

Design of Lifecycle-oriented Digital Product Passports for Circular ICT Goods

Javier Cano-Esteban¹, Thomas Rusiecki², Pedro Vilchez¹, **Felix Freitag**¹, Viola Gallina³, Arko Steinwender³, and Leandro Navarro¹

¹ Polytechnic University of Catalonia, Barcelona. Spain.

² Universidad Nacional de La Plata, La Plata, Argentina

³ Fraunhofer Austria, Vienna, Austria

felix.freitag@upc.edu

What is a Digital Product Passports (DPP)?

EU ESPR Ecodesign for Sustainable Products Regulation (July 2024)

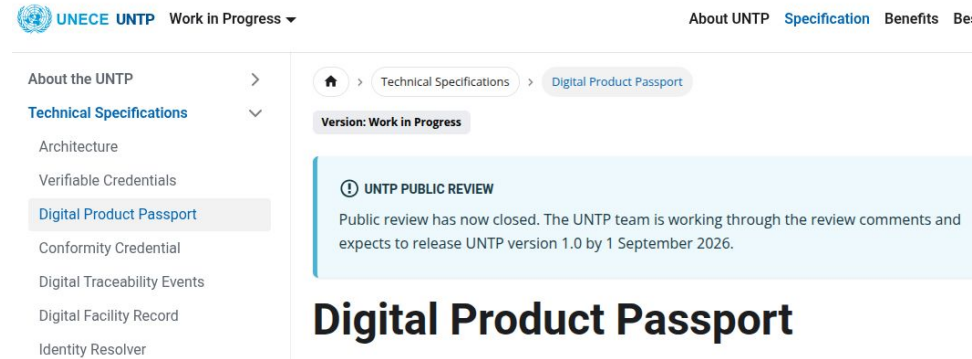
- DPPs become mandatory from market entry through end-of-life

CIRPASS2 DPP Definition: "A structured collection of product-related data with a pre-defined scope and agreed data management and access rights, conveyed through a unique identifier, and accessible via electronic means through a data carrier."

Standardization landscape of DPPs

- **UN Transparency Protocol (UNTP):**

- Built on W3C Decentralized Identifiers (DIDs) & Verifiable Credentials



- **CEN/CLC/JTC 24 - Digital Product Passport - Framework and System**
 - published in May 2026 standards for the ESPR (2024)



