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From European Large-Scale Pilots to National Higher Education Adoption: Operationalising EUDI Wallet–based Digital Credentials in Germany

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Abstract

The revision of the eIDAS Regulation and the introduction of the European Digital Identity Wallet (EUDI Wallet) (European Commission, latest public version -a) create new opportunities for issuing and verifying digital educational credentials across Europe. The European Large-Scale Pilot Digital Credentials for Europe (DC4EU) has produced a comprehensive set of artefacts, including reference user journeys, data models based on the European Learning Model (ELM), and technical and governance frameworks for EUDI Wallet–based credentials across education sectors. However, the adoption of these artefacts within national education systems and institutional IT environments remains an open challenge. This paper presents DC4EU-DE, a newly launched national initiative that aims to explore the adoption of EUDI Wallet–based educational credentials in Germany. Rather than reporting empirical results, the paper focuses on the conceptual foundations, objectives, and planned methodological approach of the initiative. Higher education serves as the initial entry point due to institutional readiness, while secondary and vocational education are explicitly considered as applicable contexts. The paper analyses the relevance of DC4EU artefacts for national adoption, proposes a structured approach for embedding these artefacts into a national education initiative, and motivates the selection of initial education-related use cases and user journeys. In addition, it outlines a conceptual technical architecture that preserves institutional autonomy and interoperability while aligning with the European EUDI Wallet ecosystem. By documenting the design and scope of an early-stage national initiative, this paper contributes a structured perspective for bridging European pilot results and coordinated national adoption of digital educational credentials.

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1 Introduction

The revision of the eIDAS Regulation and the introduction of the European Digital Identity Wallet (EUDI Wallet) establish a common European framework for trusted digital identity and attribute exchange (European Commission, 2021). Within the education domain, this framework enables the issuance, storage, and verification of digital educational credentials under the control of the credential holder, with the potential to improve interoperability, reduce administrative effort, and support cross-border mobility across different education sectors.

In this context, the European Large-Scale Pilot Digital Credentials for Europe (DC4EU) addressed the feasibility of EUDI Wallet–based credentials for education and professional qualifications at European level. The project developed and validated a comprehensive set of artefacts, including reference user journeys for educational institutions, data models based on the European Learning Model (ELM), trust and governance approaches aligned with eIDAS 2.0, and technical components supporting credential issuance and verification. DC4EU covered multiple education sectors, including higher education, vocational education and training, and secondary education, and demonstrated interoperability with existing European infrastructures such as EMREX and Europass.

While the DC4EU pilots demonstrated large-scale technical approaches, they did not explicitly address the contextual and organisational specificities of national education systems.

To address this gap, the initiative DC4EU-DE has been launched as a national effort to explore the adoption of EUDI Wallet–based educational credentials in Germany. DC4EU-DE builds explicitly on the artefacts produced by DC4EU and aims to provide a structured framework for their application within national education contexts. While higher education currently serves as the primary entry point due to institutional readiness and governance structures, the initiative is explicitly designed to remain applicable to secondary and vocational education. At its current stage, DC4EU-DE focuses on defining objectives, identifying suitable use cases and user journeys, and outlining a methodological approach for future implementation and evaluation.

The paper addresses the following research questions:

- RQ1: Which artefacts produced by the DC4EU Large-Scale Pilot are relevant for the adoption of EUDI Wallet–based educational credentials in a national education context, with a particular focus on higher education but applicability beyond higher education, including secondary and vocational education?
- RQ2: How can these artefacts be systematically embedded into a national initiative aiming to operationalise EUDI Wallet–based educational credentials across different education sectors, starting from higher education?
- RQ3: Which initial education-related use cases and user journeys provide the highest expected value for an early-stage adoption of EUDI Wallet–based credentials, and how do these differ across higher, secondary, and vocational education contexts?

The contributions of this paper are threefold. First, we analyse the relevance of artefacts developed in the DC4EU Large-Scale Pilot for a national initiative targeting the adoption of EUDI Wallet–based educational credentials across education sectors, with an initial focus on higher education. Second, we propose a structured approach for embedding DC4EU artefacts into a national education initiative, addressing organisational, technical, and governance-related aspects. Third, we identify and justify an initial set of education-related use cases and user journeys suitable for early-stage implementation of EUDI Wallet–based educational credentials, considering similarities and differences between higher, secondary, and vocational education.

