EUROPEAN CENTRAL BANK

EUROSYSTEM

The Eurosystem's exploratory work on new technologies for wholesale central bank money settlement

Annex II

Comprehensive overview of trials and experiments

1 Executive summary

This second annex to the Eurosystem's report on exploratory work on new technologies for wholesale central bank money settlement aims at extensively describing the joint efforts made by market participants, market DLT operators, the Eurosystem and the other central banks involved by showcasing the trials and experiments that took place during the exploratory work.

Financial market stakeholders were invited to take part in trials (real transactions settled in central bank money) and experiments (mock transactions settled in test environment) in two waves (May-November 2024 for Wave 1; July-November 2024 for Wave 2).[1] The Eurosystem approved the participation, over the two waves, of a total of 60 stakeholders from the financial sector and four central banks.[2]

The participants, their respective national central banks (NCBs) and the three solution-providing central banks (Deutsche Bundesbank, Banque de France and Banca d'Italia) jointly enabled 48 use cases to be conducted, including 27 trials and 21 experiments. In addition, the Eurosystem conducted six internal experiments not involving market stakeholders and four cross-border experiments with other central banks, bringing the number of activities completed to 58. This collaboration provided practical insights into a large and diverse set of use cases across the whole financial markets value chain.

The European Central Bank expresses its gratitude to the stakeholders involved for the detailed descriptions of the activities conducted that they provided for preparation of this annex.

2 Use cases

For the purpose of this document, a use case is a business scenario implemented technically and operationally during the exploratory work in experiments or trials using one of the three interoperability solutions provided by the Eurosystem. The

1 See "Call for expression of interest: exploring new technologies for wholesale central bank money settlement", *MIP news*, European Central Bank, 13 December 2023.

2 A full list of the stakeholders involved in the exploratory work is available on the ECB's website.

same scenario implemented across all three solutions counts as three distinct use cases.

The various use case categories tested within the context of the exploratory work are outlined below. While similar business scenarios are grouped together, the exact technical implementation and practical execution of use cases varied depending on the stakeholders involved, the market DLT and the interoperability solution used.

- **Category 1:** Primary issuance of bonds by financial institutions, corporates or sovereigns and delivery-versus-payment settlement, in some instances also including lifecycle management of securities (coupon payment and redemption) and secondary trading
- **Category 2:** Intraday/overnight[3] repurchase agreements (repos)
- **Category 3:** Cross-currency payment-versus-payment transactions with another central bank
- **Category 4:** Automated wholesale payments for interbank transfers
- **Category 5:** Margin calls
- **Category 6:** Tokenised deposits/deposit token transfers with related settlement in central bank money (intrabank or interbank)
- **Category 7:** Settlement of payments related to over-the-counter (OTC) derivatives via smart contracts
- **Category 8:** Interbank reconciliation of bilateral accounts with settlement of outstanding balances in central bank money
- **Category 9:** Fund share subscription, including secondary market and redemption
- **Category 10:** Secondary market activity of various financial instruments
- **Category 11:** Partial settlement

3 Trials and experiments

This section details each use case performed by market participants, market DLT operators and other central banks during the exploratory work.

Detailed descriptions of the use cases, such as the features of the DLT used, flowcharts of the steps executed and the expected objectives, are presented as received from the parties involved in each trial and experiment. The views expressed

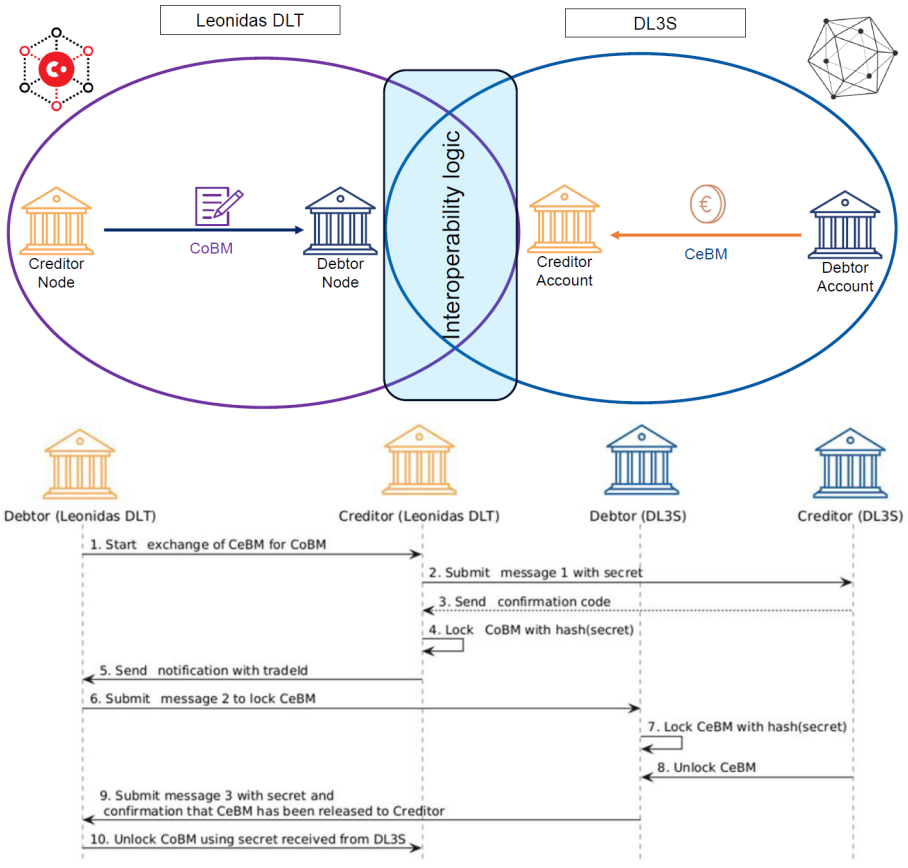
[3] Overnight repos did not involve the use of overnight central bank money in the interoperability solutions.

in the use case descriptions are those of the respective participants in the trials and experiments and do not necessarily reflect those of the ECB.

How to read the use cases:

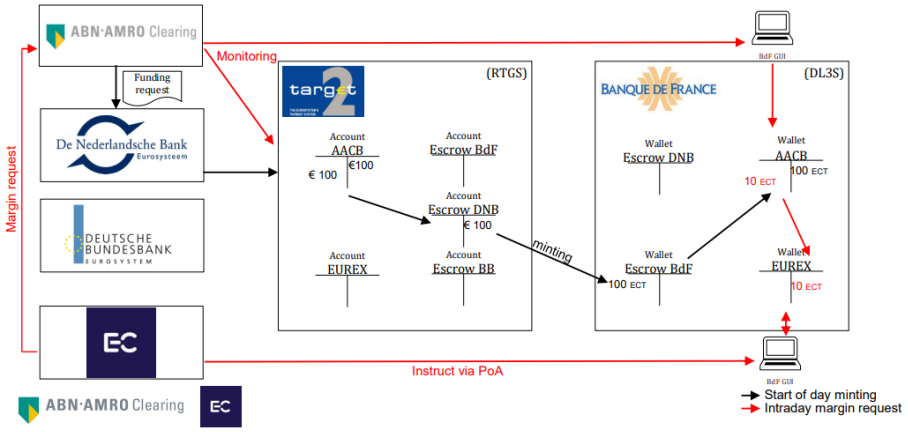
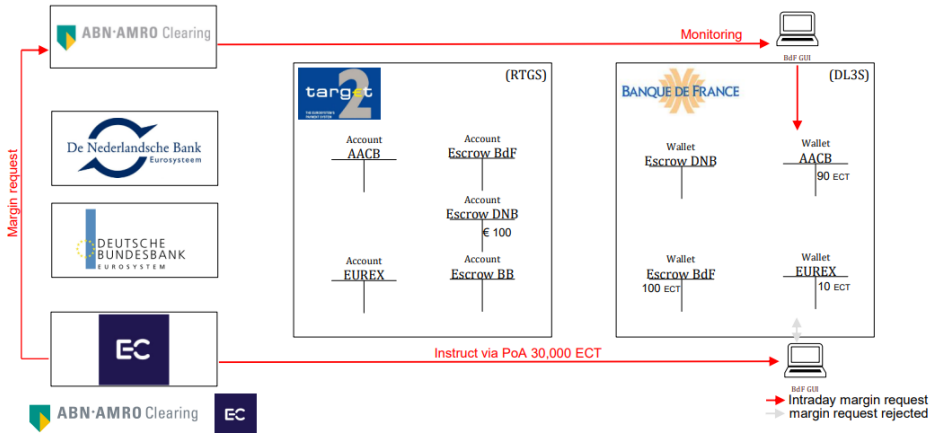
- The use cases are organised in alphabetical order under the name of the stakeholder(s) that provided the DLT infrastructure for the execution.
- If the use case was fully performed in the Eurosystem interoperability solution (without the use of additional infrastructures), the use case is presented under the name of the stakeholder(s) involved.

3.1 ABI Lab

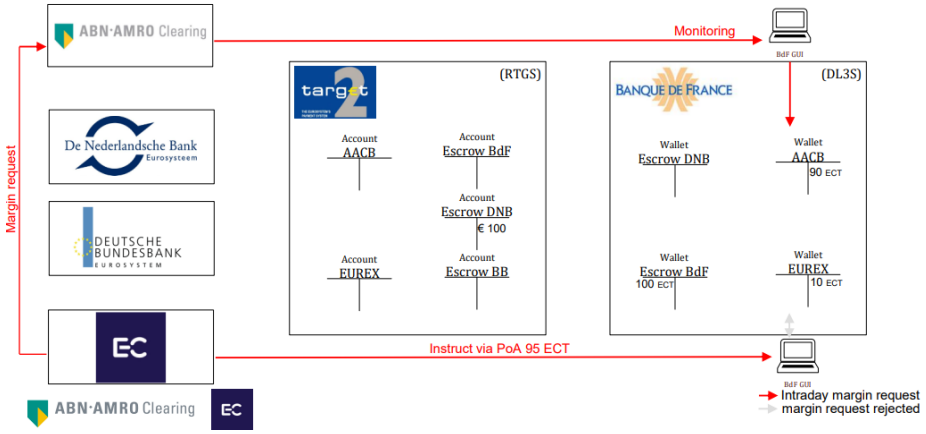
Experiment	**Category 8:** ***Interbank reconciliation of bilateral accounts with settlement of outstanding balances in central bank***
Eurosystem interoperability solution	Full DLT Interoperability Solution (BdF)
Participants	• Market Participants: ABI Lab in collaboration with ABI, and 8 Italian banks participating in Spunta and Leonidas (Intesa Sanpaolo, UniCredit, Banca Monte dei Paschi di Siena (BMPS), BNL BNP PARIBAS, Banco BPM (BBPM), BFF Bank, BPER Banca, Crédit Agricole Italia • Market DLT Operators: ABI Lab • Observers: an interbank working group supported by ABI and composed by Banca Sella, Banca Mediolanum, Banca Popolare Puglia e Basilicata, Banca Popolare di Sondrio, Cassa Centrale Banca, Cassa Centrale Raiffeisen, Credito Emiliano (CREDEM), CSE in collaboration with La Cassa di Ravenna, Iccrea Banca, Mediobanca, Cedacri.
DLT technology used on market side (as reported by market stakeholders)	The DLT to be used in the solution is Corda by R3. It is a private permissioned DLT platform designed to prioritise important factors required for the financial services industry. Primarily, security, data privacy and scalability. It is a peer-to-peer network of nodes representing onboarded legal entities (parties on the network). The set of such nodes define a 'Corda network' that is overseen by a network operator. Each node runs Corda applications named 'CorDapps' and can execute transactions with other nodes. Each node only has access to data related to transactions they are involved in, which is a subset of transactions carried out within the network. Each transaction is notarised by a special node of the network called a 'Notary'. It aims to support providing consensus for avoiding double spend issues and as an independent signer on a peer-to-peer transactions where required.
Flowchart of use case (as reported by market stakeholders)	

High-level description (as reported by market stakeholders)	The use case considered is the improvement, in a test environment, of an existing solution named 'Spunta DLT', currently used in production for bank reconciliation with more than 90 nodes active, one for each bank involved and more than 750 million transactions as of 2020, by introducing a new functionality of liquid balance debt settlement through wholesale CeBM. This is managed in Leonidas, an emanation of Spunta. The use case refers to the update of shared portions of ledger between banks (liquid balances debts on the Leonidas DLT) triggering a wCeBM payment (in the Banque de France solution). The update of the status of debt between banks in the network will be available in automatic or manual mode, according to predefined rules implemented in the solution running in the DLT within 'Spunta DLT' application. The update of liquid balances state on the DLT will be handled atomically with the exchange of wCeBM handled in the solution provided by BDF. The aim of the experiment is to identify and verify potential benefits and improvements through the usage of wCeBM settlement in a DLT vs DLT environment compared to existing solutions.
Learning objectives of the market (as reported by market stakeholders)	Verify the main benefits that the use case could introduce: i) the settlement process is nowadays managed outside the Spunta solution, not on DLT, not optimised and prone to errors, the opportunity to have a DLT based solution on the Cash Leg of the Eurosystem could enable this process (and also similar one) to be fully end-to-end; ii) the possibility to implement programmability logics at the interbank value transfer stage. We expect to have a complete overall picture at the end of the exploratory phase. It will be useful to have the opportunity to see different initiatives and different solutions applied in parallel, also to be able to collect the elements useful for a comparative analysis. Furthermore, in its role, ABI Lab aims to support and assist participating banks in the analysis and study of possible solutions for interoperability between the Eurosystem’s systems and market DLTs.

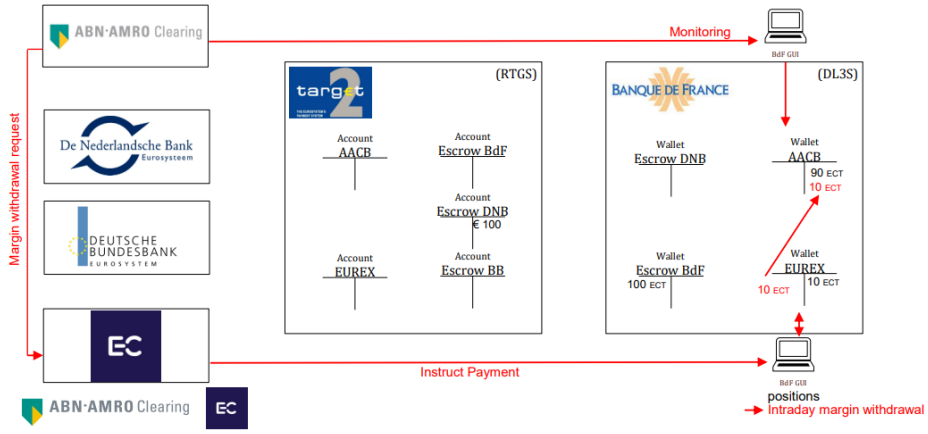
3.2 ABN AMRO Clearing Bank, Cboe Clear Europe and Eurex Clearing

Trial	Category 5: *Margin calls*
Eurosystem interoperability solution	Full DLT interoperability solution (BdF)
Participants	• Clearing member: ABN AMRO Clearing Bank N.V. • CCP: Eurex Clearing AG
DLT technology used on market side (as reported by market stakeholders)	None, direct interaction of market participants with Full DLT Interoperability solution.
Flowchart of use case (as reported by market stakeholders)	**Use case Margin Call**  **Use case Margin call failure due amount > PoA limit** 

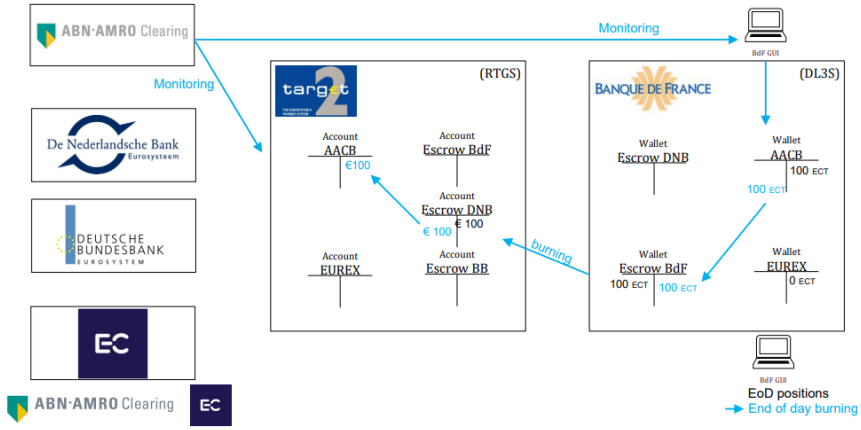
Use case Margin call failure due to insufficient ECT balance



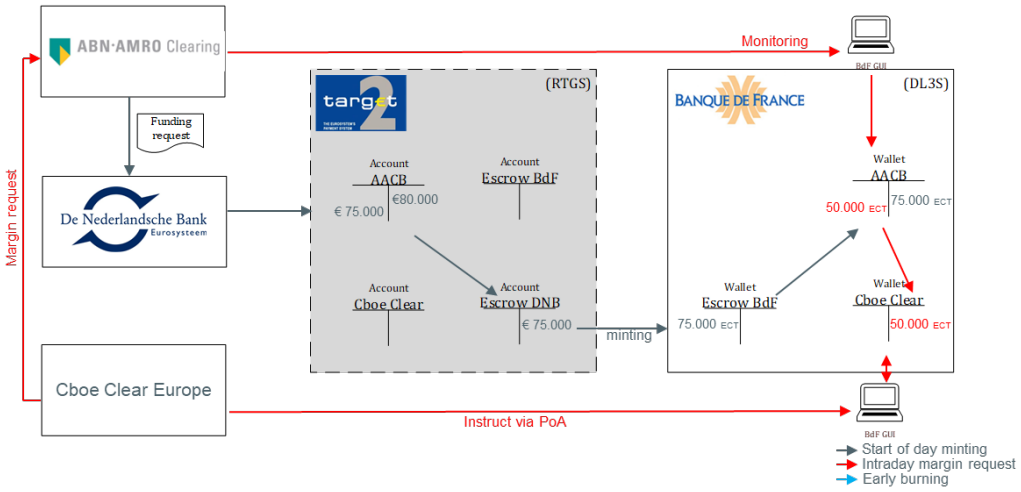
Use case Withdrawal of Margin



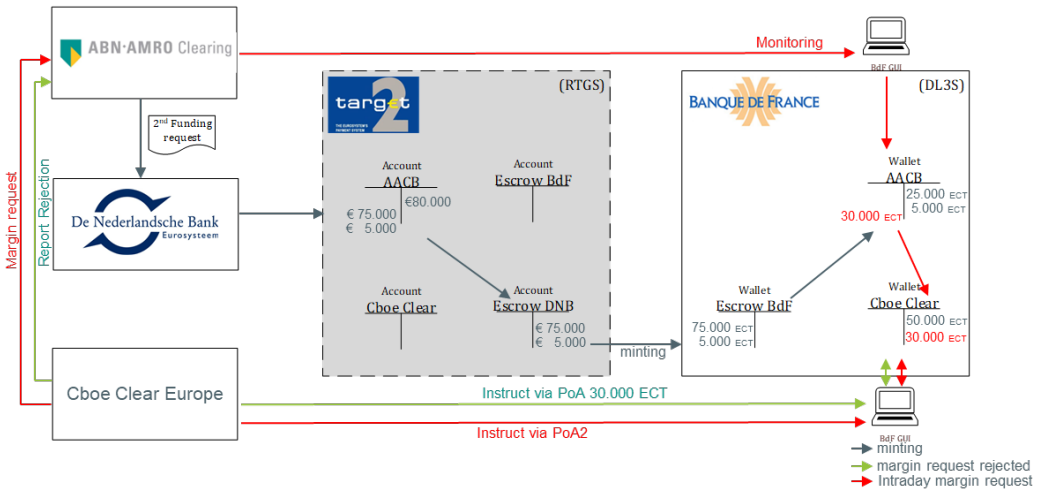
Use case End of day Redemption of Balances 14:00h



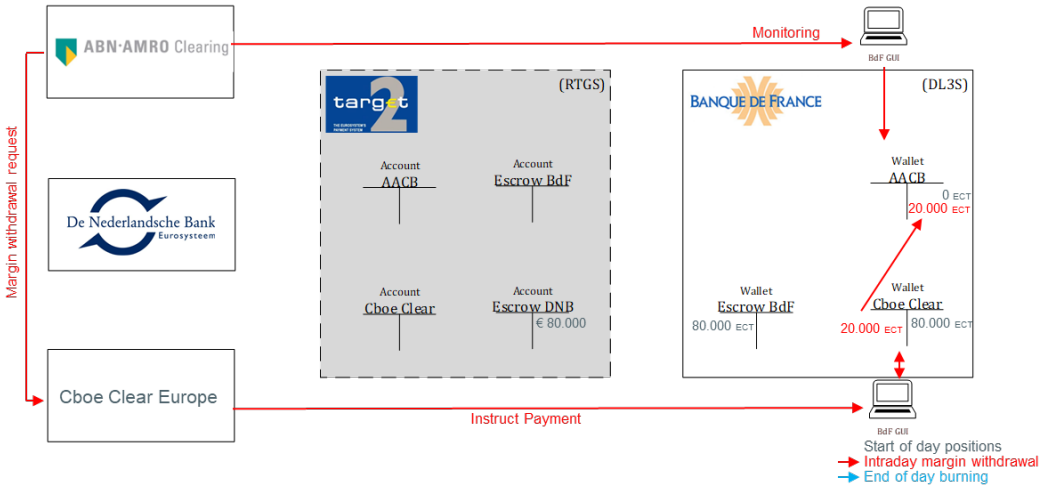
High-level description (as reported by market stakeholders)	Execution of five scenarios for the margin call use case: 1. Margin Call: Eurex Clearing initiates a margin call by debiting the wallet of AACB using power of attorney. 2. Margin Call reject (PoA Limit): Eurex Clearing initiates a margin call by debiting the wallet of AACB using power of attorney, however the amount is higher as the PoA limit set by AACB and is therefore rejected. 3. Margin Call reject (insufficient balance): Eurex Clearing initiates a margin call by debiting the wallet of AACB using power of attorney, however due to lack of funds in the AACB wallet this is rejected. 4. Withdrawal of Margin: AACB requests Eurex Clearing to return deposit collateral. 5. End of Day redemption of balance: during End of Day process the platform burns the remaining balance in the wallets.
Learning objectives of the market (as reported by market stakeholders)	Familiarise interacting with DLT based solutions running the cash leg; explore automation features (e.g programmability and power of attorney automation) provided by the technology.

Experiment	**Category 5: *Margin calls***
Eurosystem interoperability solution	Full DLT interoperability solution (BdF)
Participants	• Margin request issuer: Cboe Clear Europe • Margin request receiver: ABN AMRO Clearing Bank
DLT technology used on market side (as reported by market stakeholders)	None, direct interaction of market participants with Full DLT Interoperability solution
Flowchart of use case (as reported by market stakeholders)	1) Successful margin call triggered with CCP debiting the investor wallet in interoperability solution and obtaining ECT 

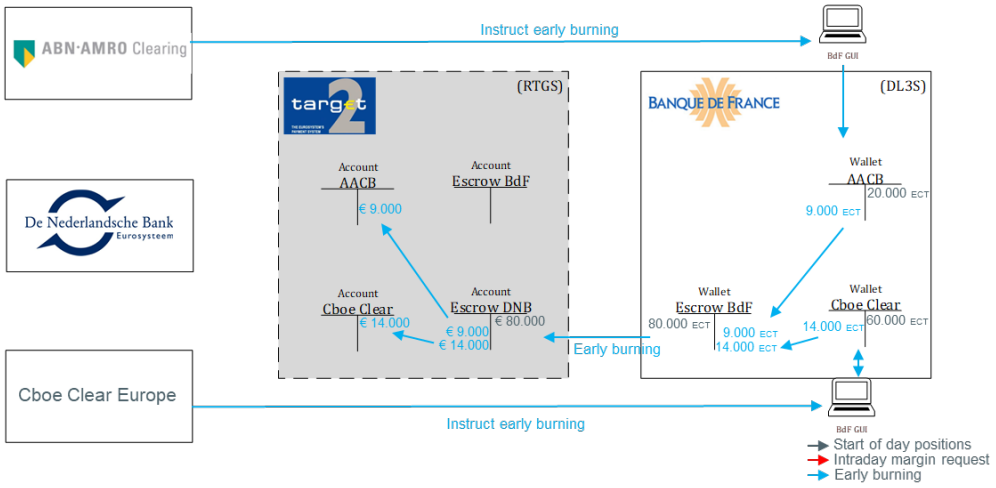
2) Unsuccessful margin call due to investor wallet insufficient ECT balance



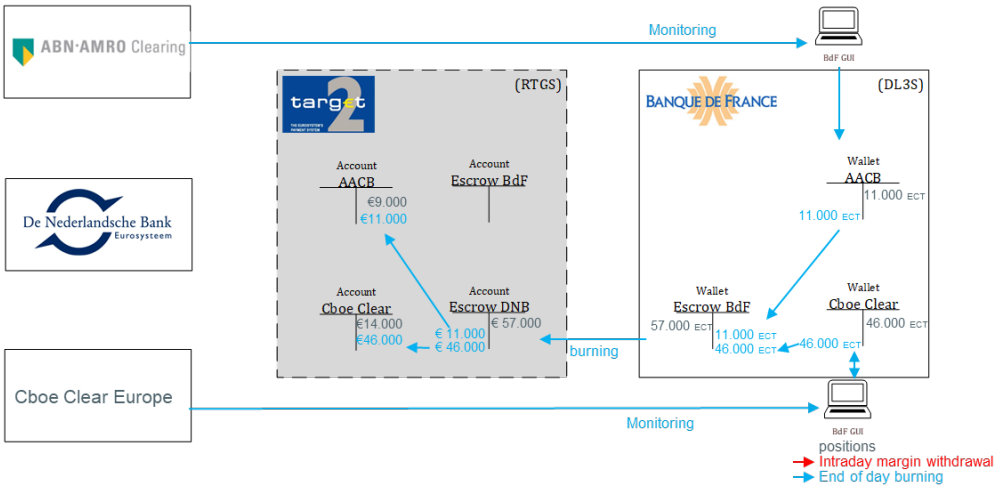
3) Return of deposit collateral triggered by the investor party



4) Early redemption of balances



5) End of day redemption of balances

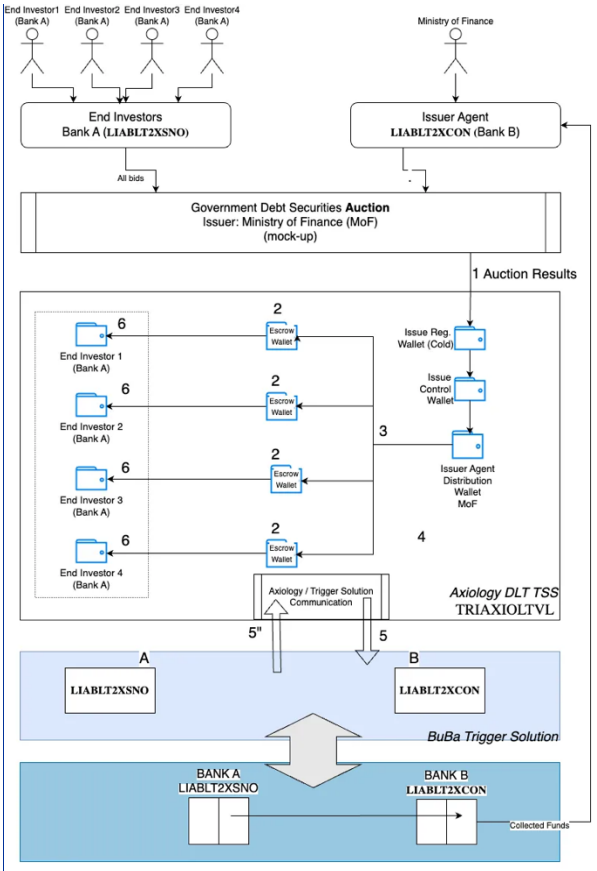


High-level description (as reported by market stakeholders)	Execution of five different scenarios for the margin call use case: 1. Margin Call: Cboe Clear initiates a margin call by debiting the wallet of AACB using power of attorney. 2. Margin call failure due to insufficient ECT balance: Cboe Clear initiates a margin call, but the transaction is rejected due to insufficient ECT balance in the wallet of AACB. 3. Withdrawal of Margin: AACB requests Cboe Clear to return deposit collateral. 4. Early redemption of balance: Cboe Clear and AACB request BdF to burn ECT in return for Euro in TARGET. Only balances on DL3S can be checked as TARGET is not linked during the experiment. 5. End of Day redemption of balance: during End of Day process the platform burns the remaining balance in the wallets.
Learning objectives of the market (as reported by market stakeholders)	The use of wCBDC can bring to 24/7 availability of CeBM; experiments are useful for exploring real-time settlement, tokenised securities and for discussing about the use of wCBDC as collateral outside TARGET opening hours.

3.3 Axiology

Experiment	**Category 1:** ***Primary issuance of bonds by financial institutions, corporates or sovereigns and delivery-versus-payment settlement, in some instances also including lifecycle management of securities (coupon payment and redemption) and secondary trading***
Eurosystem interoperability solution	Trigger Solution (BBk)
Participants	• Issuer: Axiology as mock-up Ministry of Finance (MoF)/Auction organiser • Investor: Mock-up Participants of the AXIOLOGY DLT TSS platform • DLT Market Operator: UAB AXIOLOGY DLT The use case covered the following scenarios: **Scenario 1 "Debt securities Auction, primary issuance, and settlement":** **Scenario 2 "Coupon payments":** **Scenario 3 "Maturity redemption of Debt Securities":**
DLT technology used on market side (as reported by market stakeholders)	The Axiology DLT trading and settlement system (TSS) is a private, permissioned infrastructure built using the open-source code of the XRP Ledger. While Axiology benefits from XRP Ledger technology, it operates as an independent system, designed to streamline trading, settlement, and custody of tokenized assets, such as financial securities, with enhanced security and efficiency. The platform combines accounting, trading, and settlement processes into a single infrastructure, allowing for instant Delivery Versus Payment (DVP) settlements. This integration simplifies processes and reduces data loss, with an immutable ledger ensuring an unaltered transaction history. Axiology also employs a risk management framework that addresses market integrity, investor protection, and financial stability. This is achieved through consensus-driven transactions, which require majority agreement among network nodes for validation. The platform limits on-chain functionalities to mitigate risks associated with human error typically found in traditional smart contracts. It operates on an order book basis, which minimises asset loss risks and maintains market integrity. The private, permissioned DLT infrastructure restricts node connections to eligible financial market participants, such as licensed brokers and banks, who issue tokens and manage investor wallets in compliance with EU regulations. One of its core features is the integration of certain Know Your Customer (KYC) procedures, e.g. verifying investor identities to maintain accurate data. Investors can deposit e-money tokens into their wallets via secure bank transfers, supported by stringent authentication and authorisation protocols. In cases of suspected fraudulent activity or legal issues, the platform has the ability to freeze wallets to prevent unauthorised transactions.

Flowchart of use case (as reported by market stakeholders)

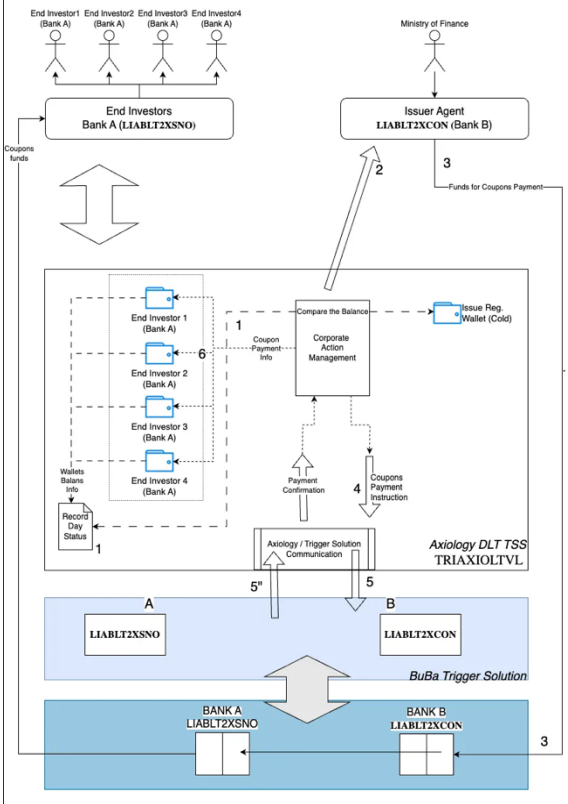


Scenario 1: Primary issuance of debt securities and settlement on Axiology DLT TSS using wCBDC

1. Auction results are submitted by the broker's agent through their own node API for distribution
2. Node creates an escrow wallet per each distribution list entry adding @Axiology operator as the only signer on the wallet. Further we will consider only a single case, as it's analogous for each distribution entry.
3. Node sends asset amount from issuers operational wallet to created escrow wallet, which uses XRP Payment transaction. Transaction contains address of the final receiver i.e. investor wallet, amount to charge them and amount to transfer to final beneficiary, given cash leg was successful.
4. Operator node receives a notification about escrow wallet payment transaction.
5. Operator node initiates cash leg with details provided in escrow wallet incoming payment transaction.

5". Operator receives confirmation of successful payment transactions

6. Operator transfers amount of asset from escrow wallet to final investors wallet, using XRP Payment transaction and thus finalizing DVP.