- **ITU-T with DDP work items**



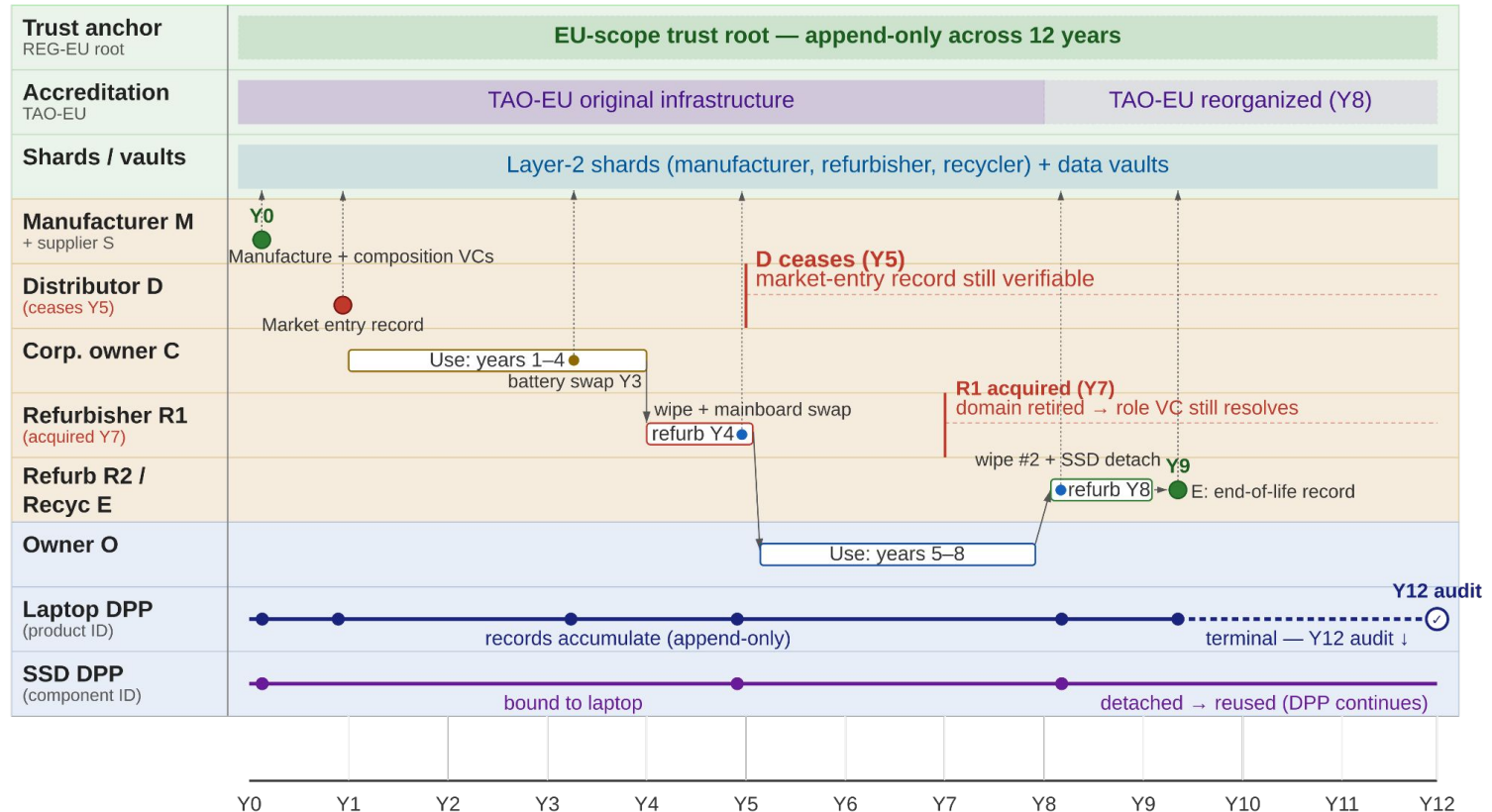
ICT Goods Are Not Ordinary Supply-Chain Products

- Simultaneously products and IoT devices
 - generating operational data (usage, configuration changes) throughout their life, not only at point of sale
- Modular by design
 - batteries, storage, displays, mainboards inspected, replaced or reused independently (laptops, server racks, modular smartphones)
- Embed storage components carrying personal or confidential data that must be sanitised before resale

The operational phase (repair, refurbishment, reuse) is where circular value is created, but existing DPP frameworks address it only in a generic way

A scenario for an ICT good (computer)

Figure I.1 — Lifecycle scenario across 12 years



We identify four open issues for ICT Goods DPPs

1

Operational lifecycle modelling

Include repair, refurbishment, reuse and recycling events after market entry (circular economy)

2

Component-level DPP continuity

Include swapped modules in verifiable product history

3

Verifiable data sanitisation

Provide evidence that data on embedded storage was securely wiped (privacy)