By explicitly focusing on the design and objectives of an early-stage national initiative, this paper contributes a structured perspective for educational institutions, IT service providers, and policy stakeholders seeking to move from European pilot results towards coordinated national adoption.

2 Background: The DC4EU Educational Pilot

DC4EU focused on the development of a coherent European framework rather than on isolated technical components. Its scope covered multiple education sectors, including higher education, vocational education and training, and secondary education, reflecting the diversity of governance structures and credential types across Europe

A central outcome of DC4EU is the definition of reference user journeys that describe end-to-end credential workflows from the perspectives of credential holders, issuers, and verifiers. These user journeys capture recurring educational processes such as enrolment confirmation, issuance of educational or professional identifiers, and the presentation and verification of achievement credentials (DC4EU Consortium, 2024c). Rather than prescribing institutional processes, the user journeys provide abstract, role-based descriptions that can be adapted to different organisational and legal contexts. In parallel, DC4EU established a common semantic foundation for educational credentials by adopting the European Learning Model (ELM) (European Commission, latest version. -b) as its primary data model. ELM-based schemas were used to describe a range of educational credentials, including qualifications, microcredentials, and attestations of student status. By relying on ELM, DC4EU aimed to align digital credential representations with existing European transparency and recognition frameworks (EMREX Community, n.d.), while maintaining compatibility with sector-specific requirements across higher, secondary, and vocational education (European Commission).

From a technical perspective, DC4EU explored different trust and deployment models compatible with eIDAS 2.0. These included classical public key infrastructure (PKI)–based approaches as well as decentralised trust mechanisms leveraging the European Blockchain Services Infrastructure (EBSI). The pilot did not prescribe a single technical architecture but instead documented alternative implementation paths, allowing participating institutions to select approaches aligned with their existing infrastructure, governance responsibilities, and regulatory positioning.

The results of DC4EU are documented in a comprehensive set of public deliverables, including business and governance blueprints (DC4EU Consortium, 2024a), technical specifications, user journey descriptions, data model definitions, and prototype implementations (DC4EU Consortium, 2024b). Taken together, these artefacts provide a structured reference framework for EUDI Wallet–based educational credentials at European level. However, they do not address in detail how such artefacts can be embedded into national education systems or institutional IT environments outside the controlled conditions of a pilot.

3 The DC4EU-DE Initiative: Scope, Objectives, and Governance

The initiative DC4EU-DE has been launched to explore the adoption of EUDI Wallet–based educational credentials within the German education system, building on the artefacts and reference framework established by the European Large-Scale Pilot DC4EU. Its primary purpose is to provide a structured national context in which European concepts, data models, and user journeys can be examined with respect to their applicability under real institutional and governance conditions. DC4EU-DE is explicitly positioned as an early-stage and exploratory initiative. At its current phase, it does not

aim to deliver production-ready services or to evaluate large-scale deployments. Instead, it focuses on defining scope, objectives, and methodological foundations that enable future implementation, testing, and evaluation activities. By doing so, the initiative seeks to create a transparent and reusable reference for educational institutions and stakeholders interested in EUDI Wallet–based credentials.

3.1 Scope and Education Sectors

The scope of DC4EU-DE encompasses multiple education sectors, reflecting the cross-sectoral orientation of DC4EU. Higher education serves as the initial entry point, primarily due to the relative maturity of institutional governance structures, existing experience with cross-border data exchange, and the availability of digital campus infrastructures. However, the initiative is not limited to higher education. From its outset, DC4EU-DE is designed to remain compatible with secondary education and vocational education and training (VET), both in terms of conceptual framing and data modelling. This sector-agnostic design approach acknowledges that while concrete use cases, legal constraints, and organisational processes differ between education sectors, many foundational elements—such as credential semantics, trust relationships, and wallet-based presentation flows—are shared. As a result, DC4EU-DE treats higher education as a pragmatic starting point rather than an exclusive target domain.

3.2 Objectives of the Initiative

The objectives of DC4EU-DE can be grouped into three main areas.

First, the initiative aims to analyse the relevance of DC4EU artefacts for national adoption. This includes reference user journeys, ELM-based data models, and documented trust and deployment approaches. The focus is on identifying which artefacts are suitable as-is for a national context and which require contextualisation or extension to align with national education structures and institutional practices.

