#STACS
Designed for Finance

Deutsche Bank

An MAS Financial Sector Technology & Innovation (FSTI) Scheme Proof-of-Concept

2020-2021

Project Benja

This report was written by the Project Benja team in Deutsche Bank (DB) as the project sponsor, and STACS (Hashstacs Pte Ltd) as the Fintech enabler and project manager, with valued contributions of Bursa Malaysia, UBS, and the Union Bank of the Philippines (UnionBank) (in alphabetical order).

Foreword by

Deutsche Bank and STACS

The 21st century has brought numerous technological advancements to evolve and influence financial services, such as e-commerce, instant payments, artificial intelligence-enabled services and Distributed Ledger Technology (DLT) based digital assets and services. These advancements are also driving changes in the capital markets as financial institutions, Fintechs, regulators, multilateral organisations and other stakeholders utilise these new capabilities to create and realise new benefits for markets, users and the society. In this capital markets' evolutionary journey, the characteristics of blockchain or DLT are playing key roles via digitalisation, decentralisation, programmability and tokenisation.

Set in the dynamic intersection of post-trade securities services and DLT, Project Benja is an experiment by Deutsche Bank's Securities Services (as the project sponsor via Deutsche Bank AG, Singapore) and STACS (as the fintech technology provider) in a MAS Financial Services Technology Innovation (FSTI) approved project to probe the convergence of today's processes with the new, represented by digital assets and DLT. The Deutsche Bank (DB) team contributed domain financial knowledge and worked with STACS on DLT and other technical designs, while the STACS team forged those designs into platform's possibilities and realisation. The teams assessed and worked on interoperability of legacy and DLT systems, digital assets, changes to workflows and paradigms, challenges, efficiencies and new possibilities. Our work at this intersection was enriched with expert legal and regulatory views by external legal counsels engaged for this project.

This report holds not just this team's efforts, but also additional depth from select use cases contributed by the project collaborators – Bursa Malaysia, UBS and the Union Bank of the Philippines. These esteemed collaborators provided insights from their different capital market roles to determine innovative deployment that leverages on the experiment's results.

Together, we were able to reach the Project's goals in these fast few months. Reaching this milestone was also facilitated by many in the industry who took time to generously explore with us on what was possible, what is difficult today, and opened our eyes to future developments that can lend to such endeavours. These assessments included account structures and flows with central securities depository, ESG/Sustainability and financial inclusion applications.

We would like to deeply thank the project collaborators, industry friends and colleagues for helping to make Project Benja a success, and to MAS for their support.

Our teams have enjoyed the work, and we also hope that our work can contribute to industry progress, to Singapore's and global securities market developments.

Boon-Hiong Chan
Co-chair, Project Benja
Securities Services, Corporate Bank
Deutsche Bank AG Singapore

Benjamin Soh
Co-chair, Project Benja
Managing Director
HASHSTACS Pte Ltd

Contents

Preambles

The interest of the financial sector in Distributed Ledger Technology (DLT) has heightened over the past few years, with a growing number of (DLT) Proof-of-Concepts (PoC) being conducted globally to explore the merits and applicability of the technology in capital markets. The industry has reached a stage where participants are progressing from PoCs to realising commercial possibilities. However, even as adoption gains pace, challenges are also arising from needs to interoperate which can lower the barrier to participation from more ecosystem participants and increase the important network effects.

Project Benja is a "Proof-of-Commercialisation" experiment that is co-led by Deutsche Bank ("DB") Securities Servicing team and STACS, to determine and establish DLT applicability in the securities markets. While it has focused on post-trade services, it also considered the changes and implications that can arise from "up-stream activities" i.e. pre-trade.

The technical objectives of Project Benja are to:

- Test the technological feasibility of creating smart contract templates for rapid creation of a standardized cross-border digital private placement bond.
- Determine the operational interoperability of different DLT-based digital assets.
- Investigate the practical, cost-effective deployment of "minimum intermediary" (or "single intermediary") in the platform for an integrated issuer-to-investor end to end servicing model.
- Test the practicality of linking the DLT platform with non-DLT systems for various aspects of reporting, custody, recording transactions and updating of investor holdings.
- Test the usage of different digital payment token models to facilitate efficient delivery-versus-payment and asset servicing payments like coupon and capital redemption, in domestic and cross-border (FX) situations.
- Conduct the above with the transaction of a "Green" bond use case, according to acceptable Green/Environmental, Social Governance (ESG) standards.

