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How will the digital euro work?
A preliminary analysis of design,
structures and challenges

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How will the digital euro work? A preliminary analysis of design, structures and challenges*

Abstract:

The digital euro project will reach an important milestone this year when the preparation phase ends and the governing council of the ECB will decide whether to enter the next phase before the launch phase. This article provides an overview on how a digital euro is intended to work. An examination of the prospective design features and architecture of the digital euro reveals the complexity of the project and the challenges associated with integrating the digital euro into the existing payment landscape.

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1. Introduction

The ECB has been working on the potential introduction of a digital euro for several years. Many other central banks are also analysing the potential benefits and risks of a central bank digital currency (CBDC). For instance, the People's Bank of China (PBOC) is exploring a digital renminbi and the Bank of England is evaluating a digital pound. Other projects include a digital US dollar, a digital yen and an e-krona in Sweden. The Bahamas introduced the first fully operational CBDC in 2020, the so-called "Sand Dollar" (Branch et al., 2023). Most of the existing literature focuses on the impact of a CBDC on monetary policy and financial stability (e.g. Ahnert et al., 2024, Ahnert et al., 2023; Minesso et al., 2022; Kumhof et al., 2021; Carapella et al., 2020; Brunnermeier et al., 2019). However, the digital euro will also substantially affect the financial services sector in Europe in a variety of ways. Transaction fees in the payment industry are likely to decrease if existing digital payment instruments are replaced by the digital euro. Moreover, refinancing costs of banks could increase to the extent that usually cheap, deposit-based financing has to be replaced by other more expensive financing instruments. Therefore, the ECB foresees a compensation model to mitigate the impact on banking sector profitability. However, a closer inspection of the structure of the digital euro scheme reveals additional challenges for the European banking sector.

In the following, we illustrate the current status of the digital euro, focusing on the design of the scheme, the role of the respective parties, key processes and the foundations of the technical architecture of a digital euro. It becomes apparent that the digital euro is essentially a huge infrastructure project that will require major investment and bring additional costs for the European banking and payment sector. Therefore, it is crucial that a digital euro integrates seamlessly into the existing European and international payment landscape.

