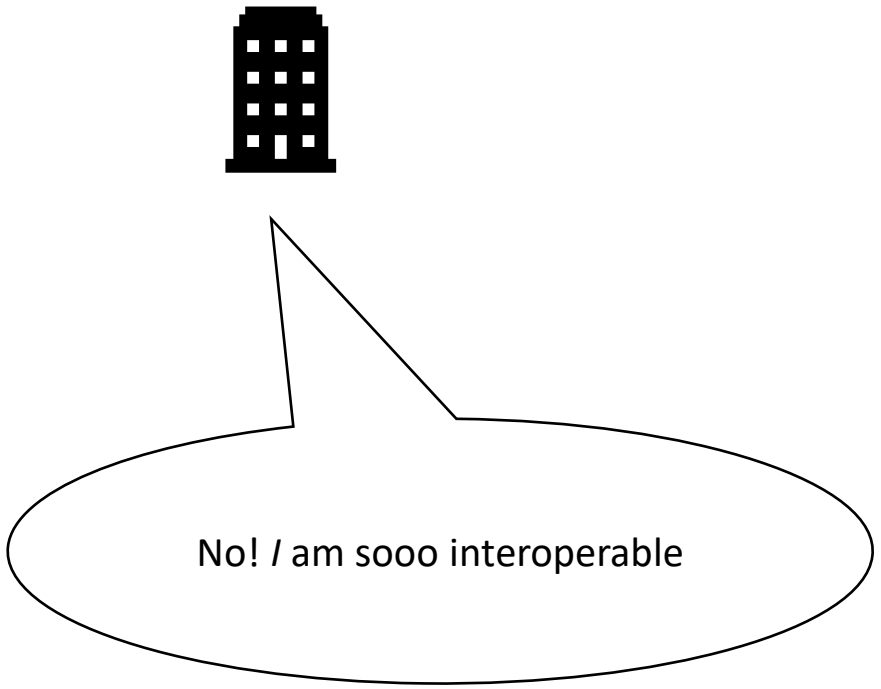
Joep van Genuchten | EPRI Europe (contractor)