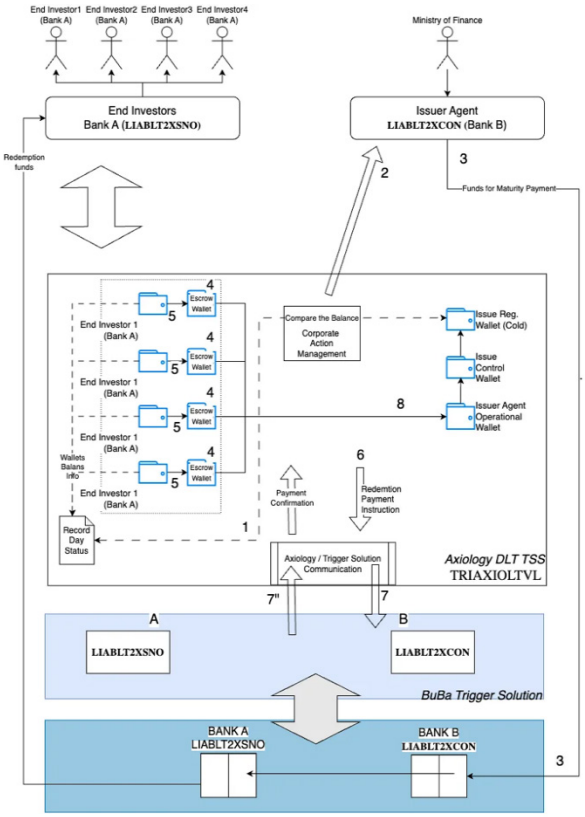


Scenario 2: Coupon payments of debt securities on Axiology DLT TSS using wCBDC

1. On the Record Date, the Operator shall identify the recipients of the coupon payments and reconcile the total cumulative balance held in all wallets belonging to end-investors with the cold wallet balance.
2. The issuer is informed of the need to accumulate the funds required for the coupon payment on the coupon payment date (in the account of the issuer's agent bank / T2 participant).
3. The Issuer accumulates the amount required for the Coupon Payment on the account of its Agent Bank (B).
4. On the Coupon Payment Date, the Operator, taking into account the result of the Record Date, creates the payment instructions to transfer the funds for the Coupon Payment from the Issuer's representative bank account to the accounts of the bank(s) representing the Final Investors and submits them to the Trigger Solution.
5. The Operator Node transmits the payment instructions with the Coupon Receiver's Wallet ID details to the Trigger Solution.

5". Operator receives confirmation of successful payment transactions.

6. Operator notifies end investor wallet holder of successful coupon payment.



Scenario 3: Maturity redemption of debt securities and settlement on Axiology DLT TSS using wCBDC

1. On the Record Date, the Operator shall identify the recipients of the redemption payments and reconcile the total cumulative balance held in all wallets belonging to end-investors with the cold wallet balance.

2. The issuer is informed of the need to accumulate the funds required for the redemption payment on the redemption date (in the account of the issuer's agent bank / T2 participant).

3. The Issuer accumulates the amount required for the Redemption Payment on the account of its Agent Bank (B).

4. Node creates an escrow wallet per each distribution list entry adding @Axiology operator as the only signer on the wallet. Further we will consider only a single case, as it's analogous for each redemption entry.

5. Node sends amount of asset from end-Investor wallet to created escrow wallet, which uses XRP Payment transaction. The transaction contains the address of the final recipient i.e. Operational Wallet, amount to charge them and amount to transfer to final Issuer Operational Wallet, given cash leg was successful.

6. Operator node receives a notification about escrow wallet payment transaction. Taking into account the result of the Record Date, the Operator creates the payment instructions to transfer the funds for the Redemption Payment from the Issuer's representative bank account to the accounts of the bank(s) representing the Final Investors and submits them to the Trigger Solution.

7. The Operator Node transmits the payment instructions with the Wallet ID details of the Redemption Payment Receiver to the Trigger Solution.

7". Operator receives confirmation of successful payment transactions.

8. Operator transfers amount of asset from escrow wallet to Issuer Agent Operational Wallet using XRP Payment transaction, thereby finalising DVP and initiating burning process. After this operation, the Cold Wallet will contain an empty balance.

High-level description (as reported by market stakeholders)

1. Primary issuance of Debt Securities (Government) via auction, including the settlement.
2. Coupon payments.
3. Maturity redemption of Debt Securities.

Investors and Issuers were simulated entities

Learning objectives of the market (as reported by market stakeholders)

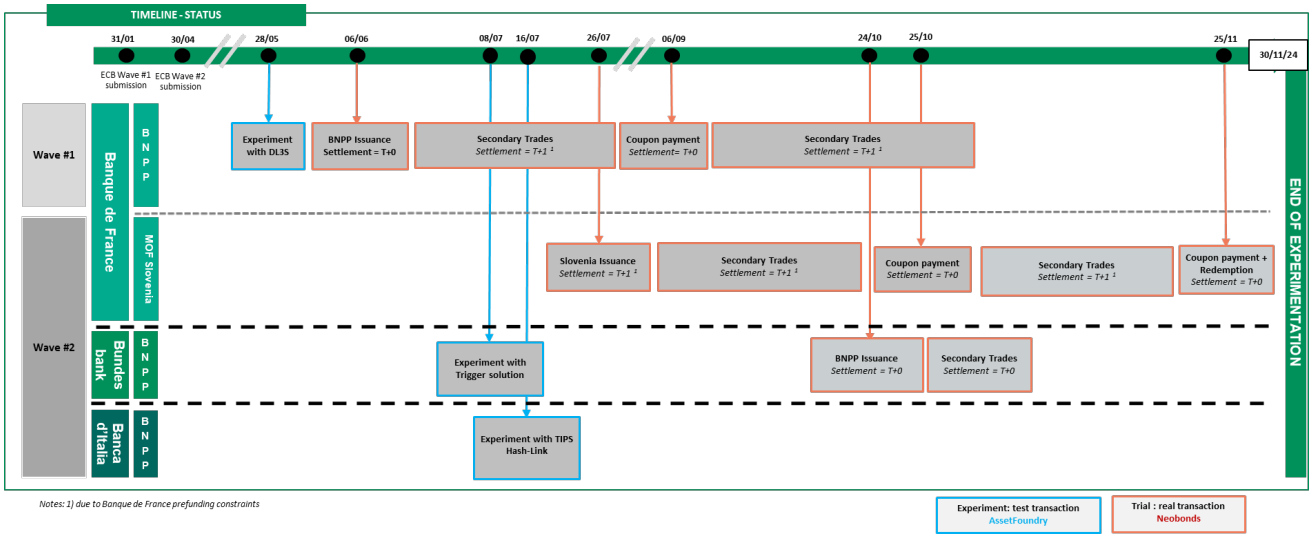
Main objective is to gain insight into the performance and reliability of the Axiology DLT TSS system and interoperability solutions for synchronizing DVP settlements in CeBM with an external settlement platform.

The scenarios focus on improving transaction efficiency and security in DVP securities settlements through the use of innovative DLT technology and central bank money. This will ensure more reliable DVP settlements using CeBM, which can lead to increased trust and participation in the DLT TSS ecosystem.

The scenarios of primary DVP distribution of bonds (e.g. government bonds), bond redemptions and coupon payments cover most popular market instruments and have market demand. By experimenting with synchronised DVP settlements, the aim is to demonstrate the capabilities of the Axiology DLT TSS system in real-world scenarios, ultimately validating the potential of its technology for widespread adoption and use of CeBM as a means of settlement on TSS platforms.

3.4 BNP Paribas

BNP Paribas tested all three solutions as part of Trials and Experiments detailed below:



Trials	**Category 1:** ***Primary issuance of bonds by financial institutions, corporates or sovereigns and delivery-versus-payment settlement, in some instances also including lifecycle management of securities (coupon payment and redemption) and secondary trading***
Eurosystem interoperability solution	Full DLT Interoperability Solution – DL3S (BdF)
Participants	Two Trials with BNP Paribas platforms as Market DLT Operator.[4] ❖ **Use Case 1: Issuance, coupon payment and secondary market transactions of a tokenised bond** • Issuer: BNP Paribas • Investor: BNP Paribas Asset Management • Wallet management and depositary bank for investor: Securities services (2S) • DLT Market Operator: BNPP Neobonds platform • Connectivity Bridge to DL3S via BNPP AssetFoundry ❖ **Use Case 2: "Issuance, coupon payment, secondary market transactions and redemption at maturity of a tokenised bond"** • Issuer: The Republic of Slovenia • Investors: AXA IM, EIB, BNP Paribas Asset Management, BNP Paribas SA + other external investors • Wallet management for investors: Securities services (2S) and Global Market (GM) • Paying agent for issuer: Securities Services (2S) • DLT Market Operator: BNPP Neobonds platform • Connectivity Bridge to DL3S via BNPP AssetFoundry
DLT technology used on market side (as reported by market stakeholders)	Digital Bond Issuances and distribution performed using Neobonds platform, BNPP's Global Markets in-house tokenisation platform that records the legal ownership of digital bonds, providing an operational framework for issuing and trading digital bonds, automatically generating coupons and supporting all lifecycle events, including secondary trading on OTC basis. Neobonds is built with Digital Asset Holdings Technology DAML and is leveraging Canton blockchain. AssetFoundry provided connectivity bridge to DL3S.

[4] Three other trials performed on DL3S as Market Participant.

Flowchart of use case (as reported by market stakeholders)

Digital Issuance with on-chain settlement using DL3S from Banque de France

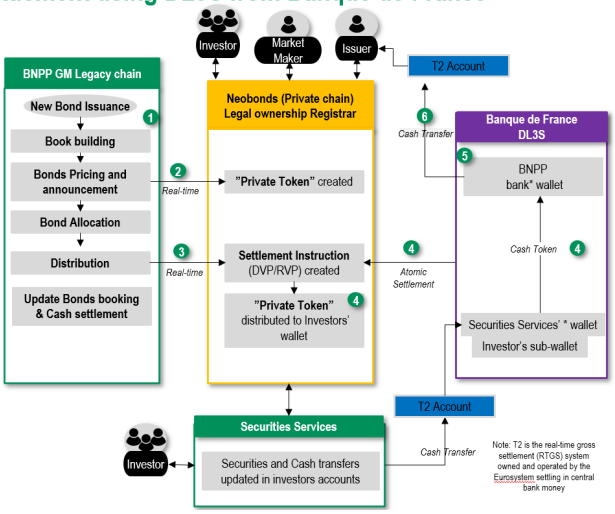
New Roles

- **Neobonds is acting as** BNPP security DLT tokenisation platform & security registrar
- **Banque de France :**
  - mints Central Bank Digital Currency (CBDC)
  - manages the Cash DLT (DL3S)
  - manages the Fiat EUR transfer in Target 2 (T2) from BdF escrow account to BNPP T2 account after burning CBDC
- **BNPP GM :** manages in DL3S Issuer's sub-wallet and its own wallet
- **2S :** Clients transaction in Neobonds, the funding in T2 and their CBDC wallet in DL3S

Debt Issuance workflow – settled at Issuance date

BdF requirement : pre-funding by 9am on T0: Investor must instruct 2S on T-1 and ensure **cash balance is available on its cash account**. On T0, 2S debit client's cash account and transfer the amount from 2S T2 account to BdF escrow account. BdF mint CBDC in DL3S in 2S wallet, allocated to the investor's sub wallet.

1. No change to issuance origination & pricing process
2. **Token created in Neobonds** once client allocation is confirmed
3. **Settlement instructions matching** confirmed in Neobonds by 2S (Received versus Payment - RVP) & BNPP (Delivery versus payment - DVP).
4. **On chain settlement,** transfer of CBDC & security tokens between BNPP and investor wallets
5. **CBDC Burnt** by Banque de France & Fiat EUR credited to BNPP GM T2 Account
6. **Issuance amount credited to Issuer account T0**



High-level description (as reported by market stakeholders)

❖ **Use Case 1: BNP Paribas issuance** (Issuance, coupon payment and secondary market transactions of a tokenised bond)

BNP Paribas issued a Senior Preferred Note, with a nominal size of EUR 10mn, coupon of 3,542%, maturity 6 June 2026. Tokenisation and Distribution with settlement on chain performed on Neobonds platform. Issuance was followed by secondary market transactions and coupon payment all settled on-chain.

❖ **Use Case 2: Republic of Slovenia issuance** (Issuance, coupon payment, secondary market transactions and redemption at maturity of a tokenised bond)

BNP Paribas arranged and placed the first Sovereign digital bond issuance for Eurozone and EMEA, for Republic of Slovenia with a nominal size of EUR 30mn, coupon of 3.650%, maturity 25 November 2024. Tokenisation and distribution were performed on Neobonds platform. Followed by secondary market transactions with various investors on OTC basis, coupon payment and redemption.

Learning objectives of the market (as reported by market stakeholders)

Business:

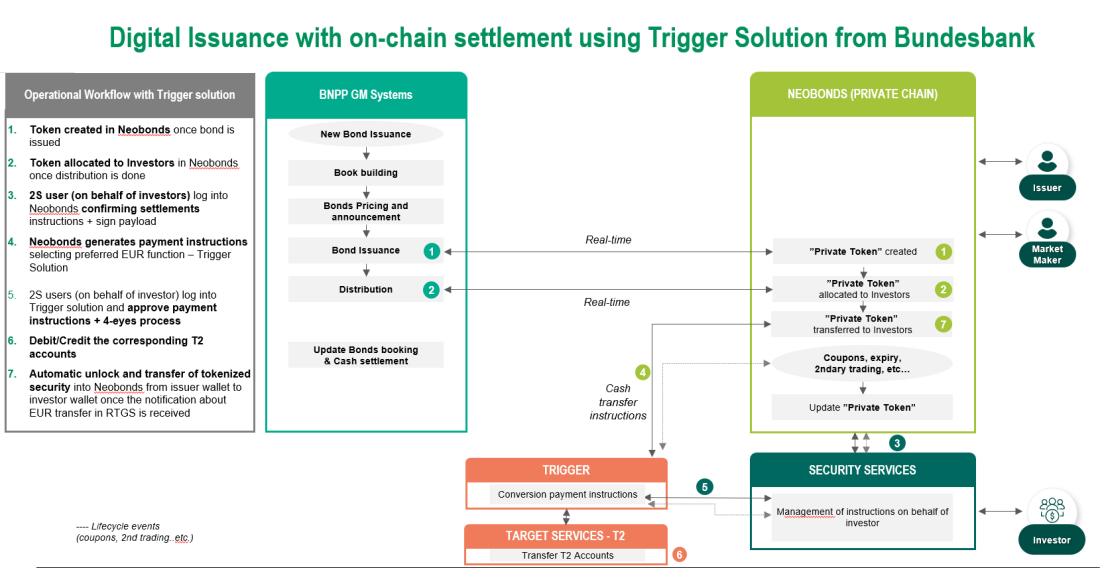
- Perform a full on-chain Delivery versus Payment (DvP) using a tokenised bond on a private blockchain versus a payment in ECT provided by Banque de France
- Share knowledge with the Eurosystem on solutions available and considered relevant for financial instruments tokenisation
- Perform real transaction using DL3S solution to test the model on a real environment, provide constructive feedback and adapt internal operational workflow accordingly
- Share feedback and help on building a Central Bank Money solution for Europe as it is instrumental for the future of tokenisation in the financial area
- Have a first understanding of requirements for investors to use Central Bank Money for settlement

Technical:

- Assess strengths and limitations of interoperability using HTLC smart contracts and HTLC settlement APIs.
- Understand technical requirements to use EUR CBDC for DvP settlement.
- Evaluate Market DLT's ability to provide settlement atomicity using BdF HTLC settlement API.
- Identify automation opportunities and scope of fall-back scenarios.

Process:

- Identify and train teams that could be involved in the use of Central Bank Money solutions
- Identify processes and tools to be involved in the use of Central Bank Money solutions
- Understand impact on operational procedures
- Understand legal/accounting/finance/compliance/tax implications of Central Bank Money solutions

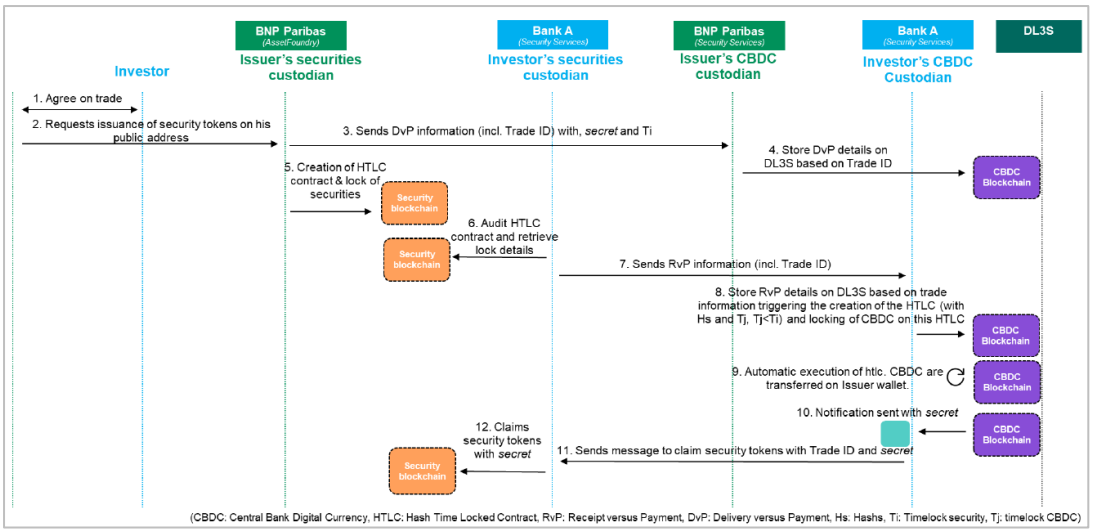
Trial	**Category 1:** ***Primary issuance of bonds by financial institutions, corporates or sovereigns and delivery-versus-payment settlement, in some instances also including lifecycle management of securities (coupon payment and redemption) and secondary trading***
Eurosystem interoperability solution	Trigger Solution (BBk)
Participants	❖ **Use Case: "Issuance and secondary market transaction on OTC basis of a digital bond"** • Issuer: BNP Paribas ALMT • Investor: BNP Paribas Asset Management • Wallet manager and depositary bank for investor: BNP Paribas Securities Services • DLT Market Operator: BNPP Neobonds platform • Connectivity Bridge to Trigger via BNPP AssetFoundry
DLT technology used on market side (as reported by market stakeholders)	Digital Bond Issuance and distribution performed using Neobonds platform, BNPP's Global Markets in-house tokenisation platform that records the legal ownership of digital bonds, providing an operational framework for issuing and trading digital bonds, automatically generating coupons and supporting all lifecycle events, including secondary trading on OTC basis. Neobonds is built with Digital Asset Holdings Technology DAML and is leveraging Canton blockchain. AssetFoundry provided connectivity bridge to Trigger.
Flowchart of use case (as reported by market stakeholders)	
High-level description (as reported by market stakeholders)	BNP Paribas issued a Senior Preferred Note, with a nominal size of EUR 1mn, maturity 24 October 2026. Tokenisation and Distribution with settlement on-chain performed on Neobonds platform with Bundesbank's Trigger Solution. Issuance was followed by secondary market transactions and coupon payment all settled on-chain.
Learning objectives of the market (as reported by market stakeholders)	Enhance securities tokenisation offer with an interoperability link to TARGET 2 (T2). Tokenisation of a vanilla bond, non-listed. Based on the tokenisation of the bond and the lock on a HTLC contract, test the capacity to unlock this security for an investor once the cash is transferred in T2. Business: • Ensure feasibility to perform a Delivery versus Payment (DvP) using a tokenised bond on a private blockchain versus a payment in T2. • Share knowledge with the Eurosystem on Trigger Solution technical and operational processes used for financial instruments tokenisation and what do we see as business trends • Share feedback and help on building a Central Bank Money solution for Europe to settle DLT transactions as it is instrumental for the future of tokenisation in the financial area • Perform real transaction using Trigger solution model to test the model on a real environment, provide constructive feedback and adapt internal operational workflow accordingly.

Technical:

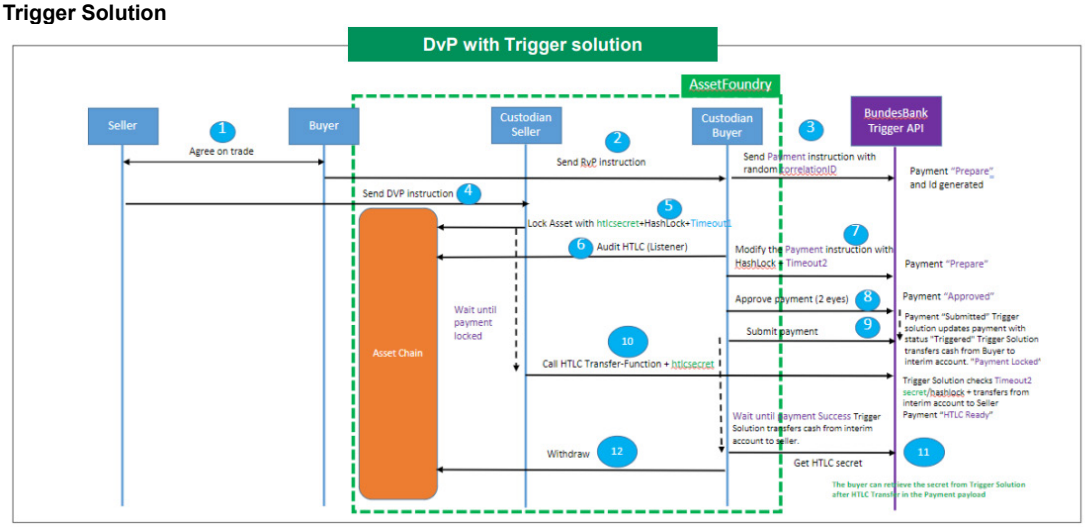
- Assess strengths and limitations of interoperability using HTLC smart contracts and HTLC settlement APIs.
- Understand technical requirements to use HTLC Payment Instructions for DvP settlement.
- Evaluate Market DLT's ability to provide settlement atomicity using Bundesbank HTLC settlement API.
- Identify automation opportunities and scope of fallback scenarios.

Process:

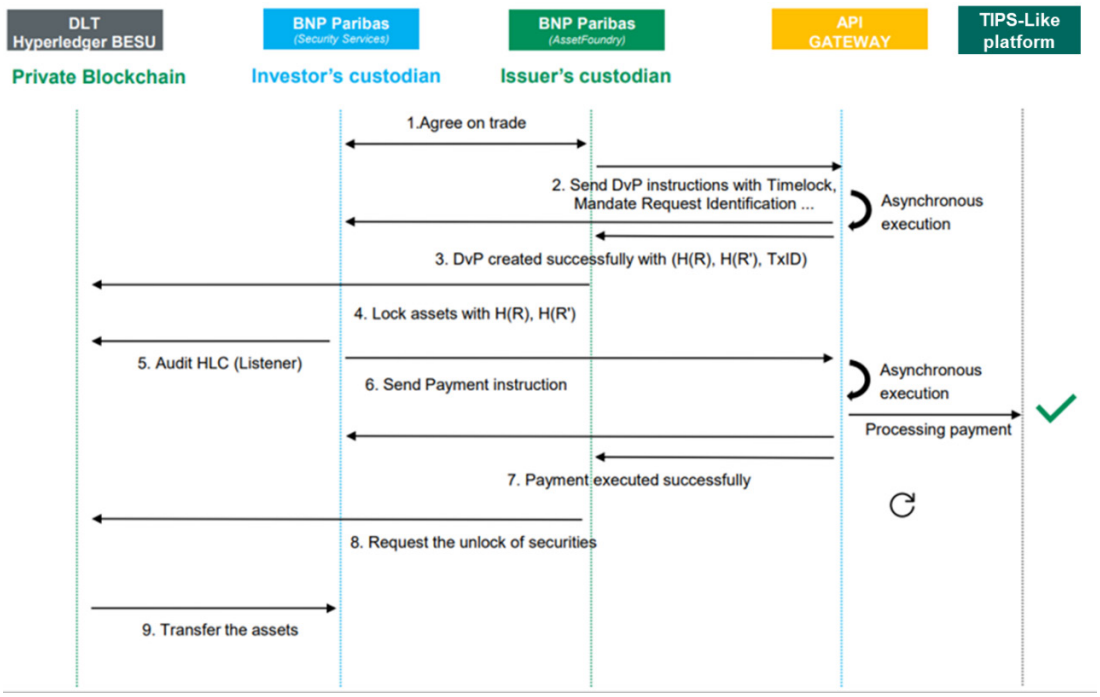
- Identify and train teams that could be involved in the use of Central Bank Money solutions
- Identify processes and tools to be involved in the use of Central Bank Money solutions
- Understand impact on operational procedures
- Understand legal/accounting/finance/compliance/tax implications of Central Bank Money solutions

Experiments	**Category 1: *Primary issuance of bonds by financial institutions, corporates or sovereigns and delivery-versus-payment settlement, in some instances also including lifecycle management of securities (coupon payment and redemption) and secondary trading***
Eurosystem interoperability solution	One experiment in Full DLT Interoperability Solution (BdF) One experiment in Trigger Solution (BBk) One experiment in TIPS Hash-Link (BdI)
Participants	❖ **Use cases 1, 2 and 3:** • Issuer: BNP Paribas • Investor: BNP Paribas • DLT Market Operator: BNP Paribas AssetFoundry
DLT technology used on market side (as reported by market stakeholders)	The AssetFoundry platform by BNP Paribas is a blockchain-based solution focused on tokenising financial instruments, including sustainable and ESG-linked data for investors. Built on Ethereum technology, AssetFoundry facilitates the creation, management, and distribution of tokenised assets as native digital securities, providing transparency and traceability throughout their lifecycle. AssetFoundry has developed audited permissioned smart contracts to represent financial instrument and can be deployed on any Ethereum-compatible networks (private or public). A key feature of AssetFoundry is its ability to embed ESG-related data directly into tokenised securities. This supports the verification and reporting of ESG impacts, addressing the need for reliable and granular data in sustainable financing. The platform also supports flexibility by allowing tokenised assets to revert to traditional forms if necessary. This capability makes AssetFoundry suitable for both institutional and smaller-scale investments, helping broaden access to financing and increase efficiency in capital markets
Flowchart of use case (as reported by market stakeholders)	**Full DLT Interoperability (DL3S)** 

Trigger Solution



TIPS Hash Link



High-level description (as reported by market stakeholders)	A Delivery versus Payment (DvP) on primary market (i.e. Issuance) with the security tokenised on AssetFoundry platform and the cash part in the form of: • Exploratory Cash Tokens (ECTs) in DL3S test environment (BdF) • Fiat money transferred in T2 test environment through the Trigger solution (BBk) • Fiat money transferred in TIPS-like test environment (BdI) No coupon paid, no redemption Underlying instrument Vanilla non listed bond. Listed company with an official rating, OTC placement

Learning objectives of the market (as reported by market stakeholders)

Enhance securities tokenisation offer with Central Bank Money solutions for DLT transactions. Tokenisation of a vanilla bond, non-listed. All data were fake. Issuer was a simulated participant. Based on the tokenisation of the bond and the lock on a HTLC contract, test the capacity to unlock this security for a simulated investor once the cash part is unlocked on Central Bank cash setup and transferred.

Business:

- Ensure feasibility to perform an on-chain Delivery versus Payment (DvP) using a tokenised bond on a private blockchain versus a payment on respective Central Banks' setups
- Share knowledge with the Eurosystem on solutions used for financial instruments tokenisation and what do we see as business trends
- Share feedback and help on building a Central Bank Money solution for DLT transactions for Europe as it as instrumental for the future of tokenisation in the financial area
- Have a first understanding of requirements for investors to use Central Bank Money solution for DLT transactions

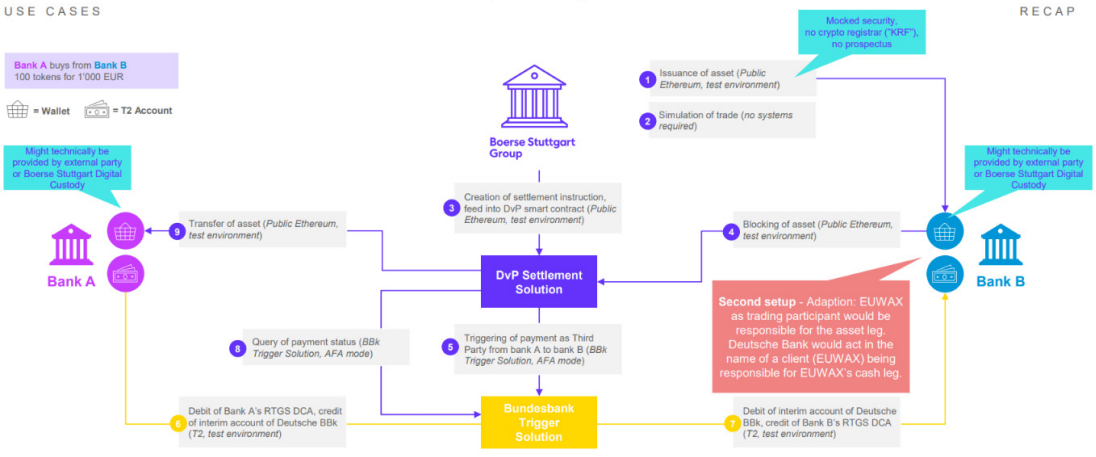
Technical:

- Gain more experience regarding HTLC contracts to lock tokenised bonds waiting for the transfer on cash setup and the interaction with another blockchain using also HTLC contracts to lock cash and the capacity for the Investor, to unlock the security using the secret revealed once the cash is unlocked and transfer to the right issuer wallet from the right investor wallet.
- Understand technical requirements to use potential future Central Bank Money solutions to pave the ground for future implementation: capacity to communicate with Central Bank cash setup information regarding DvP instruction and RvP instruction
- Gain knowledge on requirement regarding link between legacy systems for cash and future solution: test also User Interface usage to create wallets on behalf of custodians, issuer and investors, if applicable and thus gain knowledge in potential future requirements for all participants to use Central Bank Money solutions

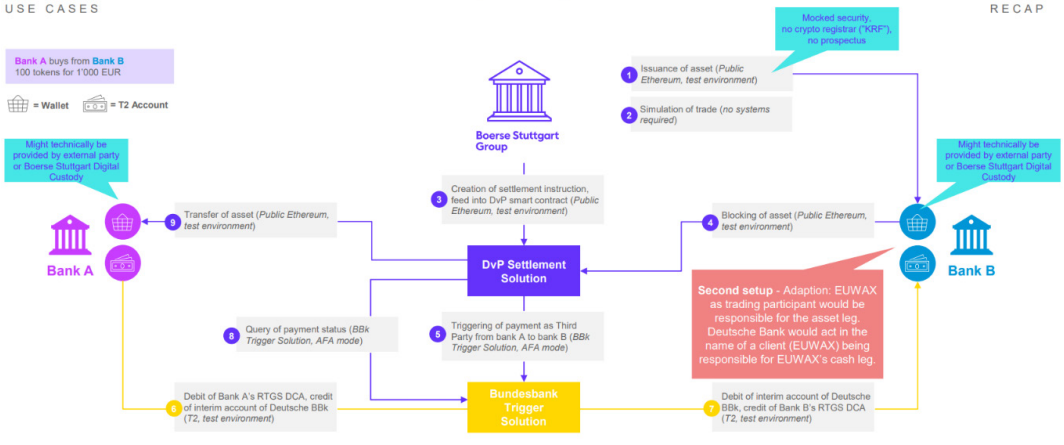
Process:

- Identify and train teams that could be involved in the use of Central Bank Money solutions
- Identify processes and tools to be involved in the use of Central Bank Money solutions
- Understand impact on operational procedures

3.5 Boerse Stuttgart (Baden-Württembergische Wertpapierbörse GmbH - BWWB)

Experiment	Category 10: *secondary market activity of various financial instruments*
Eurosystem interoperability solution	Trigger Solution (BBk)
Participants	• Secondary market trading activities with Commerzbank, DZ BANK, Deutsche Bank, LBBW, Bankhaus Metzler, V-Bank • Market DLT Operator: BWWB • Market Maker /non T2 member: Euwax AG (part of Boerse Stuttgart Group) • Tech Provider: BX Digital AG ; Boerse Stuttgart Digital Custody Five digital securities: Bond, fund, equity
DLT technology used on market side (as reported by market stakeholders)	The following features characterise the Boerse Stuttgart DLT Settlement System: • DLT-technology: the Boerse Stuttgart System is DLT/blockchain agnostic. The asset in the ECB experiments are issued on Ethereum (test environment) • Design principle “Bring your own wallet”: Market participants bring their own wallet infrastructure for digital assets and their own access to T2 for cash holdings. The Boerse Stuttgart System orchestrates the settlement between the wallets and cash accounts of the market participants (no central custody through Boerse Stuttgart) • Functionalities: the Boerse Stuttgart System receives a settlement instruction of a trade between two market participants to be matched (within the ECB experiments, such trade will only be simulated). An integral part of the Boerse Stuttgart Settlement System is its DvP (Delivery vs. Payment) Smart Contract. The Boerse Stuttgart Settlement System orchestrates asset leg onchain with payment leg offchain in T2 via Bundesbank Trigger Solution.
Flowchart of use case (as reported by market stakeholders)	**Conducted different (happy and unhappy) cases within two setups: T2 vs T2 participant and T2 vs Non-T2 via T2 participant**  **The idea is to test an end-to-end automated settlement setup in a non-production environment using existing technical infrastructure**
High-level description (as reported by market stakeholders)	Two scenarios: 1. General Scenario: Banks with T2 access are acting as trading participants and are trading for their own account 2. House Bank Scenario: One non-bank trading participant (EUWAX) will be using its house bank (Deutsche Bank) for the cash settlement leg

Learning objectives of the market (as reported by market stakeholders)	Conceptual Dimension: illustration of the benefits and challenges when using a DLT-based infrastructure for settlement of tokenised securities. Understand how a DLT-based system can integrate with traditional financial ecosystems like T2. Business Dimension: evaluate the potential of the DLT-based settlement system to be integrated in T2 for EU-wide market adoption. Investigate the different roles of market participants in a future, DLT-based ecosystem. Technical Dimension: investigate the technical feasibility and challenges of implementing the Trigger Solution between DLT platforms (like Ethereum) and the T2 system, focusing on aspects like message formats and interface connections. Operational Dimension: examine how the use of DLT and smart contracts can improve process efficiencies, reduce manual interventions and errors, and enhance the automation of financial transactions and settlements.