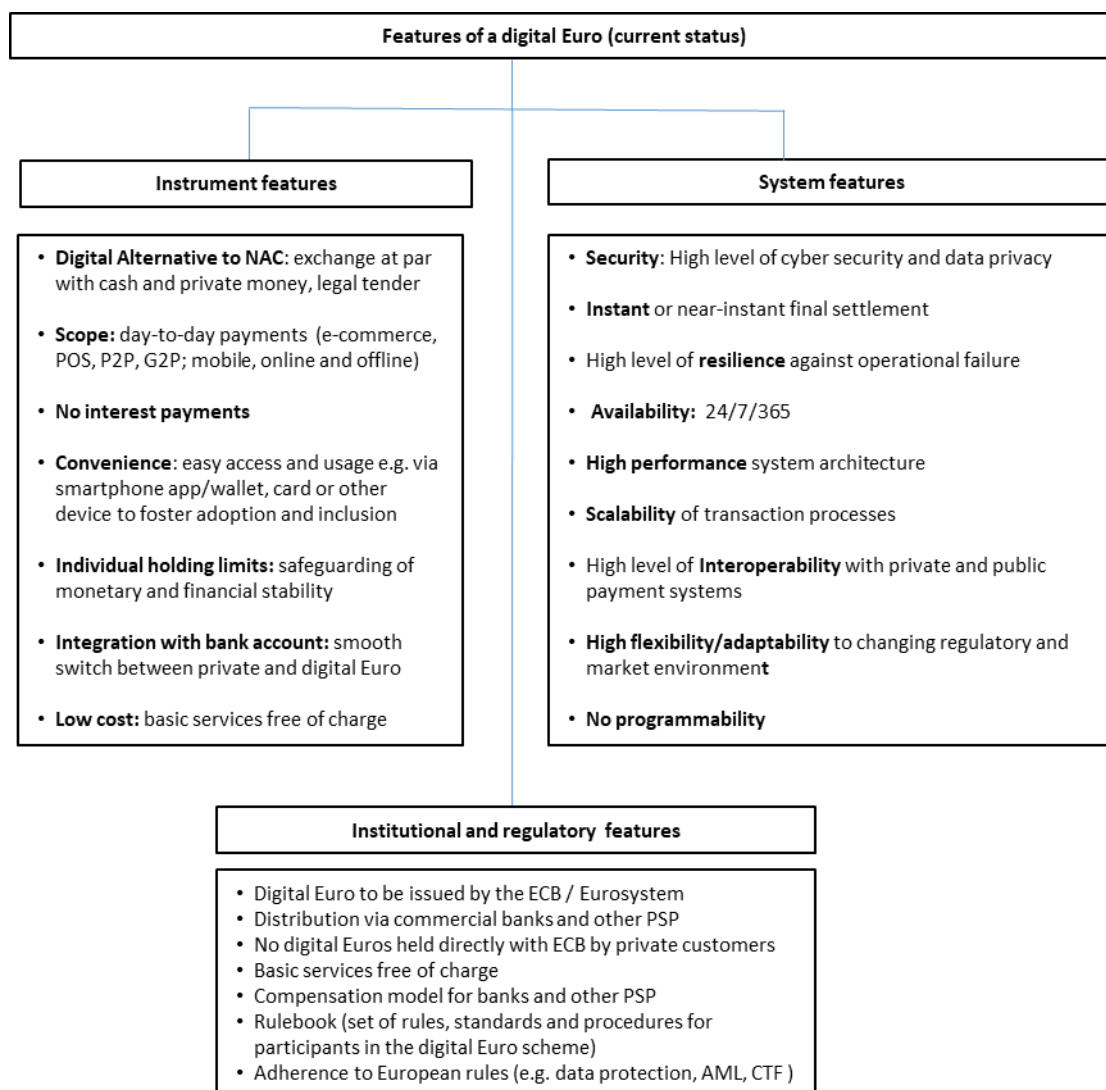
2. Status of a digital euro

The idea of a digital euro was publicly presented in 2020 (ECB, 2021; ECB, 2020). In a two-year investigation phase, the ECB evaluated the feasibility of a digital euro, including core design features, technical and legal aspects (e.g. ECB, 2023a). On 18 October 2023, the Governing Council of the ECB announced it is entering the preparation phase of the digital euro project, which started on 1 November 2023 and is scheduled for two years (ECB, 2023b). By the end of 2025, the ECB will decide whether to proceed to the next phase.

Figure 1 gives an overview of the current status of a potential digital euro that can be characterised along the three dimensions "instrument features", "system features" and "institutional and regulatory features" (e.g. BIS, 2020; BIS, 2018). The digital euro is intended to become a digital form of central bank money available to the general public as an alternative to notes and coins. As such, the digital euro will have the status of legal tender representing a direct claim to the ECB. The digital euro shall not replace the use of cash but add to the current spectrum of payment instruments. The scope of usage covers payments from person to person, at the point of sale, in e-commerce and in government transactions.

Customers will not hold direct accounts with the ECB. Access will be provided by banks and other payment service providers (PSP). To protect monetary and financial stability, holdings will not accrue interest and will be subject to individual upper limits. The system of a digital euro should allow users to settle payments instantly in central bank money at any time. The underlying infrastructure and systems should be resistant to cyber risks and counterfeiting and highly resilient against operational failures and disruptions. Furthermore, the system architecture must be able to perform many transactions and must be scalable to accommodate fast-growing volumes in the future.