Gianluca Lipari | EPRI Europe

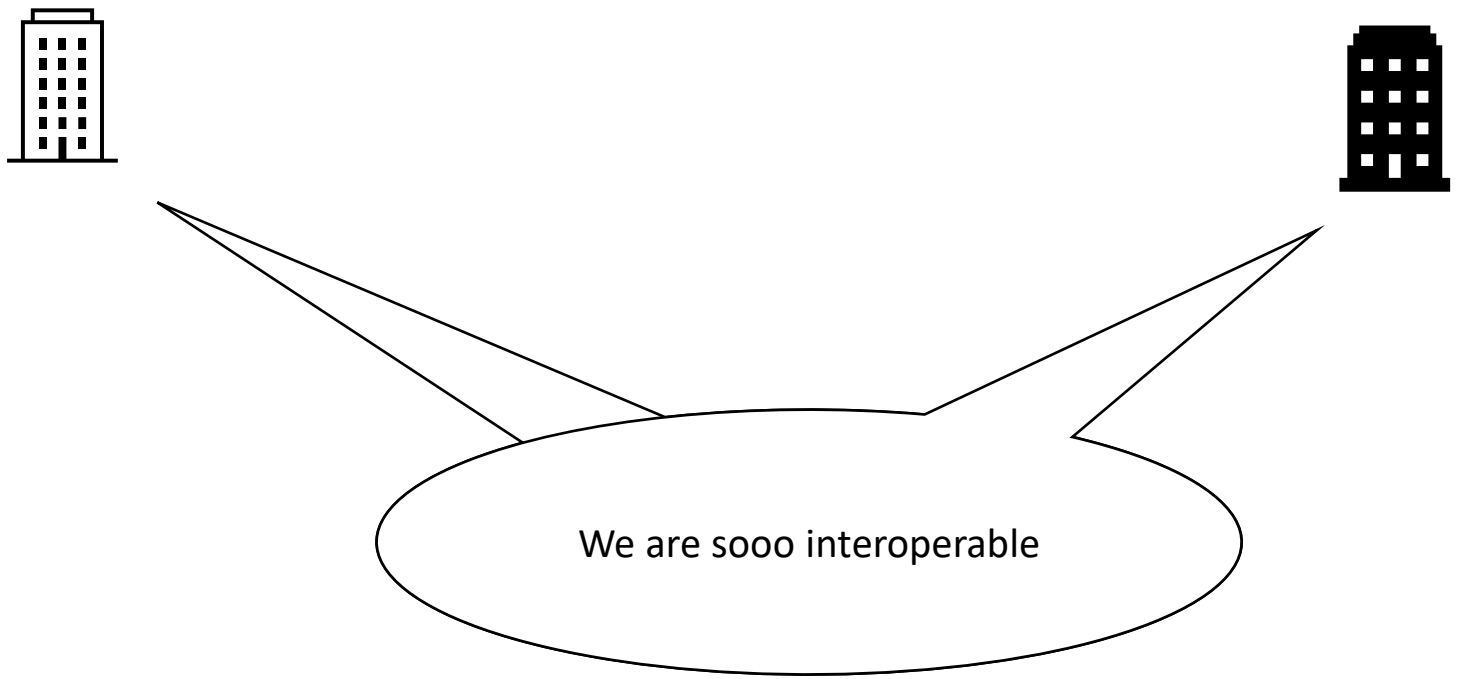
18 September 2025

The importance of communities in the pursuit of interoperability

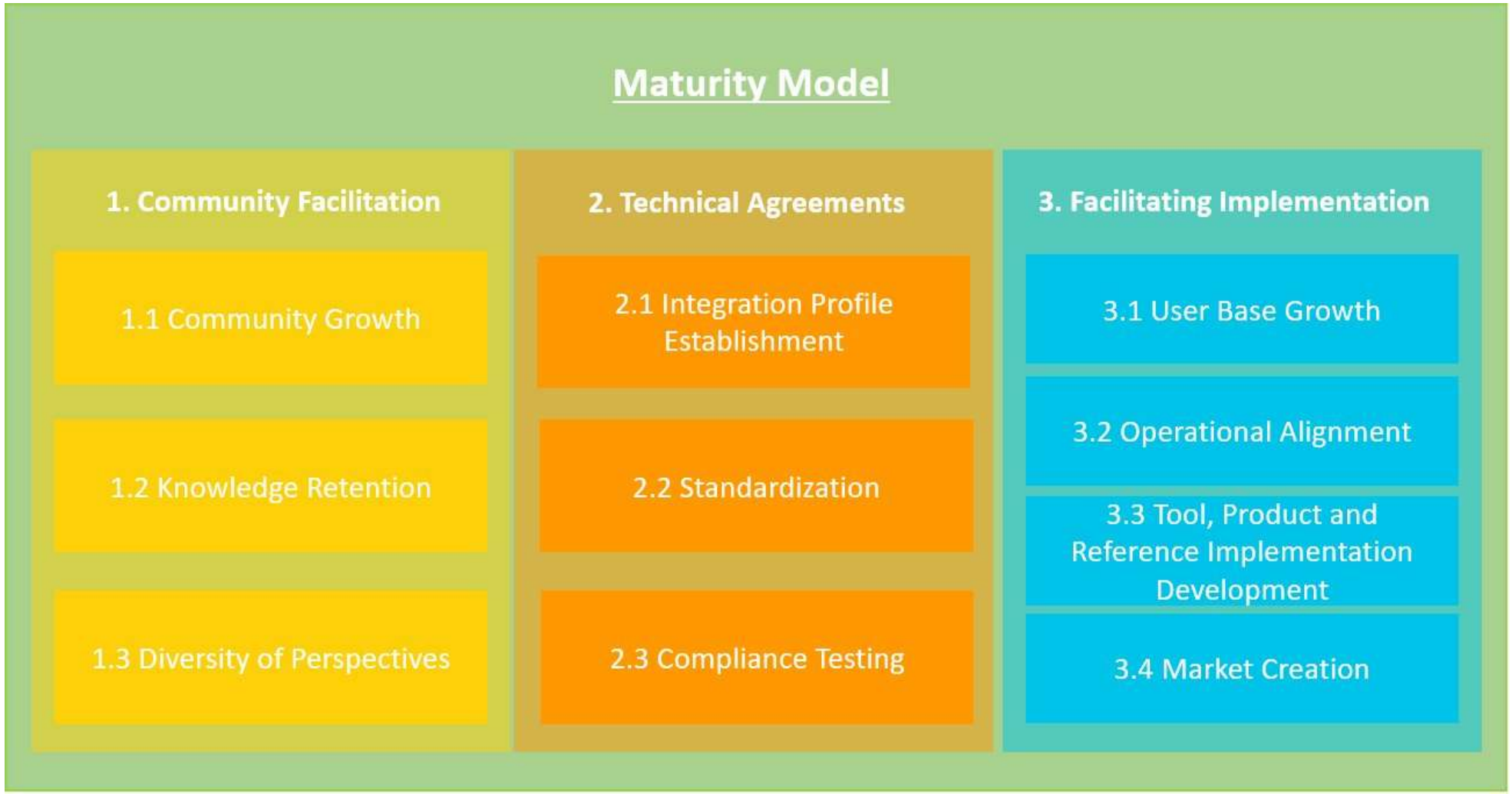




The importance of communities in the pursuit of interoperability



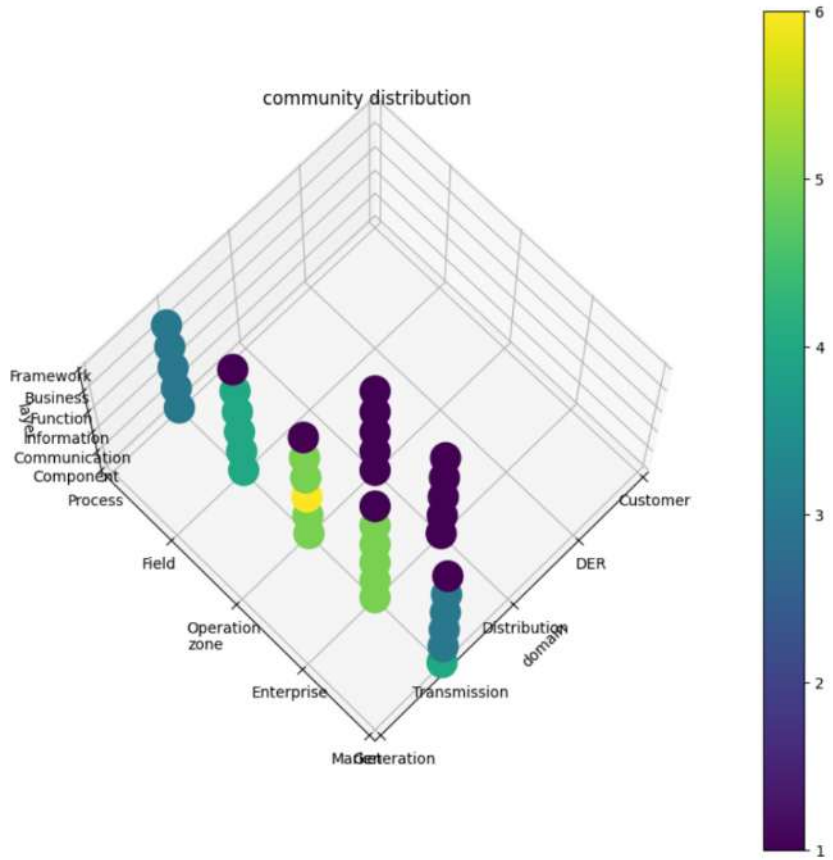
Capabilities for interoperability communities



Dimensions

Dimension	Description
Process	The activities, procedures, and workflows an organization follows to achieve its goals, emphasizing documentation, standardization, efficiency, and continuous improvement.
People and organization	The human resources and the organizational structure, including leadership, talent management, employee engagement, and culture.
Information	The management, accessibility, and utilization of data and knowledge within an organization, encompassing data governance, quality, integration, security, and analytics.
Resources	The tangible and intangible resources necessary to deliver the capability; including grid assets, buildings, vehicles, money and intangible assets like intellectual property and brand reputation.