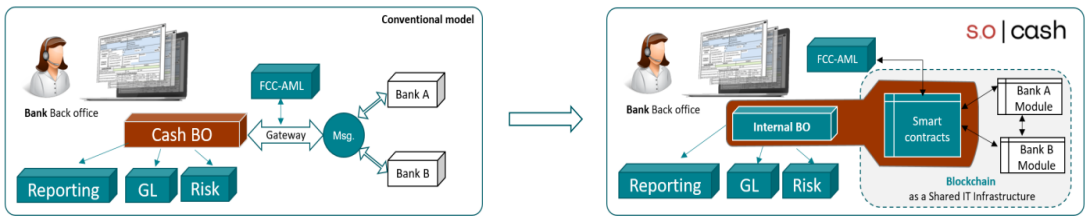
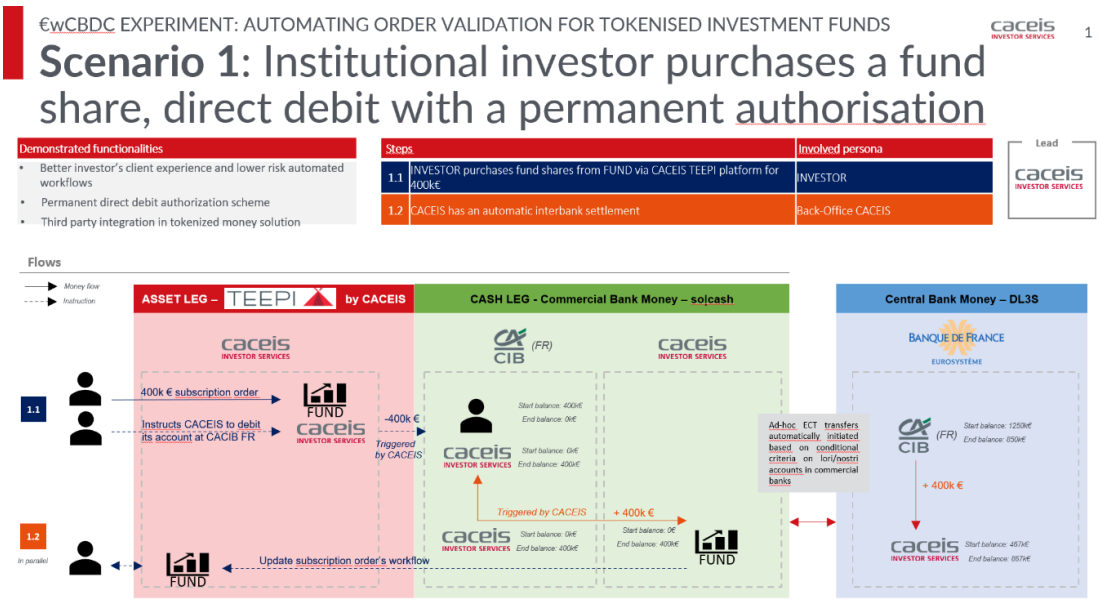
Experiment	**Category 10: *secondary market activity of various financial instruments***
Eurosystem interoperability solution	Trigger Solution (BBk)
Participants	❖ **Atomicity / unhappy path experiments** • Secondary market trading activities with Commerzbank, DZ BANK, Deutsche Bank, LBBW, Bankhaus Metzler, V-Bank • Market DLT Operator: BWWB • Tech Provider: BX Digital AG; Boerse Stuttgart Digital Custody Five digital securities: Bond, fund, equity
DLT technology used on market side (as reported by market stakeholders)	The following features characterise the Boerse Stuttgart DLT Settlement System: • DLT-technology: the Boerse Stuttgart System is DLT/blockchain agnostic. The asset in the ECB experiments are issued on Ethereum (test environment) • Design principle: “Bring your own wallet”: Market participants bring their own wallet infrastructure for digital assets and their own access to T2 for cash holdings. The Boerse Stuttgart System orchestrates the settlement between the wallets and cash accounts of the market participants (no central custody through Boerse Stuttgart) • Functionalities: the Boerse Stuttgart System receives a settlement instruction of a trade between two market participants to be matched (within the ECB experiments, such trade will only be simulated). An integral part of the Boerse Stuttgart Settlement System is its DvP (Delivery vs. Payment) Smart Contract. The Boerse Stuttgart Settlement System orchestrates asset leg onchain with payment leg offchain in T2 via Bundesbank Trigger Solution.
Flowchart of use case (as reported by market stakeholders)	**Conducted different (happy and unhappy) cases within two setups: T2 vs T2 participant and T2 vs Non-T2 via T2 participant**  **The idea is to test an end-to-end automated settlement setup in a non-production environment using existing technical infrastructure**

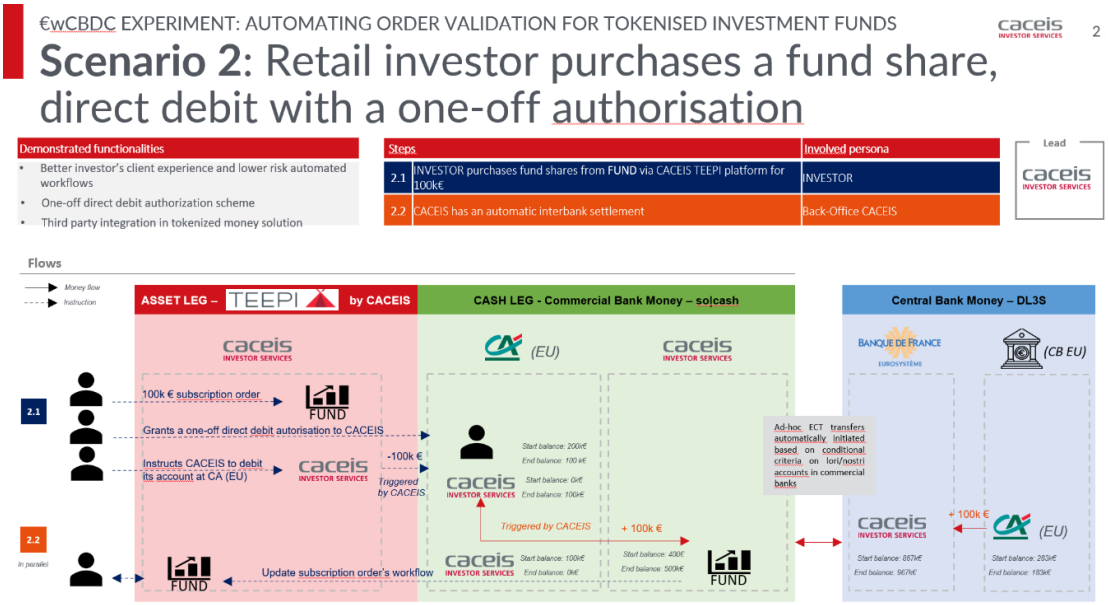
	Special cases: • **Late Cash:** Cash will be provided late, **within 5min** --> **"locked" assets** have been sent to **buyer** • **Failed Payment**: Automated cancellation upon failed payment (missing cash **>=5min**) --> "locked" assets have been sent **back to seller** • **Missing Assets (= Late allowance):** We stage a settlement where a participant has not entered sufficient allowance on the asset --> automated settlement execution, once allowance was sufficient • Settlement with a **participant without direct RTGS access** (here: EUWAX leveraged Deutsche Bank)
High-level description (as reported by market stakeholders)	In addition to the "happy path" (described in the above use case table), i.e. that the transactions go through as planned, constellations were also explicitly and deliberately created that should not occur in practise in this way, but can occur in exceptional cases. For example that the securities agreed in the trade are not available at the time of settlement or that there is insufficient liquidity on the accounts.
Learning objectives of the market (as reported by market stakeholders)	This deliberate failure of a transaction can be used to draw valuable conclusions about system behaviour and the processes implemented, which in turn helps to make the desired happy path more stable.

Experiment	**Category 10: *secondary market activity of various financial instruments***
Eurosystem interoperability solution	Trigger Solution (BBk)
Participants	❖ **Throughput / scalability experiments** • Market DLT Operator: BWWB • Tech Provider: BX Digital AG; Boerse Stuttgart Digital Custody • Booking took place on Bundesbank Testing accounts in T2 UTEST used for tests with the Trigger Solution
DLT technology used on market side (as reported by market stakeholders)	The following features characterise the Boerse Stuttgart DLT Settlement System: • DLT-technology: the Boerse Stuttgart System is DLT/blockchain-agnostic. The asset in the ECB experiments are issued on Ethereum (test environment) • Design principle: “Bring your own wallet”: Market participants bring their own wallet infrastructure for digital assets and their own access to T2 for cash holdings. The Boerse Stuttgart System orchestrates the settlement between the wallets and cash accounts of the market participants (no central custody through Boerse Stuttgart) • Functionalities: the Boerse Stuttgart System receives a settlement instruction of a trade between two market participants to be matched (within the ECB experiments, such trade will only be simulated). An integral part of the Boerse Stuttgart Settlement System is its DvP (Delivery vs. Payment) Smart Contract. The Boerse Stuttgart Settlement System orchestrates asset leg onchain with payment leg offchain in T2 via Bundesbank Trigger Solution.
Flowchart of use case (as reported by market stakeholders)	(see above use case table)
High-level description (as reported by market stakeholders)	Throughput Tests: Due to complete end-to-end automation (no single manual step), various loads of settlement-instructions were executed under parametrizable conditions and with the aim to remain within the daily limits of maximum settled transactions via the Trigger solution. Load iteration 1: 25 transactions Load iteration 2: 50 transactions Load iteration 3: 100 transactions Load iteration 4: 200 transactions BWWB instructed each load iteration in one shot/ at once within its internal applications. Owing to the processes and steps to be performed on market DLT operator side the transactions subsequently reached the Trigger Solution with a lower frequency.

Learning objectives of the market (as reported by market stakeholders)	Test an end-to-end automated settlement setup in a non-production environment using existing technical infrastructure and see how the latency evolves (on market participants as well as on Trigger Solution side). A key learning has been that the distribution of processes throughout the life-chain of a transaction between the Market DLT operator and the Trigger Solution smoothed the peak loads generated by one-shot load iterations.

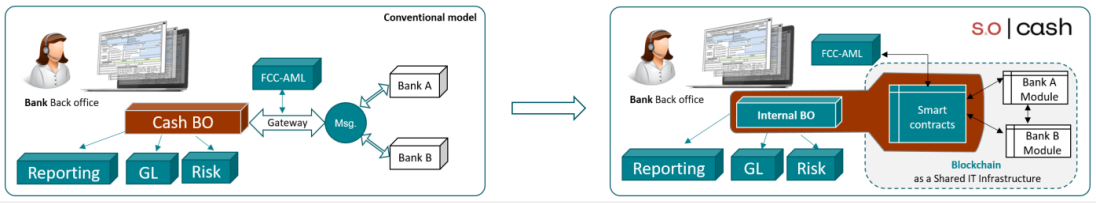
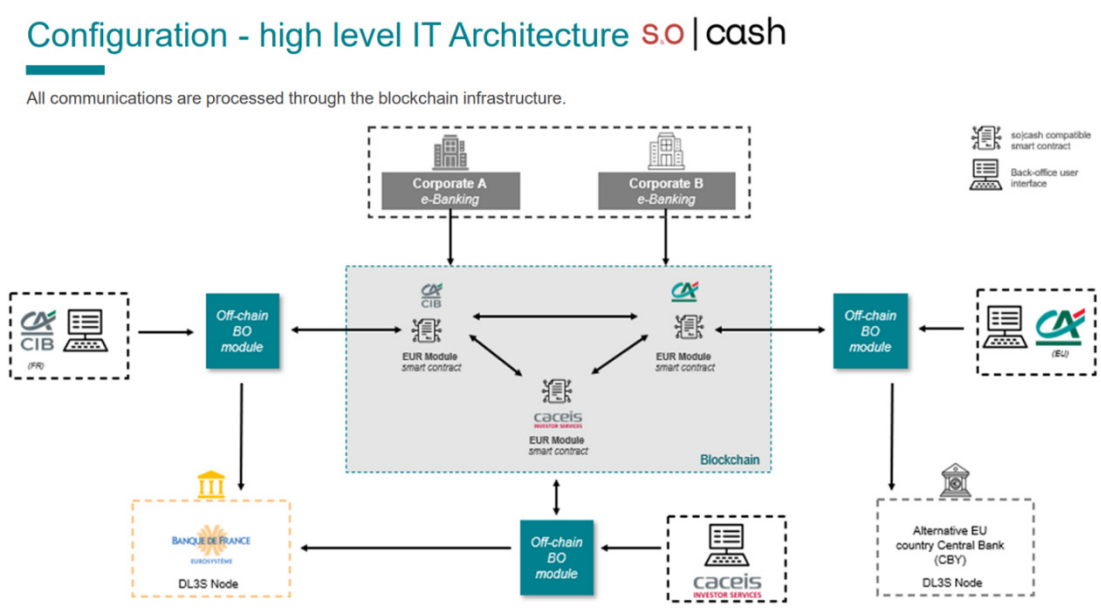
3.6 CACEIS

Experiment	Category 4: *Automated wholesale payments for interbank transfers*
Eurosystem interoperability solution	Full DLT Interoperability Solution (BdF)
Participants	• Market participants: CACEIS, CACIB • Investors: Institutional and retail clients via CACEIS services • Asset leg: CACEIS with its TEEPI platform • DLT Operator: Crédit Agricole CIB with so|cash platform a. Payer's bank: CACIB (FR), Crédit Agricole (EU) b. Payee's bank: CACEIS
DLT technology used on market side (as reported by market stakeholders)	so | cash ("Sustainable & Open Cash framework") is an open-source standard based EVM smart contracts (ERC20 compatible) to enable correspondent banking to operate on chain. This protocol enables the banking industry to operate deposit accounts in a generic shared IT infrastructure (a blockchain) while respecting laws and regulations of the banking industry. Banks can deploy a smart contract on the blockchain that acts as a back-office program in which accounts can be created, maintained and payments operated. Account holders can autonomously and instantly access their accounts and make real instant payments which will be validated by the network and written on the ledger. Payments can occur between accounts in two different banks within a single program operation. Atomic and instantaneous payments can be programmed to be executed whenever some preconditions are met. 
Flowchart of use case (as reported by market stakeholders)	

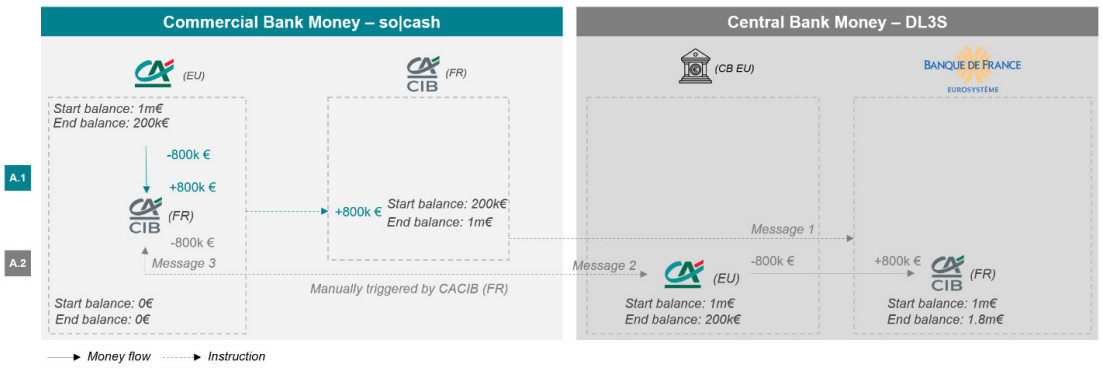


High-level description (as reported by market stakeholders)	Test scenarios aiming at demonstrating the value of programmable payments in the fund industry to further automate processes while reducing operational risks: 1. An institutional investor granting a permanent direct debit authorisation to the transfer agent of the investment fund: • Investor purchases a fund share from a fund serviced by CACEIS with an automatic direct debit • Upon completion of the payment, the purchase order is automatically validated and proposed to execution 2. A retail investor granting a one-off direct debit authorisation to the transfer agent of the investment fund: • Investor purchases a fund share from a fund serviced by CACEIS with a one-off authorisation granted to CACEIS • Investor validates the request for direct debit related to the order • Upon completion of the payment, the purchase order is automatically validated and proposed to execution Parties involved are simulated
Learning objectives of the market (as reported by market stakeholders)	Today the investment funds industry is mainly human-based as regards pre-funded investment orders: validation process is based on controls and pre-matching systems but still requires human intervention to link cash movements to orders to avoid false positives. These time consuming/error-prone tasks introduce operational risks (since payment rails and order/event management flows are independent). Investors are mainly natural or legal persons with no access to Central Bank Money and are clients of commercial banks. Thus, their investment experience will benefit from the presence of an on-chain Commercial Bank Money infrastructure which automates order validation for traditional and tokenised fund shares while enabling automated generation of payment instructions and their tracking (finality of debit and credit).

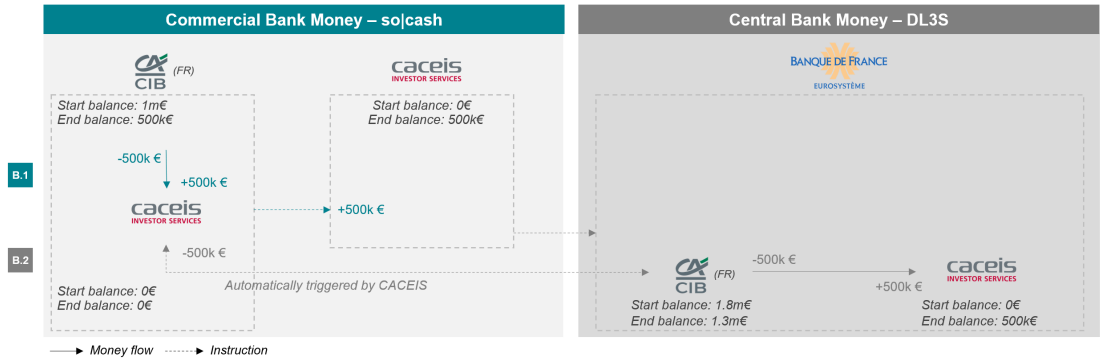
3.7 CACIB

Experiment	Category 4: *Automated wholesale payments for interbank transfers*
Eurosystem interoperability solution	Full DLT Interoperability Solution (BdF)
Participants	• Market participants: CACIB, CACEIS • Clients: Corporate companies • Market DLT operator: CACIB
DLT technology used on market side (as reported by market stakeholders)	so | cash (“Sustainable & Open Cash framework”) is an open-source standard based EVM smart contracts (ERC20 compatible) to enable correspondent banking to operate on chain. This protocol enables the banking industry to operate deposit accounts in a generic shared IT infrastructure (a blockchain) while respecting laws and regulations of the banking industry. Banks can deploy a smart contract on the blockchain that acts as a back-office program in which accounts can be created, maintained and payments operated. Account holders can autonomously and instantly access their accounts and make real instant payments which will be validated by the network and written on the ledger. Payments can occur between accounts in two different banks within a single program operation. Atomic and instantaneous payments can be programmed to be executed whenever some preconditions are met. 
Flowchart of use case (as reported by market stakeholders)	

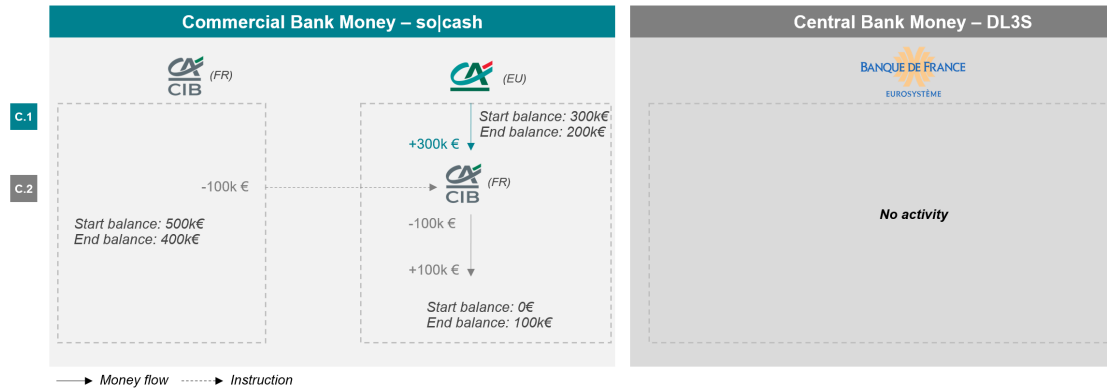
Scenario A: Corporate A instructs CA (EU) to pay Corporate B account at CACIB (FR) and manual wCBDC settlement



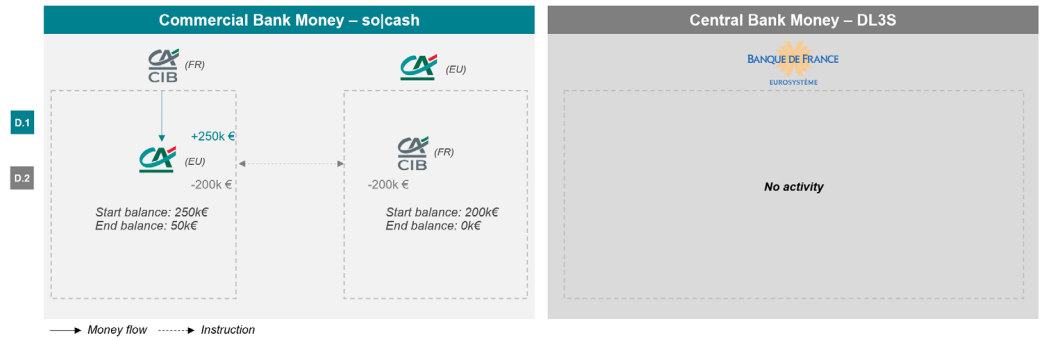
Scenario B: Corporate B treasurer transfers € to its account at CACEIS with automated interbank settlement



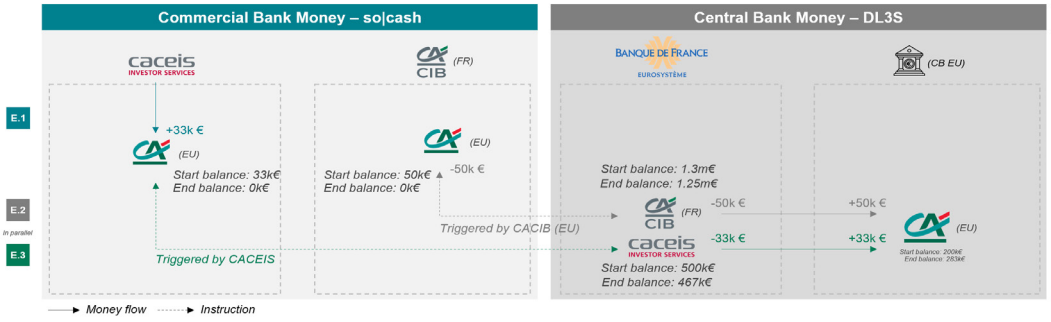
Scenario C: Corporate B treasurer transfers money to its account at CA (EU) when CACIB (FR) already has cash on its nostro



Scenario D: CACIB (FR) and CA (EU) banks net their liabilities with each other

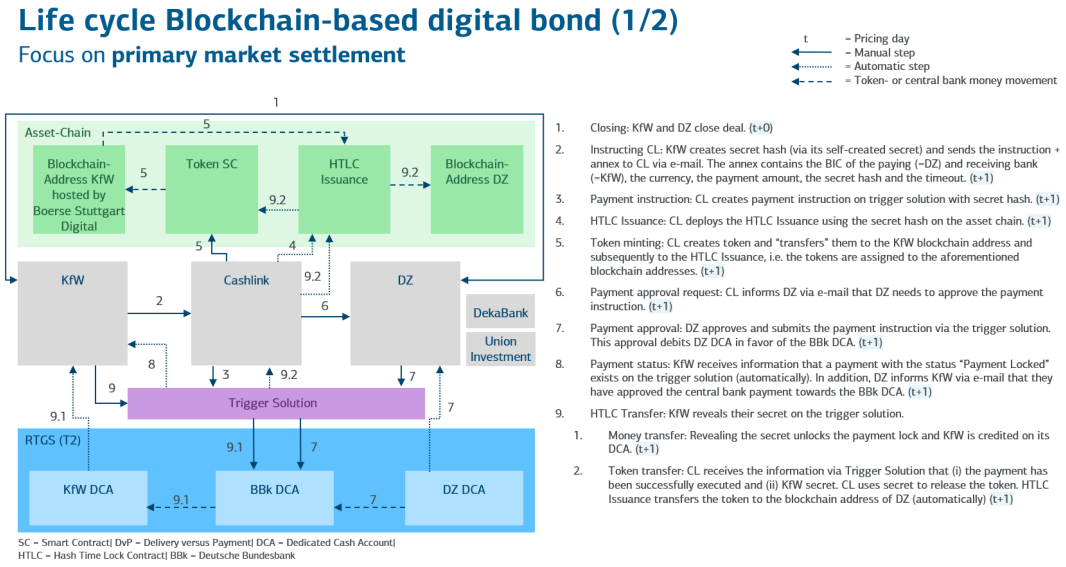


Scenario E: CA (EU) manages its end of day treasury to repatriate its funds from other banks



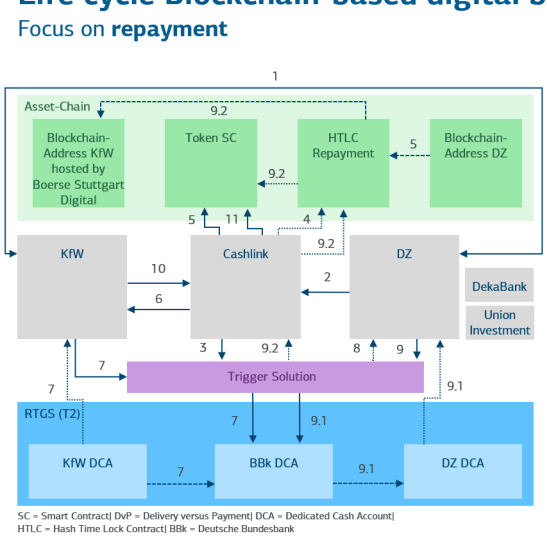
High-level description (as reported by market stakeholders)	5 different scenarios tested: A. Corporate A instructs CA (EU) to pay Corporate B's account at CACIB and manual wCBDC settlement. • Instant transfer between client accounts in two different banks: the ability to perform instantaneous and atomic interbank transfers. • Interfacing with Full DLT Interoperability (DL3S) for the interbank settlement (manually triggered): ensuring interoperability between the so|cash and DL3S environments. B. Corporate B treasurer transfers € to its account at CACEIS with automated interbank settlement • Enable client to trigger a transfer from its account • Automate the interbank settlement via DL3S C. Corporate B treasurer transfers money to its account at CA (EU) when CACIB already has cash on its nostro. • Use treasury rules for interbank commercial money exchange D. CACIB and CA (EU) banks net their liabilities with each other. • Atomic clearing of reciprocal liabilities between 2 banks E. CA (EU) manages its end of day treasury to repatriate its funds from other banks. • Multiple parallel interbank settlements via DL3S Parties involved are simulated
Learning objectives of the market (as reported by market stakeholders)	Test the interoperability model for wCBDC, using Banque de France solution (DL3S), with a decentralised correspondent banking protocol (so|cash). Assess the feasibility and merit of a unified ledger of commercial bank money for the banking industry. Foster banking cooperation and promote interbank contribution on EUR wCBDC and digital commercial bank money topic. Such a protocol does not require any central operator but relies on banks sharing a ledger where they each operate their back office module.

3.8 Cashlink Technologies

Trial	**Category 1:** ***Primary issuance of bonds by financial institutions, corporates or sovereigns and delivery-versus-payment settlement, in some instances also including lifecycle management of securities (coupon payment and redemption) and secondary trading***
Eurosystem interoperability solution	Trigger Solution (BBk)
Participants	❖ **Use Case "Issuance of senior unsecured bond":** • Issuer: KfW • Market DLT Operator: Cashlink Technologies • Bookrunner: DZ BANK • Investors: Union Investment, DekaBank, DZ BANK • Crypto securities registrar: Cashlink Technologies • Crypto custodian: Boerse Stuttgart Digital Custody • Redemption within exploratory work as DvP with Trigger Solution
DLT technology used on market side (as reported by market stakeholders)	The bond was issued on the blockchain infrastructure of the Market DLT Operator Cashlink that acted as the crypto securities registrar. The leveraged DLT is Polygon PoS, a public permissionless blockchain. It is designed to address scalability challenges within the Ethereum ecosystem. It operates as an EVM-compatible Layer-2 (L2) proof-of-stake based scaling solution for Ethereum, enhancing its throughput while also significantly bringing down gas costs, i.e., transaction fees.
Flowchart of use case (as reported by market stakeholders)	

Life cycle Blockchain-based digital bond (2/2)

Focus on **repayment**

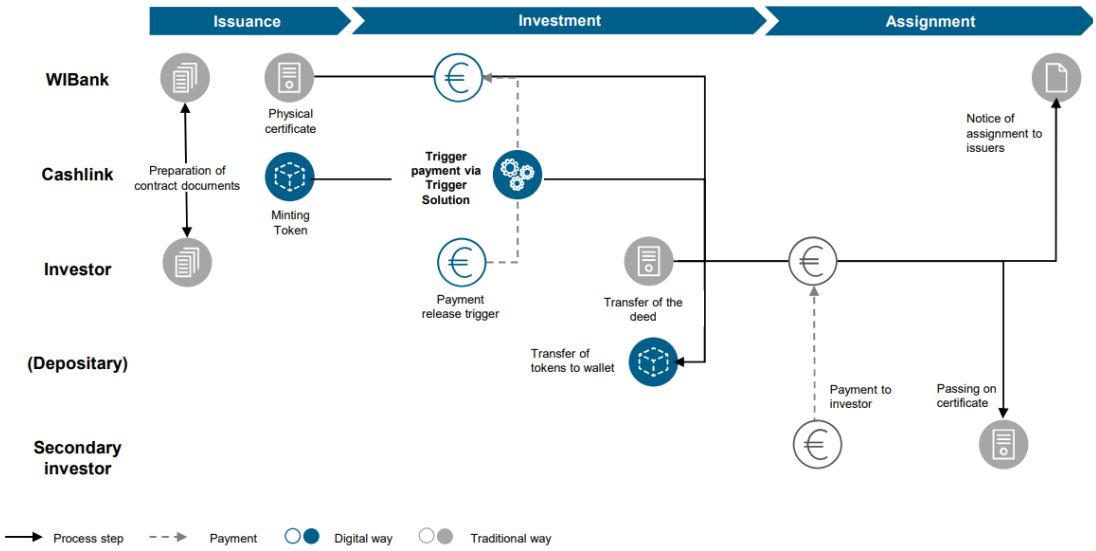


SC = Smart Contract| DvP = Delivery versus Payment| DCA = Dedicated Cash Account| HTLC = Hash Time Lock Contract| BBk = Deutsche Bundesbank

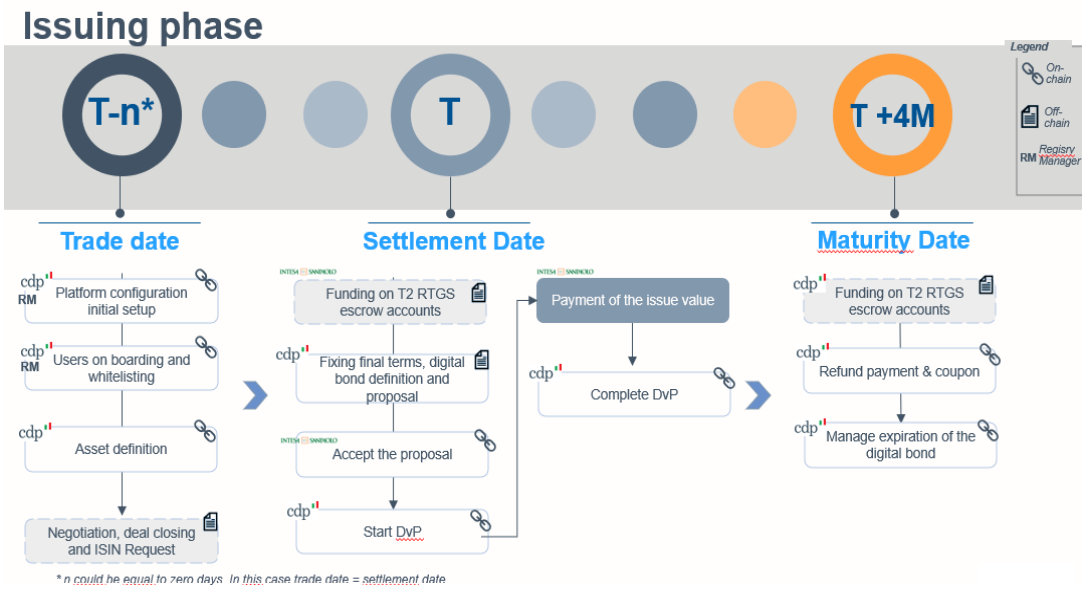
1. Payment reconciliation: KfW sends DZ payment note for reconciliation. DZ checks payment note and sends KfW a counter confirmation. (t-3)
2. Instructing CL: DZ creates secret hash (via its self-created secret) and sends the instruction + annex to CL via e-mail. The annex contains the BIC of the paying (=KfW) and receiving bank (=DZ), the currency, the payment amount, the secret hash and the timeout. (t+0)
3. Payment instruction: CL creates payment instruction on Trigger Solution with secret hash. (t+0)
4. HTLC Repayment: CL deploys the HTLC Repayment using the secret hash on the asset chain. (t+0)
5. Token transfer: CL "transfers" token to HTLC Repayment on the basis of the instruction of DZ, i.e. the tokens are assigned to the aforementioned blockchain address. (t+0)
6. Payment approval request: CL informs KfW via e-mail that KfW needs to approve the payment instruction. (t+0)
7. Payment approval: KfW approves and submits the payment instruction via the trigger solution. This approval debits KfW DCA in favor of the BBk DCA. (t+0)
8. Payment status: DZ receives information that a payment with the status "Payment Locked" exists on the trigger solution (automatically). In addition, KfW informs DZ via e-mail that they have approved the central bank payment towards the BBk DCA. (t+0)
9. HTLC Transfer: DZ reveals their secret on the trigger solution.
   1. Money transfer: Revealing the secret unlocks the payment lock and DZ is credited on its DCA. (t+0)
   2. Token transfer: CL receives the information via Trigger Solution that (i) the payment has been successfully executed and (ii) DZ secret. CL uses secret to release the token. HTLC Issuance transfers the token to the blockchain address of KfW (automatically) (t+0)
10. Burn instruction: KfW sends the instruction to destroy the token ("burn") to CL via e-mail. (t+0)
11. Token burn: CL destroys the token. (t+0)

High-level description (as reported by market stakeholders)	Issuance of a senior unsecured bond according to MiFID II in the form of a crypto security under Elektronisches Wertpapiergesetz (eWpG) with duration > 90 days. Main focus is DvP settlement with wCeBM for the primary issuance and redemption, including coupon payment.
Learning objectives of the market (as reported by market stakeholders)	Strengthen the perception of KfW as an innovation driver and gain valuable experience from the interaction with a DLT hosting wCeBM (regarding legal and technical aspects). Develop standardised & scalable products within the framework of current regulatory conditions. Further testing of the second strand of the eWpG to issue a crypto security. Establish operational readiness according to which establish a roadmap for the internal adaptation of IT systems.