To share both the technology and securities perspectives to these goals in this report, we have adopted the following approach of writing the report from STACS' and DB's perspectives, and establishing connections between both for a holistic overview.

The first part of the report is written from STACS' perspective. In this part, opportunities are identified pertaining to the use of DLT to capture strategic fund-raising advantages in a potentially quicker and more efficient manner. It also outlines the achievements of the project's objectives of designing a legal and optimal operating model for fund-raising with DLT as the underlying backbone for a simpler and more effective fund-raising and secondary market platform. This is achieved through interoperability between DLT and existing non-DLT systems, multiple payment channels with the support of multiple payment/currency options, and extending into the ESG space to fulfil practicality and sustainability. Challenges faced and overcome along the way will also be covered to illustrate how DLT can resolve similar pain points faced by industry players in their own contexts.

The second part of the report is from the perspectives of the DB Securities Services team, while the third part of the report reflects our collaborators' views.

1 Part 1: STACS Perspectives

1.1 Introduction

1.1.1 Current Bond Issuance Process

A typical bond lifecycle encompasses origination, subscription and distribution in the primary market, trading, clearing and settlement in the secondary market, and finally, post-trade processing, custody and asset-servicing activities. Inefficiencies are observed particularly in the bond issuance, distribution and post-trade asset servicing stages.

Today, an average bond issuance timeline can range from weeks to months, typically involving a large quantum of committed capital. The intensive planning process requires companies to navigate the regulatory and financial implications of the bond issuance process, with the market only open to those with the resources to support the intermediary processes of bond issuance. The requirements surrounding book building and origination of bonds result in missed brief fund-raising opportunities, that are potentially cheaper, and restricts the issuer base to larger corporates. The opportunity cost of the long lead times often have financial impacts on companies looking to raise funds in the first place. Moreover, current issuance to secondary market processes are also fraught with paper trails and manual processes that increase the inefficiency and costs to action.

Project Benja was set up as a first step to facilitate bond issuances more seamlessly and to enhance operational efficiencies in the end-to-end lifecycle of the bond, particularly in the origination, and post-trade processing stages, tackling the issues found in the bond market today. The highlighted achievements of Project Benja in this report represent the first steps in commercialisation. Further refinements and exploration of use cases and extension of the proposed platform's interoperability with different ICSD/CSDs and trading venues, are still ongoing.

1.1.2 Scope of Project

A new approach is required to allow for cost-effective fund-raising that Arranging Banks can offer to their local corporate clients and/or to the public sector, matching them with qualified investors, and allowing other financial institutions and intermediaries to participate as required. This is done while ensuring effective allocation, distribution, and the maintenance of the end-to-end lifecycle of a bond issue, including custody and asset servicing. Furthermore, an extension to the ESG dimension (section 5.5) has also been considered in the work towards ensuring a sustainable solution for the capital markets.

While all other use cases are viable, Project Benja focused on the Bonds use case because it had one of the most fragmented and inefficient lifecycles out of all other investment instrument management lifecycles. With it being highly inefficient and manual with large volumes of paperwork, USD$800 billion[1] worth of capital in the capital markets are locked up in the financial industry. Furthermore, there is an annual cost of USD$298 billion[2] on trade executions, settlement, asset servicing and custody services. As such, Project Benja aims to crunch down these numbers and tackle the root cause of a lack of a common technology infrastructural nexus through our proposed *Bond in a Box* solution.

1.2 Opportunities

Project Benja aims to deploy a cross-border and open-architecture *Bond in a Box* platform that fills a need amongst capital markets participants, which is uniquely made possible through the use of an open architecture and cross-border DLT infrastructure. In our journey, we have received clear interest of client demand to produce a project like Benja, which allows for multiple market participants to utilise a synchronised and open-architecture platform. Market participants like Issuers, Investors, Arrangers and Service Providers can interact by performing transactions with each other on a more cost-effective basis. This allows the platform to also function as a ready "distribution network" consisting of already connected market participants, on a cross-border basis. Connectivity can be established by running a node, or integrating via front-end GUIs or ready APIs. This setup aims to provide products, issued on the platform, with similar access to liquidity as compared to conventional markets today.

The platform will also provide smart contracts with programmed business logic to progressively automate the full spectrum of services from issuance, subscription, settlement, asset servicing, custody and reporting. It can also facilitate the settlement of secondary market trades done outside the platform, resulting in a readily deployable technology platform for market participants like custodians and registrars. Practically, such a model allows issuers and investors to proceed towards live transactions, with assurance that their needs across the lifecycle will be met. Service providers will also be able to step in and provide new DLT-relevant services – performing their roles with completeness and adapting their business models to suit evolving client needs.