Example results



Conclusions and lessons learned

1. Eminent has successfully identified strengths and weaknesses within multiple interoperability communities.
2. The insights from the reports have resulted in discussions about how the members of these communities could improve their collaboration.
3. 'Communities' have provided a fruitful perspective for thinking about how interoperability comes to exist.
4. The phrasing of the questionnaire is dense and could use improvement

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Thank you for your attention.

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Establishing a continuous improvement process

IntMAS

Ludwig Karg, B.A.U.M.

18 September 2025

IntMAS approved organisation

Interoperability Management and Audit System

modelled after:

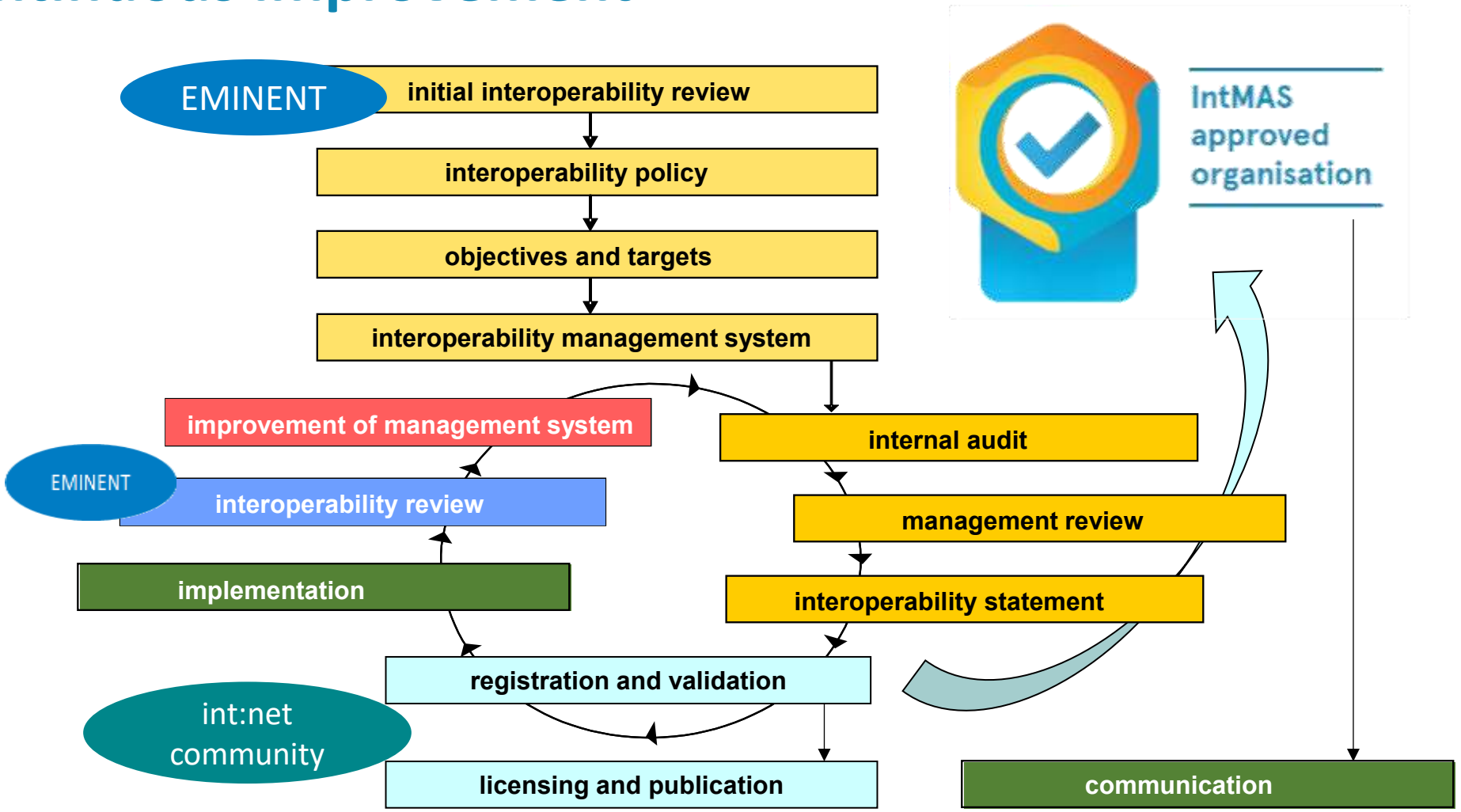
ISO 9001 CERTIFIED

ISO 26000

ISO 50001 ENERGY MANAGEMENT

EMAS

A process for continuous improvement



Guideline and tools

- ✓ reference to backgrounds
- ✓ goals and requirements
- ✓ work process
- ✓ references and links to tools
- ✓ summary of steps
- ✓ step by step guidance
- ✓ key points and hints
- ✓ **templates for the artefacts**
- ✓ **templates for the assessment**

IntMAS artefacts for management and communication

Interoperability Policy (IP)

- commitment
- strategic goals

Interoperability Performance Programme (IPP)

- SMART objectives
- action plan with selected measures (for 3 years)

Interoperability Management System (IMS)

- management goals and assignments
- management structures and responsibilities

publishable summary

IntMAS approved organisation

Interoperability Performance Statement (IPS)