4

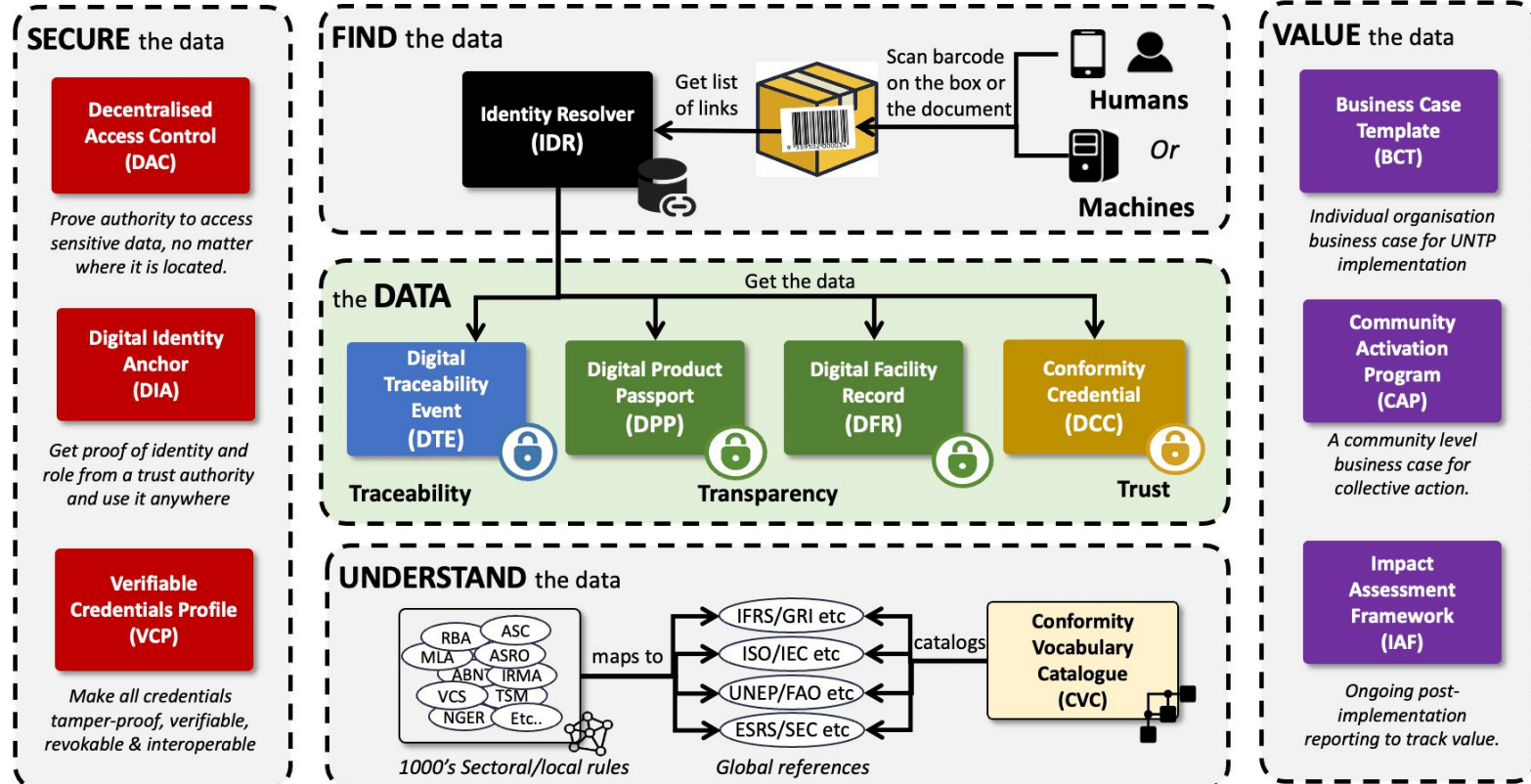
Unified trust for credentials & sensors

Extend trust from human-issued credentials to automated evidence from sensors/tools

Objective

Create a long-lived, interoperable, verifiable record (DPP) for a physical ICT good whose composition, custodian, and accreditation context can change over time?