Trial	**Category 1:** ***Primary issuance of bonds by financial institutions, corporates or sovereigns and delivery-versus-payment settlement, in some instances also including lifecycle management of securities (coupon payment and redemption) and secondary trading***
Eurosystem interoperability solution	Trigger Solution (BBk)
Participants	❖ **Use Case "Issuance of registered bond":** • Issuer: WIBank • Cash Settlement Agent: Helaba for WIBank • Investor: Bankhaus Metzler • Market DLT Operator: Cashlink Technologies • Redemption within exploratory work as DvP with Trigger Solution
DLT technology used on market side (as reported by market stakeholders)	The market DLT operator Cashlink tokenised the registered bond and provided the blockchain infrastructure for executing the settlement. The leveraged DLT is Polygon PoS, a public permissionless blockchain. It is designed to address scalability challenges within the Ethereum ecosystem. It operates as an EVM-compatible Layer-2 (L2) proof-of-stake based scaling solution for Ethereum, enhancing its throughput while also significantly bringing down gas costs, i.e., transaction fees.

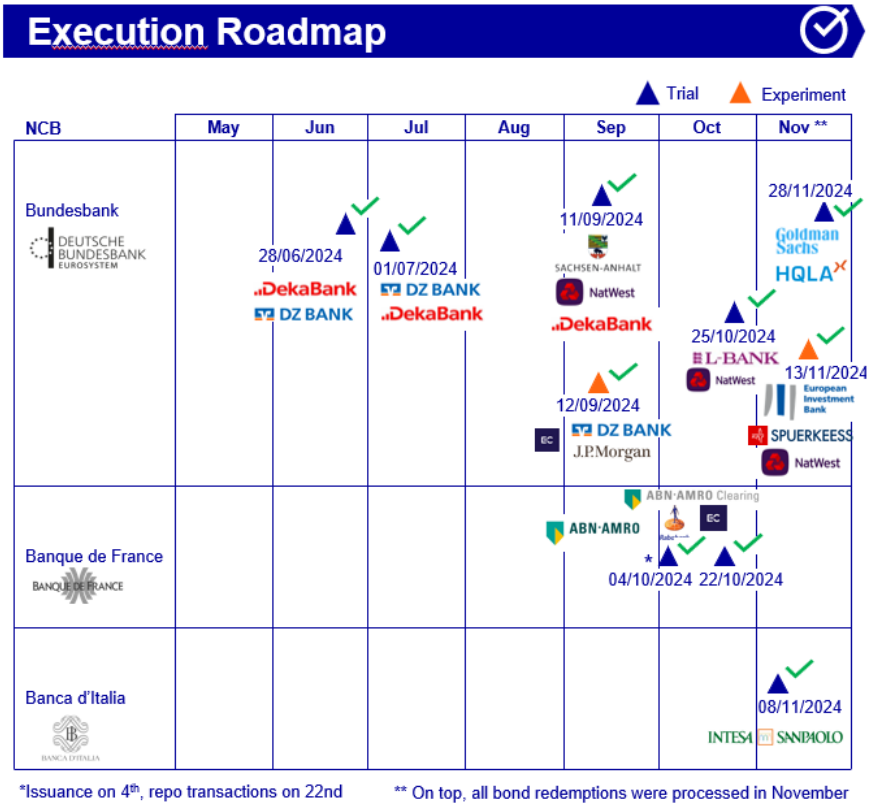
Flowchart of use case (as reported by market stakeholders)	**Process PoC** 
High-level description (as reported by market stakeholders)	The trial includes the issuance, investment and the redemption of the digital registered bond. Issuance: WIBank issues a physical certificate and a digital twin in token form, which is used to trigger the settlement via the trigger solution. Investment: After settlement of the payment by the investor and the transfer of the token, the physical certificate is also transferred to the investor or to the investor's outsourced custodian. Redemption: At the end of the term, the digital registered bond was redeemed. The physical certificate and the token were transferred to the issuer, with the token again being used as the trigger for settlement via the trigger solution.
Learning objectives of the market (as reported by market stakeholders)	WIBank plans to digitize a registered bond (NSV) using DLT technology. The aim is to test technical solutions and gather practical findings in connection with the digital issuance of financial products. Legal analysis on how to classify the digital registered bond.

3.9 Cassa Depositi e Prestiti

Trial	**Category 1:** ***Primary issuance of bonds by financial institutions, corporates or sovereigns and delivery-versus-payment settlement, in some instances also including lifecycle management of securities (coupon payment and redemption) and secondary trading***
Eurosystem interoperability solution	TIPS Hash-Link (BdI)
Participants	• Issuer: Cassa Depositi e Prestiti • Investor: Intesa SanPaolo • DLT Market Operator: Cassa Depositi e Prestiti
DLT technology used on market side (as reported by market stakeholders)	CDP has implemented an advanced platform that harnesses distributed ledger technology (DLT) to facilitate efficient and effective operations for the issuance and circulation of digital financial instruments. The platform is built upon EVM-compatible blockchains, specifically utilizing Polygon PoS Chain for this use case, which operates as a public and permissionless layer 2 solution based on Ethereum. It is noteworthy that this platform enables users to conduct actions both on-chain (via web3 components) in compliance with the Italian legal framework (the so called "Fintech Decree"), as well as off-chain (utilizing web 2 components) for managing information requiring stringent privacy measures.
Flowchart of use case (as reported by market stakeholders)	
High-level description (as reported by market stakeholders)	DVP involving issuance, primary distribution, coupons payment and redemption at maturity of a digital bond. The asset-leg was implemented on the Ethereum-based Polygon public blockchain.
Learning objectives of the market (as reported by market stakeholders)	Contribute to a new technological and operational model that can ease the fund-raising process and potentially expand the investor base, by issuing bonds in digital form; assess the use of DLT technology for a concrete decentralisation of the processes underlying the trading and settlement of financial instruments; implement financial DLT-based transactions for the issuance of financial instruments to verify the validity and the benefits (i.e programmability, reduced settlement related times and risks) of a new technological model, which can constitute a "forerunner" for the issuance of digital bonds in the context of the national regulatory framework.

3.10 Deutsche Börse Group/Clearstream (Clearstream Banking S.A., Clearstream Banking AG, LuxCSD) via D7 platform

Overview of Deutsche Börse Group/Clearstream activities. Via the group owned D7 platform, they tested all three interoperability solutions with Trials.



Trials	**Category 1:** ***Primary issuance of bonds by financial institutions, corporates or sovereigns and delivery-versus-payment settlement, in some instances also including lifecycle management of securities (coupon payment and redemption) and secondary trading***
Eurosystem interoperability solution	Trigger Solution (BBk)
Participants	❖ **Use Case "Issuance of commercial papers 1":** • Issuer: DekaBank • Investor: DZ BANK • Registrar: Clearstream Banking AG, Frankfurt (CBF) • DLT Market Operator: Clearstream Banking AG, Frankfurt (CBF) via D7 platform • Redemption within exploratory work as DvP with Trigger Solution ❖ **Use Case "Issuance of commercial papers 2":** • Issuer: DZ BANK • Investor: DekaBank • Registrar: Clearstream Banking AG, Frankfurt (CBF) • DLT Market Operator: Clearstream Banking AG, Frankfurt (CBF) via D7 platform • Redemption within exploratory work as DvP with Trigger Solution

❖ **Use Case "Issuance of sub-sovereign commercial paper 3":**

- Issuer: Land Sachsen-Anhalt
- Dealer: NatWest
- Investor: DekaBank
- Registrar: Clearstream Banking AG, Frankfurt (CBF)
- DLT Market Operator: Clearstream Banking AG, Frankfurt (CBF) via D7 platform
- Cash settlement agent for Land Sachsen-Anhalt: Deutsche Bundesbank
- Redemption within exploratory work as DvP with Trigger Solution

❖ **Use Case "Issuance of commercial paper 4":**

- Issuer: L-Bank
- Dealer: NatWest
- Investor: NatWest
- Registrar: Clearstream Banking AG, Frankfurt (CBF)
- DLT Market Operator: Clearstream Banking AG, Frankfurt (CBF) via D7 platform
- Redemption within exploratory work as DvP with Trigger Solution

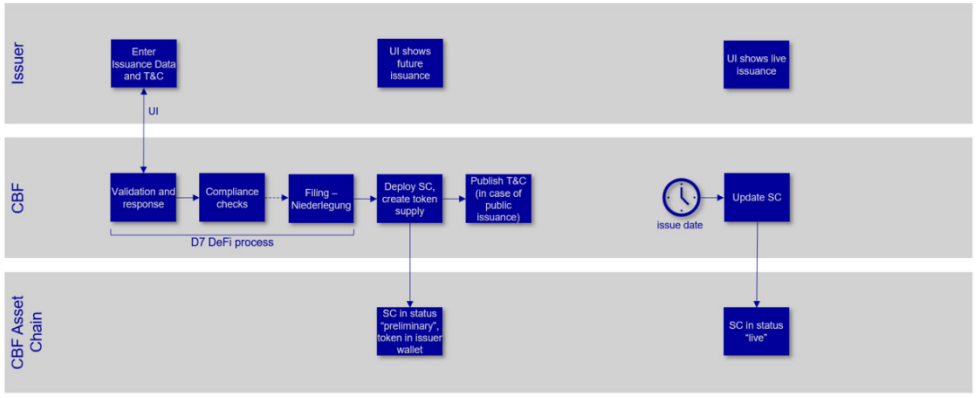
DLT technology used on market side (as reported by market stakeholders)

Clearstream's D7 platform is a digital asset management system that integrates Distributed Ledger Technology (DLT) to enhance efficiencies in securities processing. It supports the digital issuance and tokenisation of various asset classes, facilitating their conversion into digital tokens for streamlined trading and management. The platform is designed to improve settlement processes by enabling near real-time transactions, which helps reduce counterparty risk and enhances liquidity while maintaining transparency and traceability. D7 is built to be interoperable with other blockchain networks, ensuring seamless integration within the broader financial market infrastructure. The platform also incorporates features to assist with regulatory compliance, including processes for Know Your Customer (KYC) and Anti-Money Laundering (AML).

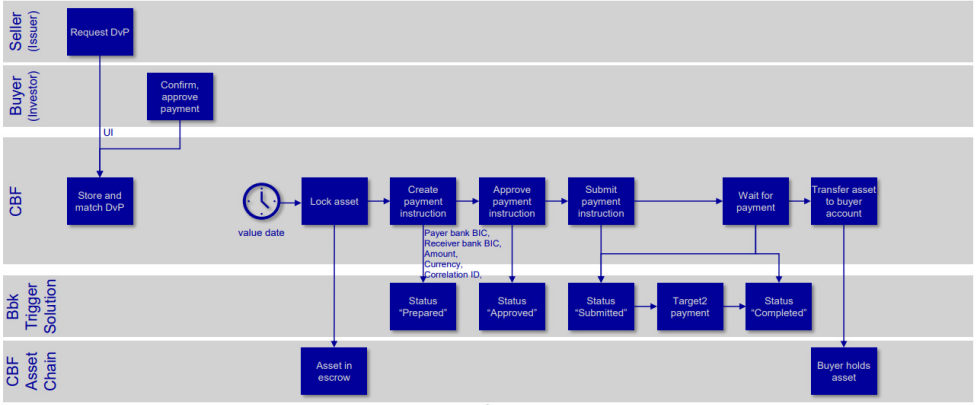
D7 leverages advanced blockchain frameworks that provide security and scalability, although specific details about the blockchain technology used are not publicly detailed by Clearstream. The platform offers secure custody solutions and asset servicing for digital securities, supporting their safekeeping and management.

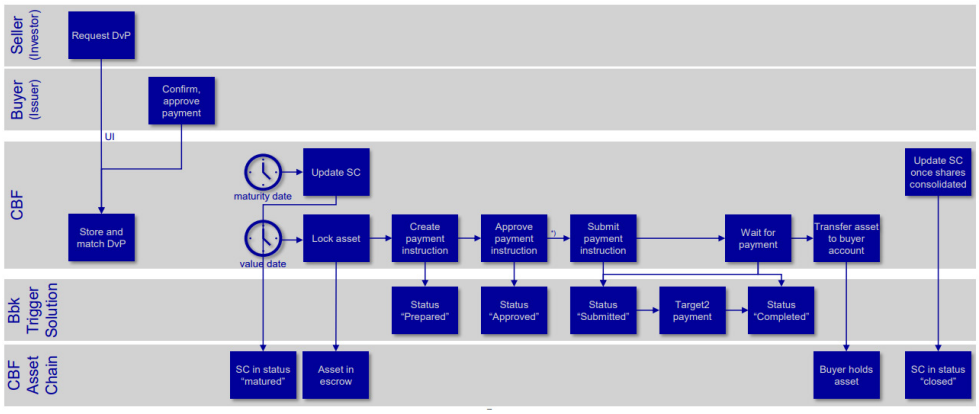
Flowchart of use case (as reported by market stakeholders)

Issuance:

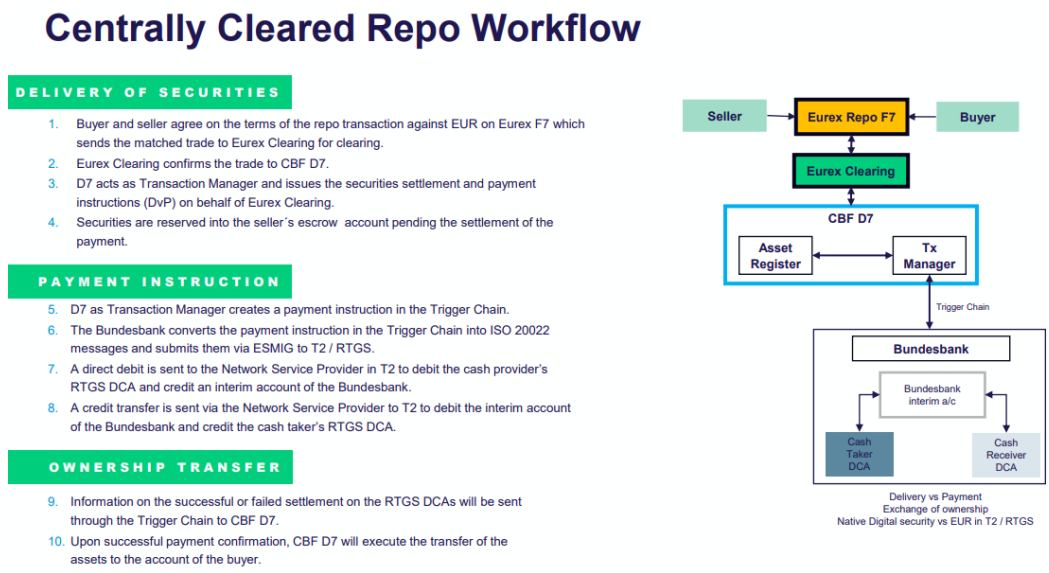


Primary distribution:



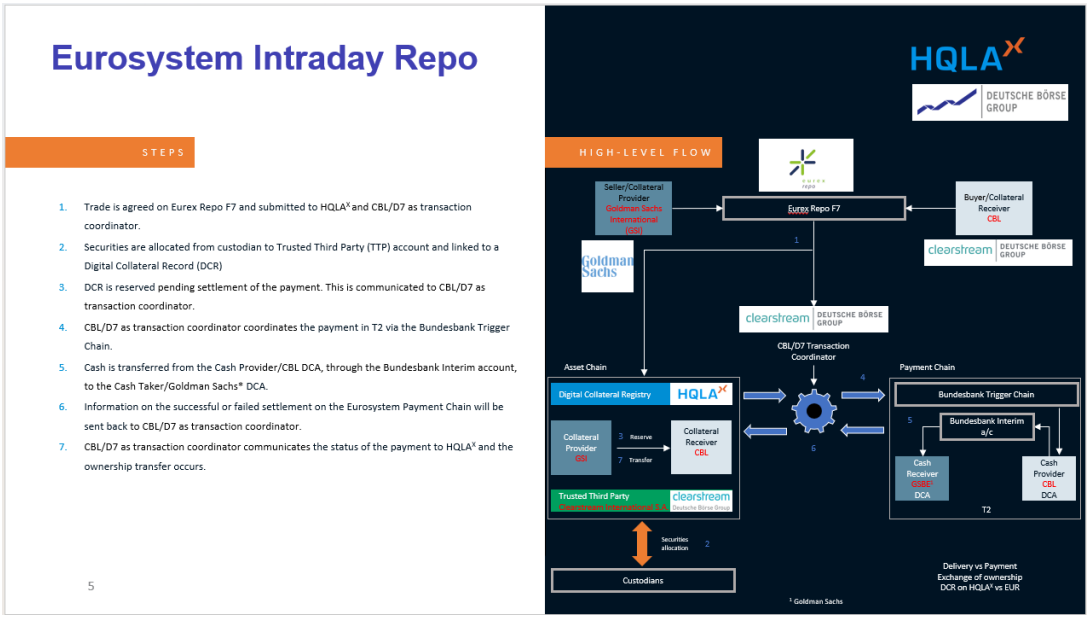
	Redemption: 
High-level description (as reported by market stakeholders)	Issuance, primary distribution and redemption of an electronic security (a 'Commercial Paper').
Learning objectives of the market (as reported by market stakeholders)	Explore all relevant aspects of the end-to-end life-cycle for the issuance, settlement and redemption of a digital asset; understand and learn the operational, business and technical requirements to send and receive payments leveraging the Eurosystem interoperability solutions; discover the advantages of real DvP by delivering digital assets via D7 versus payment via DLT infrastructure; address the digitisation of the financial instrument at the same time combining centralised and decentralised services into one joint offering thus enabling the entire value chain from issuer to investor to reap benefits

Experiment	**Category 2: *Intraday/overnight repurchase agreements (repos)***
Eurosystem interoperability solution	Trigger Solution (BBk)
Participants	❖ **Use Case "Centrally cleared intraday repo":** • Collateral Provider: DZ BANK • Collateral Receiver: J.P. Morgan • Trading Facility: Eurex Repo F7 • CCP: Eurex Clearing AG (ECAG) • Market DLT Operator: Clearstream Banking AG, Frankfurt (CBF) with D7 • The asset was previously issued (see the trial use case "Issuance of commercial paper 1")
DLT technology used on market side (as reported by market stakeholders)	Clearstream's D7 platform is a digital asset management system that integrates Distributed Ledger Technology (DLT) to enhance efficiencies in securities processing. It supports the digital issuance and tokenisation of various asset classes, facilitating their conversion into digital tokens for streamlined trading and management. The platform is designed to improve settlement processes by enabling near real-time transactions, which helps reduce counterparty risk and enhances liquidity while maintaining transparency and traceability. D7 is built to be interoperable with other blockchain networks, ensuring seamless integration within the broader financial market infrastructure. The platform also incorporates features to assist with regulatory compliance, including processes for Know Your Customer (KYC) and Anti-Money Laundering (AML). D7 leverages advanced blockchain frameworks that provide security and scalability, although specific details about the blockchain technology used are not publicly detailed by Clearstream. The platform offers secure custody solutions and asset servicing for digital securities, supporting their safekeeping and management.

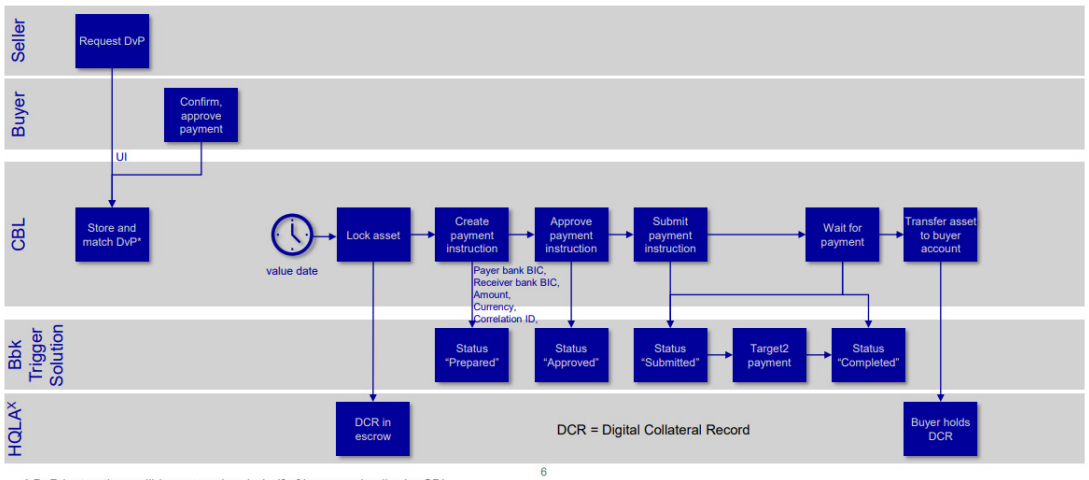
Flowchart of use case (as reported by market stakeholders)	
High-level description (as reported by market stakeholders)	Centrally cleared intraday single ISIN repo with native digital commercial paper issued on D7 DLT with the cash amount settled via the Trigger Solution of Bundesbank. A simulated version of the commercial paper issued in previous trial served as the underlying security for the intraday repo use case (see “Issuance of commercial paper 1” trial).
Learning objectives of the market (as reported by market stakeholders)	Learn about new technologies assuming a contributing role in shaping financial ecosystems of the future; assess the potential that new technologies such as DLT can bring by delivering cost efficiencies and optimizing processes; contribute to the development of efficient and secure clearing and settlement infrastructure.

Trial	**Category 2: *Intraday/overnight repurchase agreements (repos)***
Eurosystem interoperability solution	Trigger Solution (BBk)
Participants	❖ **Intraday repurchase agreements** • Trading facility: Eurex Repo F7 • DLT Market Operator: Clearstream Banking S.A. (CBL) with D7 in collaboration with HQLA^X • Cash receiver / collateral provider: Goldman Sachs • Cash provider / collateral receiver: CBL (Treasury)
DLT technology used on market side (as reported by market stakeholders)	Clearstream's D7 platform is a digital asset management system that integrates Distributed Ledger Technology (DLT) to enhance efficiencies in securities processing. It supports the digital issuance and tokenisation of various asset classes, facilitating their conversion into digital tokens for streamlined trading and management. The platform is designed to improve settlement processes by enabling near real-time transactions, which helps reduce counterparty risk and enhances liquidity while maintaining transparency and traceability. D7 is built to be interoperable with other blockchain networks, ensuring seamless integration within the broader financial market infrastructure. The platform also incorporates features to assist with regulatory compliance, including processes for Know Your Customer (KYC) and Anti-Money Laundering (AML). D7 leverages advanced blockchain frameworks that provide security and scalability, although specific details about the blockchain technology used are not publicly detailed by Clearstream. The platform offers secure custody solutions and asset servicing for digital securities, supporting their safekeeping and management.

Flowchart of use case (as reported by market stakeholders)



Workflow for CBL as Market DLT Operator DvP HQLA^X and Bbk Trigger Solution



* DvP instructions will be entered on behalf of buyer and seller by CBL

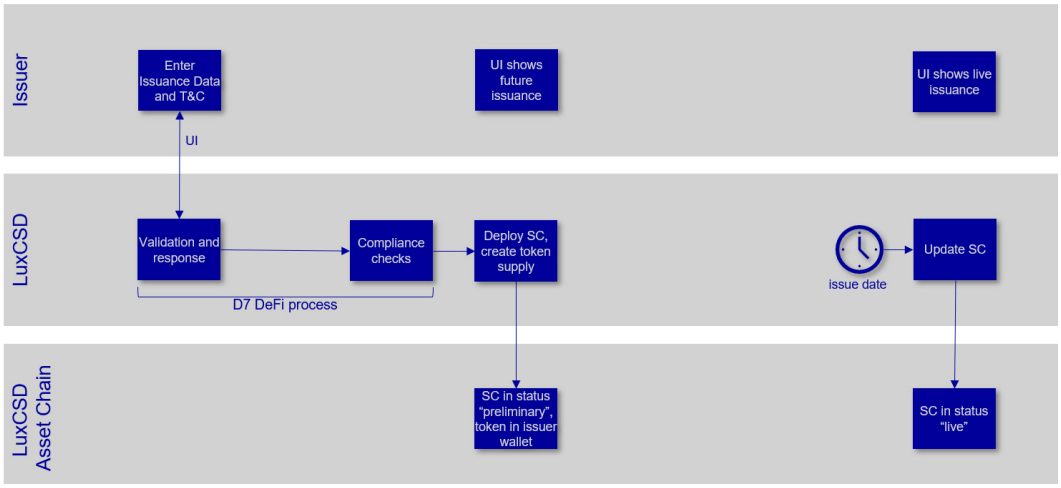
High-level description (as reported by market stakeholders)

Settlement of intra-day repo transactions across two independent ledgers. The collateral was a Triparty basket of traditional securities, with ownership represented as a Digital Collateral Record (DCR) on the HQLA^X ledger. The cash leg leveraged the Bundesbank Trigger Solution. Use case steps:

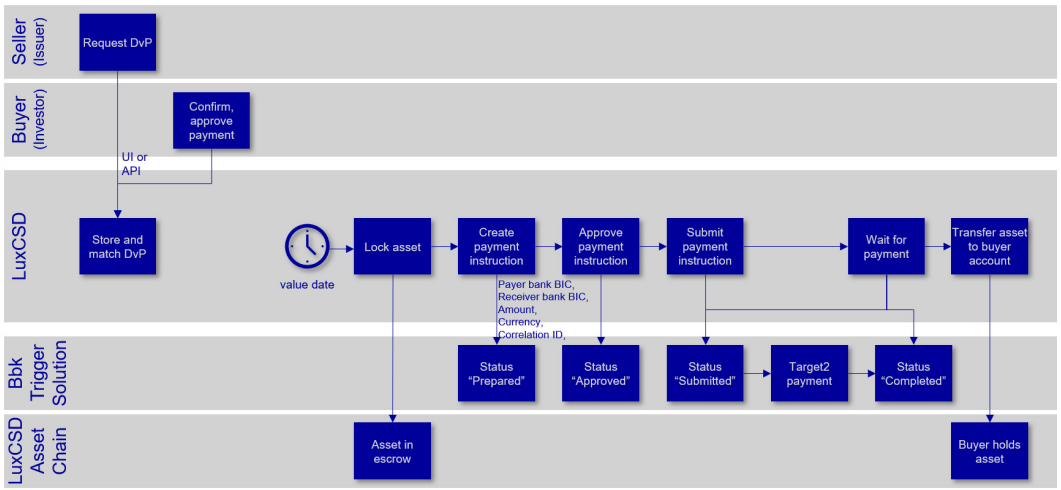
1. Trading of repo transaction on Eurex Repo's F7 platform
2. DvP instructions into CBL's D7 platform
3. Settlement of front leg and term leg (as DvPs) on the same day – instructed by CBL

Learning objectives of the market (as reported by market stakeholders)	Evolving legal frameworks are expected to increase demand for developing and investing in decentralised asset products, extending to their use in collateral trading, such as repo transactions. Distributed Ledger Technology (DLT) is anticipated to significantly improve securities processing and reduce reconciliation costs by enhancing information sharing. Deutsche Börse's D7 project reflects these advancements by integrating distributed services to benefit the entire value chain from issuer to investor. HQLA^X aims to enhance collateral mobility through Delivery versus Payment (DvP) transactions, facilitated by dual-ledger interoperability. For clients, DLT streamlines DvP settlement, reducing costs through a more efficient post-trade process. DLT also improves collateral mobility by reducing cross-custodial movements and facilitating ownership transfers on a distributed ledger. The proposed use-case offers a unique opportunity to develop a digital intraday repo market by potentially reducing intraday liquidity risk and the related capital buffer requirements for banks. This new channel allows for the sourcing of secured intraday liquidity with the precision to trade to the nearest minute and in general is an opportunity to learn how DLT can be used to reduce risk and improve the precision and speed of transaction settlement while lowering operational costs.