In addition, referencing the core role of DLTs in supporting registry-related functions, it should be noted that the approach we have taken for the *Bond in a box* solution will involve CSDs hosting a node on the blockchain to allow for flexibility – such that the platform is scalable to other jurisdictions' CSDs, as long as there is one depository agent involved.

The following sub-sections highlight how Project Benja's proposed solution can address issues from different perspectives.

1.2.1 *Bond in a Box* Model for Banks, CSDs, Issuers, and Investors

- Availability of different bond smart contract templates to allow responsive issuances to tap narrow funding windows.
- APIs integration to different systems to facilitate adoption, regulatory compliance and network effect.
- Confidential digital transactions for client assurance
- Interoperability of different digital assets, including Ubin and different payment methods for Delivery versus Payment (DVP).
- Practical securities and cash digital account structures to facilitate commercial execution readiness.
- Re-engineered processes that would also enable participants to use Benja as a "bolt on" cost effective middle office/operations platform, as a golden source of related data, etc. for completeness of operations.

1.2.2 *Bond in a Box* Model for Potential New Competitive Advantages

- *Bond in a Box* as a value-added Arranger-offered solution for issuers/clients, enabling them to support the issuance, distribution and servicing of DLT-based digital securities.
- *Bond in a Box* as a platform that Sovereign and Public Sector bodies can use to issue instruments directly to a wider base of end-investors (e.g. retail investors, etc.).
- *Bond in a Box* offering a suite of smart contracts that can be flexibly managed and maintained to rapidly reflect changes in operating requirements and new product developments.

1.3 Methodology

1.3.1 Industry Driven Engagements

Recognising the importance of the wider ecosystem, a large focus of the project was the in-depth conversational engagements with industry participants such as DB, UBS, UnionBank, and Bursa Malaysia in different permutations. In order to hit the milestones set out throughout the project and attain practicality in the proposed solution, insights were gathered from industry participants. These insights were valuable in providing different perspectives towards the use cases scoped for exploration, contributing ideas to resolve gaps towards commercialisation.

The invaluable engagement and inputs from these participants are outlined in section 3.

1.3.2 Technology Development Efforts

Given that Project Benja was not the first PoC conducted that focuses on the bonds space, aspects of business practicality and technology feasibility were prioritised in parallel with technology integration and regulatory considerations. This was possible with regular and focused efforts and engagement across participants.

To further differentiate this PoC from others that have been conducted, two important added developments were explored. The first, was an extension into the ESG dimension, to demonstrate extended functionalities where DLT attributes (e.g. around transparency, data and programmability) enable client value-added product opportunities and propositions. The second, was the inclusion of a CSD to understand practical integration considerations in the journey towards full DLT-enabled digitalisation. These will continue to be explored upon post this initial phase of the project.

1.3.3 Key Deliverables

Bond in a Box solution is the main key deliverable of this project, offering the efficiencies that synchronises the fragmented bond management lifecycle, as elaborated in section 5.1.

Project Benja's proposed solution had also been demonstrated during the Singapore Fintech Festival in 2020 as a means to promote the adoption of DLT, specifically highlighting the value that can be unlocked through its application (i.e. cost savings in efficiencies through automation, single source of digital ledger leading to reduction in man-hours on reconciliation, etc.). This ties in nicely with the ultimate goal of commercialising this PoC. The panel discussions and live demonstrations of the platform integrated with Ubin payment systems, had received positive feedback and interests in this space, which highlights the value of the work within Project Benja. This was further refined with inputs from all participants in the months that followed, culminating in the following achievements and findings covered in Section 5 below.

2 Part 2: DB Perspectives

The Deutsche Bank team consisted of Investor Services, Securities Services, Securities Service Information Technology, and Compliance and Legal colleagues, who assessed the DLT characteristics from their respective expert fields of the end-to-end tokenised securities (bond) lifecycle. Focus for the DB team was on the issuer services, post-trade, digital custody and asset servicing areas.

On the back of the accelerating market momentum to utilise DLT to issue and trade tokenised securities, new digital issuance and trading venues have and are being launched to accommodate these tokenised assets, that currently cannot seek the established routes to "traditional" exchanges. However, even as the benefits of DLT are being realised, the presence of multiple platforms risk fragmenting market liquidity which can prevent more investors from participating. Smaller pools of investors can spillover to deter issuer participation as well. The use of an innovative yet different technology to create tokenised securities is inspiring but can raise the barrier to adoption by issuers and investors if they need to be directly exposed to different types of new technology risks. Therefore, while the technology is rapidly maturing and is complemented by greater clarity in laws and regulations towards usability, there is still a need to facilitate market liquidity's flows and market adoption to support the demand for tokenised securities.