Figure 1: Features of a digital euro (overview, current status)



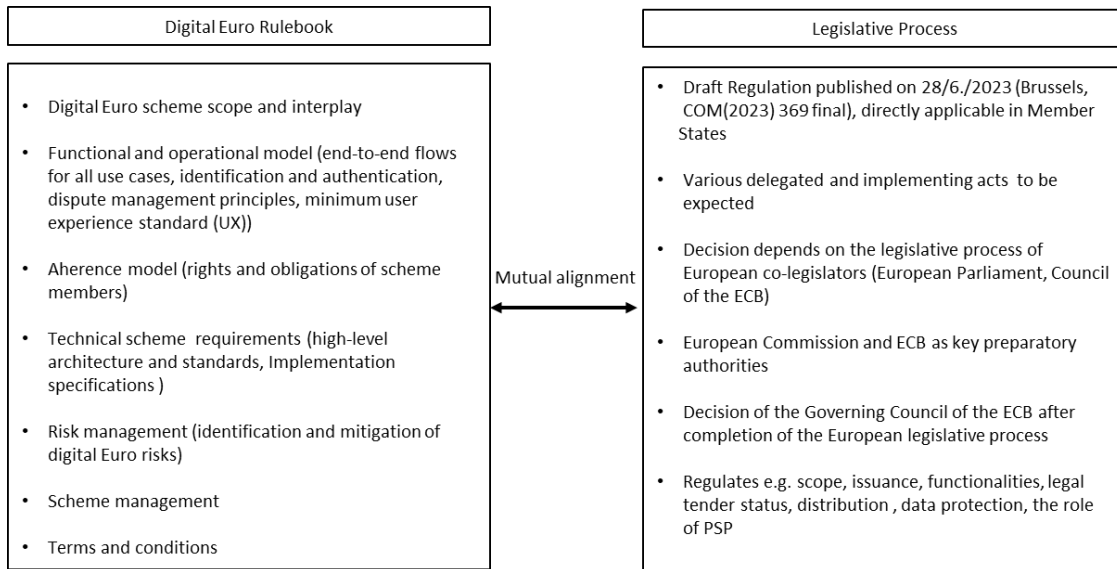
Source: Own illustration

3. Rulebook and legislative process

At the same time, the Eurosystem has to make sure that market participants comply with EU law and that end-users are protected from fraudulent activities. Therefore, the technical design of a digital euro should improve capabilities to counteract financial crime like tax evasion, terrorist financing and money laundering.

The ECB has been working on a digital euro scheme rulebook, which will provide a single set of rules, standards and procedures for usage of a digital euro (ECB, 2024a; ECB, 2024b). The introduction of a digital euro would require a corresponding legal framework that must be established by European legislative procedures. An initial draft regulation on the establishment of the digital euro was published on 28 June 2023 by the European Commission (European Commission, 2023). Figure 2 provides an overview of the major components of the current structure of the rulebook, which has to be closely aligned with the various legal acts to be adopted upon the establishment of a digital euro.

Figure 2: Digital euro rulebook and draft regulation (selection as of end of 2024)