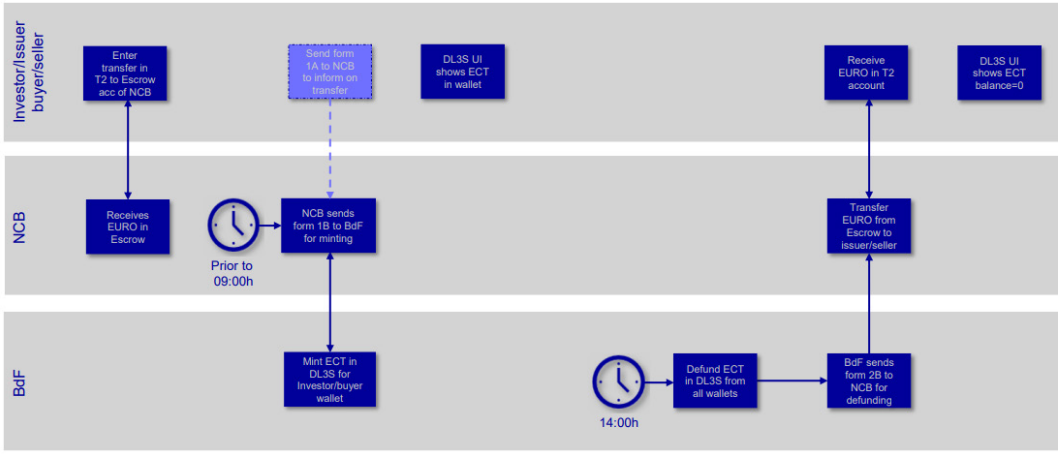
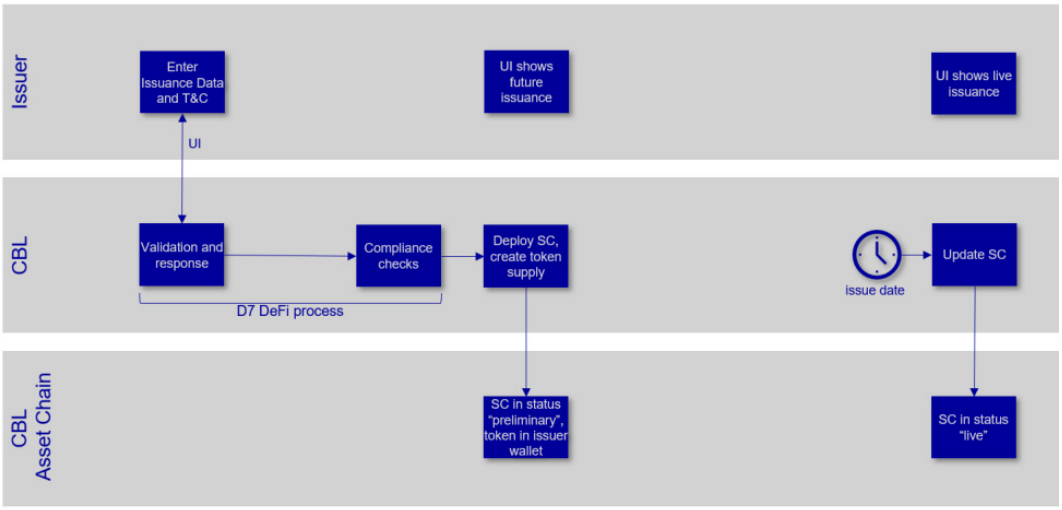
Experiment	**Category 1:** ***Primary issuance of bonds by financial institutions, corporates or sovereigns and delivery-versus-payment settlement, in some instances also including lifecycle management of securities (coupon payment and redemption) and secondary trading***
Eurosystem interoperability solution	Trigger Solution (BBk)
Participants	❖ **Use Case "Issuance of Digital Security":** • Issuer: European Investment Bank (EIB) • Lead manager: NatWest • Investors: NatWest and Spuerkeess, the Banque et Caisse d'Epargne de l'Etat Luxembourg • DLT Market Operator: LuxCSD with D7
DLT technology used on market side (as reported by market stakeholders)	Clearstream's D7 platform is a digital asset management system that integrates Distributed Ledger Technology (DLT) to enhance efficiencies in securities processing. It supports the digital issuance and tokenisation of various asset classes, facilitating their conversion into digital tokens for streamlined trading and management. The platform is designed to improve settlement processes by enabling near real-time transactions, which helps reduce counterparty risk and enhances liquidity while maintaining transparency and traceability. D7 is built to be interoperable with other blockchain networks, ensuring seamless integration within the broader financial market infrastructure. The platform also incorporates features to assist with regulatory compliance, including processes for Know Your Customer (KYC) and Anti-Money Laundering (AML). D7 leverages advanced blockchain frameworks that provide security and scalability, although specific details about the blockchain technology used are not publicly detailed by Clearstream. The platform offers secure custody solutions and asset servicing for digital securities, supporting their safekeeping and management.
Flowchart of use case (as reported by market stakeholders)	**Issuance:**



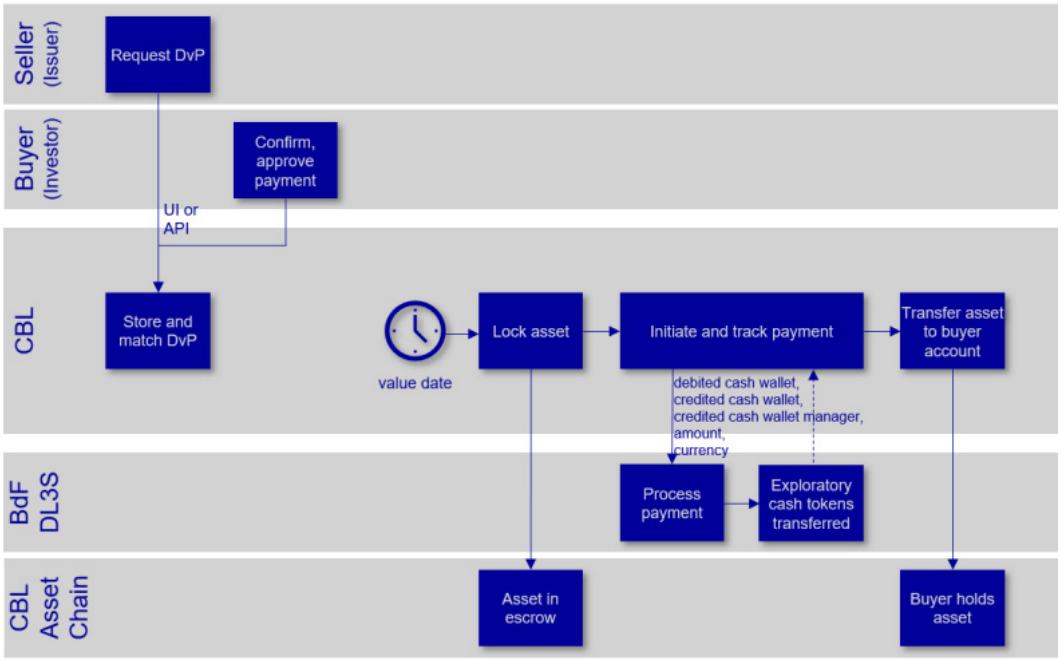
Primary distribution:



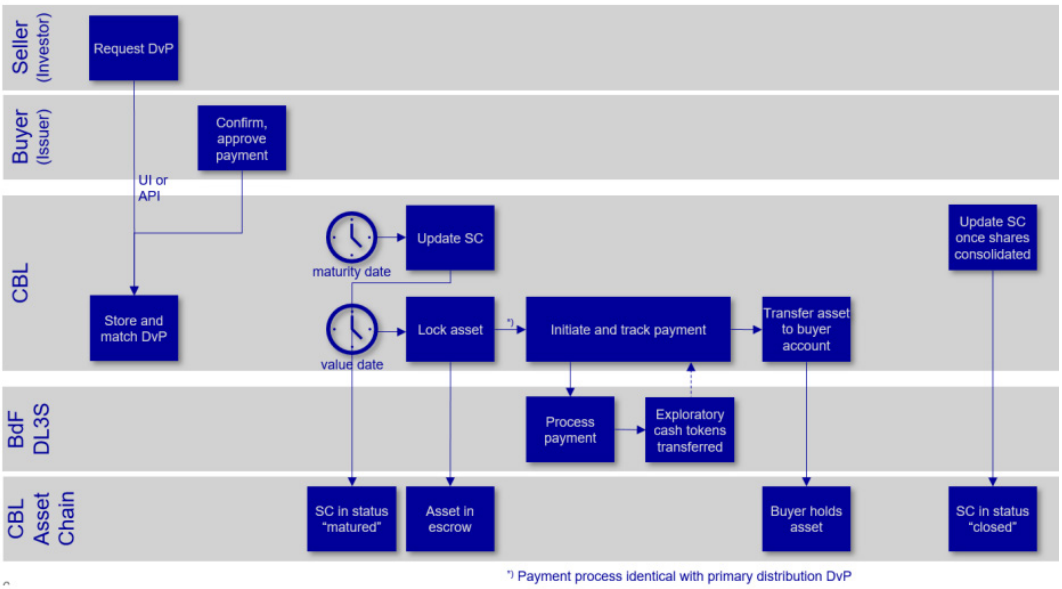
High-level description (as reported by market stakeholders)	Issuance of a digital security. The European Investment Bank (EIB), the Luxembourg central securities depository LuxCSD, the Luxembourg bank Spuerkeess and NatWest simulated the issuance of a digital security in the form of an experiment. The EIB acted as the issuer of the paper which was technically issued on the test environment of Deutsche Börse's D7 platform.
Learning objectives of the market (as reported by market stakeholders)	Explore all relevant aspects of the end-to-end life-cycle for the issuance and settlement of a digital asset; understand and learn the operational, business and technical requirements to send and receive payments leveraging the Eurosystem interoperability solutions; discover the advantages of real DvP by delivering digital assets via D7 versus payment via DLT infrastructure; address the digitisation of the financial instrument at the same time combining centralised and decentralised services into one joint offering thus enabling the entire value chain from issuer to investor to reap benefits

Trial	**Category 1:** ***Primary issuance of bonds by financial institutions, corporates or sovereigns and delivery-versus-payment settlement, in some instances also including lifecycle management of securities (coupon payment and redemption) and secondary trading***
Eurosystem interoperability solution	Full DLT interoperability solution (BdF)
Participants	• Issuer: ABN AMRO Bank • Investors: ABN AMRO Clearing, Rabobank • Market DLT Operator: Clearstream Banking S.A. (CBL)
DLT technology used on market side (as reported by market stakeholders)	Clearstream's D7 platform is a digital asset management system that integrates Distributed Ledger Technology (DLT) to enhance efficiencies in securities processing. It supports the digital issuance and tokenisation of various asset classes, facilitating their conversion into digital tokens for streamlined trading and management. The platform is designed to improve settlement processes by enabling near real-time transactions, which helps reduce counterparty risk and enhances liquidity while maintaining transparency and traceability. D7 is built to be interoperable with other blockchain networks, ensuring seamless integration within the broader financial market infrastructure. The platform also incorporates features to assist with regulatory compliance, including processes for Know Your Customer (KYC) and Anti-Money Laundering (AML). D7 leverages advanced blockchain frameworks that provide security and scalability, although specific details about the blockchain technology used are not publicly detailed by Clearstream. The platform offers secure custody solutions and asset servicing for digital securities, supporting their safekeeping and management.
Flowchart of use case (as reported by market stakeholders)	**Funding/Defunding:**  **Issuance:** 

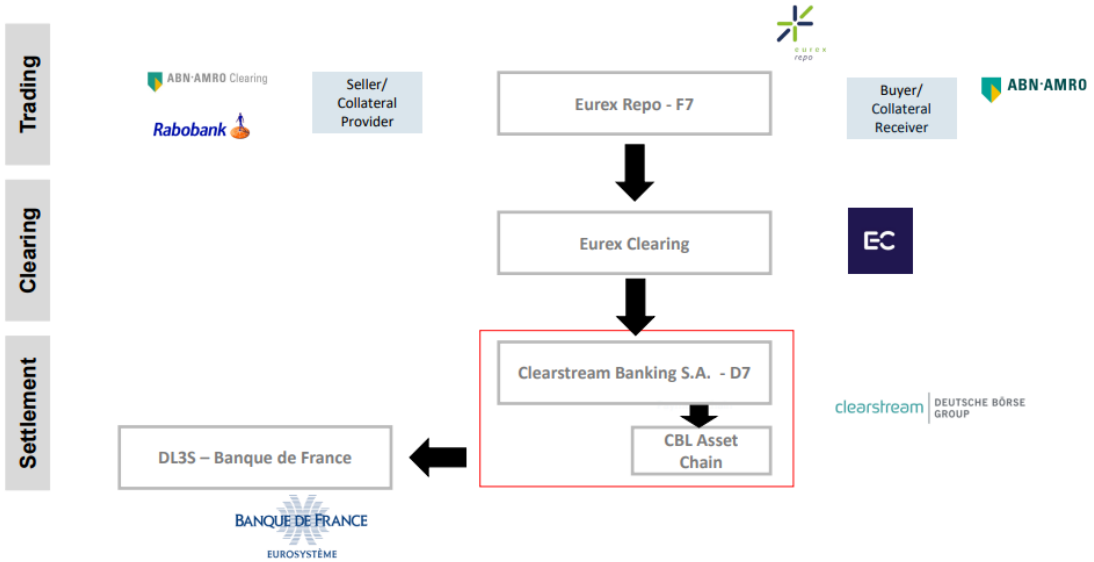
Primary distribution:

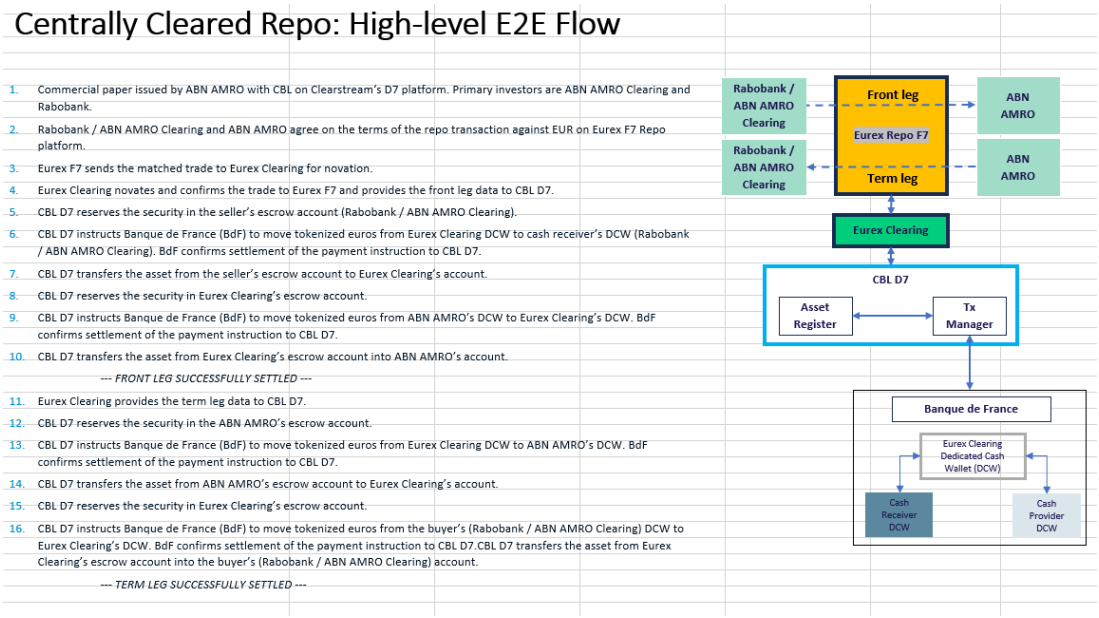


Redemption:



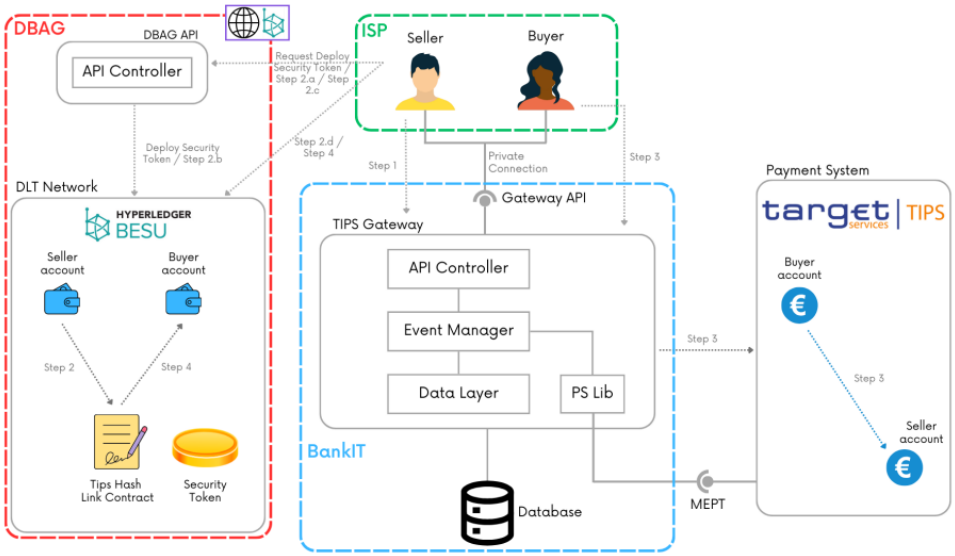
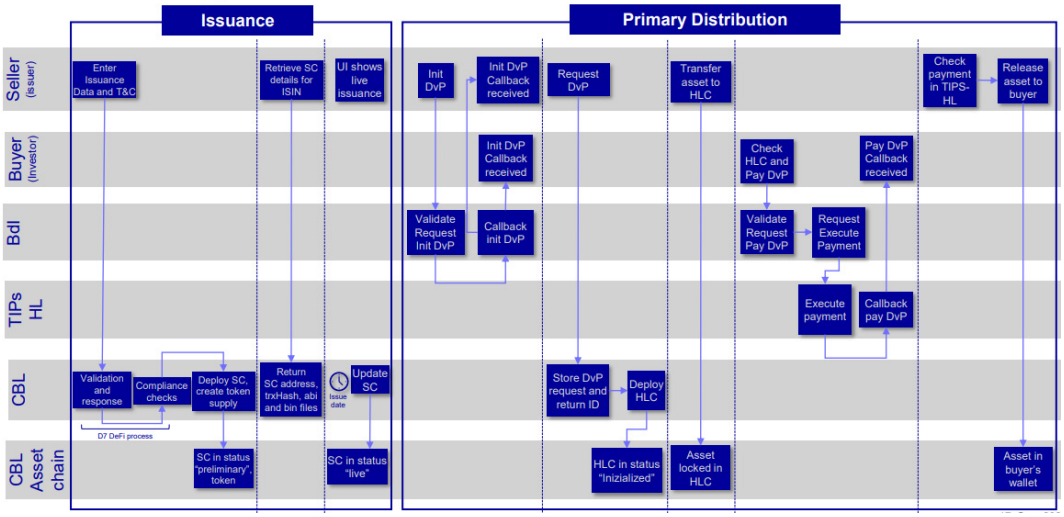
High-level description (as reported by market stakeholders)	Issuance of digital commercial paper Followed by intraday and overnight repo transactions of a native digital commercial paper issued by ABN AMRO Bank (see table below)
Learning objectives of the market (as reported by market stakeholders)	Explore all relevant aspects of the end-to-end life-cycle for the issuance, settlement and redemption of a digital asset; understand and learn the operational, business and technical requirements to send and receive payments leveraging the Eurosystem interoperability solutions; discover the advantages of real DvP by delivering digital assets via D7 versus payment via DLT infrastructure; address the digitisation of the financial instrument at the same time combining centralised and decentralised services into one joint offering thus enabling the entire value chain from issuer to investor to reap benefits.

Trial	Category 2: *Intraday/overnight repurchase agreements (repos)*
Eurosystem interoperability solution	Full DLT interoperability solution (BdF)
Participants	❖ **Intraday and overnight repurchase agreements** • CCP: Eurex Clearing (ECAG) • Repo participants: ABN AMRO Bank, ABN AMRO Clearing, Rabobank, ECAG • Market DLT Operator: Clearstream Banking S.A. (CBL)
DLT technology used on market side (as reported by market stakeholders)	Clearstream's D7 platform is a digital asset management system that integrates Distributed Ledger Technology (DLT) to enhance efficiencies in securities processing. It supports the digital issuance and tokenisation of various asset classes, facilitating their conversion into digital tokens for streamlined trading and management. The platform is designed to improve settlement processes by enabling near real-time transactions, which helps reduce counterparty risk and enhances liquidity while maintaining transparency and traceability. D7 is built to be interoperable with other blockchain networks, ensuring seamless integration within the broader financial market infrastructure. The platform also incorporates features to assist with regulatory compliance, including processes for Know Your Customer (KYC) and Anti-Money Laundering (AML). D7 leverages advanced blockchain frameworks that provide security and scalability, although specific details about the blockchain technology used are not publicly detailed by Clearstream. The platform offers secure custody solutions and asset servicing for digital securities, supporting their safekeeping and management.
Flowchart of use case (as reported by market stakeholders)	

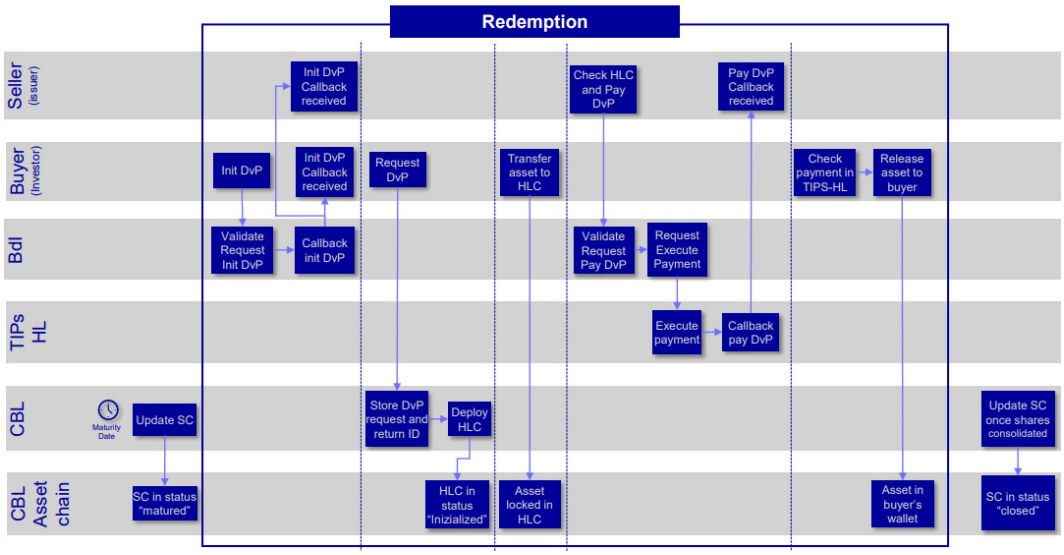


High-level description (as reported by market stakeholders)	Intraday and overnight repo transactions of a native digital commercial paper issued by ABN AMRO Bank (see issuance in previous table)
Learning objectives of the market (as reported by market stakeholders)	Explore all relevant aspects of the end-to-end life-cycle for the issuance, settlement and redemption of a digital asset; understand and learn the operational, business and technical requirements to send and receive payments leveraging the Eurosystem interoperability solutions; discover the advantages of real DvP by delivering digital assets via D7 versus payment via DLT infrastructure; address the digitisation of the financial instrument at the same time combining centralised and decentralised services into one joint offering thus enabling the entire value chain from issuer to investor to reap benefits

Trial	**Category 1:** ***Primary issuance of bonds by financial institutions, corporates or sovereigns and delivery-versus-payment settlement, in some instances also including lifecycle management of securities (coupon payment and redemption) and secondary trading***
Eurosystem interoperability solution	TIPS Hash-Link (BdI)
Participants	• Issuer: Intesa Sanpaolo Bank Luxembourg • Investor: Intesa Sanpaolo S.p.A. • Registrar: Clearstream Banking S.A. (CBL)
DLT technology used on market side (as reported by market stakeholders)	Clearstream's D7 platform is a digital asset management system that integrates Distributed Ledger Technology (DLT) to enhance efficiencies in securities processing. It supports the digital issuance and tokenisation of various asset classes, facilitating their conversion into digital tokens for streamlined trading and management. The platform is designed to improve settlement processes by enabling near real-time transactions, which helps reduce counterparty risk and enhances liquidity while maintaining transparency and traceability. D7 is built to be interoperable with other blockchain networks, ensuring seamless integration within the broader financial market infrastructure. The platform also incorporates features to assist with regulatory compliance, including processes for Know Your Customer (KYC) and Anti-Money Laundering (AML).

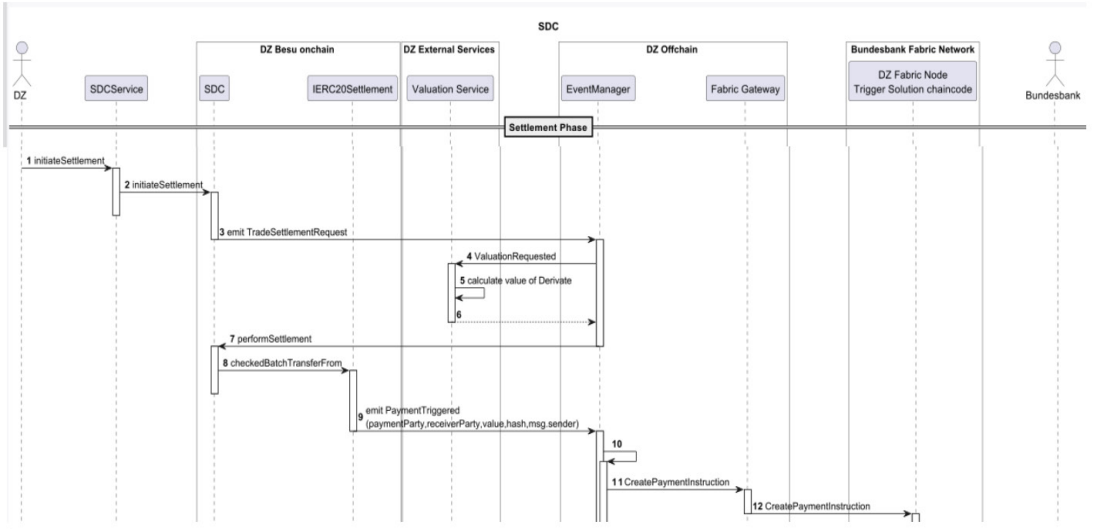
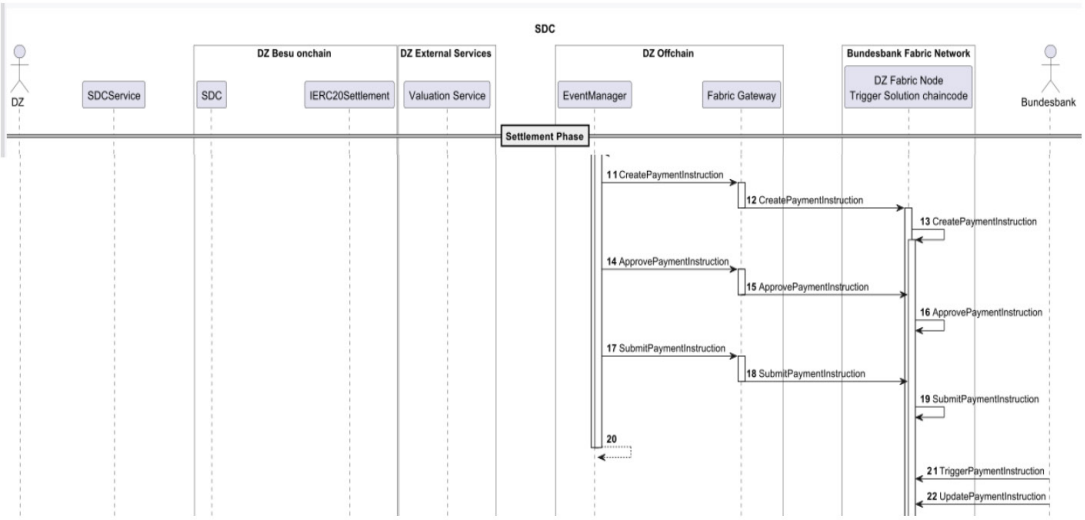
	D7 leverages advanced blockchain frameworks that provide security and scalability, although specific details about the blockchain technology used are not publicly detailed by Clearstream. The platform offers secure custody solutions and asset servicing for digital securities, supporting their safekeeping and management
Flowchart of use case (as reported by market stakeholders)	**DBAG Intesa BdI - Workflow Interaction** **HLC Protocol Architecture**  **Issuance & Primary Distribution** 

Redemption

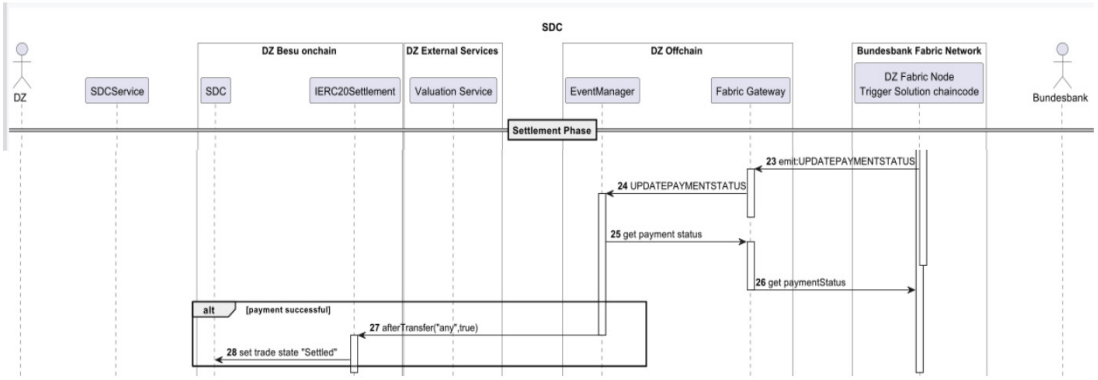


High-level description (as reported by market stakeholders)	Issuance, primary distribution and redemption of a native tokenized security (a 'Euro Commercial Paper').
Learning objectives of the market (as reported by market stakeholders)	Given Intesa Sanpaolo (ISP) nature of financial institution, participation in trials and experiments is crucial for fostering innovation and enhancing the financial ecosystem. Moreover, the Bank could improve its competitiveness by participating in projects developing potential new products and enhancing its reputational/corporate image. From a business level, conducting trials and experiments would allow ISP to adapt to changing market dynamics, meet the evolving needs of its customers and face competitiveness. From the operational level instead, conducting joint trials and experiments with the regulators such as Banca d'Italia, would allow ISP to reduce and mitigate potential operational risk, associated with new product development, together with ensuring compliance with regulatory requirements. Furthermore, trials offer ISP the possibility of verifying and analysing the risks associated with new emerging technologies, due to regulatory changes (e.g. regulatory technical standards - RTS - which are currently in consultation, in the context of products related to crypto assets) and digital asset characteristics (e.g. their global reach and the speed of transactions). From a technical perspective, trials allow ISP to exploit a controlled environment to test new products or services, which could grant ISP more efficient and cost-saving processes and technologies. This would in turn lead to the possibility of improving the product offering based on user feedback, allowing the delivery of market-ready solutions. To conclude, ISP aims to participate in trials and experiments with the dual purpose of fostering innovation and gaining new market segments. The advantages on ISP side extend beyond product development, including competitive positioning, risk management and cost efficiencies which would allow the Bank to adapt to a rapidly evolving financial landscape.

3.11 DZ BANK

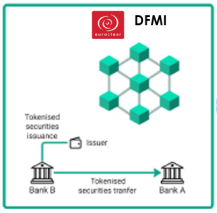
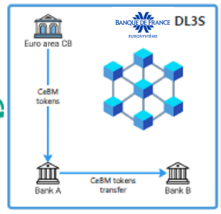
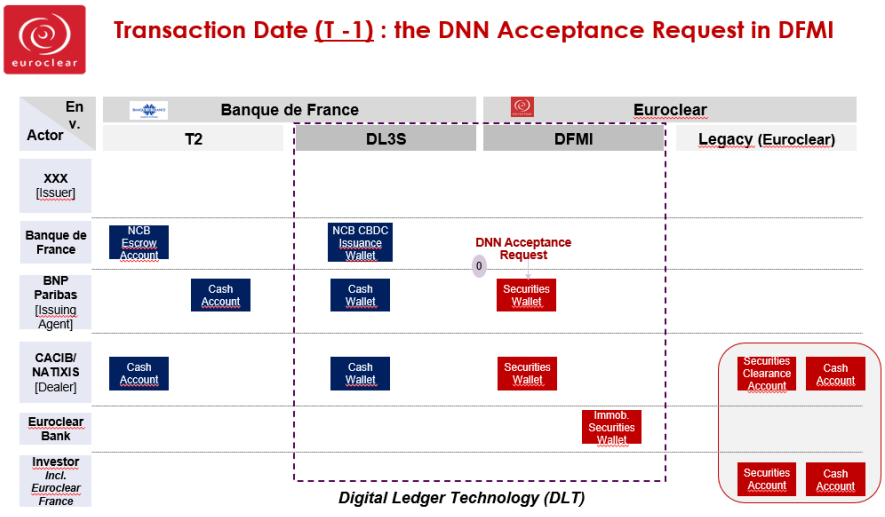
Experiment	**Category 7: *Settlement of payments related to over-the-counter (OTC) derivatives via smart contracts***
Eurosystem interoperability solution	Trigger Solution (BBk)
Participants	• DZ BANK
DLT technology used on market side (as reported by market stakeholders)	No DLT operator involved. DZ BANK operated two peer nodes as part of the Bundesbank Trigger Solution Hyperledger Fabric network. Updates on the network and the running smart contract were performed through cooperation with Bundesbank. The backend components of the applications connected directly to the DZ BANK peers in order to run query operations and submit payment instructions. Being on part of the same network DZ BANK nodes and Bundesbank's were synchronised and both could see the newly validated blockchain transactions written in the blocks. A Smart-Derivative Contract (SDC) was deployed for the purpose of the experiment via the ERC-6123 standard proposal on the underlying Hyperledger Besu EVM-compatible blockchain.
Flowchart of use case (as reported by market stakeholders)	**Process Flow – 1. Valuation-Phase and Payment Trigger**  **Process Flow – 2. Payment Processing** 

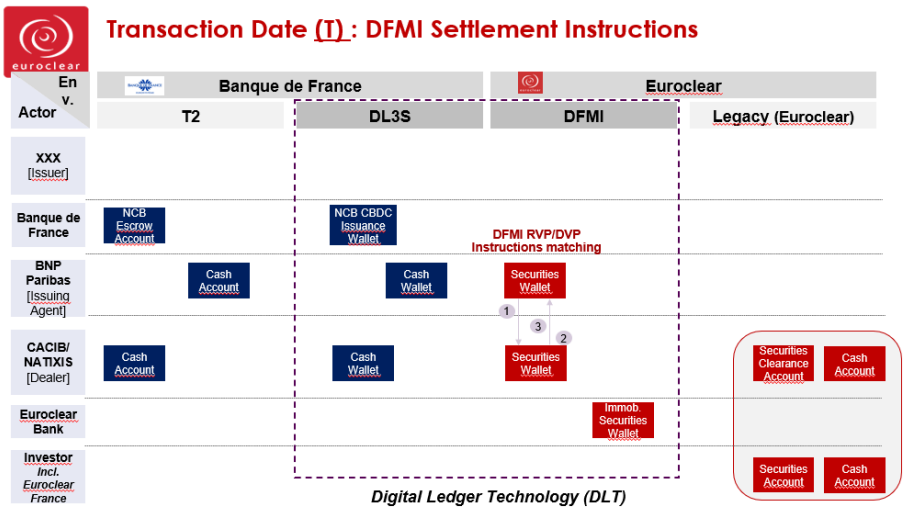
Process Flow – 3. Settlement Finalisation

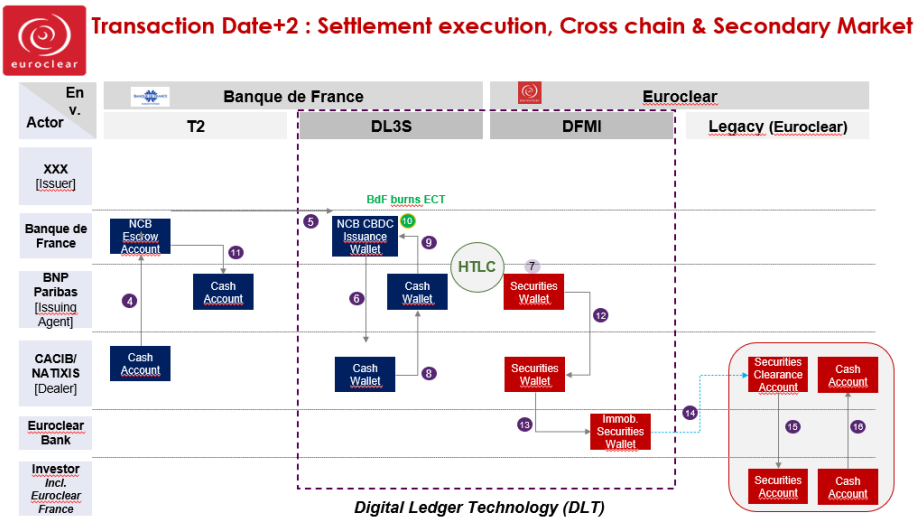


High-level description (as reported by market stakeholders)	DZ BANK explored the automated post-trade processing of a Smart Derivative Contract (SDC). The SDC is in itself a new financial OTC derivative. It wraps a specific underlying reference derivative (e.g. an interest rate swap) in a smart contract with capped settlement value, and allows fully automizing and securing the financial product's complete trade life cycle. The SDC settles the changes of the respective underlying reference derivative up to a pre-defined margin-buffer level (cap). It leverages the advantages of smart contracts to remove many of the frictions associated with the classical derivative life cycle (no contract risk, disputes, collateral process, counterparty, and close-out risk,). The experiment simulated the processing of an over-the-counter derivative ("OTC"), with an interest rate swap as underlying reference derivative, that was traded as a Smart Derivative Contract under real market conditions and then settled fully automated twice each day over several business days using a live market data feed. The resulting payments were settled via the Eurosystem interoperability solution. DZ BANK operated its own node in the Trigger Solution DLT network and deployed the SDC code, an ERC-6123 SDC, on the blockchain. The experiment led to bookings in the T2 UTEST, the test environment of the Eurosystem's payment system.
Learning objectives of the market (as reported by market stakeholders)	Willingness to technically prove a full-automated settlement process for an OTC-Derivative against Bundesbank Trigger Solution to enable other trading parties to act as a real counterparty for a SDC based transaction.