Second, DC4EU-DE seeks to define and justify an initial set of education-related use cases and user journeys that are suitable for early-stage exploration. These use cases are selected based on their expected value for institutions and learners, their alignment with DC4EU reference scenarios, and their feasibility within existing organisational and technical constraints. Rather than striving for completeness, the initiative deliberately limits the initial scope to a manageable set of representative scenarios.

Third, the initiative aims to outline a structured approach for future implementation and evaluation. This includes the identification of relevant stakeholders, clarification of institutional roles, and definition of high-level technical and organisational building blocks required to support EUDI Wallet–based credential workflows. The objective is not to prescribe a single solution, but to provide a transparent framework that can guide subsequent implementation activities.

3.3 Governance and Collaboration Model

DC4EU-DE follows a collaborative governance model that reflects both national education structures and the decentralised nature of digital credential ecosystems. The initiative does not assume a central issuing authority or a single technical operator. Instead, it builds on the principle that educational institutions retain control over credential issuance while relying on shared frameworks for interoperability, trust, and compliance. Collaboration with educational institutions plays a central role in the initiative. Selected institutions participate in the definition of use cases and user journeys, providing domain-specific knowledge about academic processes, administrative constraints, and existing IT systems. This collaboration is essential to ensure that the initiative remains grounded in institutional reality rather than abstract design assumptions.

At the same time, DC4EU-DE maintains close alignment with European-level developments, particularly the outputs of DC4EU and the evolving EUDI Wallet ecosystem. This alignment ensures that national exploration does not diverge from European interoperability objectives and that insights gained at national level can be fed back into broader discussions on digital educational credentials.

4 Methodology and Planned Approach

The methodological approach of DC4EU-DE is designed to support the early-stage exploration of EUDI Wallet–based educational credentials in a national education context. Given the exploratory character of the initiative, the methodology does not aim at empirical evaluation or large-scale validation. Instead, it focuses on structured analysis, informed design decisions, and the preparation of future implementation and evaluation activities. The approach builds on three core methodological principles: reuse of validated European artefacts, incremental scoping through representative use cases, and close collaboration with educational institutions.

4.1 Reuse and Analysis of DC4EU Artefacts

As a starting point, DC4EU-DE systematically analyses the artefacts produced by the DC4EU Large-Scale Pilot. These artefacts include reference user journeys, ELM-based data models, trust and governance descriptions, and documented technical deployment options. Rather than treating these artefacts as prescriptive solutions, the initiative considers them as design inputs that need to be assessed with respect to national education structures and institutional practices.

The analysis focuses on identifying artefacts that can serve as stable reference points for national adoption, as well as those that may require contextualisation or extension. Particular attention is given to the semantic expressiveness of ELM-based credential models (European Commission, latest version. -b) and to the abstraction level of DC4EU user journeys, as both are critical for cross-sectoral applicability across higher, secondary, and vocational education.

4.2 Selection of Initial Use Cases and User Journeys

A central methodological step in DC4EU-DE is the selection of a limited number of initial use cases and corresponding user journeys. These are not intended to represent the full spectrum of educational credentials but to serve as representative entry points for early-stage exploration.The selection process is guided by qualitative criteria, including expected value for learners and institutions, relevance across education sectors, alignment with DC4EU reference journeys, and feasibility within existing organisational and technical constraints. By limiting the number of initial use cases, the initiative seeks to balance analytical depth with practical relevance, avoiding premature complexity while retaining meaningful coverage of core credential workflows.The selected use cases are described using role-based user journeys that distinguish between credential holders, issuing institutions, and verifying parties. This abstraction allows the methodology to remain independent of specific institutional processes while supporting later refinement and sector-specific adaptation.

4.3 Institutional Collaboration and Contextualisation

DC4EU-DE follows a collaborative approach that actively involves educational institutions in the methodological process. Participating institutions contribute domain knowledge about academic and administrative processes, existing IT systems, and regulatory constraints. This input is used to contextualise DC4EU artefacts and to ensure that proposed approaches remain grounded in institutional reality.