- clear messages for communication and dialogue with interested parties
- full Interoperability Policy (IP)
- summaries of IMS and IPP
- result of validation

Benefits for IntMAS implementing organisations

- ✓ A systematic approach uncovers all risks and guarantees full compliance with interoperability models, standards and legislation.
- ✓ Well defined structures of procedures, programmes, documentation and continual assessment help to act efficiently.
- ✓ A complete assessment of activities and their impact on the energy domain gives a chance to allocate (the always limited) personnel and financial resources in a proper way.
- ✓ Public relation activities demonstrate commitment and enforce interoperability action by other stakeholders.
- ✓ The “int:net approved” label supports communication and creates credibility.
- ✓ Structured management systems allow for step-by-step improvement. Systemic approaches help to avoid starting too many projects at the same time.
- ✓ The open IntMAS approach allows for combining existing and new tools (e.g. EMINENT, …)

Certification and awarding process

1. goto IntMAS platform https://intmas.eu
2. upload documentation artefacts
3. wait for results of AI and EI check
4. close license contract online
5. get certificate and guidebook to use the label

And the winner is …


energie.

ecoplanet as a transformation platform
for everything related to energy

Interoperability Targets & Performance Program

Goals with respect to interoperability

- **Maximize the potential of energy management** by integrating and connecting all relevant information and market participants
- **Foster collaboration within the ecosystem** to create differentiated solutions that deliver real added value

Interoperability Performance Program

- **Proactive standards management**
- **Joint offering with partners**
- **Optimized product testing**
- **Maintain and strengthen partner network**
- **Optimise close collaboration with market participants**

2025

IntMAS APG

APG Interoperability Policy Statement

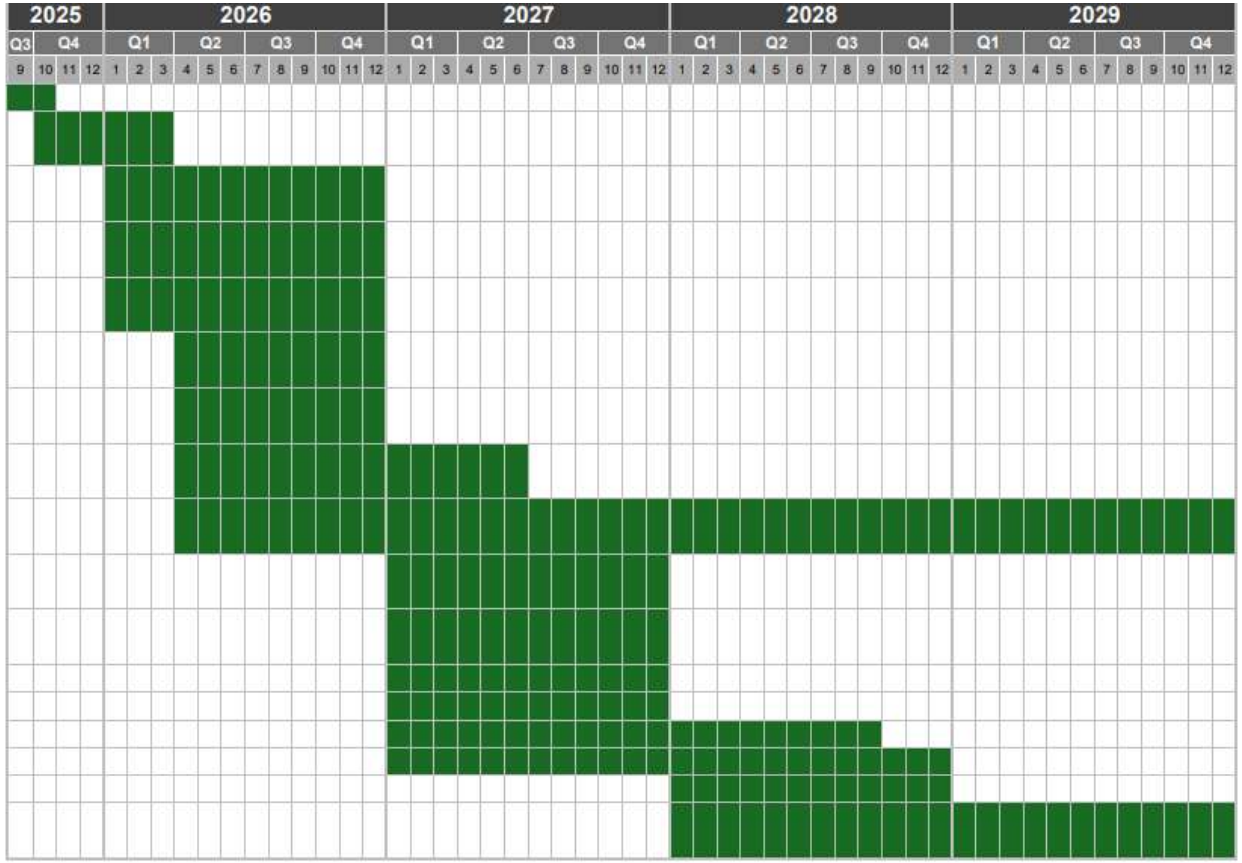
- **Purpose:** Ensure a secure, efficient, and future-proof electricity system through seamless interaction of actors, systems, and technologies.

- Key Objectives:
  - **Customer-Centric Solutions:** Clear, transparent interfaces for efficient market participation and cost reduction.
  - **Resilience & Innovation:** Enable integration of new technologies (storage, e-mobility, hydrogen) into the European power system.
  - **European Harmonization:** Promote common standards for efficient and secure cross-border operations.

- Strategic Principles:
  - **Customer Orientation & Efficiency:** Transparent, efficient processes that lower system costs.
  - **Resilience & Innovation:** Interoperability as a foundation for secure integration of new technologies.
  - **Harmonization & Standardization:**
    - External systems: use of unified European standards, data models, and interfaces.
    - Internal systems: flexible but interoperable to external systems
  - **Regulatory Compliance:** Full adherence to EU/national rules, including cybersecurity.
  - **Holistic Integration:**
    - **Horizontal:** Across organizations and borders for a consistent European system.
    - **Vertical:** From TSO to DSO to prosumers for transparency and flexibility.