3.12 Euroclear Bank

Trial	**Category 1:** ***Primary issuance of bonds by financial institutions, corporates or sovereigns and delivery-versus-payment settlement, in some instances also including lifecycle management of securities (coupon payment and redemption) and secondary trading***
Eurosystem interoperability solution	Full DLT Interoperability Solution (BdF)
Participants	• Issuer: Caisse des dépôts et Consignations (CDC) • Issuing agent: BNP Paribas • Arrangers / Dealers: Crédit Agricole CIB & Natixis CIB • Issuer CSD: Euroclear Bank • Investor CSD: either in Euroclear bank or in Euroclear France, the latter acting as Investor CSD • DLT Market Operator: Euroclear Bank (D-FMI)
DLT technology used on market side (as reported by market stakeholders)	D-FMI DLT platform is based on R3 Corda technology. It is using a Proof-of-Authority consensus. DLT network and Nodes hosting are fully managed by Euroclear on its Azure cloud. It is a private and permissioned DLT network with no exposure to outside world. D-FMI application has been fully implemented by Euroclear and has been adapted to cope with trial requirements to allow for the issuance of a Digital Native Note (DNN) complemented via a DVP transfer occurring in "DLT/tokenised" central bank money instead of in "DLT/tokenised" commercial bank money.
Flowchart of use case (as reported by market stakeholders)	**"D-FMI"**, the **DLT platform - based component** of the **Euroclear System** (the securities settlement system operated by Euroclear Bank) supporting the issuance, distribution and primary market settlement of fully dematerialized securities in **the form of Digitally Native Notes (DNN).**   **"DL3S" (Distributed Ledger for Securities Settlement System)** a private and permissioned **Cash DLT platform** provided and operated by **Banque de France: Central Bank Money** is issued in the form of **tokens** ("Exploratory Cash Tokens") **circulating on DL3S**. The platform **DL3S is interconnected** with D-FMI via an HTLC protocol allowing cross chain DVP execution ; i.e. the DNN delivery against Exploratory Cash Token. 





High-level description (as reported by market stakeholders)

The use case encompasses a Digital Native Note (DNN) issued on a security DLT operated by Euroclear (Digital Financial Market Infrastructure – D-FMI) with the primary settlement in Exploratory Cash Token (ECT), reflecting central bank money (CeBM) value, on a Cash DLT operated by Banque de France (DL3S).

The Issuing Agent DNN Acceptance Request is authorised in D-FMI by EB. D-FMI Settlement instructions are matched in T2 on issuance date:

1. BNP Paribas as Issuing Agent enters DVP (Delivery vs Payment) instruction in D-FMI
2. Each Dealer enters RVP (Reception vs Payment) instruction in D-FMI
3. Instructions are matched

ECT creation and distribution:

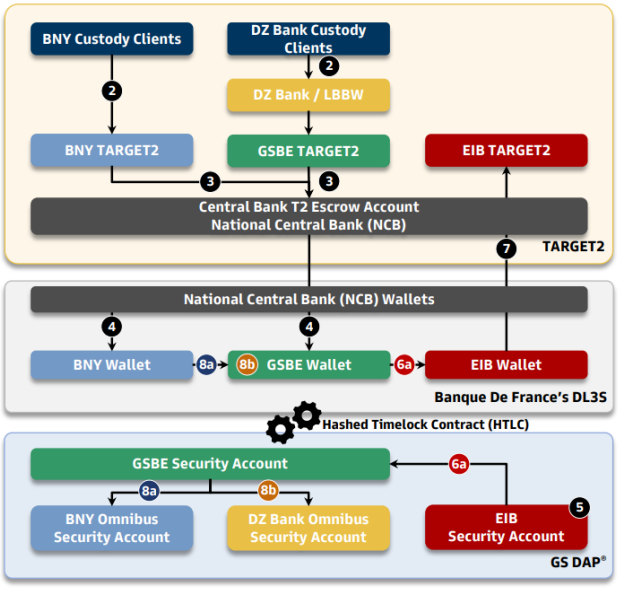
4. Crédit Agricole CIB & Natixis CIB [Dealers] send instructions to transfer net proceeds in Euro to the Banque de France “National Central Bank Escrow Account” in T2 payment system.
5. Banque de France keeps the net proceeds in Euro in the Banque de France “NCB Escrow Account” and creates Exploratory Cash Tokens (ECT) in the “NCB CBDC Issuance Wallet” on (DL3S)
6. Banque de France transfers ECT to the Cash Wallets of Crédit Agricole CIB & Natixis CIB [Dealers] on DL3S

Issuance and DVP execution:

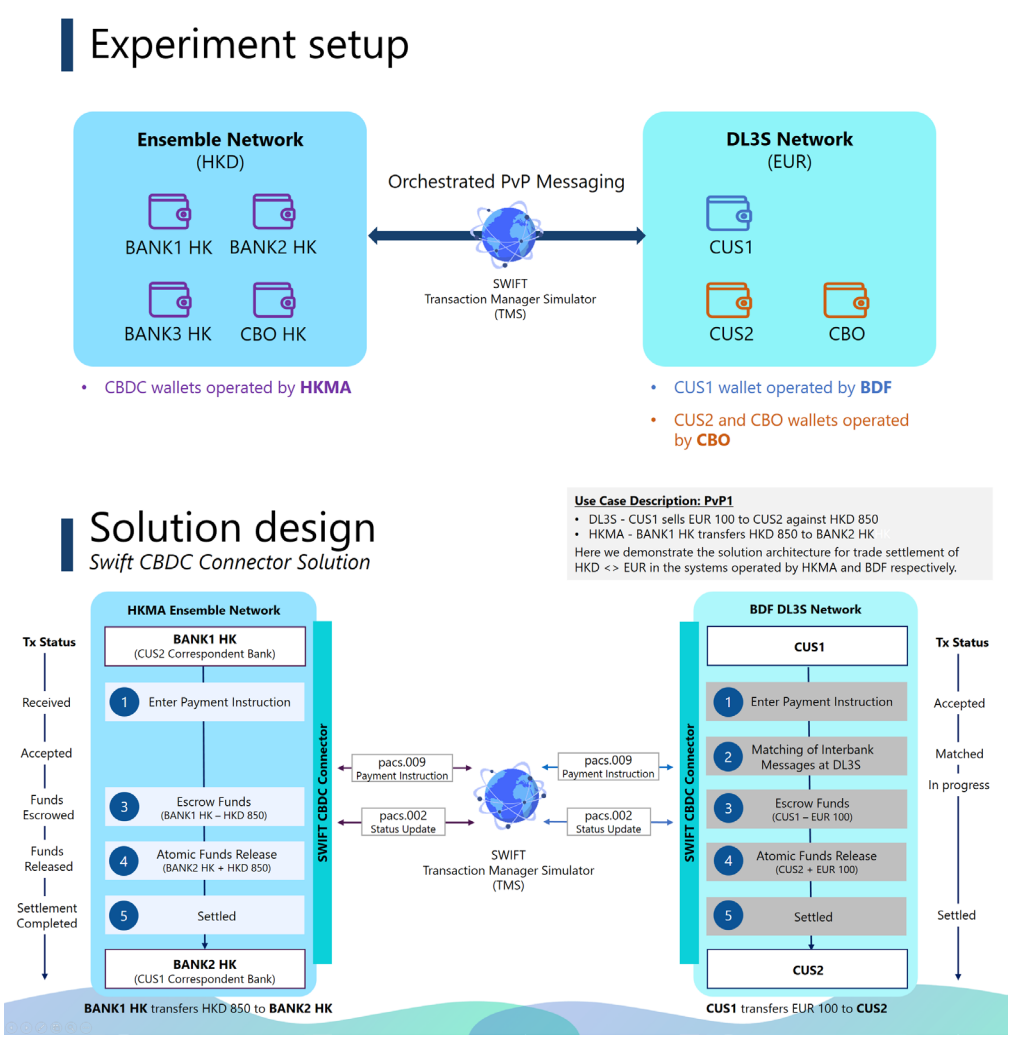
7. Cross chain DVP is initiated and DNN are locked on D-FMI in the securities wallet of the Issuing Agent
8. ECT transfer executed in DL3S from the cash wallets of the Dealers to the cash wallet of the Issuing Agent
9. Issuing Agent instructs ECT transfer from its cash wallet to the “NCB CBDC Issuance Wallet”
10. Banque de France burns ECT

	11. Banque de France executes T2 transfer of net proceeds in EUR from its “NCB Escrow Account” to the Issuing Agent’s T2 account Issuing Agent and Banque de France confirm net proceeds received in the Issuing Agent’s T2 account (and issuer account) → triggers HTLC mechanism to unlock the DNN in D-FMI: 12. Finality of the payment is reached and DNN issuance is finalised: DNN unlocked triggering transfer between the securities wallet of the Issuing Agent to the securities wallets of the Dealers Interoperability between Euroclear D-FMI and Euroclear Legacy system: 13. Euroclear transfers the DNN from the securities wallet of the Dealers to the Euroclear Immobilisation Securities Wallet on D-FMI DNN to be transferred to the securities clearance accounts of the Dealers in the Euroclear Bank legacy system Delivery to investors: Investor settlement will be executed either in EB or EF as per the existing legacy processes: 14. DNN to be transferred, directly or indirectly, to the accounts of Account Holders maintained in the books of Euroclear Bank or Euroclear France 15. DNN to be transferred to the securities account of investors maintained with Account Holders 16. Euro transfer from investors to dealers’ accounts
Learning objectives of the market (as reported by market stakeholders)	Assess the overall framework (legal, risk, technical) where market participants subscribe and settle a primary issuance in an interoperable model. Having both security and cash legs on DLT is an optimal way to assess the benefits and hurdles brought by DLT technology for FMI and its participants. Euroclear Bank leveraged on a complete ecosystem interconnected with DLT & Legacy systems, to get a 360° view to explore Front to Back efficiencies within a CSDR compliant framework. Focus has been given on operational and reconciliation processes aligning them with SSS legal and risk frameworks. We considered it as a first step for setting standards in adequation with capital market requirements.

3.13 Goldman Sachs Digital Assets

Trial	**Category 1:** ***Primary issuance of bonds by financial institutions, corporates or sovereigns and delivery-versus-payment settlement, in some instances also including lifecycle management of securities (coupon payment and redemption) and secondary trading***
Eurosystem interoperability solution	Full DLT Interoperability Solution (BdF)
Participants	• Issuer: European Investment Bank (EIB) • On-chain custodian: The Bank of New York SA/NV, DZ BANK, Goldman Sachs Bank Europe SE • Joint lead managers: Goldman Sachs Bank Europe SE, DZ BANK, LBBW • Market DLT Operator: Goldman Sachs Bank Europe SE via GS DAP®
DLT technology used on market side (as reported by market stakeholders)	GS DAP® by Goldman Sachs leverages Distributed Ledger Technology (DLT) to enhance the efficiency, transparency, and security of financial transactions involving digital assets. By utilizing blockchain technology, GS DAP® facilitates the tokenisation of traditional financial instruments, such as bonds, enabling their end-to-end lifecycle to be digitized and managed on-chain. GS DAP® is built on Canton protocol leveraging Daml smart contracts and is underpinned by the Hyperledger Besu private permissioned blockchain.
Flowchart of use case (as reported by market stakeholders)	**Primary Market Digital Bond Settlement, facilitated across 2 DLT platforms via a Hash-Time-Lock-Contract (HTLC)** **Funding:** 1 Primary market allocations are finalized 2 Investors fund their BNY or DZ Bank cash account 3 BNY and GSBE transfer fiat cash to the Bundesbank Escrow Account. 4 The Banque de France creates exploratory cash tokens ("ECT"s) and deposits them into BNY's and GSBE's wallet on the DL3S platform **Takedown:** 5 Bond tokens are originated in GS DAP® and minted in EIB's account on-chain. 6 Takedown trade between EIB and GSBE as Lead Bank: 6a On DL3S: Transfer of ECTs from GSBE's wallet to EIB's wallet 6a On GS DAP®: Transfer of bond tokens from EIB's Security Account to GSBE's Security Account 7 EIB requests an early burn of the ECTs in their wallet to Euro fiat which NCB pays out to their Target2 account. **Distribution:** 8 Allocation of newly issued digital bonds to BNY custody clients: 8a On DL3S: Transfer of ECTs from BNY's Wallet to GSBE's wallet 8a On GS DAP®: Transfer of bond tokens from GSBE Security Account to the BNY Omnibus Account (on behalf of investors) 8 Allocation of newly issued digital bonds to DZ Bank custody clients: 8b On DL3S: Transfer of ECT's from GSBE's wallet to GSBE's wallet 8b On GS DAP®: Transfer of bond tokens from GSBE's Security Account to DZ Bank's Omnibus Security Account 
High-level description (as reported by market stakeholders)	Primary market digital bond settlement, facilitated across 2 DLT platforms, Banque de France Full DLT Interoperability Solution (DL3S) vs. GS DAP®, via a Hash-Time-Lock-Contract (HTLC).
Learning objectives of the market (as reported by market stakeholders)	Achieve a T+0 (instant) settlement by using a cross-chain interoperability solution between bond and cash technology solutions; optimise investors' participation by expanding the set of on-chain custodians available and enable investors to begin quantifying the perceived benefits of blockchain technology; demonstrate a post-trade market structure that leverages DLT to drive efficiencies and risk reduction for issuers and investors.

3.14 HKMA

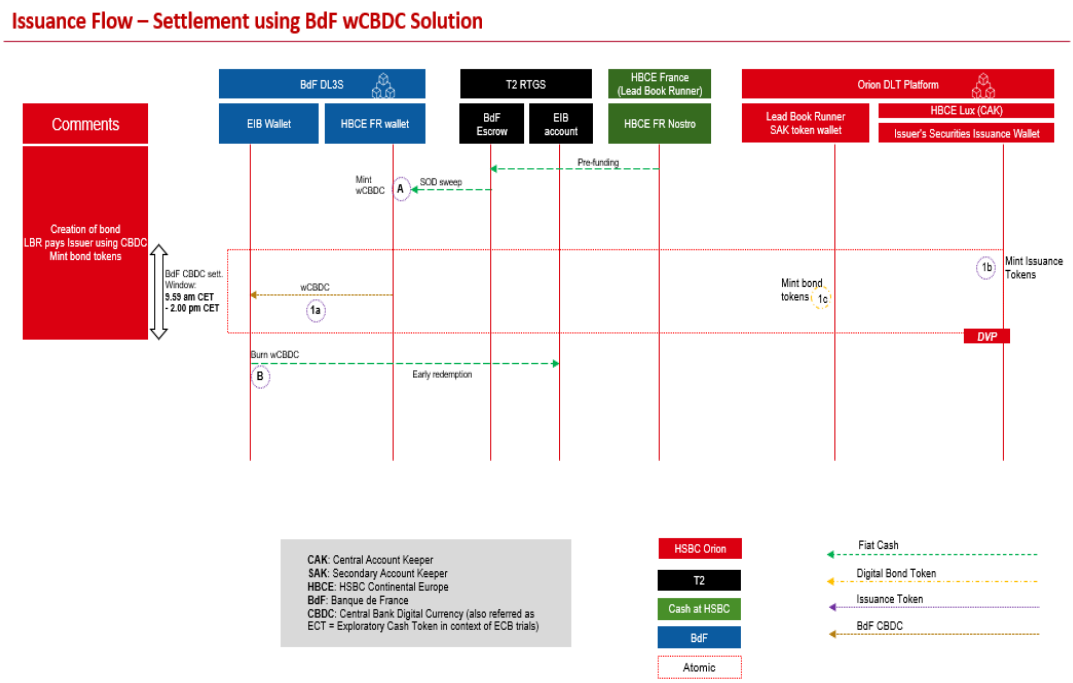
Experiment	Category 3: *Cross-currency payment-versus-payment transactions with another central bank*
Eurosystem interoperability solution	Full DLT Interoperability Solution (BdF)
Participants	• Foreign Central Bank: HKMA • Interoperability solution provider: SWIFT
DLT technology used on market side (as reported by involved stakeholders)	SWIFT acts as the provider of interoperability solution using their Transaction Manager Simulator and their connector gateways deployed on NCBs' cash DLTs. The HKD wholesale CBDC network is based on Ethereum Virtual Machine (EVM) architecture, using Hyperledger Besu and make use of smart contracts. The network natively supports EVM compatible wallet and is integrated with Swift Connector.
Flowchart of use case (as reported by involved stakeholders)	

Experiment test cases

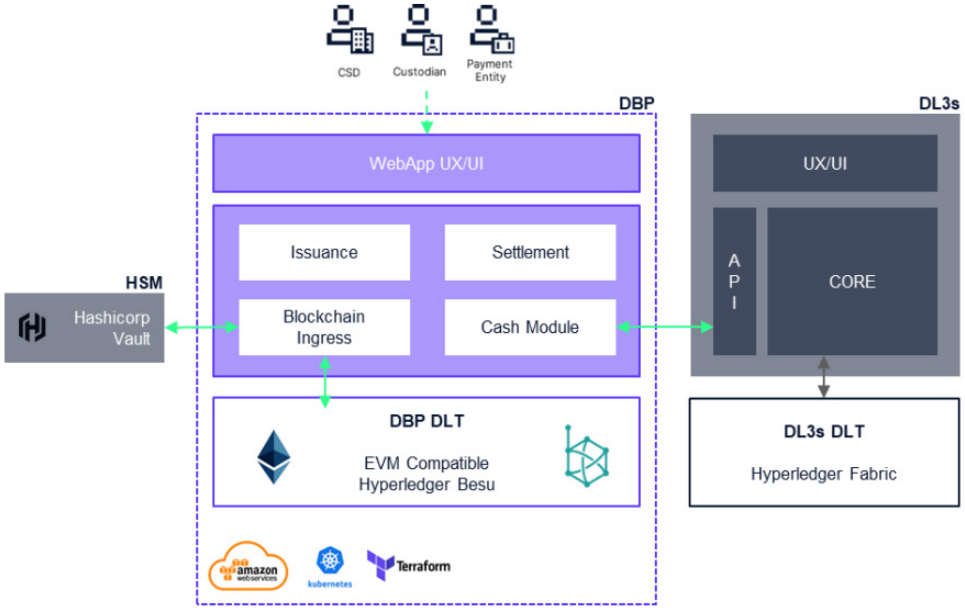
Test Case	Description	DL3S Network		Amount (EUR)	Ensemble Network		Amount (HKD)
		Seller	Buyer		Payer	Payee	
PvP1	CUS1 ⇄ CUS2 (EUR 100 / HKD 850)	CUS1	CUS2	100	BANK1 HK (CUS2 corr bank)	BANK2 HK (CUS1 corr bank)	850
PvP2	CUS2 ⇄ CUS1 (EUR 1,000 / HKD 8,400)	CUS2	CUS1	1,000	BANK2 HK (CUS1 corr bank)	BANK1 HK (CUS2 corr bank)	8,400
PvP3	CUS1 ⇄ CBO (EUR 950 / HKD 8,000)	CUS1	CBO	950	CBO HK (CBO corr bank)	BANK3 HK (CUS1 corr bank)	8,000
PvP4	CBO ⇄ CUS1 (EUR 2,000 / HKD 17,000)	CBO	CUS1	2,000	BANK3 HK (CUS1 corr bank)	CBO HK (CBO corr bank)	17,000
PvP5	CBO ⇄ CUS2 (EUR 150 / HKD 1,250)	CBO	CUS2	150	BANK2 HK (CUS2 corr bank)	CBO HK (CBO corr bank)	1,250
PvP6	CUS2 ⇄ CBO (EUR 2,500 / HKD 21,000)	CUS2	CBO	2,500	CBO HK (CBO corr bank)	BANK2 HK (CUS2 corr bank)	21,000

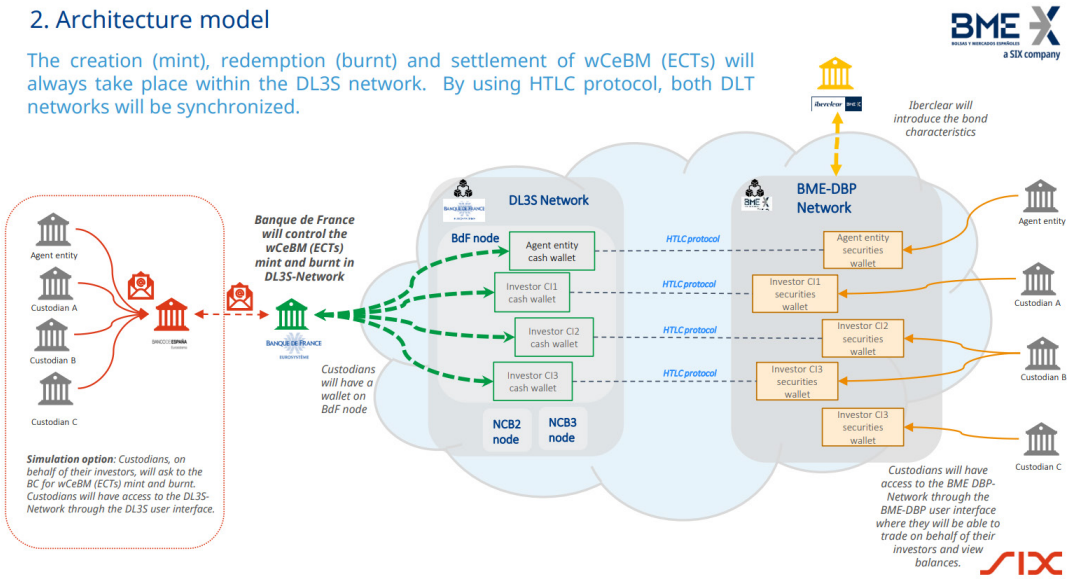
High-level description (as reported by involved stakeholders)	Cross-currency PvP transactions involving simulated banks in different jurisdictions according to the correspondent banking model. A pair of custodians exchanged EUR against a transfer of HKD between the related correspondent banks: the entire process was orchestrated by a connector sending and receiving ISO20022 messages.
Learning objectives (as reported by involved stakeholders)	Enhance the international payment ecosystem and foster cross-jurisdictional interoperability; assess possible improvements of cross-border PvP payments; carry out tests to demonstrate successful cross-border PvP with atomic and instantaneous settlement across different networks, thus paving the way for future DvP testing & development; assess the scalability of the tested solution; enrich the use cases thanks to the involvement of commercial banks in different jurisdictions and take the opportunity to co-create a tokenisation market with the industry.

3.15 HSBC

Trial	**Category 1:** ***Primary issuance of bonds by financial institutions, corporates or sovereigns and delivery-versus-payment settlement, in some instances also including lifecycle management of securities (coupon payment and redemption) and secondary trading***
Eurosystem interoperability solution	Full DLT Interoperability Solution (BdF)
Participants	• Issuer: EIB • Lead Book Runner: HSBC Continental Europe, France • Market Operator: HSBC Continental Europe, France (cash side as T2 direct RTGS participant) • DLT Market Operator: HSBC Continental Europe, Luxembourg
DLT technology used on market side (as reported by market stakeholders)	HSBC Orion is a DLT platform that can be used for issuing, settling, and recording digital assets, in particular digital bonds. It can also be used to record legal ownership of physical gold held in HSBC's vault in London, represented by HSBC Gold tokens, as well as currently developing a new digital assets custody service. HSBC Orion offers distinct architecture patterns to support both private and public blockchain connectivity. In Luxembourg, HSBC Orion is designed and built to reflect the two-tier account structure under the Luxembourg blockchain laws, with HSBC acting as Central Account Keeper and Secondary Account Keeper (Custodian).
Flowchart of use case (as reported by market stakeholders)	
High-level description (as reported by market stakeholders)	The European Investment Bank (EIB) issued a digitally native bond on HSBC's asset tokenisation platform, HSBC Orion, under Luxembourg law. Instead of using fiat cash to settle the primary issuance, it used Exploratory Cash Token (ECT), minted on the Banque de France's Full DLT Interoperability (DL3S) platform as part of the ECB trials.
Learning objectives of the market (as reported by market stakeholders)	• Keep pace with digital innovation in central bank money in the European markets. • Understand/evaluate how (i) wholesale CBDCs can reduce settlement times, including, if possible, in a cross-border transaction, (ii) regulatory implications of CBDCs are aligning with existing frameworks, (iii) integration with existing systems and interoperability across distributed ledgers can be established, and (iv) adequate legal and governance structures around CBDC can be implemented. • Increase digital assets and currencies capabilities to support CBDC, in addition to other digital money forms.

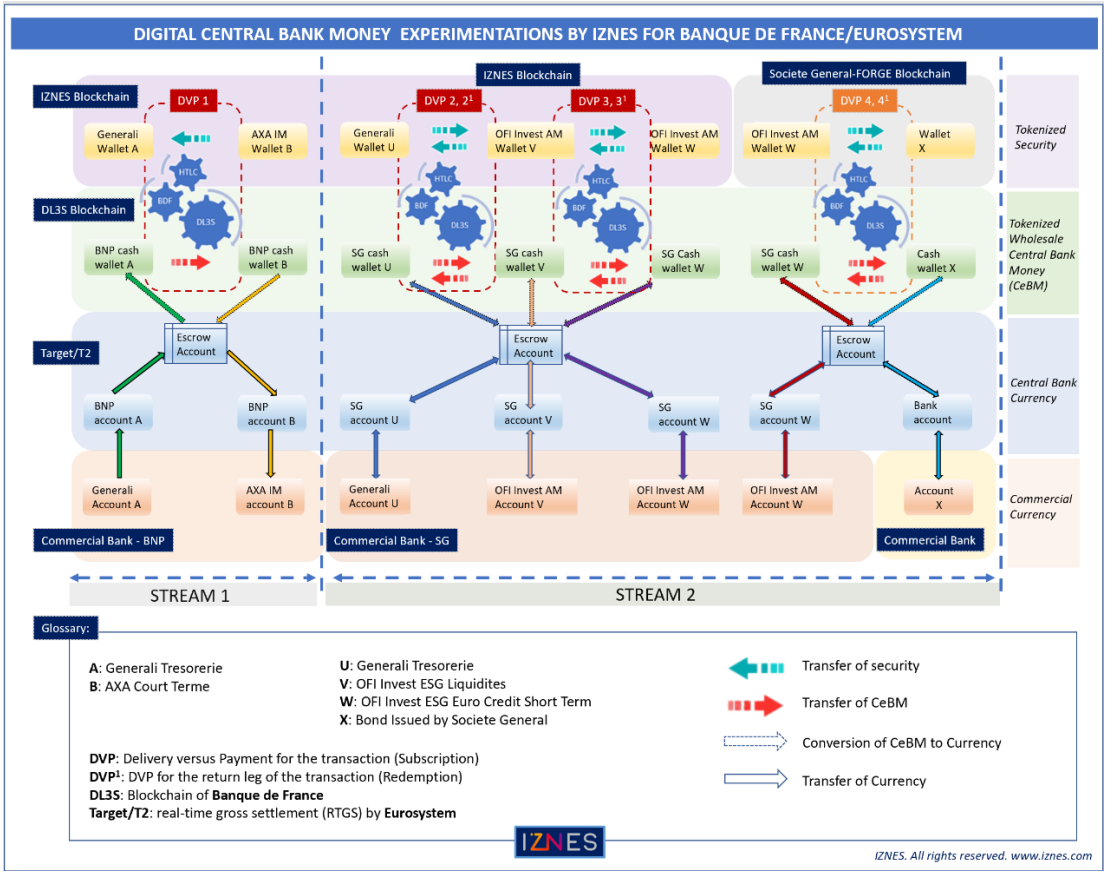
3.16 Iberclear (BME Group)

Experiment	**Category 1:** ***Primary issuance of bonds by financial institutions, corporates or sovereigns and delivery-versus-payment settlement, in some instances also including lifecycle management of securities (coupon payment and redemption) and secondary trading***
Eurosystem interoperability solution	Full DLT Interoperability Solution (BdF)
Participants	• Issuer: Simulated • Payment Agent: Cecabank S.A. • Investors: Société Générale Sucursal en España, Unicaja Banco S.A., Cecabank S.A., Kutxabank Investment S.V. S.A.U., CaixaBank S.A., Banco de Sabadell S.A., BNP Paribas S.A. Sucursal en España, Renta 4 Banco S.A., CACEIS Bank Spain S.A.U., Banco Cooperativo Español S.A. • Market DLT Operator: Iberclear (BME Group)
DLT technology used on market side (as reported by market stakeholders)	The BME Digital Bond Platform is designed to streamline the process of issuing, trading, and settling digital bonds. It utilises distributed ledger technology (DLT), specifically Hyperledger Besu, the EVM-compatible, private permissioned blockchain, to enhance the transparency and security of transactions. The platform leverages the ERC-1410 Ethereum token standard for implementing HTLCs, particularly useful when representing real-world assets like securities: these enable the automation of various bond-related processes such as interest payments and redemptions. For regulatory compliance and security, the platform integrates digital identity verification, employing cryptographic methods to authenticate participant identities and prevent fraud.
Flowchart of use case (as reported by market stakeholders)	



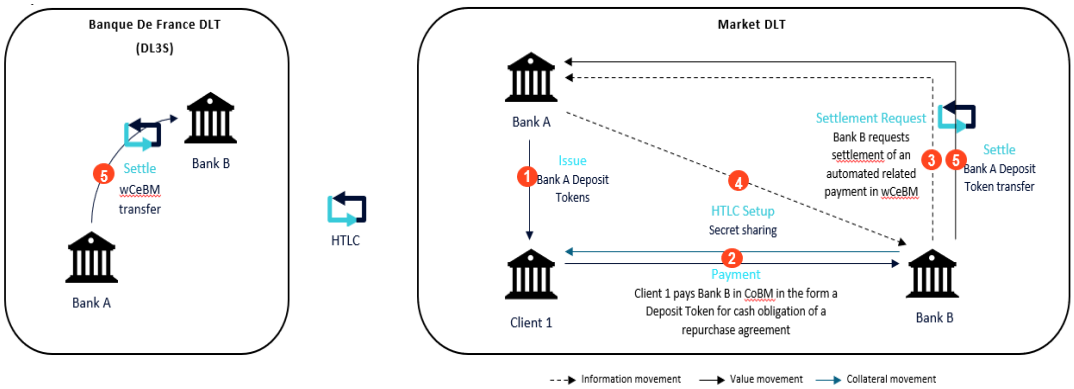
High-level description (as reported by market stakeholders)	More than 200 transactions executed over 3 months covering the following cases: 1. Bond issuance and distribution 2. OTC settlement: a. OTC Settlement between 2 investors of 2 custodians b. OTC Settlement between 2 custodians c. OTC Settlement between 2 investors of the same custodian 3. Coupon payment 4. Bond redemption
Learning objectives of the market (as reported by market stakeholders)	Iberclear believes that by involving Spanish banking players, they could learn together, as a financial community, the benefits that this technology could bring to their ecosystem, seek to improve on the developments made and contribute to the development of the European capital market. For Iberclear, access to wholesale central bank money on DLT is very relevant to facilitate the development of securities infrastructure based on DLT.

3.17 IZNES

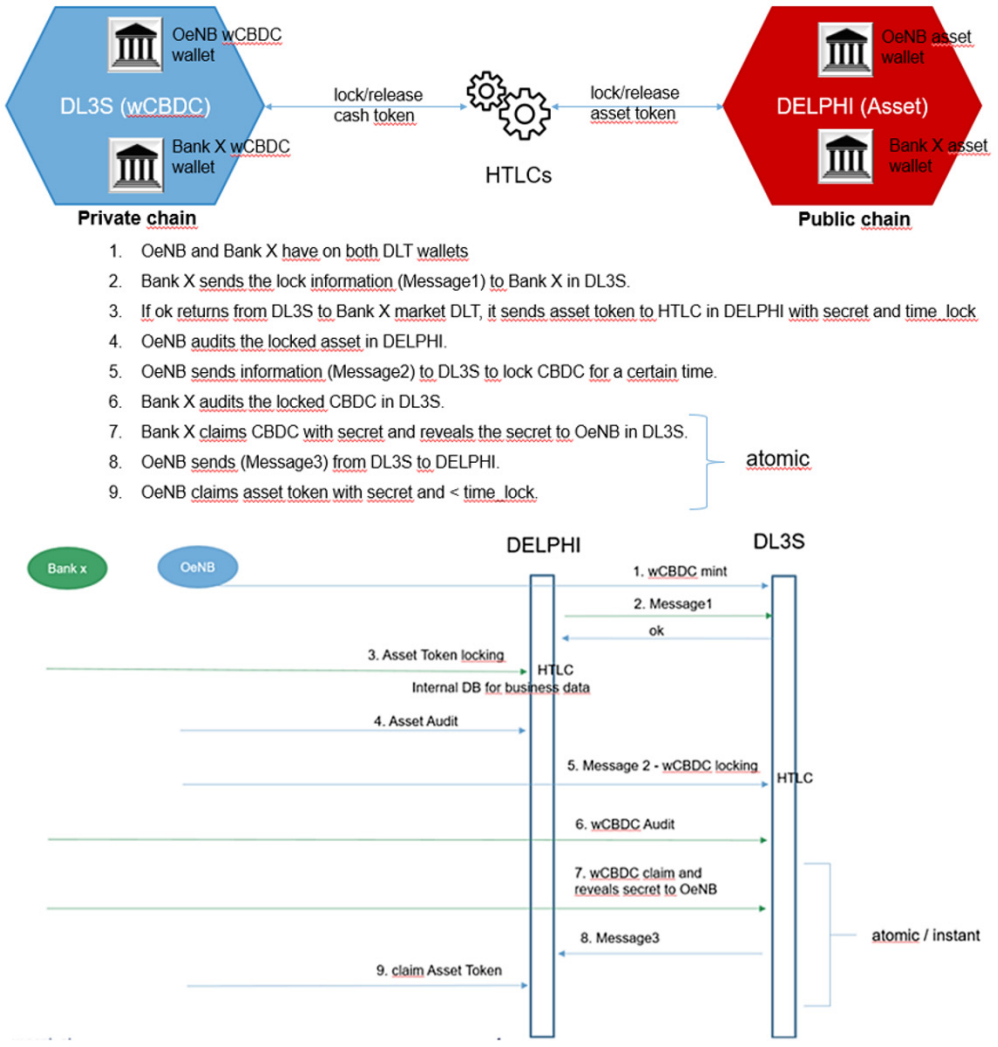
Trial	Category 9: *Fund share subscription, including secondary market and redemption*
Eurosystem interoperability solution	Full DLT Interoperability Solution (BdF)
Participants	• Asset management companies: OFI Invest, AXA Investment Managers • Investor's custodian: Société Générale, BNP Paribas • DLT Market Operator: IZNES • Investor: Generali
DLT technology used on market side (as reported by market stakeholders)	The blockchain layer that records transactions was completely redeveloped in 2022 in Hyperledger Fabric technology: it is a private blockchain, permissioned, with a proof-of-authority protocol and a limited number of nodes, all controlled by IZNES. The IZNES platform is hosted by three Cloud hosting providers with data centres based in France and Ireland to guarantee consensus on the blockchain (5 nodes): - AWS, Paris hosting center (France and Germany) - Azure, Paris hosting center (France) - AMB, Dublin hosting center (Ireland).
Flowchart of use case (as reported by market stakeholders)	
High-level description (as reported by market stakeholders)	The experiment consisted of two streams: **Stream 1:** In collaboration with Generali as investor, AXA IM as issuer / asset manager of the tokenized fund, and BNP Paribas' Securities Services business providing existing services and managing its clients' wallets in BdF's Full DLT Interoperability (DL3S), the experiment focused on the subscription of fund units using Banque de France's Exploratory Cash Token (ECT).