4.4 Planned Prototypical Exploration

While DC4EU-DE does not aim to deliver production systems, the methodology includes the planned development of a prototypical environment to support conceptual validation. This environment is intended to illustrate credential issuance, storage, and verification workflows for selected use cases, using EUDI Wallet–conformant components where feasible.

The purpose of this prototypical exploration is to support informed discussion and technical understanding rather than performance evaluation or user acceptance testing. Architectural decisions are therefore documented at a conceptual level, focusing on component roles and interaction patterns instead of concrete implementation choices.

4.5 Methodological Limitations

The chosen methodology deliberately accepts several limitations. The focus on early-stage exploration means that no quantitative evaluation, usability assessment, or large-scale interoperability testing is conducted within the scope of this paper. Furthermore, while higher education provides the initial institutional context, insights for secondary and vocational education are derived analytically rather than empirically.

These limitations are considered acceptable given the objectives of the initiative and are explicitly documented to avoid overstating the maturity of the results. They also serve to delineate the scope of future work, including empirical evaluation and sector-specific implementations. This methodological positioning follows a design-oriented research perspective, in which making assumptions, constraints, and design decisions explicit at an early stage is considered a necessary prerequisite for subsequent empirical evaluation and operational validation (Hevner, March, Park, & Ram, 2004).

5 Initial Use Cases and User Journeys

As part of its early-stage exploratory approach, DC4EU-DE focuses on a deliberately limited set of initial use cases and corresponding user journeys. These use cases are not intended to be exhaustive, but to serve as representative entry points for analysing the applicability of DC4EU artefacts in a national education context. The selection reflects a balance between practical relevance, conceptual clarity, and cross-sectoral applicability.

The use cases are framed in a sector-agnostic manner, while higher education currently serves as the primary context for analysis. Where appropriate, similarities and differences with secondary and vocational education are explicitly considered.

5.1 Selection Rationale

The selection of initial use cases follows the qualitative criteria outlined in Section 4. In particular, use cases were prioritised that:

- represent common and recurring processes across education sectors,
- can be expressed using existing DC4EU reference user journeys,
- rely on well-defined credential semantics supported by the European Learning Model (ELM),
- offer clear value for credential holders and issuing institutions,
- and can be analysed without requiring deep integration into institution-specific processes.

5.2 Use Case Categories

Based on this rationale, the initial use cases fall into three broad categories.

The first category comprises educational status attestations, such as enrolment confirmations or student status certificates. These credentials are typically required for interactions with third parties, including public authorities, service providers, or partner institutions. From a conceptual perspective, they are well suited for early exploration because they involve clearly defined attributes, limited lifecycle complexity, and recurring verification needs across education sectors.

The second category covers achievement-related credentials, including microcredentials, course completions, or comparable attestations of learning outcomes. These credentials are increasingly relevant in higher and vocational education and align closely with ELM-based representations developed in DC4EU. They also illustrate more complex lifecycle aspects, such as revocation, expiration, and selective disclosure, while remaining manageable at an early stage.

The third category includes educational identifiers, such as institutional or sector-specific educational IDs. These credentials do not represent achievements themselves but provide a stable basis for linking individuals to education-related roles or affiliations. As such, they play a foundational role in multiple user journeys and support the composition of more complex credential workflows.

5.3 User Journey Abstraction

For each selected use case, DC4EU-DE relies on abstract, role-based user journeys derived from DC4EU reference scenarios. These user journeys describe interactions between three primary roles: the credential holder, the issuing institution, and the verifying party. By abstracting from concrete institutional processes, the user journeys remain applicable across higher, secondary, and vocational education contexts.

5.4 Sectoral Considerations

While the initial use cases are selected for their cross-sectoral relevance, DC4EU-DE explicitly acknowledges differences between education sectors. In higher education, institutional autonomy, heterogeneous IT systems, and international mobility requirements play a significant role. In secondary and vocational education, governance structures may be more centralised, and credential semantics may be more tightly regulated at national or regional level.

Rather than attempting to resolve these differences at this stage, DC4EU-DE treats them as analytical dimensions that inform the design and adaptation of user journeys. This approach allows commonalities to be identified while preserving the flexibility needed to accommodate sector-specific constraints in later phases.