Base of the solution: United Nations Transparency Protocol (UNTP)



Contributions

- Design an [ICT lifecycle credential profile](#) on top of UNTP + an ICTGoodsPassport extension with CHID:PHID identifier
- Validate with an [open-source prototype](#)
- Demonstrate with [real-world refurbishment pilot](#) on 40 devices

The ICT Lifecycle Profile: Six Structural Elements

(i) Persistent identifier

resolvable across the good's lifecycle and organisational changes

(ii) Lifecycle-aware data model

static attributes, dynamic characteristics, time-stamped events

(iii) Lifecycle evidence

credentials from trusted actors + data from sensors / inspection tools

(iv) Structural representation

hierarchy of products, modules and components

(v) Trust & disclosure model

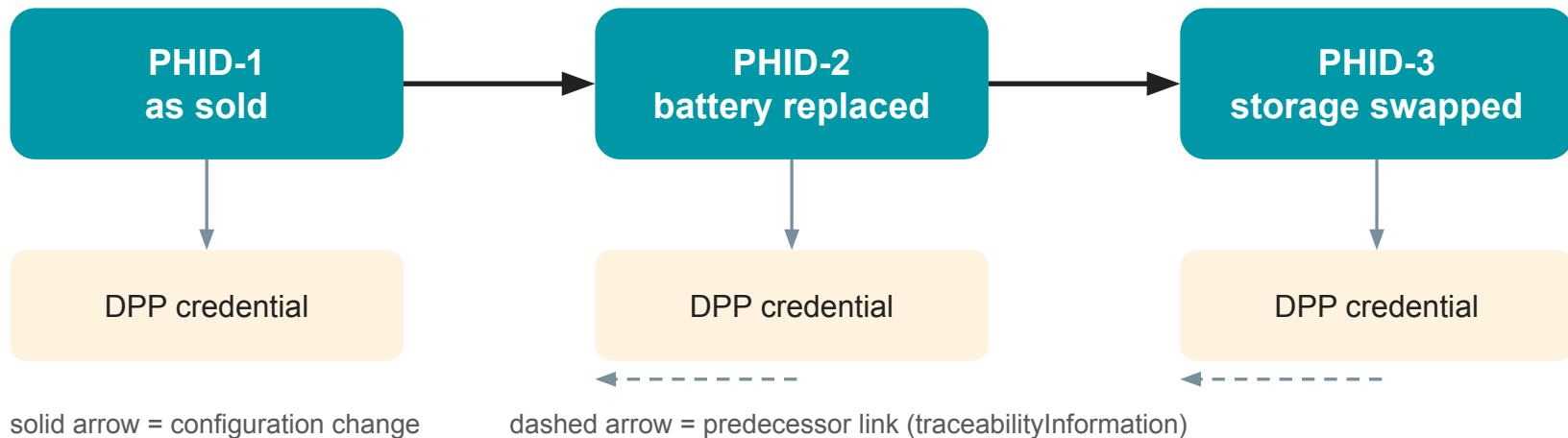
how evidence is verified and selectively exposed to verifiers