	Stream 2: Partnering with Generali as investor, OFI Invest AM as issuer / asset manager of the tokenized fund, Société Générale and Société Générale -FORGE, this stream demonstrated the wholesale CeBM's capabilities in a complex, multi-layered financial operation. 1. Generali IARD subscribes for 1 million euros in OFI Invest ESG Euro Credit Short Term. 2. OFI Invest ESG Euro Credit Short Term: 3. Subscribes 900,000 euros to the OFI Invest ESG Liquidités fund. 4. Buys 100,000 euros of a structured product issued by Société Générale-FORGE. 5. OFI Invest ESG Euro Credit Short Term receives repayment from the structured product. 6. OFI Invest ESG Euro Credit Short Term redeems its shares in the OFI Invest ESG Liquidités fund. 7. Generali IARD redeems its units in the OFI Invest ESG Euro Credit Short Term fund. Société Générale Securities Services acted as Paying Agent.
Learning objectives of the market (as reported by market stakeholders)	This successful experimentation highlights the potential of wholesale CeBM to enhance the efficiency, security, and resilience of financial markets. It sets a precedent for the integration of a wholesale CeBM into real-world financial applications, demonstrating their viability as a cornerstone of the future financial ecosystem.

3.18 Kinexys by J.P. Morgan

Experiment	**Category 6: Tokenised deposits / *deposit token transfers with related settlement in central bank money (intrabank or interbank)***
Eurosystem interoperability solution	Full DLT Interoperability Solution (BdF)
Participants	• Issuer: J.P. Morgan SE • Investor: J.P. Morgan SE • DLT Market Operator: J.P. Morgan SE
DLT technology used on market side (as reported by market stakeholders)	For the purpose of this experiment J.P. Morgan SE uses a DLT setup that is an Ethereum virtual machine (EVM) compliant test private and permissioned network. An ERC20 token based smart contract represents the commercial bank money (CoBM). Further the DLT network maintains an allow-list of wallets on the platform to ensure only simulated clients of the CoBM issuer are allowed to hold tokens and transact with them. The test environment is taken down at the end of the experiment.
Flowchart of use case (as reported by market stakeholders)	 **Experimental steps:** (1) Client 1 requests Deposit Tokens from Bank A. Bank A issues Deposit Tokens to Client 1's wallet by debiting Client 1 bank account. (client 1 bank account not depicted here as it sits on Bank A traditional ledger) (2) Client 1 pays Bank B in CoBM in the form of Deposit Tokens (both clients of Bank A), as the cash obligation of a repurchase agreement where Bank B transfers tokenized collateral to Client 1. (3) Bank B requests from Bank A settlement an automated related payment in wCeBM. Bank B may prefer to do this at the back of multiple repo transactions to convert CoBM into wCeBM, and hold wCeBM until they need to return Deposit Tokens back to their counterparties (for example next business day). (4) HTLC setup: Bank A generates secret and sets a programmable instruction for a balance movement of 10,000 EUR wCeBM from Bank A to Bank B. Bank A communicates the secret to Bank B on the Market DLT platform. (5) HTLC secret release triggers payment execution; 10,000 EUR Deposit Tokens is moved from Bank B (as client of Bank A) to Bank A on the DLT platform and simultaneously, 10,000 EUR wCeBM is moved from Bank A to Bank B on DLT3S platform.
High-level description (as reported by market stakeholders)	The use case demonstrated how EUR CoBM tokens on the Market DLT platform were settled against EUR wCeBM on the Full DLT Interoperability (DL3S) platform. The HTLC mechanism was used to demonstrate simultaneous exchange on these two separate DLT platforms.
Learning objectives of the market (as reported by market stakeholders)	• Demonstrate the co-existence of CoBM and wholesale Central Bank Money (wCeBM) on DLT platforms and in particular CoBM can be settled against wCeBM. • Learn from the experiment the ease of interoperability and the performance; develop thinking on how various adjacent solutions may be needed to support wholesale settlements (such as liquidity saving mechanisms).

3.19 Oesterreichische Nationalbank (OeNB)

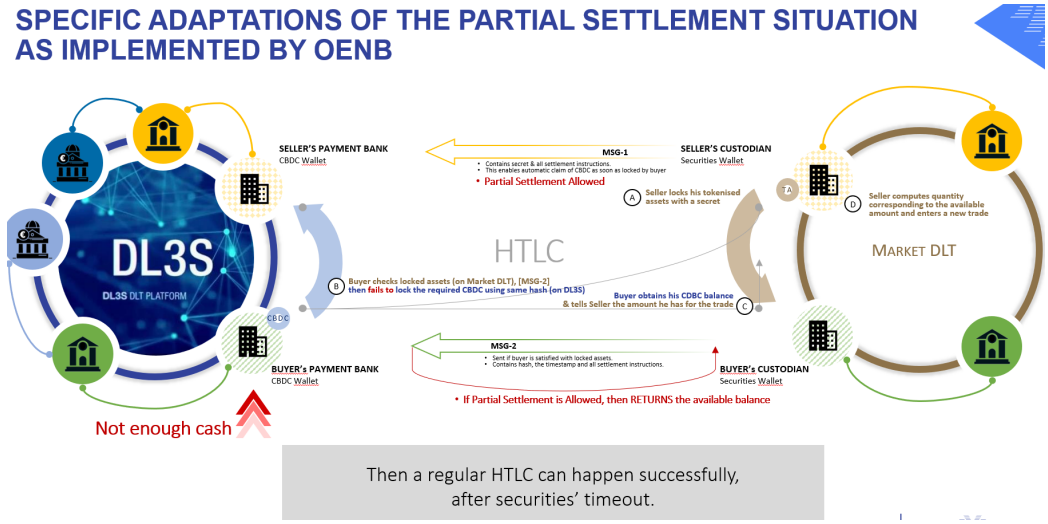
Experiment	**Category 1:** ***Primary issuance of bonds by financial institutions, corporates or sovereigns and delivery-versus-payment settlement, in some instances also including lifecycle management of securities (coupon payment and redemption) and secondary trading***
Eurosystem interoperability solution	Full DLT Interoperability Solution (BdF)
Participants	• Investor: OeNB • DLT Market Operator: OeNB
DLT technology used on asset side (as reported by the OeNB)	The DELPHI (Delivery vs. Payment Hybrid Initiative) project aims to explore the feasibility of issuing and settling Austrian government bonds as tokenised securities on a blockchain platform. A public permissioned blockchain (Ethereum testnet) is used to simulate the technical token creation and settlement of a DvP transaction.
Flowchart of use case (as reported by the OeNB)	
High-level description (as reported by the OeNB)	The experiment involves the DVP Settlement of a mock Austrian government bond (previously created on OeNB platform as part of project DELPHI). The cash leg is provided by Full DLT Interoperability (DL3S). The seller of the security token on the DELPHI platform is a simulated bank, named as “Bank X”. OeNB appears as the buyer.
Learning objectives (as reported by the OeNB)	The successful completion of DvP related experiments provide a good basis for future developments. The usage of central bank money instead of privately issued stablecoins is a core necessity to build and scale a DLT based infrastructure.

In DELPHI, the cash part has so far only been running in a test network (sandbox) on a public DLT. As part of the ECB experiment, it is now possible to run the cash part in a production-related environment - via DL3S from the Banque de France - which is more realistic and should therefore provide essential insights into its practical suitability.

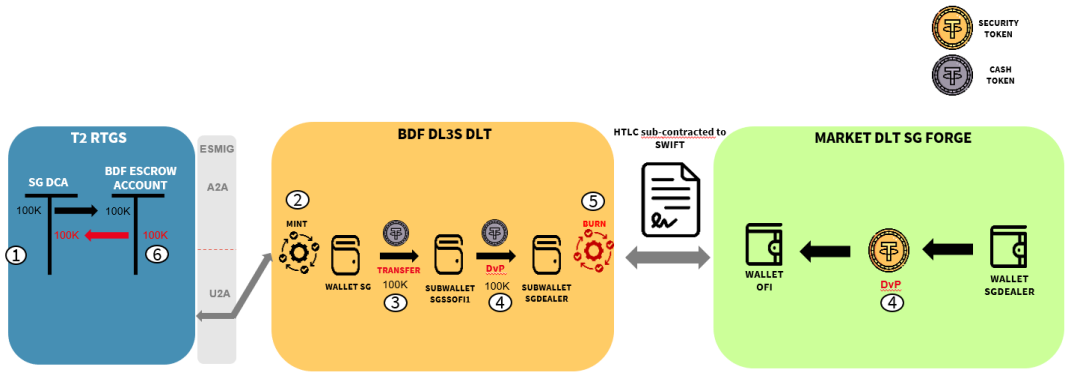
Since DELPHI has so far been a purely national initiative with Austrian stakeholders, the experiments should be used to intensify exchange and contacts in the Eurosystem and perhaps identify further cross-border use cases.

The experiments and intensified exchange showcased:

- **The need to broaden secondary market transactions**: Market participants voiced their concerns and the need for secondary trading applications and experiments, as most of the work has focused on primary markets alone. They are rather hesitant with investing and providing resources. Furthermore, an emphasis on interoperability with legacy systems is required.
- **Private vs. public chains**: While DL3S is a private permissioned chain, the DELPHI platform runs on an Ethereum Virtual Machine (EVM) using a testnet. As Ethereum is a public blockchain, transaction fees could vary, based on congestion of the network (Gas fees). On the other hand, a decentral public blockchain provides the security that there is no single point of failure which could lead to a downtime.

Experiment	**Category 11: *Partial Settlement***
Eurosystem interoperability solution	Full DLT Interoperability Solution (BdF)
Participants	• DLT Market Operator: OeNB
DLT technology used on asset side (as reported by the OeNB)	The DELPHI (Delivery vs. Payment Hybrid Initiative) project aims to explore the feasibility of issuing and settling Austrian government bonds as tokenised securities on a blockchain platform. A public permissioned blockchain (Ethereum testnet) is used to simulate the technical token creation and settlement of a DvP transaction.
Flowchart of use case (as reported by the OeNB)	
High-level description (as reported by the OeNB)	The experiment involved the DVP Settlement of a mock bond, with the cash leg settled in central bank money provided by Full DLT Interoperability (DL3S) of Banque de France on the testnet. Buyer and seller were simulated entities. It simulated the lack of sufficient funds to fully settle the transactions to test the partial settlement functionality.
Learning objectives of the market (as reported by the OeNB)	As the buyer does not have sufficient cash tokens, the DvP transaction is stopped and DL3S sends a message to the DELPHI platform. This message includes information on the funds and provides the basis to arrange a new trade. This can be used to facilitate a partial settlement. In our concluded experiment, we had one cancelled trade and a new trade that settled with the new amount. Potential to automate: The demonstration showcased the potential to fully automate partial settlement, if agreed beforehand.

3.20 SG Forge

Trial	**Category 1:** ***Primary issuance of bonds by financial institutions, corporates or sovereigns and delivery-versus-payment settlement, in some instances also including lifecycle management of securities (coupon payment and redemption) and secondary trading***
Eurosystem interoperability solution	Full DLT Interoperability Solution (BdF)
Participants	• Issuer: SG Forge • Seller: SG-Dealer • Investor: OFI-Invest • Investor custodian: SGSS • Cash DLT: Full DLT Interoperability (DL3S) • Market DLT Operator: SG Forge • HTLC Subcontractor: SWIFT
DLT technology used on market side (as reported by market stakeholders)	SG Forge market DLT is the Ethereum public blockchain. The access to the DLT financial instruments is permissioned, while the access to the DLT is permissionless, in compliance with the CAST framework used by SG Forge and being integrated to ISDA/ICMA agreements.
Flowchart of use case (as reported by market stakeholders)	 1. **SG DCA** initiates a liquidity transfer towards **BdF ESCROW** for 100K 2. **M**inting ECTs (Exploratory Cash Token) for 100K 3. **SG** transfers ECTs token to **OFI1** subwallet for 100K. *Reminder : Subwallets work as a purchasing power. Subwallet owners own the token but have only a read-only mode on the subwallet* 4. **OFI 1** subscribes to **SG Forge** tokenized structure product for 100K (**DvP**) 5. **Banque de France** burns ECTs for 1M 6. **Banque de France** initiates a liquidity transfer from **BdF ESCROW** account **to SG DCA** for 100K
High-level description (as reported by market stakeholders)	Issuance a Senior Preferred Note Structured Product on a public blockchain as a permissioned token with related DvP settlement leveraging the Eurosystem provided interoperability solution. Issuance and settlement happened during trial day, then the product had been bought back at maturity (2 days after issuance). SWIFT was part of the connectivity between asset and cash leg platforms.
Learning objectives of the market (as reported by market stakeholders)	Using the same technology substrate (DLT) between all actors (investor, custodians, issuers, market DLT operators) enabling a single source of data that simplifies data reconciliation and transactions management. DLT enables the same infrastructure for all securities (listed, unlisted etc…), reduces settlement time and simplifies processes by bringing closer issuers and investors by reducing intermediaries. The Client (OFI Invest) demonstrates that buy-side actors can orchestrate interoperability between many platforms (i.e. IZNES, SG FORGE) with few IT investments as connectivity leverages existing SWIFT's network. Société Générale makes a market on its structured products.

3.21 SWIAT (as technological provider for Market DLT Operators DekaBank, LBBW and BayernLB)

Overview of SWIAT activities. SWIAT tested the Trigger Solution

Trials	**Category 1:** ***Primary issuance of bonds by financial institutions, corporates or sovereigns and delivery-versus-payment settlement, in some instances also including lifecycle management of securities (coupon payment and redemption) and secondary trading***
Eurosystem interoperability solution	Trigger Solution (BBk)
Participants	❖ **Use Case "DvP Institutional Bearer Bond 1":** • Issuer: DekaBank • Registrar: DekaBank • Investor: Bankhaus Metzler • Market DLT Operator: DekaBank using SWIAT as DLT software solution • Redemption within exploratory work as DvP with Trigger Solution ❖ **Use Case "DvP Institutional Bearer Bond 2":** • Issuer: DekaBank • Investor: LBBW • Market DLT Operator: DekaBank using SWIAT as DLT software solution • Redemption within exploratory work as DvP with Trigger Solution ❖ **Use Case "DvP Registered Bond 1":** • Issuer: BayernLB • Investor: Stadtsparkasse München • Paying agent: Helaba for Stadtsparkasse München • Market DLT Operator: BayernLB using SWIAT as DLT software solution • Redemption within exploratory work as DvP with Trigger Solution

❖ **Use Case "DvP Registered Bond 2":**

- Issuer: Sparkasse Dortmund
- Registrar: DekaBank
- Paying agent: Helaba for Sparkasse Dortmund
- Investor: DekaBank
- Market DLT Operator: DekaBank using SWIAT as DLT software solution.

❖ **Use Case "DvP Registered Bond 3":**

- Issuer: LBBW
- Registrar: LBBW
- Investor: DekaBank
- Market DLT Operator: LBBW using SWIAT as DLT software solution

❖ **Use Case "DvP Corporate Bearer Bond":**

- Issuer: Siemens
- Registrar: DekaBank
- Paying agent: Deutsche Bank.
- Investors: BayernLB, DekaBank, DZ BANK, Helaba and LBBW.
- DLT Market Operator: DekaBank using SWIAT as DLT software solution

DLT technology used on market side (as reported by market stakeholders)

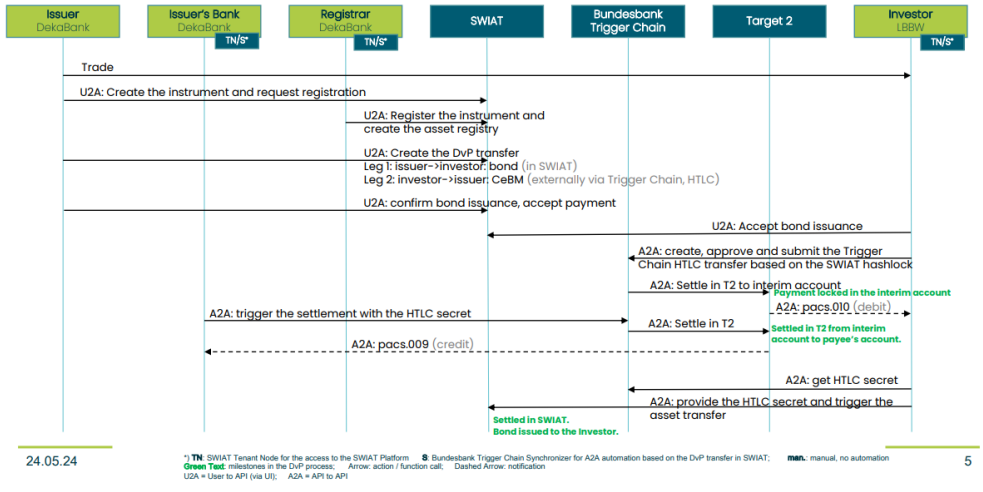
SWIAT Ecosystem consisting of SWIAT dApps like its digital assets solution for tokenization and the SWIAT Blockchain – a regulatory compliant blockchain from the financial industry for the financial industry.

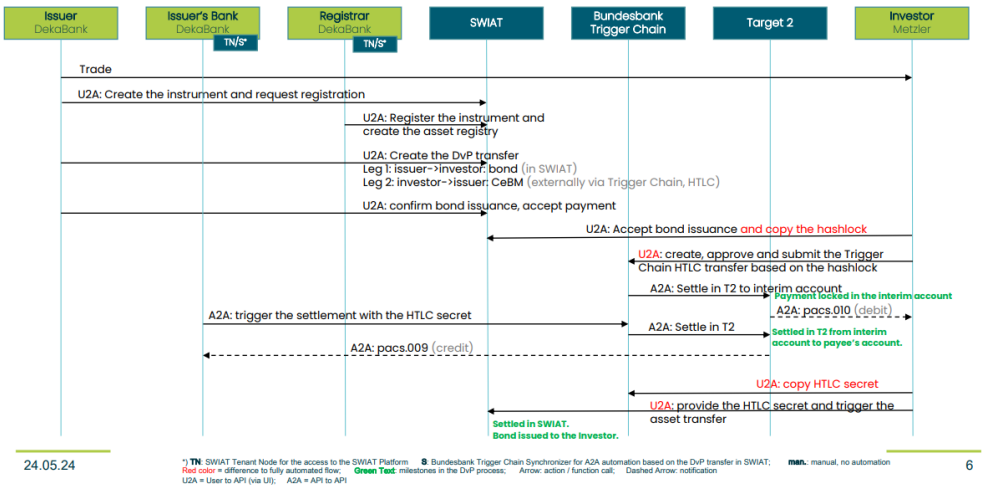
The SWIAT Ecosystem with more than 30 financial institutions is the interconnected and interoperable suite of decentralized applications such as tokenization, issuance of digital securities, DvP-synchronization mechanisms and securities financing solutions.

The SWIAT Blockchain is an EVM-compatible, private permissioned blockchain. It is based on Hyperledger Besu Enterprise Ethereum Client and supports Ethereum Smart Contracts. The consensus algorithm used is Proof-of-Authority (PoA). In particular, it uses IBTF 2.0 (Istanbul byzantine fault-tolerant), which is a variant of PBFT (practical byzantine fault tolerant) algorithm.

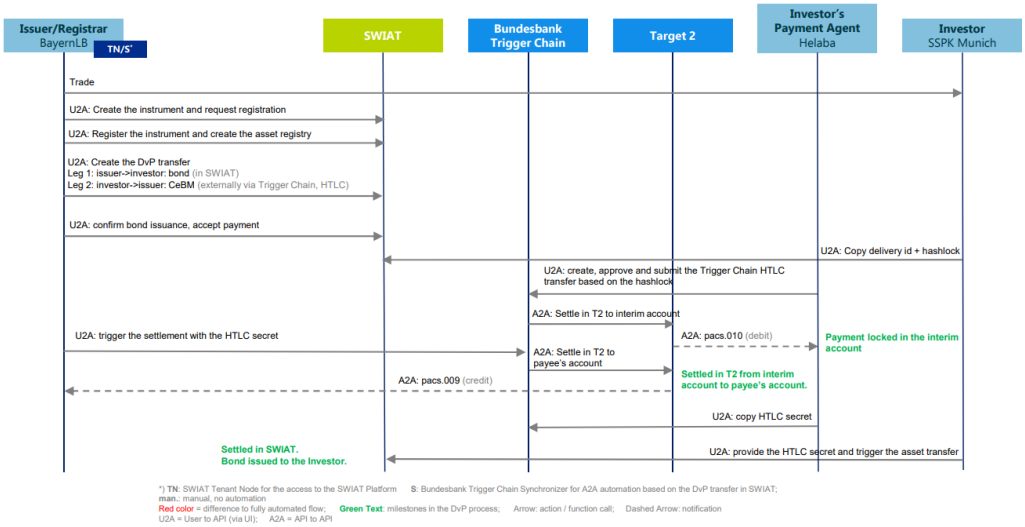
Flowchart of use case (as reported by market stakeholders)

Use Case "DvP Institutional Bearer Bond 1 and 2":

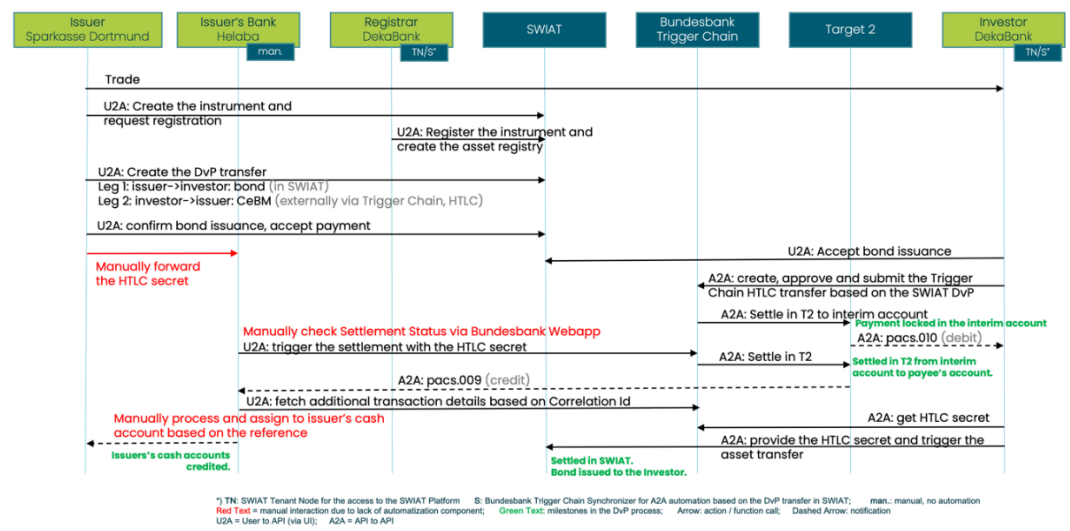




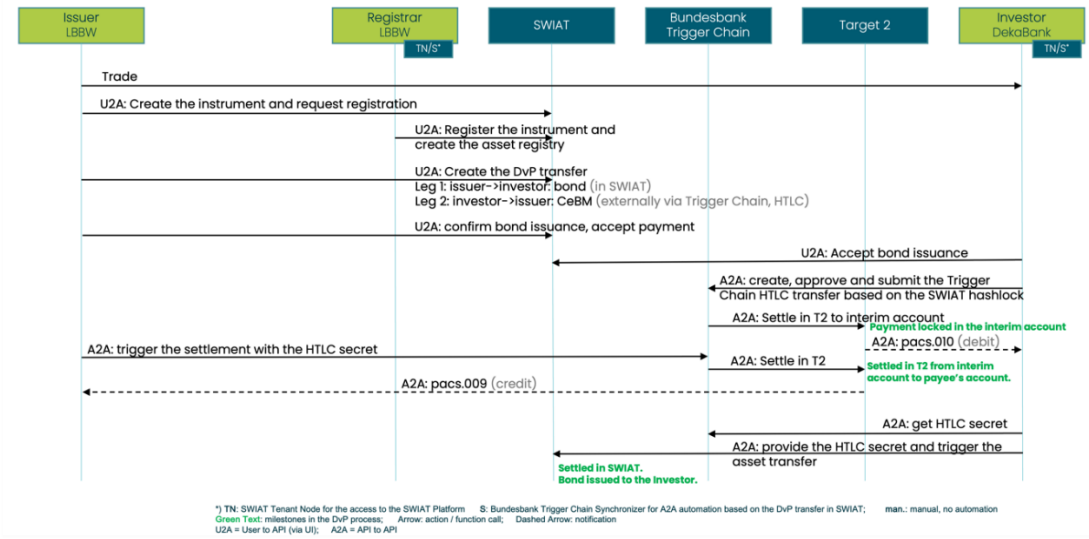
Use Case "DvP Registered Bond 1":



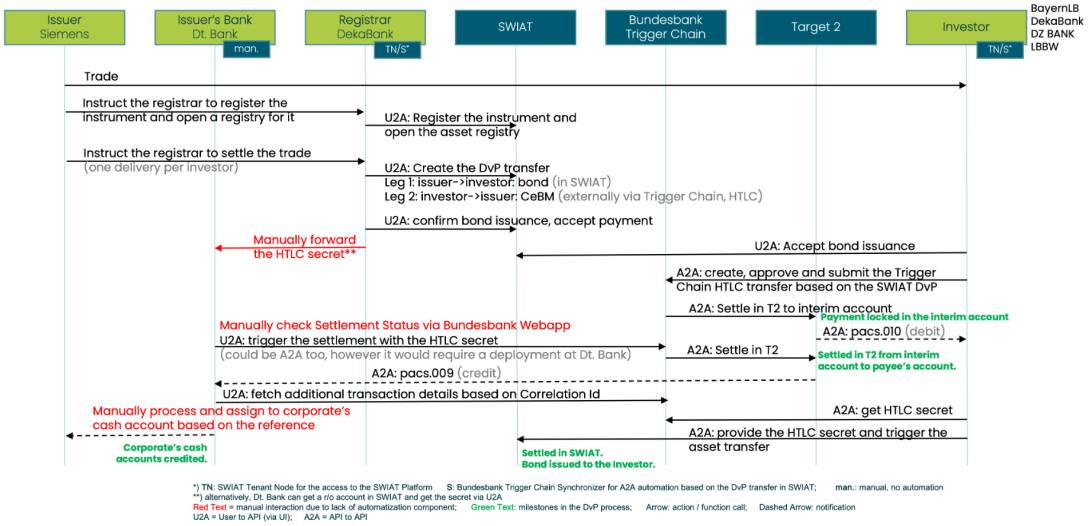
Use Case "DvP Registered Bond 2":



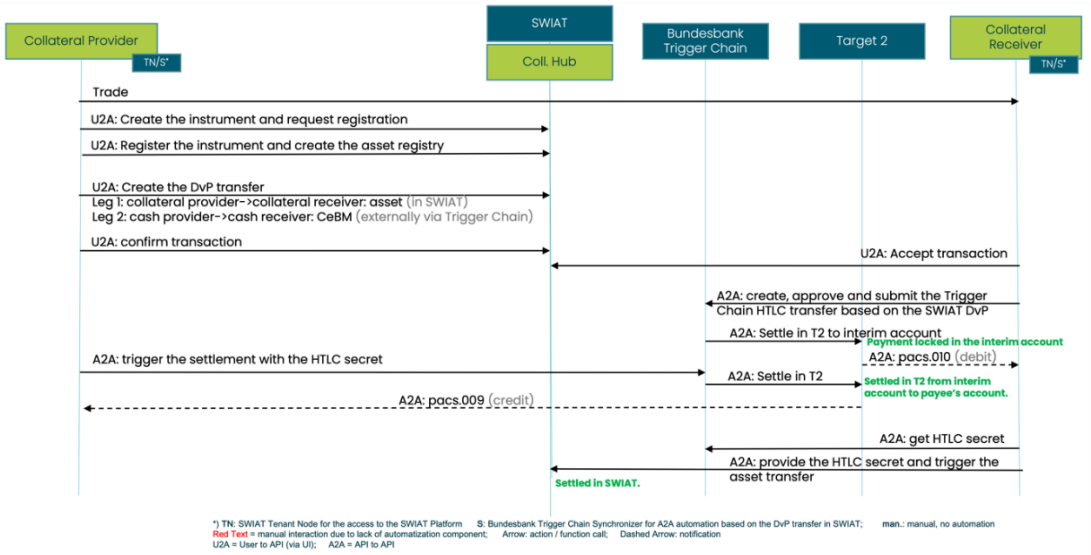
Use Case "DvP Registered Bond 3"



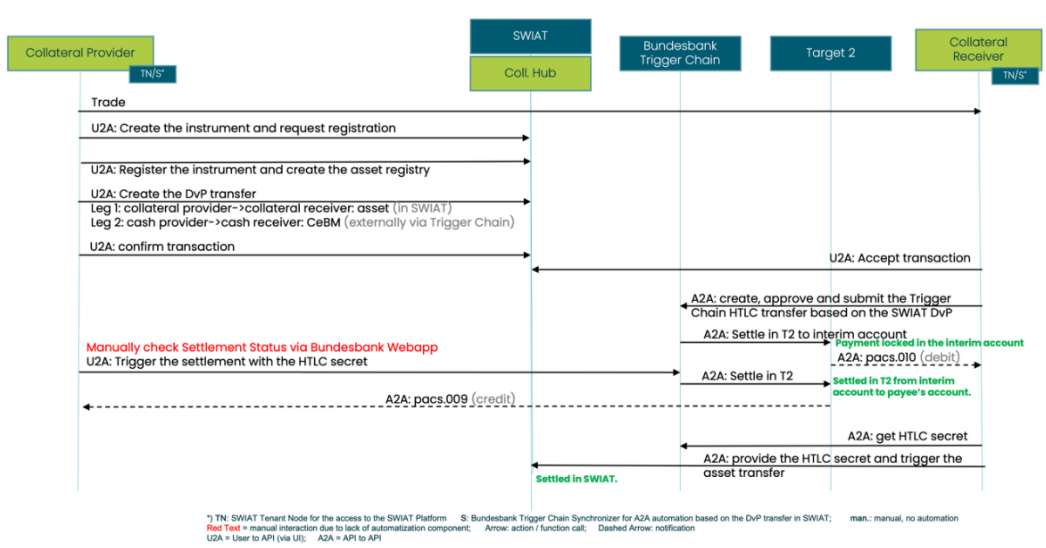
Use Case "DvP Corporate Bearer Bond":



High-level description (as reported by market stakeholders)	DvP involving Bonds: issuance and primary distribution of a corporate bond leveraging SWIAT blockchain and services for the asset-leg and Eurosystem interoperability solution for the cash-leg.
Learning objectives of the market (as reported by market stakeholders)	Validate whether DvP with CeBM via the Eurosystem provided interoperable solution is reliable and applicable to corporate bond issuance and secondary market operations; in general, check if the DvP process can: be automated, be scaled in production, allow for instantaneous or near-time settlement, reduce counterparty-risks, be seamlessly integrated into existing banking processes; understand the operational, business and technical requirements to be met in order to send and receive payments via the Eurosystem provided interoperable solution; expand the expertise and promote future advantages of blockchain technology; assess if the interoperability mechanism can be reused in other settings (e.g. with CoBM, E-Money Tokens, Stable Coins).

Trial	Category 2: *Intraday/overnight repurchase agreements (repos)*
Eurosystem interoperability solution	Trigger Solution (BBk)
Participants	❖ **Use Case "Digital bilateral repo 1 (overnight)":** • Collateral Receiver: Deka. • Cash Receiver: LBBW. • DLT Market Operator: DekaBank using Collateral Hub by SWIAT for on-ramping traditional security.
DLT technology used on market side (as reported by market stakeholders)	SWIAT Ecosystem consisting of SWIAT dApps like its digital assets solution for tokenization and the SWIAT Blockchain – a regulatory compliant blockchain from the financial industry for the financial industry. The SWIAT Ecosystem with more than 30 financial institutions is the interconnected and interoperable suite of decentralized applications such as tokenization, issuance of digital securities, DvP-synchronization mechanisms and securities financing solutions. The SWIAT Blockchain is an EVM-compatible, private permissioned blockchain. It is based on Hyperledger Besu Enterprise Ethereum Client and supports Ethereum Smart Contracts. The consensus algorithm used is Proof-of-Authority (PoA). In particular, it uses IBTF 2.0 (Istanbul byzantine fault-tolerant), which is a variant of PBFT (practical byzantine fault tolerant) algorithm.
Flowchart of use case (as reported by market stakeholders)	
High-level description (as reported by market stakeholders)	DvP involving collateral: on-ramping of the collateral and exchange against CeBM leveraging SWIAT blockchain and services for the asset-leg and Eurosystem interoperability solution for the cash-leg.