5.5 Role of Use Cases in the Initiative

Within DC4EU-DE, the initial use cases and user journeys serve multiple purposes. They provide a concrete anchor for analysing DC4EU artefacts, support structured discussion with participating institutions, and offer a basis for planned prototypical exploration. At the same time, they define clear boundaries for the initiative's early-stage scope, preventing premature expansion into highly complex or sector-specific scenarios.

By documenting the rationale and structure of these initial use cases, DC4EU-DE establishes a transparent starting point for future implementation, evaluation, and extension activities. The use cases thus function as both analytical tools and practical reference points within the broader objective of national adoption of EUDI Wallet–based educational credentials.

6 Conceptual Technical Architecture

The technical architecture considered within DC4EU-DE is conceived as a conceptual reference rather than a fixed implementation blueprint. Its purpose is to provide a structured way of reasoning about the components, roles, and interactions involved in EUDI Wallet–based educational credential workflows, while remaining flexible enough to accommodate different institutional contexts and education sectors.

The architecture builds on the principles and artefacts established by DC4EU and aligns with the evolving EUDI Wallet ecosystem. It deliberately avoids assumptions about specific products, vendors, or deployment models.

6.1 Architectural Principles

Several guiding principles inform the conceptual architecture of DC4EU-DE.

First, wallet-centric control is treated as a foundational assumption. Educational credentials are issued to, stored in, and presented from an EUDI Wallet–conformant wallet under the control of the credential holder (European Commission, latest public version -a). Institutions do not directly exchange personal credential data with verifiers, but instead enable holder-mediated presentation.

Second, institutional autonomy is preserved. Issuing institutions remain responsible for credential content, lifecycle management, and compliance with sector-specific governance rules. The architecture therefore avoids centralised issuing or verification services that would undermine institutional responsibilities.

Third, interoperability by design is prioritised. All components are assumed to rely on open standards and shared semantic models, in particular W3C Verifiable Credentials (W3C, 2022) and ELM-based data schemas (European Commission, latest version. -b), in order to support cross-institutional and cross-sectoral interoperability.

Finally, loose coupling between components is emphasised. The architecture separates concerns between issuance, wallet storage, and verification, allowing institutions to integrate wallet-based credential workflows alongside existing campus or school IT systems without deep system entanglement (DC4EU Consortium, 2024c).

6.2 Core Components

Within this conceptual framework, four core component roles can be identified.

The Issuer represents the educational institution or authorised body responsible for creating and signing educational credentials. Issuers are assumed to integrate with existing administrative or academic systems that act as authoritative sources for credential data. The issuer component exposes interfaces for credential issuance that align with EUDI Wallet interaction patterns but does not require changes to internal institutional data models beyond necessary mappings.

The Wallet is the EUDI Wallet–conformant application controlled by the credential holder. It is responsible for securely storing credentials, enabling selective disclosure, and mediating presentation to verifiers. In the DC4EU-DE context, the wallet is treated as an external component whose internal implementation is out of scope, provided that it adheres to relevant European specifications.

The Verifier represents any relying party that needs to verify educational credentials, such as public authorities, employers, or partner institutions. Verifiers interact with the wallet during credential presentation and perform validation checks based on trust frameworks, credential signatures, and relevant metadata.

Supporting these interactions is a set of Trust and Governance Services, which provide the necessary information to establish issuer legitimacy and credential validity. These services may include trust registries, metadata services, or decentralised infrastructures such as EBSI, depending on the selected

trust model. The conceptual architecture allows for different trust arrangements as documented in DC4EU, without prescribing a single approach.

6.3 Interaction Patterns

The conceptual architecture supports a small number of recurring interaction patterns that correspond to the user journeys described in Section 5.

During credential issuance, the issuer authenticates the credential holder and issues a signed credential that is delivered to the holder's wallet. The interaction is assumed to follow EUDI Wallet–compliant protocols and does not involve direct communication between issuer and verifier.

During credential presentation, the credential holder initiates a presentation from the wallet in response to a verifier request. The wallet enables selective disclosure where applicable and transmits the presentation to the verifier.

During credential verification, the verifier validates the presented credential by checking cryptographic signatures, issuer authorisation, and status information via the relevant trust and governance services. No personal data is retrieved from the issuer during this process.

These interaction patterns are intentionally simple and abstract, allowing them to be reused across education sectors and credential types.