(vi) DID method & trust infrastructure

keeps identifiers resolvable beyond an issuing organisation's lifetime

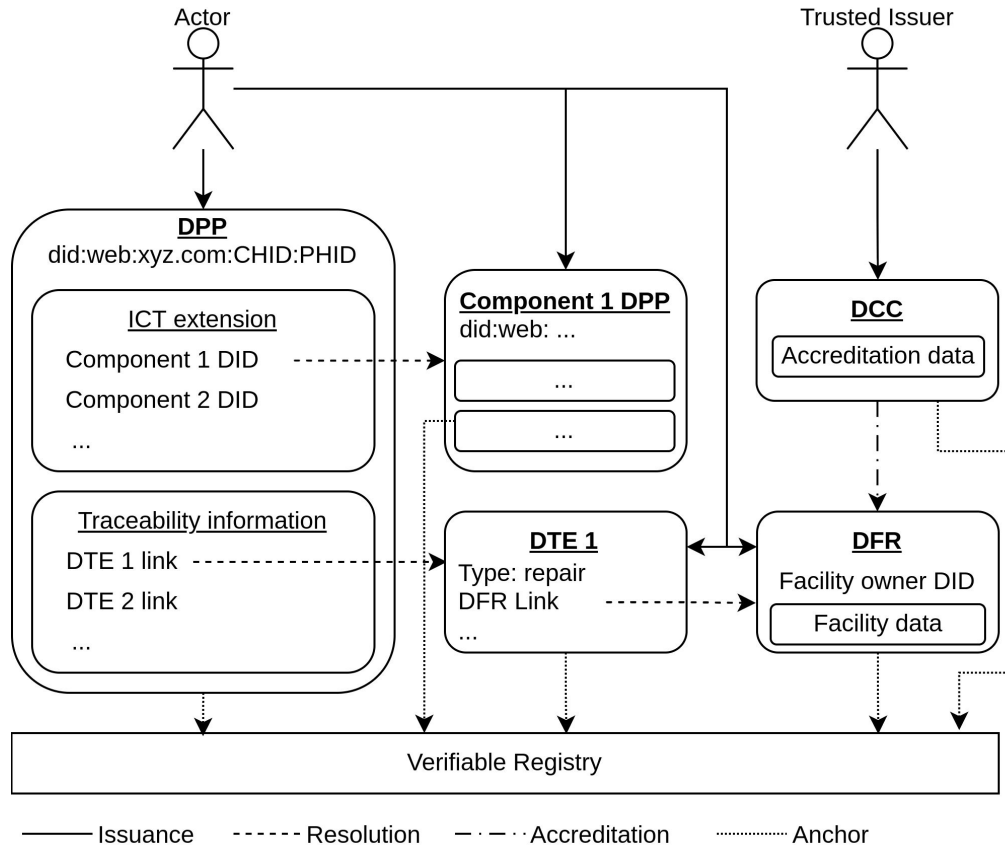
A Two-Part Identifier: CHID : PHID

CHID (Chassis ID) — derived from immutable chassis attributes: stable for the device's entire lifespan