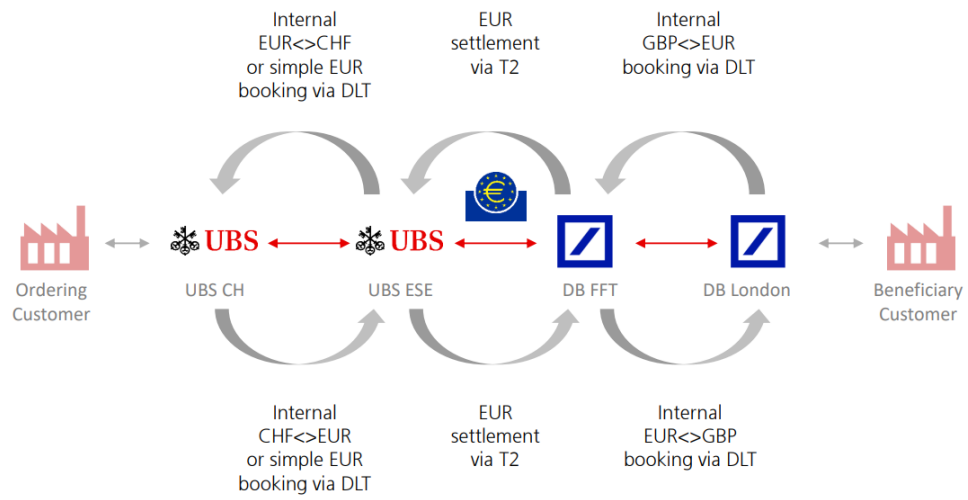
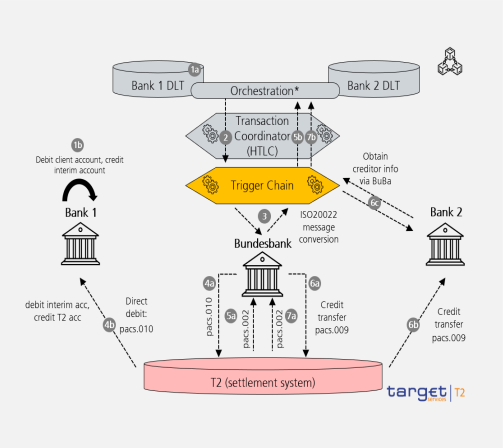
Learning objectives of the market (as reported by market stakeholders)	• Validate if digital bilateral repo versus payment with CeBM via Bundesbank Trigger Solution is applicable for our use case
	  • is reliable, robust and it can be scaled in production
	  • allows for instantaneous or near-time settlement
	  • reduces counterparty-risks
	  • can be seamlessly integrated into existing banking processes
	  • the Collateral Hub protocol can be automated
	• Understand and learn in general how the operational, business and technical requirements to send and receive payments via Bundesbank Trigger Solution work.
	• Expanding our expertise and promoting future advantages of blockchain technology in Europe and Germany
	• Learn how the Trigger Solution is impacting the liquidity of RTGS DCA and how bank internal payment & liquidity systems are affected in detail
	• Analyse if the interoperability mechanism can be reused in other settings, e.g. with CoBM, E-Money Tokens, Stable Coins, etc. (SWIAT, future work)

Experiment	Category 2: *Intraday/overnight repurchase agreements (repos)*
Eurosystem interoperability solution	Trigger Solution (BBk)
Participants	❖ **Use Case "Digital bilateral repo 2 (intraday)":** • Collateral Receiver: NatWest • Cash Receiver: DekaBank • Two scenarios: (1) on-ramped traditional security // (2) native digital security where DekaBank acts as crypto securities registrar • DLT Market Operators: DekaBank using Collateral Hub by SWIAT (for on-ramping traditional security.)
DLT technology used on market side (as reported by market stakeholders)	SWIAT Ecosystem consisting of SWIAT dApps like its digital assets solution for tokenization and the SWIAT Blockchain – a regulatory compliant blockchain from the financial industry for the financial industry. The SWIAT Ecosystem with more than 30 financial institutions is the interconnected and interoperable suite of decentralized applications such as tokenization, issuance of digital securities, DvP-synchronization mechanisms and securities financing solutions. The SWIAT Blockchain is an EVM-compatible, private permissioned blockchain. It is based on Hyperledger Besu Enterprise Ethereum Client and supports Ethereum Smart Contracts. The consensus algorithm used is Proof-of-Authority (PoA). In particular, it uses IBTF 2.0 (Istanbul byzantine fault-tolerant), which is a variant of PBFT (practical byzantine fault tolerant) algorithm.
Flowchart of use case (as reported by market stakeholders)	
High-level description (as reported by market stakeholders)	DvP involving collateral: on-ramping of the collateral and exchange against CeBM leveraging SWIAT blockchain and services for the asset-leg and Eurosystem interoperability solution for the cash-leg.

Learning objectives of the market (as reported by market stakeholders)	• Validate if digital bilateral repo versus payment with CeBM via Bundesbank Trigger Solution is applicable for our use case
	  • is reliable, robust and it can be scaled in production
	  • allows for instantaneous or near-time settlement
	  • reduces counterparty-risks
	  • can be seamlessly integrated into existing banking processes
	  • the Collateral Hub protocol can be automated
	• Understand and learn in general how the operational, business and technical requirements to send and receive payments via Bundesbank Trigger Solution work.

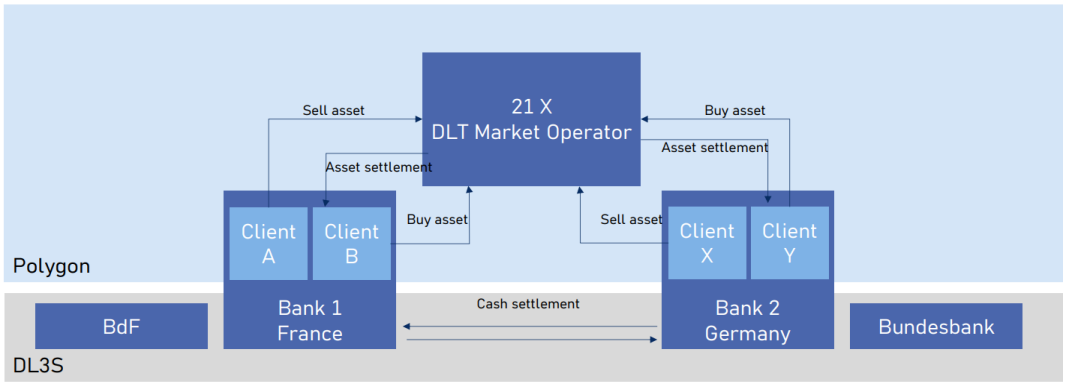
- Expanding our expertise and promoting future advantages of blockchain technology in Europe and Germany
- Learn how the Trigger Solution is impacting the liquidity of RTGS DCA and how bank internal payment & liquidity systems are affected in detail
- Analyse if the interoperability mechanism can be reused in other settings, e.g. with CoBM, E-Money Tokens, Stable Coins, etc. (SWIAT, future work)

3.22 UBS and Deutsche Bank

Experiment	**Category 6: *Tokenised Deposit / deposit token transfers with related settlement in central bank money (intrabank or interbank)***
Eurosystem interoperability solution	Trigger Solution (BBk)
Participants	• Payer/Payee: UBS and Deutsche Bank
DLT technology used on market side (as reported by market stakeholders)	UBS and Deutsche Bank test blockchains were used in the experiment to mirror account positions. The Orchestration of deposit movements on the bank-centric blockchain networks of each bank as well as the settlement via the Trigger Solution was performed by orchestration smart contracts that were issued on a third network operated by one of the banks. The networks used private permissioned Hyperledger Besu clients provided by the Fintech Adhara.
Flowchart of use case (as reported by market stakeholders)	Payment Flow between UBS and DB / DB and UBS  The aim was to keep the blockchain and internal systems in sync (account mirror) but not to integrate the blockchain as the orchestrator for internal transactions. Process Visualization  Process Steps 1 1a) Payment is instructed via Bank 1 DLT, orchestration service informs bene agent (Bank 2), banks accept payment obligations and place holds on all accounts. Debtor instructs (via orchestration layer) BuBa payment. 1b) Debtor agent debits debtor account in legacy system & credits interim account. 2 After payment is approved by creditor agent and submitted by debtor agent at Bundesbank portal via API, settlement is instructed by Bundesbank Trigger Chain. 3 Bundesbank converts payment instruction on Trigger Chain into ISO20022 messages and submits them to T2 (step 4 and 6). 4 4a) Direct debit instruction processed: debits T2 account of debtor agent and credits interim account of Bundesbank. 4b) Pacs.010 sent to debtor agent that debits interim account and credits T2 DCA. 5 Update of settlement status (success or failure) sent to Trigger Chain (5a). Orchestration layer and all banks retrieve update (5b) and instruct credit transaction to Bundesbank to finalize settlement via secret sharing as per the HTLC mechanism that is used. 6 6a) Credit transfer instruction processed: Debits Bundesbank-interim account and credits T2 account of creditor agent. 6b) Pacs.009 sent to creditor agent, debits T2 DCA and credits interim account. 6c) Creditor information is obtained by Bundesbank system that is used to debit interim account and credit beneficiary account. 7 Update of settlement status (success or failure) sent to Trigger Chain (7a). Orchestration layer receives update of final settlement which executes the holds (debits / credits on DLT accounts), which finalizes the whole payment process (7b). *Orchestration is done by one of the banks (or in future by an FMI). Aim is to orchestrate the payment and settlement across both banks' and Bundesbank's DLT

High-level description (as reported by market stakeholders)	The aim was to test a real-world cross-border payment scenario starting with corporate bank client payments. Use Case 1: • EUR transaction instructed by corporate at UBS / DB and settlement via Bundesbank Trigger Solution between DB and UBS • Focus on time critical transaction that are normally as well routed via T2 Use Case 2 • CHF transaction instructed by corporate client of UBS CH. Settlement via UBS ESE, T2 & DB FFT to DB LDN and corporate client account • GBP transaction instructed by corporate client of DB LDN. Settlement via DB FFT, T2 and UBS ESE to UBS CH and corporate client account • Transaction and FX is orchestrated via smart contracts between UBS CH and ESE on dummy Blockchain-accounts only Corporate clients were simulated
Learning objectives of the market (as reported by market stakeholders)	Financial markets are embracing the opportunities of DLT for process optimisation. There are plenty of initiatives worldwide aiming to achieve open and interoperable market infrastructures for tokenised assets and international payments. More and more banks are actively exploring for tokenised deposit solutions but the interoperability between the tokenised deposits issued by individual banks is still lacking and solutions to allow this are only advancing slowly. There is no efficient solution yet to carry out settlements in central bank money, hence, emerging payment offerings might be forced to choose alternative clearing or settlement methods. The industry is searching for solutions to increase scalability of tokenised deposits such as using bilateral nostro accounts between each other, stablecoins, liquidity providers between banks, etc; but so far, settlement in central bank money was barely possible. The UK Fnality Payment System (FnPS) is an example of a solution that comes the closest. It can be described best as a licensed “synthetic CBDC” network in which member banks enable wholesale settlement between each other on Blockchain-rails on which representations of funds at the Bank of England are used as a settlement asset. In the above-described experiment, the involved banks and Bundesbank showcased successfully that settlement and interoperability between bank-centric tokenised deposit networks can be facilitated by the Bundesbank Trigger Solution. The aim was to assess whether the solution allows efficient interoperability between DLT networks, whether it can be used for interbank settlements, how it compares to “token based” representations of central bank money and what the implications are for integration into bank back-end systems.

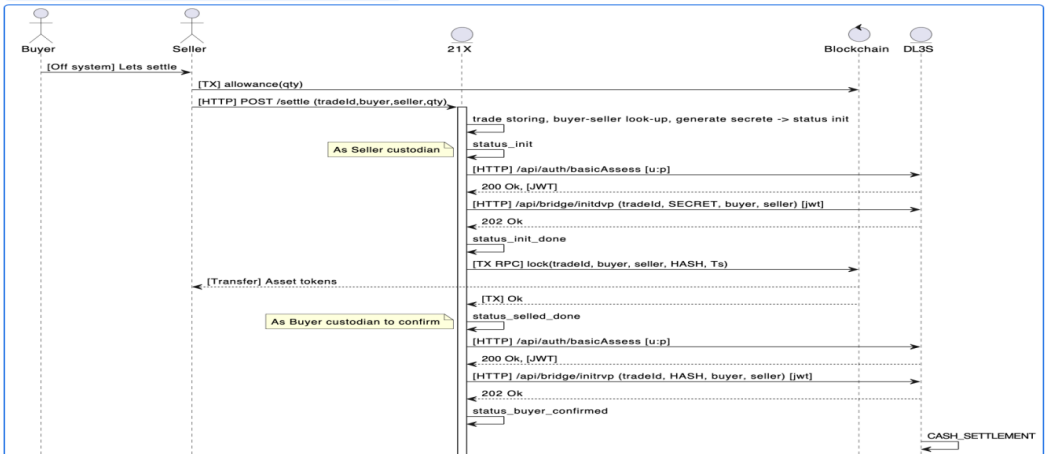
3.23 21X

Experiment	Category 10: *secondary market activity of various financial instruments*
Eurosystem interoperability solution	Full DLT Interoperability Solution (BdF)
Participants	• DLT market operator: 21X
DLT technology used on market side (as reported by market stakeholders)	21X offers an on-chain, institutional-grade market infrastructure to enable issuance, trading and settlement of DLT financial instruments. Leveraging a Polygon based blockchain solution, 21X allows for near-real time (T+0) matching and settlement with trading happening on-chain. ERC20 Smart contracts permits atomic trading and settlement and representation of equity, funds and debt instruments. Both wallet self-custody and custodial solutions are available.
Flowchart of use case (as reported by market stakeholders)	

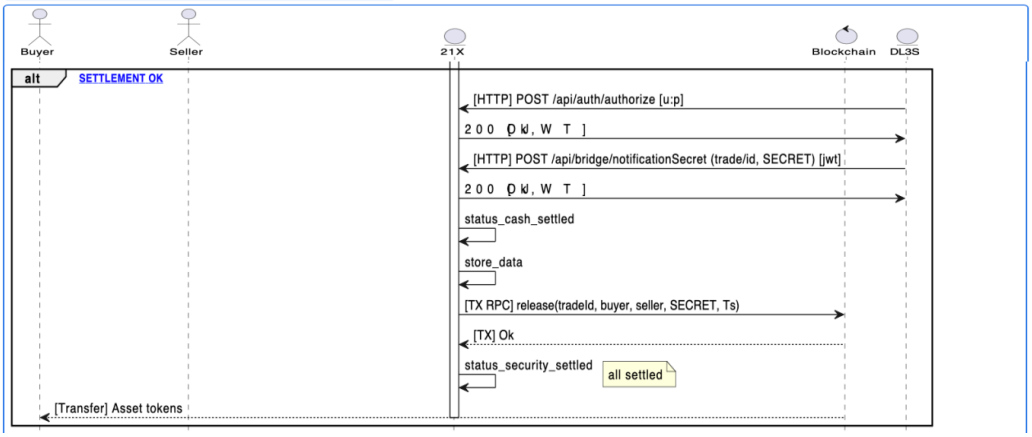
Transaction 1: Client A from Bank 1 sells the asset and Client Y from Bank 2 buys the asset
- The asset will be locked at 21X, Cash settlement will be initiated via HTLC
- 21X Unlocking asset based on secret and cash settlement on DL3S

Transaction 2: Client X from Bank 2 sells the asset and Client B from Bank 1 buys the asset
- The asset will be locked at 21X, Cash settlement will be initiated via HTLC
- 21X Unlocking asset based on secret and cash settlement on DL3S

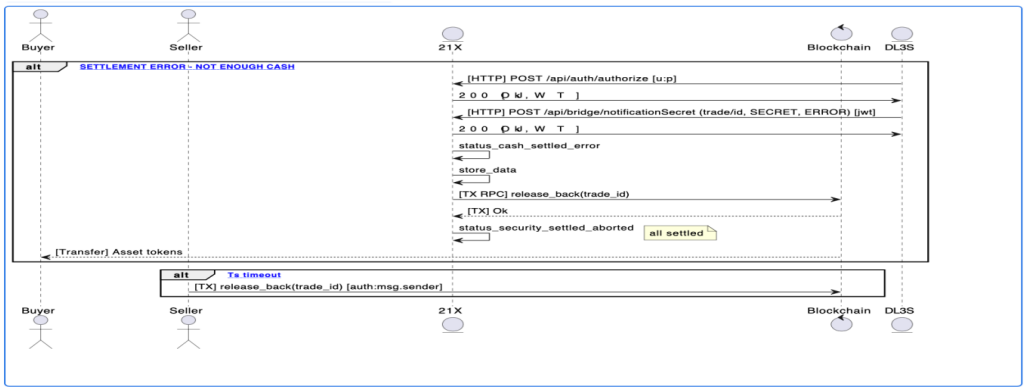
Order Placement



Settlement – positive scenario



Settlement – negative scenario



High-level description (as reported by market stakeholders)

The use-case was chosen to demonstrate how DLT can simplify the asset transfer process between different countries reducing reliance on intermediaries. The use case also focuses on cash and asset settlement in a synchronised manner. Banks and clients were simulated entities.

The flow of transactions within this experiment involves multiple entities and steps:

- Bank 1 in France and Bank 2 in Germany facilitate the buying and selling of assets between Client A (Bank 1) and Client Y (Bank 2).
- 21X acts as the central DLT market operator, responsible for locking assets and ensuring settlements using Full DLT Interoperability (DL3S).

Transactions occur in two phases:

- Client A sells an asset to Client Y. The asset is locked at 21X, and cash settlement is initiated via HTLC. Upon settlement, the asset is unlocked and transferred.
- Client X from Bank 2 sells the asset to Client B from Bank 1, following the same process.

The entire transaction involves:

1. Locking of assets on the DLT platform (21X).
2. Initiating cash settlement via HTLC on DL3S.
3. Unlocking of assets based on the completion of the cash transfer.

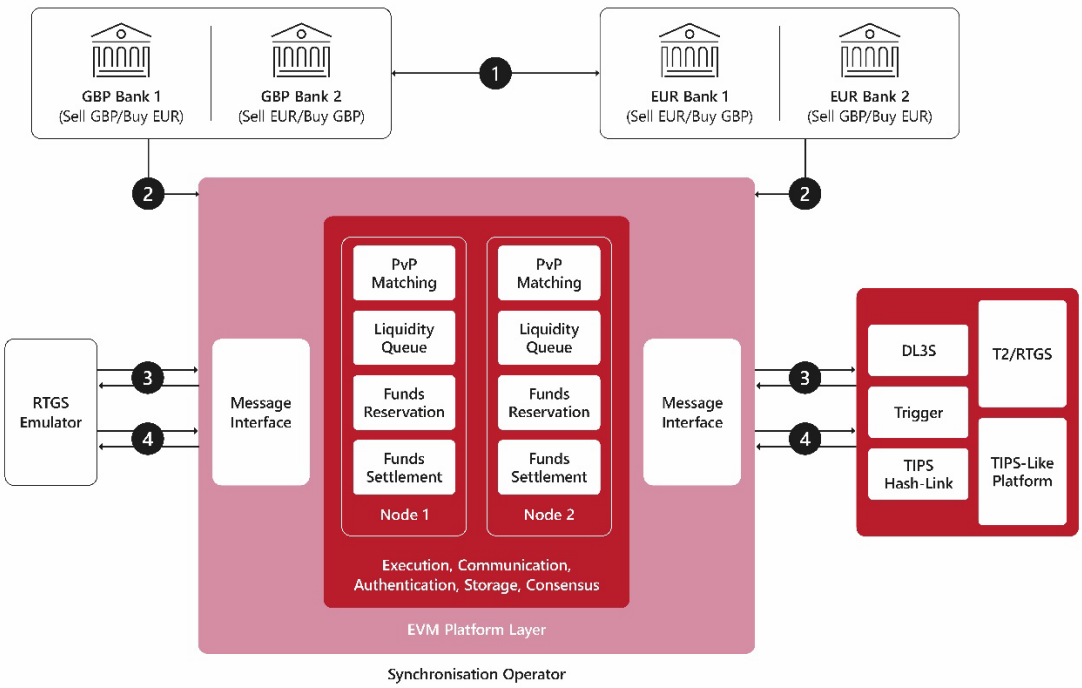
Learning objectives of the market (as reported by market stakeholders)

The experiment's primary goal is to explore the integration of DLT for cross-border asset transactions. The business case involves: enhancing efficiency in cross-border transactions; advancing towards real-time settlement and asset delivery using DLT; improving transparency and security in international trading using Hashed Time Lock Contracts (HTLC). After the experiment, participants will: gain practical knowledge of cross-border transaction management using HTLC, be equipped to identify potential operational efficiencies; have a deeper understanding for both the current and the evolving regulatory landscape surrounding the use of DLT in financial asset transactions.

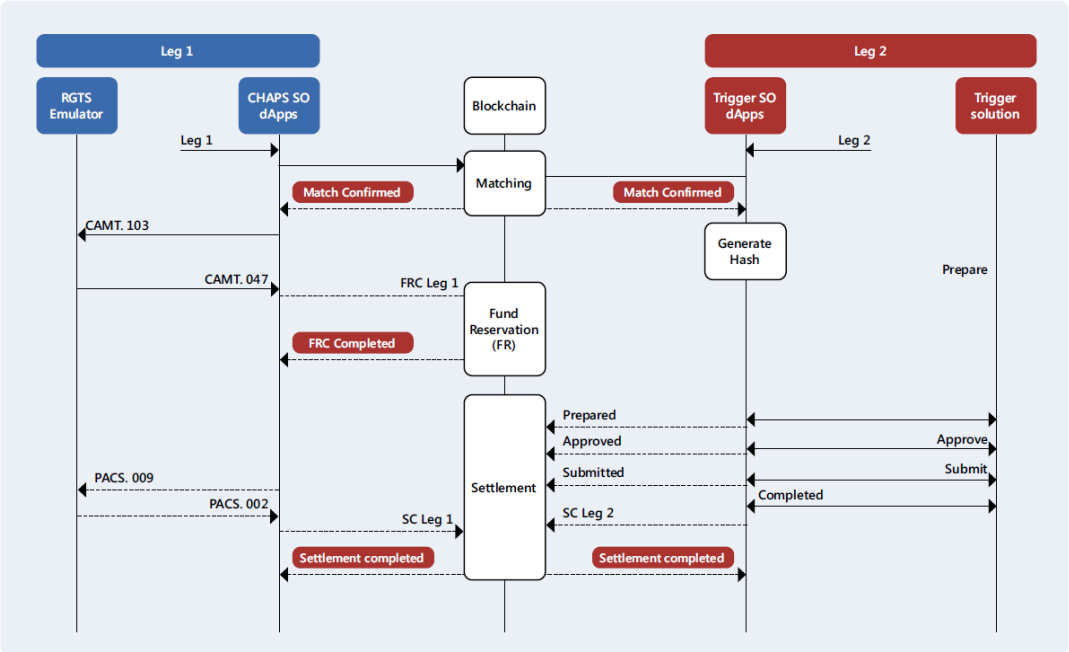
4 Other experiments conducted during exploratory work

In parallel to the activities with market stakeholders, the Deutsche Bundesbank, the Banque de France, the Banca d'Italia and the ECB took part in additional experiments to improve their technical understanding of the three interoperability solutions.

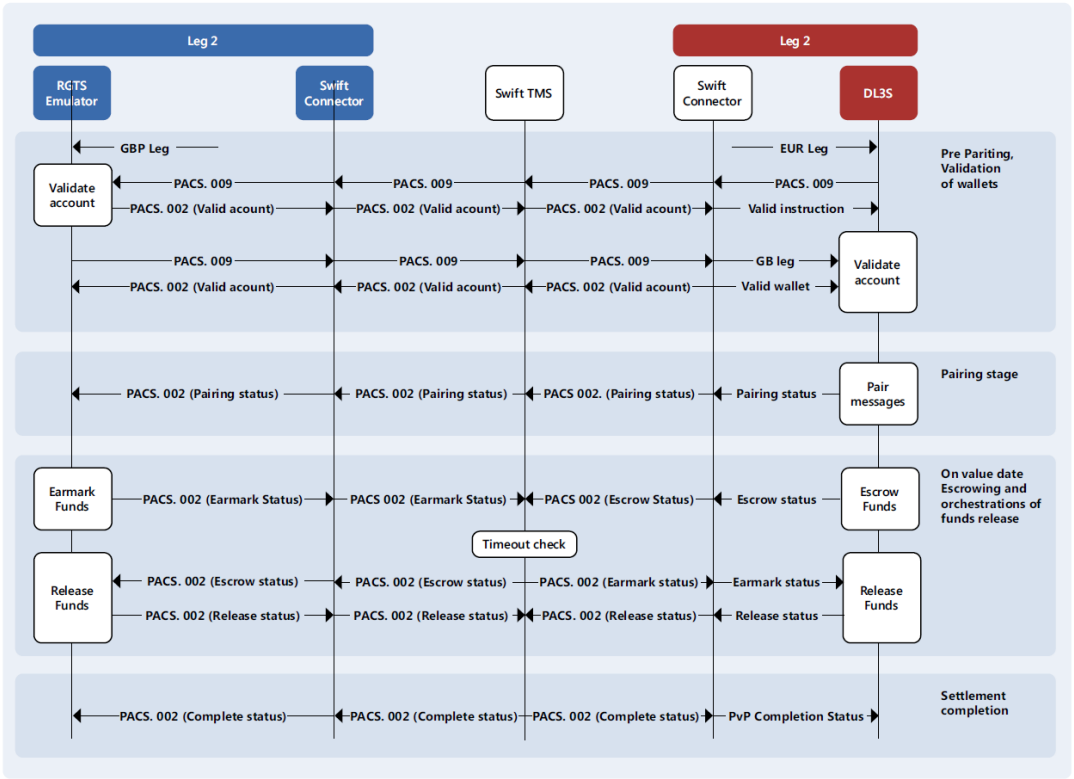
4.1 BIS Innovation Hub London Centre – Project Meridian FX (jointly with Bank of England)

Experiment	Category 3: *Cross-currency payment-versus-payment transactions with another central bank*
Eurosystem interoperability solution	Trigger Solution (BBk) Full DLT Interoperability Solution (BdF) TIPS Hash-Link (BdI)
Participants	Bundesbank, Banque de France, Banca d'Italia, European Central Bank with the Bank of England, the BIS Innovation Hub London and Eurosystem Centres
DLT technology used on market side	Meridian FX builds upon the concept of the synchronisation Operator from Project Meridian to demonstrate its technical feasibility in a multi-currency FX transaction.
Flowchart of use case	

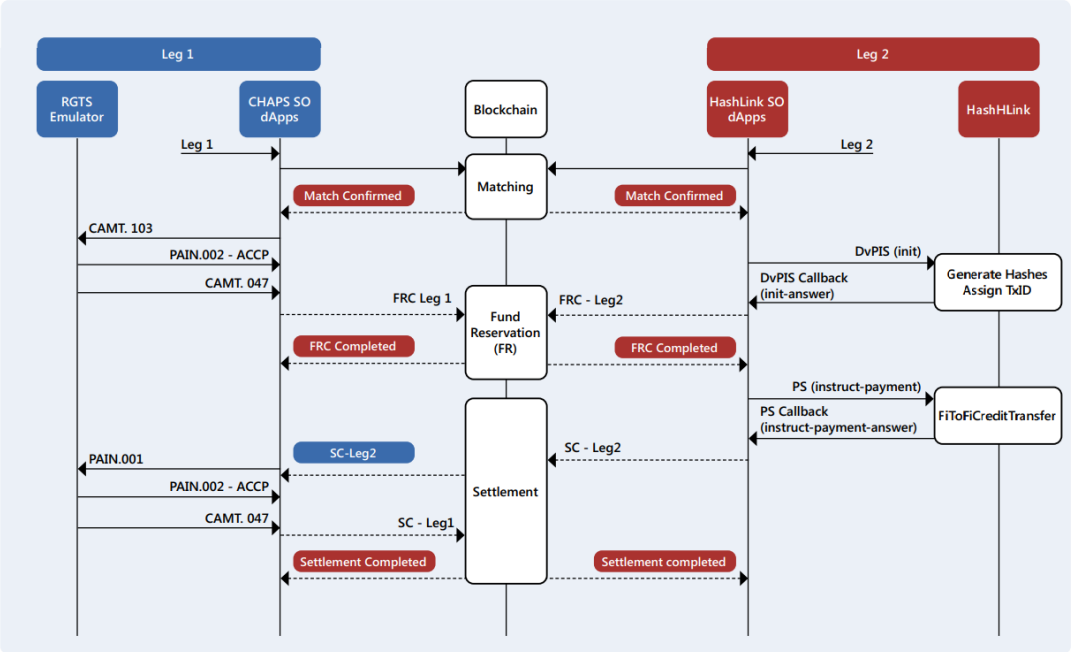
Trigger Solution



Full DLT Interoperability (DL3S)



TIPS Hash-Link



High-level description of the scenarios

The project explores how operators of wholesale payment infrastructures can enable interoperability with new technologies, such as distributed ledger technology (DLT), with a focus on foreign exchange (FX) transactions. Through the experiments conducted during the Project, synchronisation operators enabled atomically settled FX transactions between different RTGS systems in various jurisdictions, and between an RTGS system and a DLT platform

The following scenarios were tested

- Happy path: basic scenario proving PvP functionality
- Unhappy path 1: what happens if a funds reservation is rejected
- Unhappy path 2: what happens if settlement fails in one leg

Simulated counterparties were used to conduct the transactions

Project Meridian FX: exploring synchronised settlement in FX

Learning objectives

Two core objectives were identified:

- demonstrate that a synchronisation operator can orchestrate synchronous settlement of an FX transaction, i.e. the synchronisation operator can enable the atomic settlement of an FX transaction involving payment systems in different jurisdictions.
- demonstrate that a synchronisation operator can orchestrate a synchronous settlement of FX transactions involving ledgers based on different technologies, for example, to enable the atomic settlement of an FX transaction between a DLT-based platform and non-DLT systems.

The ECB, BdF, BBk and BdI's specific objective for the Project is to gain experience with the three Interoperability solutions in a cross-currency context, as part of the Eurosystem's exploratory work programme.

4.2 Eurosystem-led experiments on atomicity

Experiment	*Atomicity / unhappy path experiments*
Participants	BBk, BdF, BdI, and Oesterreichische Nationalbank
Eurosystem interoperability solution	7 scenarios (including subscenarios) in Trigger Solution (BBk) 7 scenarios (including subscenarios) in Full DLT Interoperability Solution (BdF) 7 scenarios (including subscenarios) in TIPS Hash-Link (BdI)
High-level description of the scenarios	Experiments were conducted internally by the Eurosystem (without market participants) to compare the three Eurosystem solutions. A first set of experiments investigated how each of the three solutions managed errors and failure scenarios and tested if/how the result of the transaction remained consistent across the three Eurosystem solutions and the market DLT involved (e.g. ensuring atomicity, from an operational and technical perspective, so that the cash and the asset were returned to their original positions and that one party did not have access to both cash and asset at any one time during a DvP process) Scenarios tested: • Lack of enough cash • Lack of enough securities • Incorrect matching of a transaction (preventing settlement of transactions with parameters different from what was agreed in trading phase) • Locking not executed correctly (for the asset and cash when applicable) • Timeout errors (when assets/cash are locked with timeout)) • Incorrect instructions submitted (several scenarios) • Loss of connectivity at different steps of the settlement process (several scenarios)
Learning objectives	Observe how the solutions cope with these scenarios and whether atomicity is guaranteed or potentially broken (e.g. the seller is paid but the securities are returned to the seller instead of being delivered to the buyer).

4.3 Eurosystem-led experiment on throughput/scalability

Experiment	*Throughput / scalability experiments*
Participants	BBk, BdF and BdI
Eurosystem interoperability solution	Two experiments in Trigger Solution (BBk) Two experiments in Full DLT Interoperability Solution (BdF) Two experiments in TIPS Hash-Link (BdI)
DLT technology used on market side	Market stakeholders not involved. Only the interoperability solutions and in-house transaction simulators were used. For the purpose of the throughput tests in the interoperability solutions, the actions of the market participants/market DLT operators were simulated by a script generating the needed traffic load and performing the requests needed within the settlement process for each payment instruction.
High-level description of the scenarios	Conduct experiment for a lower peak workload for a longer timeframe: 5 DvP transactions per second for 30 minutes, resulting in 5 x 60 x 30 = 9.000 transactions over 30 minutes Conduct experiment for a higher peak workload for a shorter timeframe. The workload is increased gradually Gradually increase the throughput from 5 to 15 DvP transactions per second, resulting in a total of 9.000 transactions.
Learning objectives	Confirm the three solutions in the exploratory work are currently able to reach the lower peak workload Identify (potential) bottlenecks as the workload gradually increase

5 Acronyms

Application-to-application	A2A
Application programming interface	API
Banca d'Italia	BdI
Bank for International Settlements	BIS
Banque de France	BdF
Central bank money *(Wholesale central bank money)*	CeBM *(wCeBM)*
Central counterparty	CCP
Central liquidity management	CLM
Central securities depository	CSD
Commercial bank money	CoBM
Dedicated cash account	DCA
Delivery-vs-Payment	DvP
Deutsche Bundesbank	BBk
Digital Native Note	DNN
Distributed ledger technology	DLT
Distributed Ledger for Securities Settlement System *(Full DLT Interoperability solution)*	DL3S
DLT trading and settlement systems	DLT TSS
Ethereum Virtual Machine	EVM
eWpG	Elektronisches Wertpapiergesetz (German law for electronic securities)
Exploratory Cash Token	ECT *(cash tokens used in the Full DLT Interoperability solution)*
Financial market infrastructure	FMI
Foreign exchange	FX
Hashed timelock contract	HTLC
Key performance indicator	KPI
National central bank	NCB
New Technologies for Wholesale settlement Contact Group	NTW-CG
Payment-vs-Payment	PvP
Real-time gross settlement	RTGS
TARGET Instant Payments Settlement	TIPS