6.4 Integration with Institutional IT Systems

From an institutional perspective, the conceptual architecture positions wallet-based credential workflows as an extension rather than a replacement of existing systems. Issuer components are expected to interface with campus management systems, student information systems, or comparable administrative platforms, which remain the authoritative sources of truth for educational data.

The architecture assumes that integration is achieved through well-defined interfaces and mapping layers, avoiding the need for deep restructuring of institutional IT landscapes. This approach is particularly relevant for higher education institutions with heterogeneous systems, but also applicable to secondary and vocational education contexts with more centralised infrastructures.

6.5 Architectural Scope and Limitations

The conceptual architecture described in this section deliberately omits several aspects that are outside the scope of the DC4EU-DE initiative at its current stage. These include performance considerations, scalability analysis, security hardening, and operational monitoring. Likewise, no assumptions are made about specific deployment models, such as self-hosted versus managed services.

By keeping the architecture at a conceptual level, DC4EU-DE aims to support structured discussion and informed design decisions without constraining future implementation choices. The architecture therefore serves as a shared reference point for stakeholders rather than a prescriptive technical specification.

7 Limitations and Outlook

Despite some limitations, the DC4EU-DE initiative provides a structured foundation for future work. Planned next steps include the prototypical exploration of selected use cases, deeper engagement with educational institutions across different sectors, and the gradual transition from conceptual analysis to implementation-oriented investigation. These activities will enable empirical assessment of the assumptions and design decisions documented in this paper. In the longer term, DC4EU-DE aims to contribute to a sustainable national pathway for adopting EUDI Wallet–based educational credentials

that remains aligned with European interoperability objectives. By explicitly building on DC4EU artefacts while addressing national and institutional contexts, the initiative seeks to support a coordinated transition from European pilot results towards operational adoption. The approach and perspectives outlined in this paper may also serve as a reference for similar national initiatives in other Member States.

8 Conclusion

The DC4EU-DE initiative positions itself between European pilot experimentation and future operational deployment. Its contribution lies in making assumptions, design choices, and limitations explicit at an early stage, thereby enabling transparent discussion among educational institutions, IT service providers, and policy stakeholders. While further work is required to validate and operationalise the proposed approach, the perspectives presented in this paper provide a structured starting point for coordinated national adoption and for similar initiatives in other Member States.

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Author biographies

Guido Bacharach is an independent researcher working on digital education infrastructures and the adoption of European frameworks for educational data exchange. He is also affiliated with GovPart GmbH and has been actively involved in the European Large-Scale Pilot Digital Credentials for Europe (DC4EU). His work focuses on the transition from European pilot initiatives to national and institutional implementation contexts, with particular attention to interoperability, governance, and organisational integration. He has contributed to European initiatives related to EMREX, the European Learning Model (ELM), and EUDI Wallet–based educational credentials. His current interests include design-oriented approaches to digital credential ecosystems, institutional adoption pathways, and privacy-preserving architectures in regulated public-sector environments.

Dr. Tamas Molnar is the head of unit of the Service Centre Campuscard since 2015 and project manager for the Campus card system since 2011. He has studied electrical engineering at the University of Technology in Budapest, business information systems with a focus on public IT at the Corvinus University Budapest and the University of Potsdam before doing a Ph.D. in software usability at Humboldt-Universität zu Berlin in 2014. He worked in various IT projects parallel to his studies and was also a teaching assistant at Corvinus University Budapest. After receiving a degree in business information systems, he worked in the IT department of the Brandenburg State Forestry Institute as a software security specialist and project lead. From 2011 he works at Humboldt-Universität zu Berlin first as project manager for the student card project and later from 2015 onwards as head of unit for the Campuscard Berlin, which is responsible for the student IDs for 10 universities in Berlin.

Helmut Nehrenheim worked in the state administration of North Rhine-Westphalia from 1977 to 2021. From 2007 to 2021, he was employed in the ministries responsible for coordinating information technology in North Rhine-Westphalia and was responsible for technical issues and projects. Among other things, he initiated the DIGIZ NRW project together with the Ministry of Education and Science and is co-founder of the “Netzwerk Digitale Nachweise” (Digital Evidence Network) community. Since 2021, he has been managing director of GovPart GmbH, which participates in EU-funded projects in the areas of identity and education and also offers consulting/project management for the IT Planning Council's “Online Security Check (OSiP)” product.