APG IntMAS Action Plan

ID	Target description	Assigned to	Start	End
Int1	Approved Interoperability Policy including guiding principles.	Cross-Function Department	01.06.2025	30.10.2025
Int15	IntMAS integrated into the existing IMS so that interoperability is covered in the next IMS audit.	Cross-Function Department	01.10.2025	31.03.2026
Int2	Interoperability explicitly integrated as a strategic principle in the corporate strategy framework.	Cross-Function Department	01.01.2026	31.12.2026
Int3	Updated Software Development Guideline including clear interoperability criteria.	Cross-Function Department	01.01.2026	31.12.2026
Int16	Interoperability explicitly assessed as part of the project approval process	Cross-Function Department	01.01.2026	31.12.2026
Int5	A single, structured reference list of all key interoperability requirements relevant to APG.	System Division	01.04.2026	31.12.2026
Int6	A single, structured reference list of all key interoperability requirements relevant to APG.	Asset Division	01.04.2026	31.12.2026
Int17	SGAM-based assessment integrated into process analysis for selected critical use cases.	Cross-Function Department	01.04.2026	30.06.2027
Int4	Interoperability explicitly high-lighted by the Executive Board as a key pillar for APG's future	C-Level	01.04.2026	31.12.2029
Int7	Overview of interoperability relevance and maturity across all ongoing research and innovation initiatives	Cross-Function Department	01.01.2027	31.12.2027
Int9	Defining Interoperability for Internal Apps, updated non-functional requirements (NFR)	Cross-Function Department	01.01.2027	31.12.2027
Int10	Resourcing Strategy for Interoperability	System Division	01.01.2027	31.12.2027
Int11	Closing OT Interoperability Gaps	Asset Division	01.01.2027	31.12.2027
Int12	Integrate Interoperability in Risk Assessment	Cross-Function Department	01.07.2027	30.09.2028
Int8	Defining and Integrating Interoperability in Data Policy	Cross-Function Department	01.01.2027	31.12.2028
Int14	Resourcing Strategy for Interoperability	Asset Division	01.01.2028	31.12.2028
Int13	Defined and published standard interface patterns and data exchange formats for internal applications	Cross-Function Department	01.01.2028	31.12.2029



Something missing?

Help spreading the news!

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Interoperability Network for the Energy Transition

Int:net Final Conference

Making it happen

Rene Kuchenbuch (Offis) | Laia Guitart (E.DSO)

18 September 2025

Presentation of the Int:Net Interoperability Compass

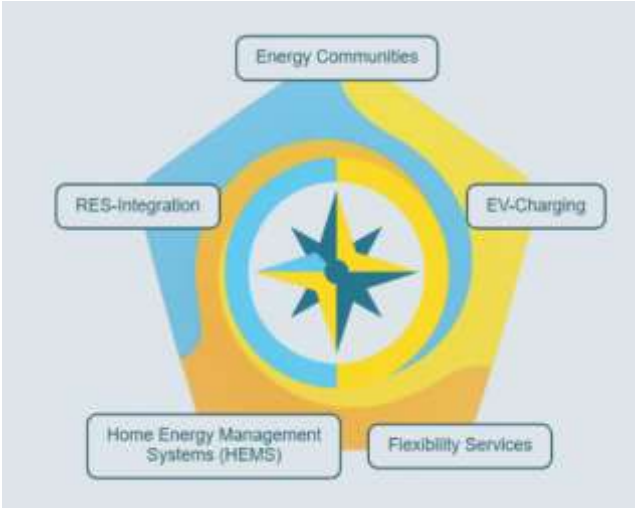
What is it?

- A single point of access to interoperability regulations, standards, roles and testing facilities connected to the Int:Net Ucs.
- A capacity building tool to raise awareness of interoperability across society.
- A tool to foster buy-in for interoperable solutions by making interoperability clear, practical and actionable.
- A one stop-hub that simplifies complex information.

For whom?

- Experts from non-technical backgrounds (economics, regulation or policy)
- Citizens, policy makers and other experts who need simple explanations and good understanding of interoperability to make the right choice.
- Practitioners and projects: Researchers, innovators and SMEs looking for a map of regulations, standards, main actors and testing facilities.

How does it work?



Step 1: Click on the UC
Step 2: Select the category to see the content boxes
Step 3: Display the content boxes

The content boxes aligns with the Int:net WPs

Overview of the content boxes:
Each content box includes the following subcategories:

1. **Regulation (WP4):**
   - Highlights relevant legal frameworks and policies.
   - Displays compliance requirements (if any).

2.Data (WP2):
   - Provides insights into the role of data in enabling interoperability.
   - Features an interactive map showcasing existing ontologies, data models, and standards.

3.Roles & Actors (WP1):
   - Maps out key stakeholders, organizations, and entities.
   - Provides descriptions of their roles in the ecosystem and how do they interact in the specific UC.

4.Interoperability Communities (WP5):
   - Displays networks and communities involved in interoperability on that specific UC.
   - Includes links to initiatives, working groups, and collaboration opportunities.

5. Testing (WP3)
   - Maps the testing facilities in Europe, that are relevant for the specific Use Case**.**

A glimpse of the compass:

- The compass is available here.

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Thank you for your attention.