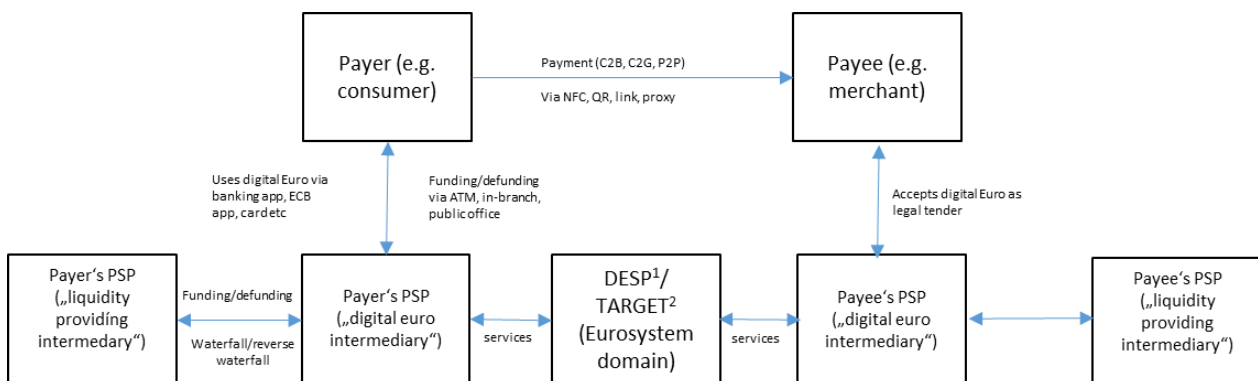


Source: Own illustration

The rulebook sets forth the functional and operational model, including a detailed description of the process flows for all use cases of the digital euro and minimum standards for the user experience (UX). Furthermore, the adherence model contains the rights and obligations of major actors, the interplay between them and the respective technical requirements.

The main parties involved in the digital euro scheme include the payer, the payee, the intermediaries of both parties and the Eurosystem, which operates the central infrastructure. This comprises the Digital Euro Services Platform (DESP) and the TARGET system, which is the real-time gross settlement (RTGS) system for central bank money operated by the Eurosystem (Figure 3). Intermediaries could fulfil roles such as funding/defunding (“liquidity providing intermediaries”) or providing other services such as access management to the DESP (“digital euro intermediary”). In many cases, banks will offer the full range of services, while other PSPs could focus on providing specific services.

Figure 3: Parties of the digital euro scheme



¹DESP = Digital Euro Service Platform; ²TARGET includes T2 (payments), T2S (securities), TIPS (instant payments), ECMS (collateral management)

Source: Own illustration based on ECB

Figure 4 gives an overview of the core digital euro services for end users and their interaction with the DESP and the national central banks (NCB), which play a pivotal role in onboarding, offboarding and supervising national PSPs within the digital euro scheme.

4. Core services for a digital euro

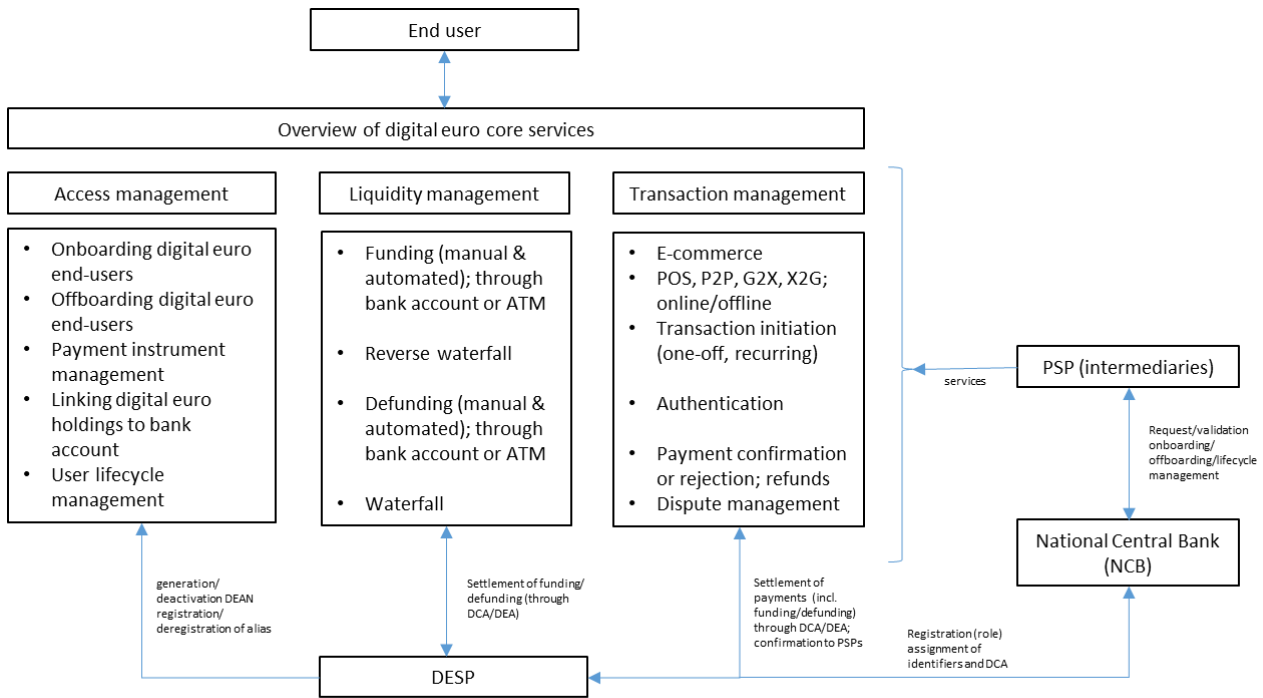
The spectrum of services that participants in the digital euro scheme need to use can be divided into “access management”, “liquidity management” and “transaction management” (ECB 2024a, ECB 2024b). Users will be able to access digital euro services via their payment service provider’s proprietary app and online interface, or via a digital euro app provided by the Eurosystem. Access management services include the onboarding of users by a registered PSP, i.e. validation of user authentication, pseudonymised registration with the DESP, allocation of a digital euro account number (DEAN) and coupling with a private bank account.