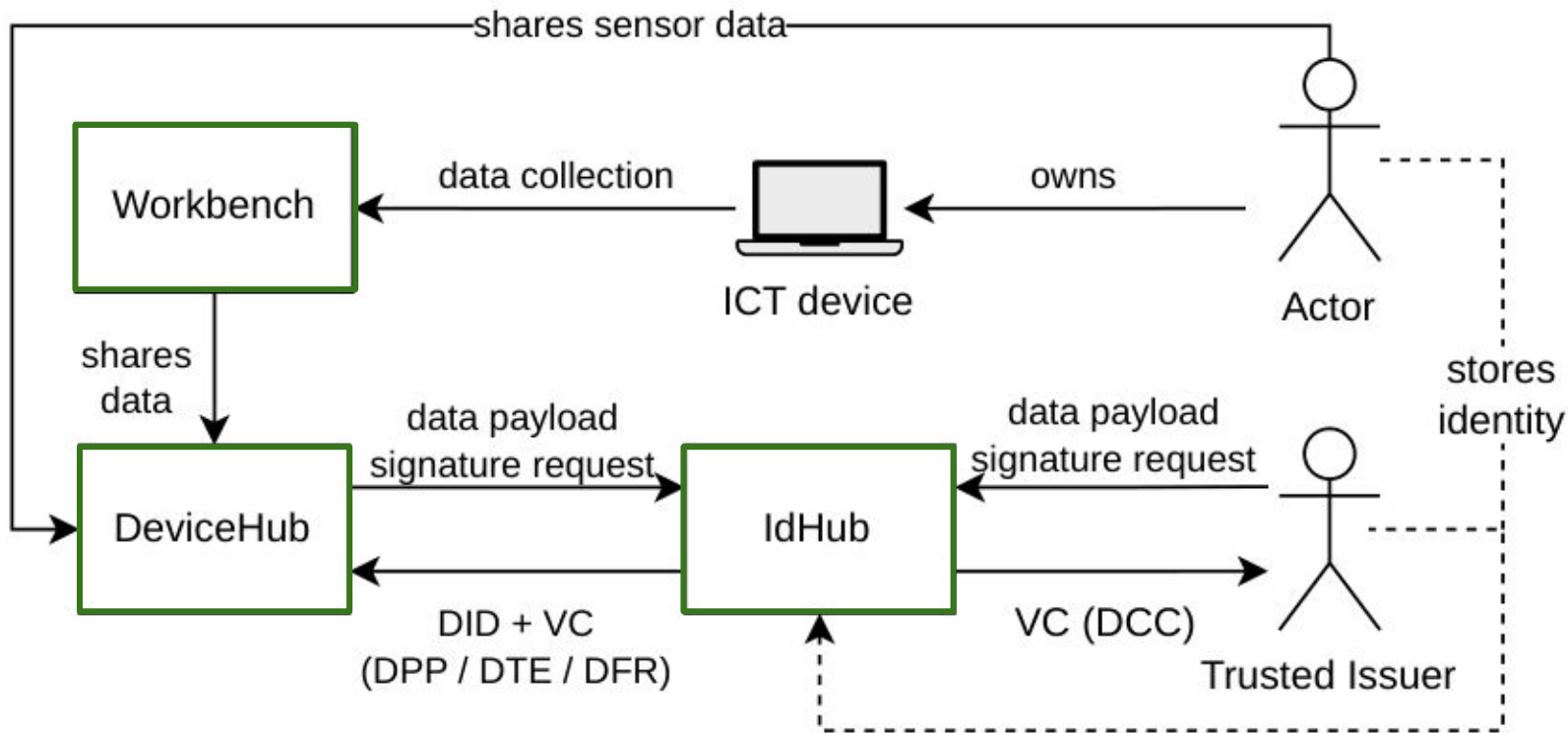


Any component substitution triggers a new PHID and a new linked DPP — CHID stays constant.

Solution model



Prototype implementation with **eReuse** tools



A DPP Credential, in Practice

```
"type": ["VerifiableCredential", "DigitalProductPassport"],
"issuer": { "id": "did:web:refurb.example.org" },
"credentialSubject": {
  "id": ".../devices/CHID-7F3A:PHID-12B9",
  "ictGoodsPassport": {
    "chassisId": "CHID-7F3A",
    "productHardwareId": "PHID-12B9",
    "itemConditionGrade": "A" },
  "traceabilityInformation": [{
    "eventType": "refurbishment",
    "previousDPP": "urn:uuid:9a2b...-dpp-prev" }]
}
```

Abbreviated UNTP DPP credential for a refurbished laptop: CHID:PHID anchoring, the ICTGoodsPassport extension, and a link to the predecessor DPP.

Dashboard

Users

Roles

Credentials

- Object DIDs
- View credentials
- Organization's wallet
 - Manage Identities
 - View org. credentials
- Webhook Tokens

Templates

Data

Credential management

Manage identities

eIDAS2

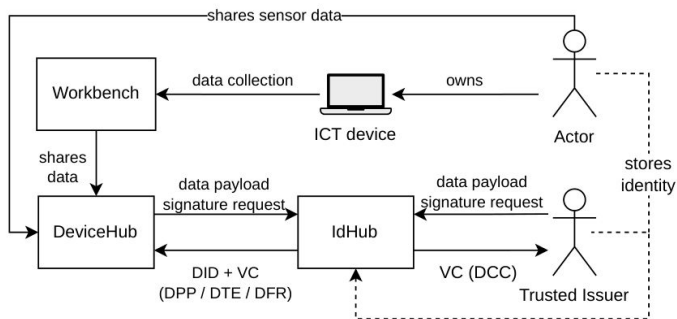
Date	Label	ID	Edit	Delete	Service URI endpoint
May 26, 2026, 4:55 p.m.	DEMO	did:web:lab15.ereuse.org:s4BrYs	Edit	Delete	—
May 26, 2026, 8:12 p.m.	test_fha	did:web:lab15.ereuse.org	Edit	Delete	—
May 28, 2026, 4:35 p.m.	asd	did:web:lab15.ereuse.org:test	Edit	Delete	—
June 3, 2026, 6:35 p.m.	test_localhost	did:web:lab15.ereuse.org:test_localhost	Edit	Delete	—

Add DID identity +

eIDAS1

Date	Label	ID	Edit	Delete	Service URI endpoint
------	-------	----	------	--------	----------------------