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Interoperability Network for the Energy Transition

From the int:net community to the Interoperability People and Project Connector (**int:ppc**)

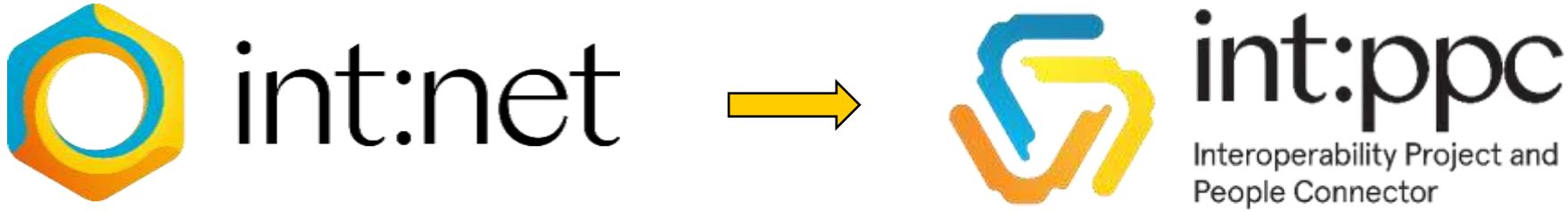
Establishing a diverse knowledge and collaboration network

Alphin Tom | B.A.U.M. Consult

18 September 2025

Today, int:net Evolves

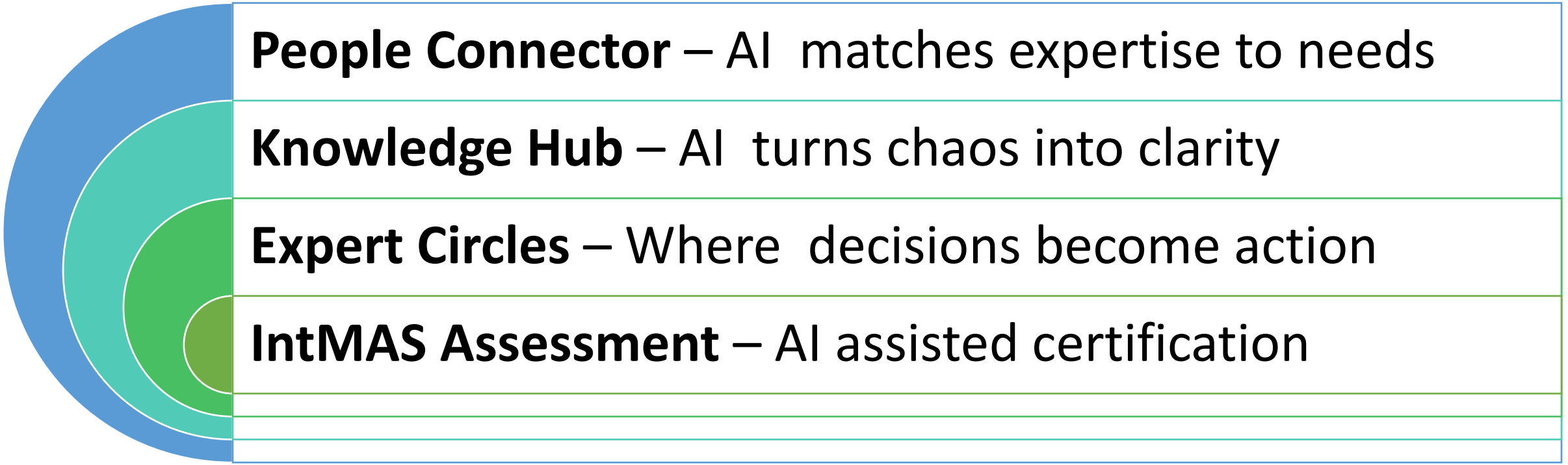
- **What we've built together:**
  - A trusted community of energy professionals
  - Proven frameworks and assessment tools
  - Validated approaches to interoperability
- **What happens next:**
  - This knowledge becomes actionable.
  - These connections multiply.
  - This community scales its impact.



The platform where our collective intelligence comes alive.

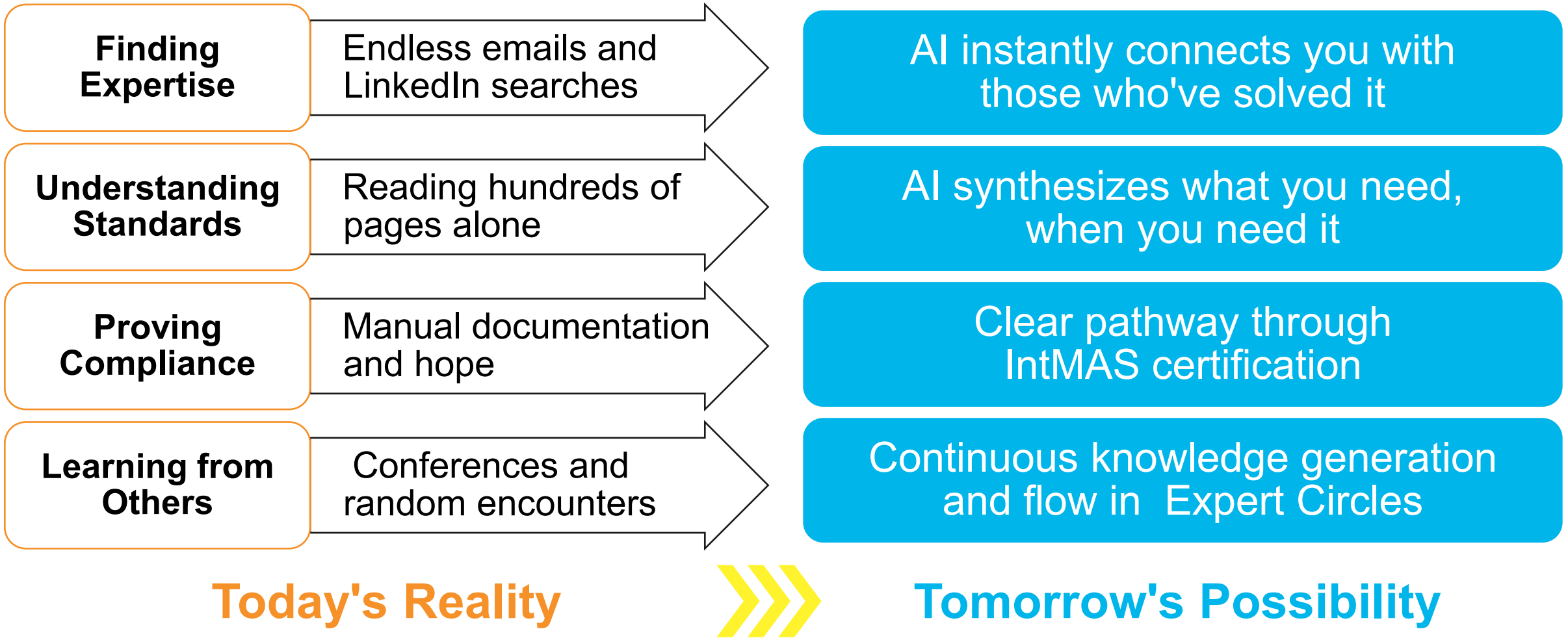
Why Even the Best Standards Aren't Enough