Liquidity management covers the funding and defunding operations, primarily via a commercial bank account (alternatively via an ATM, for example), including settlement with the DESP debiting/crediting the dedicated cash account (DCA) of the respective bank with the Eurosystem. Transaction management comprises the end-to-end execution of digital euro payments, from initiation and authentication to settlement of the payment in all use cases. The national central banks play an important role in onboarding and offboarding of PSPs, as they check eligibility and compliance with registration requirements before approval by the DESP.

The Rulebook Development Group (RDG) recommends introducing a unique pseudonymised digital euro end user identifier when requesting a DEAN from the DESP. This should comply with the attributes of personal identification data (PID) under the European Digital Identity Regulation (Regulation (EU) 2024/1183, “eIDAS 2.0”), which entered into force on 20 May 2024. The European Digital Identity will be available to EU citizens, residents, and businesses who want to identify themselves or provide confirmation of certain personal information. It can be used for both online and offline public and private services across the EU. Every EU citizen and resident will be able to use a personal digital wallet to share digital documents or to prove a specific personal attribute, such as age, without revealing their full identity or other personal details. This approach ensures that digital euro holding limits are respected while the Eurosystem is prevented from accessing data that could directly identify an end user.

Any user may be registered through an admitted intermediary with the DESP. Users will get a unique identifier linked to a digital euro account number. Payments can be conducted from consumers to businesses (C2B), between consumers (P2P) and between consumers and governmental institutions (C2G). Transactions can be completed online (e-commerce, POS) and offline (P2P, in store) using different technical interfaces (e.g. NFC, QR, links). Access to the digital euro scheme will usually be provided by intermediaries (banks or other PSPs) that will manage the interface between the user and the DESP while keeping the transaction details separate from the DESP to ensure privacy and data protection. Services will include the on- and offboarding of the user as well as the funding and defunding of the respective digital euro account. In most cases the digital euro account will be linked to a bank account. Funds may then be easily transferred between the bank account and the digital euro account. To remain within the holding limit, inflows of digital euros exceeding the limit will be automatically transferred to the commercial account (waterfall). If the digital euro balance is below the payment amount, additional euros will be transferred from the bank account to the digital euro account in order to complete the transaction (reverse waterfall). Funding and defunding of digital euros would also be feasible through ATMs or in-branch.