Project Benja extended a Securities Services (SES) 2019 experiment on smart contracts and tokenisation impacts on processes with deeper investigations of DLT and digital asset servicing commercialisation possibilities. In the experiment's partnership with STACS, the teams assessed the technological and practical feasibility of digital assets interoperability, DLT and non-DLT system interoperability, digital securities and digital cash DVP, smart contract templates for new operating models, and legal implications.

The project utilised STACS' DLT platform that was able to encompass bond lifecycle activities. From the angle of tokenised bonds, the DB team investigated the financial servicing information and details required in issuance services in the primary market to trading and settlement in the secondary market, including post-trade processing, custody and asset servicing. In the experiment, we deployed the platform as a "multi-plug gateway" operating model for operational flows assessment, with digital account structures that can interoperate with different DLT and non-DLT systems, and to support effective settlement and custody of cross-chain digital securities, such as Ethereum-based smart contracts, Diem and UBIN. This is anchored on creating a diversity of choices for clients.

In this investigation, previously identified new value creation points were further examined. For example, the attributes as well as rights and obligations of parties involved in the different stages of the bond lifecycle can be "programmed" upfront, at the issuance stage where a bond is tokenised, as conditional business logic in smart contracts. Corporate action details can also be included as a part of the token's program at this stage to enable secondary market's automated asset servicing activities. This new characteristic brings post-trade servicing upstream to the issuance stages, and highlighted an ability of programmable tokenised assets to reorder certain post-trade value chain activities to release new benefits. "Atomic Settlement" or the tokenised securities characteristic, where the point of trading, settlement and custody of tokenised securities are melted together, is another example of workflow change that we had investigated. In Project Benja, the 2nd order technological, legal, regulatory and licensing implications were inquired of these and other changes. Another challenge

confronted was how an intermediary like a custodian can exercise effective operational control of tokenised assets that were created using different technologies. This ability is important for asset safety and investor protection in tokenised securities and other digital assets.

While many of today's 3rd party digital and tokenised assets' issuance platforms offer seamless end-to-end capabilities including custody, an investor or for the investor's agent would need to be a direct member to these platforms. However, to an investor, scalability can become an issue if there were multiple counterparties to risk manage or in administrative management like "Know-Your-Customer", if such an investor needed to hold multiple platform accounts in order to invest into the different assets. The management of (digital) cash accounts, remittances and needs for governance are also key considerations. Using an intermediary could be a potential solution for the investor; however, concerns like asset safety, technology risk and outsourcing can arise for the intermediary if it was to be wholly reliant on 3rd party platforms' capabilities for effective transactional control of the tokenised assets.

Innovations in the uses of cryptographic-based escrow structures, hashed time locked contracts and "wrapped bitcoin" in the cryptocurrency space lent inspirations to tackle this thorny issue of effective custody controls of digital assets created using different technology stacks. With the help of STACS who implemented the technical designs, and legal assessments that overlaid Singapore's legal and regulatory views, the project was able to meet this objective to assess effective control for asset safety and investor confidence.

From a client-centric lens, the ability to consolidate DLT-based and traditional assets' post-trade information for ease of viewing and reporting was also evidenced, which met another of the experiment's objective as a "multi-plug". These new post-trade, custody and asset servicing results were then applied to the project collaborators' use cases, and tested for practical "commercial-grade" differentiation and transformative outcomes. The use cases included ESG/Sustainability, financial inclusion and operational structure of central securities depository-maintained accounts. The project also showed that interoperability is a differentiator, and is essential to today's ecosystem to facilitate the flourishing tokenisation adoption.

Equally, the areas of tokenised securities, digital cash, processing, value creation and risks management also emphasised holistic multidisciplinary expertise approaches – represented in the project by the teams from DB, STACS and the collaborators – that can be a paradigm shift from today's "silo" and sequential approaches. Singapore's legal and regulatory frameworks provided a needed conducive jurisdiction for the experiment's requirements and parameters.