One Place. Four Pillars.



A place is where people, projects, and knowledge converge to accelerate interoperability.

How int:ppc Changes the Game



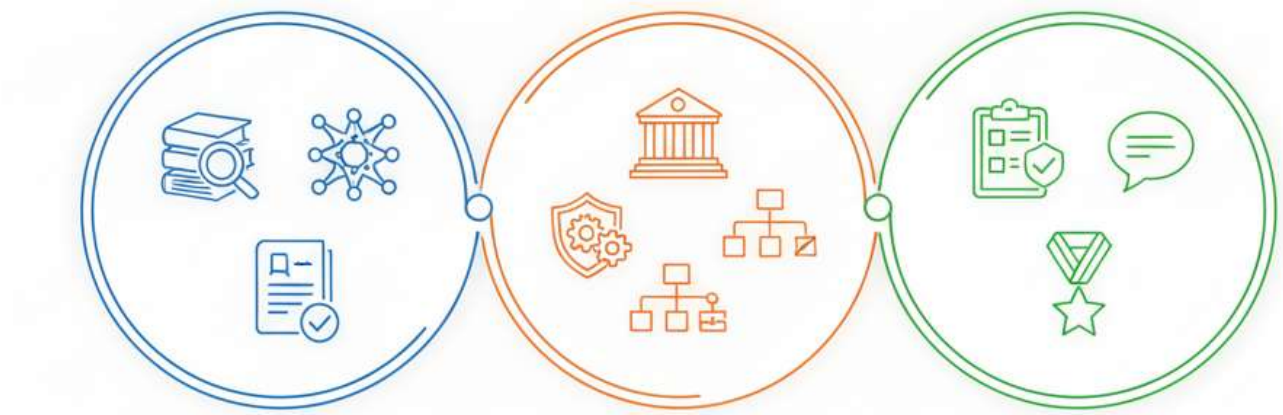
AI That Speaks Energy & Interoperability

int:ppc ai: not just any AI: energy-fluent AI!

built on int:net's knowledge

The Collaboration Architecture: Three Spaces for Real Work

Expert Circles



Knowledge Circles

Where understanding deepens

- Data model harmonization
- Standard interpretations
- Best practice documentation