Figure 4: Core digital euro services and interfaces



¹DEA(N) = Digital Euro Account (Number) ²Registration at DESP in a pseudonymised way (alias) ³DCA = Direct Cash Account

Source: Own illustration based on ECB

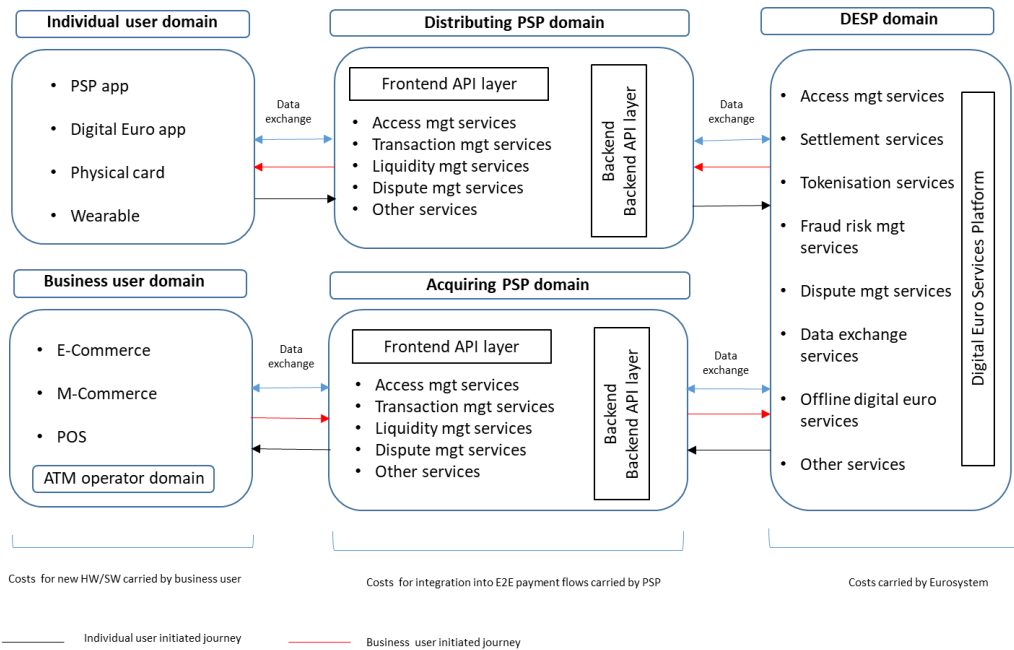
The data flow between participants in the digital euro scheme, i.e. between end users, PSPs and the Eurosystem, will be designed to prevent the Eurosystem from directly linking transactions to specific individuals. Messages among PSPs and between PSPs and the Eurosystem will be pseudonymised and/or encrypted. In addition, the data exchanged between PSPs and the Eurosystem would be segregated (ECB, 2024a)

5. High-level architecture

Seamless interaction between users, PSPs and the DESP requires a fast and secure data exchange. In addition, efficient interfaces between the different domains allow for a smooth customer journey in all use cases (ECB, 2024b). An examination of the high-level architecture of the digital euro scheme (Figure 5) underscores the complexity associated with integrating digital euro services into the existing payment landscape. Private users will get access to core services via different routes, in most cases using an app developed by a private PSP or the digital euro app offered by the Eurosystem with little to no up-front investment. However, PSPs will have to establish the front end for the core services, including the interfaces with the DESP. Among other things, the DESP will be responsible for access management, settlement services, fraud risk management and dispute management. In addition, hardware investments by business users (e.g. in POS terminals, ATMs, mobile devices, card solutions) need to be taken into account. Although it is hardly possible to seriously estimate the costs for the financial sector at this point, it seems reasonable to set up a dedicated workstream within the digital euro project to cover the cost implications for the banking and payment sector in particular, as there is a political agreement that private users should be able to pay with a digital euro and use basic services without any additional charges. These basic services offered by banks and other PSPs could include: (i) opening/holding/closing of a digital euro payment

account, (ii) non-automated and automated funding and defunding from a non-digital euro payment account, (iii) waterfall/reverse waterfall services, (iv) provision of a basic payment instrument, and (v) initiating and receiving payment transactions.