Add identity eIDAS1 +

IdHub <https://lab15.ereuse.org/>

 Dashboard Users Roles Credentials

- Object DIDs
- **View credentials**
- Organization's wallet
- Webhook Tokens

 Templates Data

Credential management

View credentials

Type	Details	Issued	Status	User	View
['VerifiableCredential', 'DigitalTraceabilityEvent']	An array of Traceability Events as a VC	June 8, 2026, 8:04 p.m.	Issued	admin@lab15.ereuse.org	
['VerifiableCredential', 'DigitalTraceabilityEvent']	An array of Traceability Events as a VC	June 8, 2026, 8:04 p.m.	Issued	admin@lab15.ereuse.org	
['VerifiableCredential', 'DigitalFacilityRecord']	A digital verifiable credential holding facility performance information.	July 1, 2026, 7:43 a.m.	Issued	admin@lab15.ereuse.org	
['VerifiableCredential', 'DigitalProductPassport']	Extended UNTP DPP schema for ICT product characteristics (currently computers only)	July 1, 2026, 7:55 a.m.	Issued	admin@lab15.ereuse.org	

Previous 1 2 **3**

Issued credentials

Issuer

Admin

Devices

All

Lots

Evidences

Device

[Device / Details](#)

A91763

Add a note

Assign to lot

Print Label

Change state (None)

[General details](#)[Properties](#)[Digital Credentials](#)[Lots](#)[Components](#)[Evidences](#)[Web](#)[Log](#)[Environmental impact](#)

Digital Credentials

Issue DPP

Manage Verifiable Credentials issued for this device, including Product Passports and Traceability Events.

Issued Date	Credential Type	Description	Issued To	Issuer	Actions
2026-05-28 13:11	DPP	Digital Product Passport	Device (609506d2)	admin@example.org	View
2026-05-28 13:10	DIDDOC	DID Document for ereuse24:a9176368f25b48b66dd5d8ebba096f2f02cc6cdf4999c331cb93a6b790276634	Device (828cdcb1)	admin@example.org	View

Showing 1 to 2 of 2

Hosted credential

Issue Dismantle Traceability Event

Select the materials or components recovered from this device. This will issue a Traceability Event, a new item to the inventory, and permanently update the device state.

Component Type	Amount	Description / Name
Desktop	1	
Confirm Dismantle		

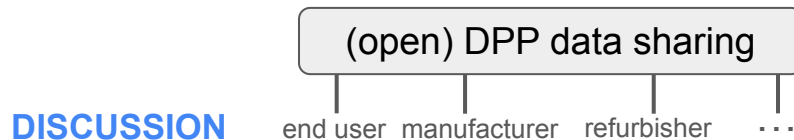
Real-World Pilot: EKOa, National University of La Plata, Argentina



refurbished laptops
donated to students

- DPP prototype used in real-world operational context
- 40 refurbished laptops by EKOa. 3 month process.
 - **Workbench** tool automated characterization of computer hardware
 - **DeviceHub-IdHub** for computer **DPPs**
 - **DTEs** for EKOa's refurbishment steps
- Result
 - Demonstration of DPP workflows by refurbisher.
 - End user adoption gap remains

Discussion and Conclusion



- The DPP can be interpreted as a shared, trusted **information registry**, featuring:
 - lower transaction costs,
 - reduced information asymmetry
 - new lifecycle-oriented services

CONCLUSION

- ICT specific DPP demonstrated with ICT UNTP-based lifecycle profile, open-source prototype, real-world pilot
- ICTGoodsPassport extension interoperable with the broader UNTP DPP ecosystem
- Future work: towards UNTP v1.0, DPP architecture, broader actor inclusion.

Thank you for your attention!

This work was funded by the Spanish Ministerio de Ciencia Innovación y Universidades PID2023-146066OB-I00, AEI 2023 Knowledge Generation Projects; the Recovery and Resilience Mechanism of the European Union, and by the European Union NextGenerationEU.



Funded by
the European Union