Policy Circles

Where decisions form

- Regulatory alignment
- Governance frameworks
- Compliance pathways

Validation Circles

Where proof emerges

- Test results sharing
- Certification journeys
- Implementation feedback

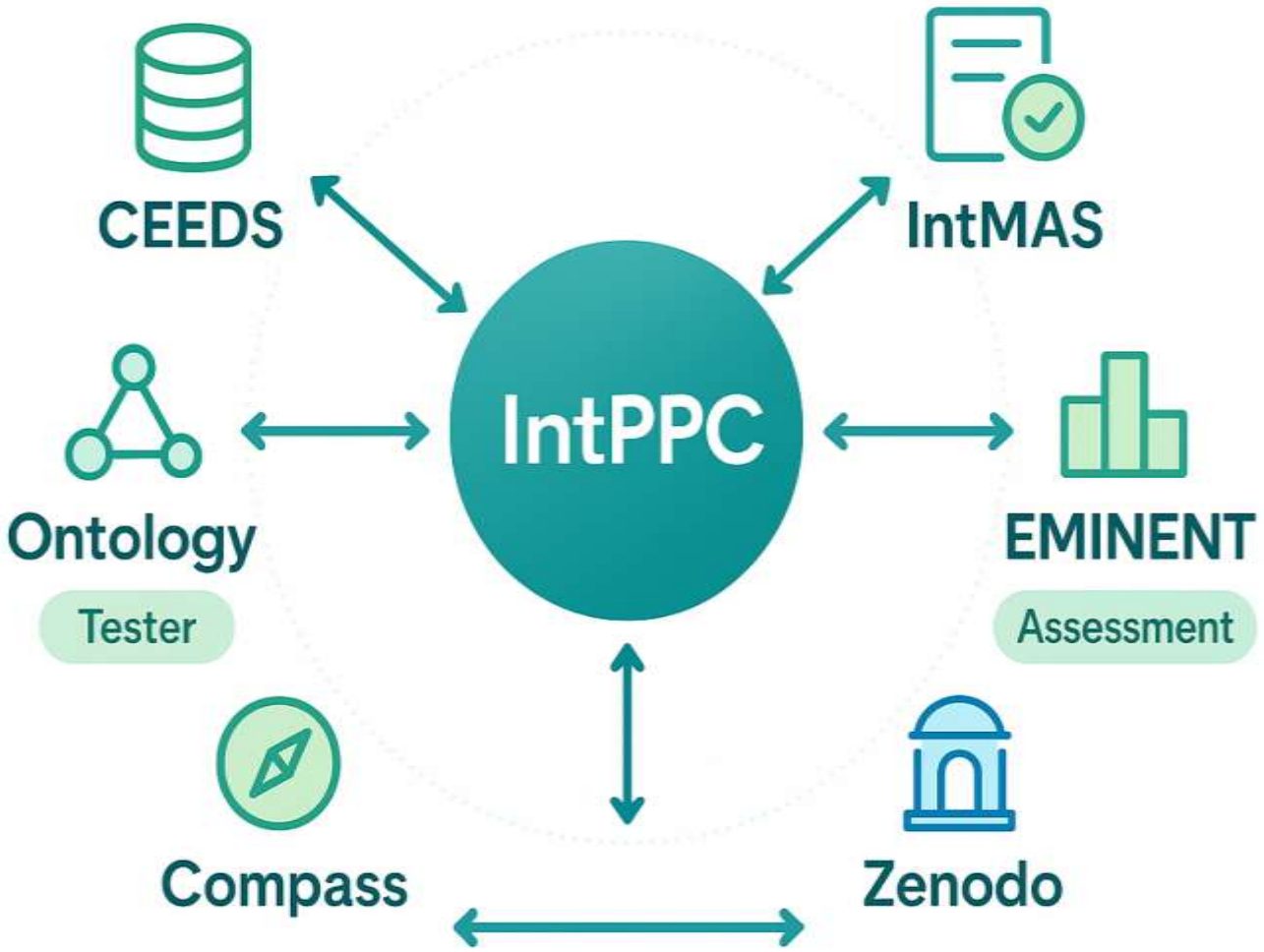
int:net + int:ppc = Exponential Impact

- What int:net proved:
  - SGAM framework extensions work
  - IntMAS assessment drives improvement
  - EMINENT measures real maturity
  - Community collaboration succeeds

- How IntPPC scales it:

int:net achievement	int:ppc enhancement
Framework validated	AI guides implementation
Assessment method proven	Process automated
Maturity measured	Progress tracked continuously
Community formed	Network effects unleashed

Everything Connected – Potential for Seamless Integrations



Available Now in Preview:

IntMAS AI Assessment Tool

1. Upload your policy documents
2. Get automated pre-assessment in minutes
3. Understand gaps before formal certification

Possible in Future

CEEDS for data models → int:ppc finds who else uses them

Ontology Tester results → int:ppc shares validation patterns

EMINENT assessment → int:ppc tracks improvement journey

What Happens Next – Start Your Journey with int:ppc

- **For int:net Community Members:**
  - **September 2025** - Platform Launch
    - Activate using int:net community e-mail
    - IntMAS AI Assessment Tool goes live
  - **October 2025** - Enhanced Content
    - All working groups become Expert Circles
    - Improved knowledge-base
- **For New Members:**
  - Register today and create a profile
  - Immediate access to all features
  - Connect with 200+ experts

Live Demo

intppc.eu & intmas.org

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Interoperability Network for the Energy Transition

Thank you for your attention.

Alphin Tom, B.A.U.M. | Brussels

Coffee Break

Please be back
at 15:00!

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Interoperability Network for the Energy Transition

Introduction to the panel: Appraisal and outlook by the EU Commission

Ludwig Karg
B.A.U.M. Consult

Mark van Stiphout
DG ENER

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Interoperability Network for the Energy Transition

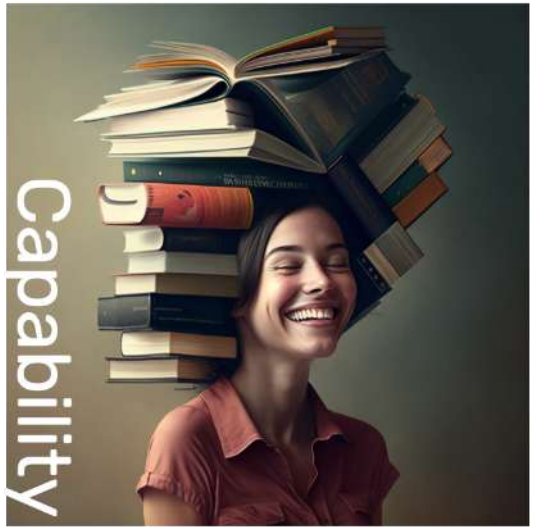
Panel: The multi-faceted interoperability challenge: learnings, expectations and plans

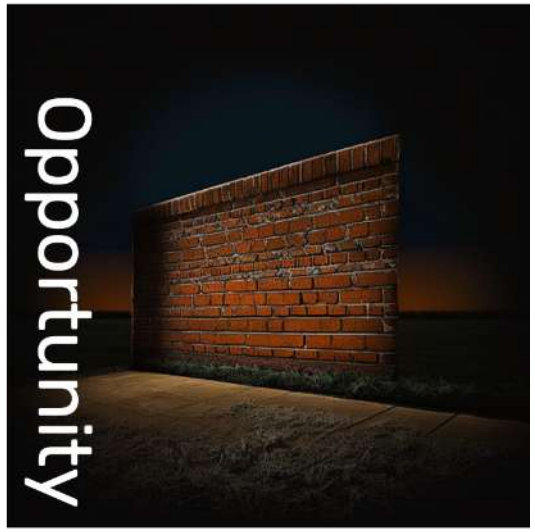
Ludwig Karg

B.A.U.M. Consult

Panelists

- Mark v. Stiphout, DG ENER
- Svetoslav Mihaylov, DG CNECT
- Michael Hübner, BMIMI / CET Partnership
- Christiane Mann, T&D Europe
- Massimo Bertoncini, Engineering / Rome Flex
- Natalie Samovich, AIOTI
- Frederik Loeckx, Flux50
- Mona Marie Bielig, Seeburg Castle University





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Interoperability Network for the Energy Transition

Closing Words

Univ.-Prof. Antonello Monti

Fraunhofer FIT
RWTH Aachen University

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Thank you for participating in the int:net Final Conference!

18 September 2025