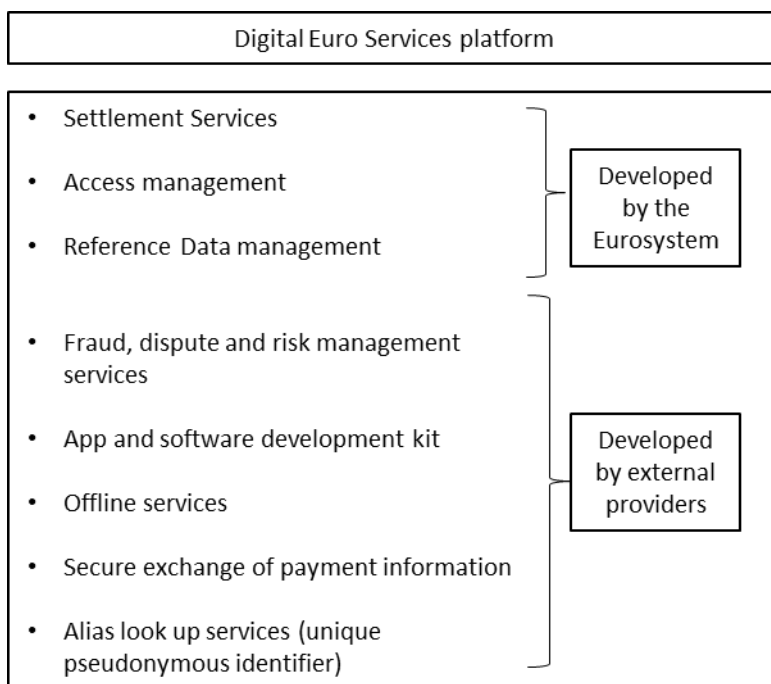
Figure 5: High-level architecture of the digital euro ecosystem



Source: Own illustration based on ECB

Furthermore, it is envisaged that major components of the DESP will be developed by external providers, while the Eurosystem will develop settlement, access and reference data management internally. All in all, the technological platform for the digital euro will be highly complex and will constitute a critical infrastructure in the eurozone (Figure 6).

Figure 6: Development concept for the Digital Euro Services Platform (DESP)



Source: Own illustration based on ECB

6. Conclusions

The introduction of a new payment instrument is a highly complex undertaking, due to the large number of parties involved, the heterogeneous landscape of existing payment systems, the challenge of integrating a digital euro into international payment architectures such as SWIFT and the need for new hardware solutions (e.g. mobile devices, POS terminals or ATMs). In fact, a digital euro could revolutionise the European payment sector and beyond, provided that European users adopt the digital euro on a large scale. Otherwise, the huge investments from both the public and private sector could go to waste. A clear and convincing communication strategy towards the general public is needed to convey the benefits of a digital euro, which will be challenging in light of the wide range of digital payment instruments already available to private and business users. At the same time, PSPs (such as banks and payment card companies) need to have sufficient economic incentives to distribute the digital euro to their customers and to provide acquiring services to merchants.

It should be noted that a digital euro could diminish transaction fees in the payment industry and increase refinancing costs of banks if comparatively cheap financing from deposits must be replaced by other, usually more expensive, financing instruments. Furthermore, the introduction of a digital euro will require substantial capital expenditures, not only by the Eurosystem but also market participants such as banks, other PSPs and merchants. In addition, there will be running costs, including for executing transactions, IT-maintenance, cyber security and corresponding costs for regulatory compliance. Therefore, a fair compensation model is crucial to enable market participants to recover their costs and establish a viable business model. Furthermore, the digital euro system must be compatible with international electronic data exchange standards such as ISO 20022 to be integrated into the international payment landscape and to facilitate cross-border transactions.

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