Maybank
HSBC

3 Part 3: Collaborators Perspectives (in alphabetical order)

3.1 Bursa Malaysia - Collaborator

In order to truly complete the picture of an end-to-end DLT-enabled capital markets, Bursa Malaysia's expertise was pivotal to consider the possibilities of a blockchain powered CSD that allows for efficient and orderly maintenance of records. Bearing in mind that fragmentation in information stemming from different systems used in the financial industry is a major pain point, a blockchain-powered CSD would make great sense in addition to that of other stages of the bond settlement cycle, because this would allow for a seamless record of all securities transactions, maintain the integrity of investor holdings upon successful DVP of funds and securities, and allow for timely processing of corporate actions.

As such, Bursa Malaysia enriched the workflow design and functionalities from the perspective of a central depository, providing information on how processes on account structure and identity may change with the adoption of technology that automates and hence potentially reduces business processes that are resource intensive and onerous (i.e. reconciliation in allocation process). This would bring about new strategic business opportunities in DLT-enabled capital markets. Furthermore, noting that Bursa Malaysia is a Malaysian CSD, further studies would still be required to examine these jurisdictional specific workflows.

3.2 UBS - Collaborator

UBS provided industry perspectives pertaining to the roles and responsibilities of a Bond Arranger and Investors across the end-to-end bond management lifecycle. Insights around primary market workflows were shared, alongside potential opportunities for use of DLT and smart contracts to unlock greater lifecycle efficiencies and value-added opportunities.

UBS also provided industry perspectives regarding various ESG/green bond formats (e.g. Sustainability-linked bonds) and ESG-focused investor preferences. This helped to inform where digitisation could help to address emerging industry needs. Furthermore, perspectives around payment interoperability were shared to help explore the practicality of various digital payment and settlement methods.

3.3 Union Bank of the Philippines (UnionBank) - Collaborator

As a premier financial institution in the Philippines and a leader in the digital space, UnionBank collaborated with participants on Project Benja by sharing its expertise from the perspective of a bond issuer. The team shared the pain points that issuers currently face in the traditional capital markets financial infrastructure. These insights were critical in piecing together a concrete solution which that can alleviate the pain points of the issuer stemming from the need of elaborate services provided by the custodian, paying agent, trustee and arranger. This ensures the aspect of practicality in this

project's proposed operating model. In addition, since UnionBank is located in the Philippines, their collaboration has helped Project Benja in factoring in the requirements for cross-border issuances, thus furthering the feasibility of the *Bond in a Box* operating model, and expanding work on possible use cases for later phases.

To achieve the objective of SME inclusivity in the bonds fund-raising space, UnionBank provided expertise in the domain of social inclusion and MSME financing. Their team was able to highlight the needs and gaps faced by retail issuers and investors as well as ideating on workflows powered by DLT as a solution. Conversations on bond fractionalisation and social inclusion as added dimensions to an issuance amplifies the financial inclusion and sustainability factors of this operating model.

UnionBank's knowledge and suggestions were in line with other participants where topics overlapped, therefore increasing the confidence in the reliability of research, and hence usefulness of our findings and development actions.

4 Project Technology Overview

4.1 STACS

STACS was the DLT solution partner and managing party of this project. Through the facilitation of countless meetings and calls between the different stakeholders, work around ensuring the delivery of the full end-to-end technology platform that caters to the needs and bridges the gaps in the traditional financial market infrastructure was the key responsibility of STACS. We ensured that the demands of the capital markets were taken into full consideration in designing and building the operating model, while maintaining legality and cybersecurity needs. Undoubtedly, our proposed solution would not have been possible without the help of the above participants.

4.2 Technical Architecture

The platform encompasses the Application Layer, comprising of a Frontend GUI component and an Application Backend component which is linked to the underlying STACS Blockchain. The deployment architecture has been designed to be platform-agnostic and deployed on various occasions since 2019 on many different platforms ranging from Amazon Web Services (AWS), Microsoft Azure private cloud and on-premise hardware (Dell).

The STACS Blockchain is an Enterprise permissioned blockchain solution. It has been deployed on various occasions since 2019. Business logic is designed at the Application Layer to facilitate fluidity in business requirements, while a unified data state is maintained at the STACS Blockchain layer.

Cyber security is implemented with a Defence in Depth strategy across the board covering the frontend UI, API layer and blockchain setup. Multi-Factor Authentication is 1 of the implementations used to secure the frontend UI against unauthorized user access. The TLS protocol is implemented at the API layer to secure messages in transit to prevent man in the middle attacks and timestamps are required for each API call as well to prevent replay attacks. Hardening is performed for the blockchain nodes to close off all unused network ports for node-to-node communications. The blockchain data is encrypted at rest in persistent storage to prevent access at the hardware level.

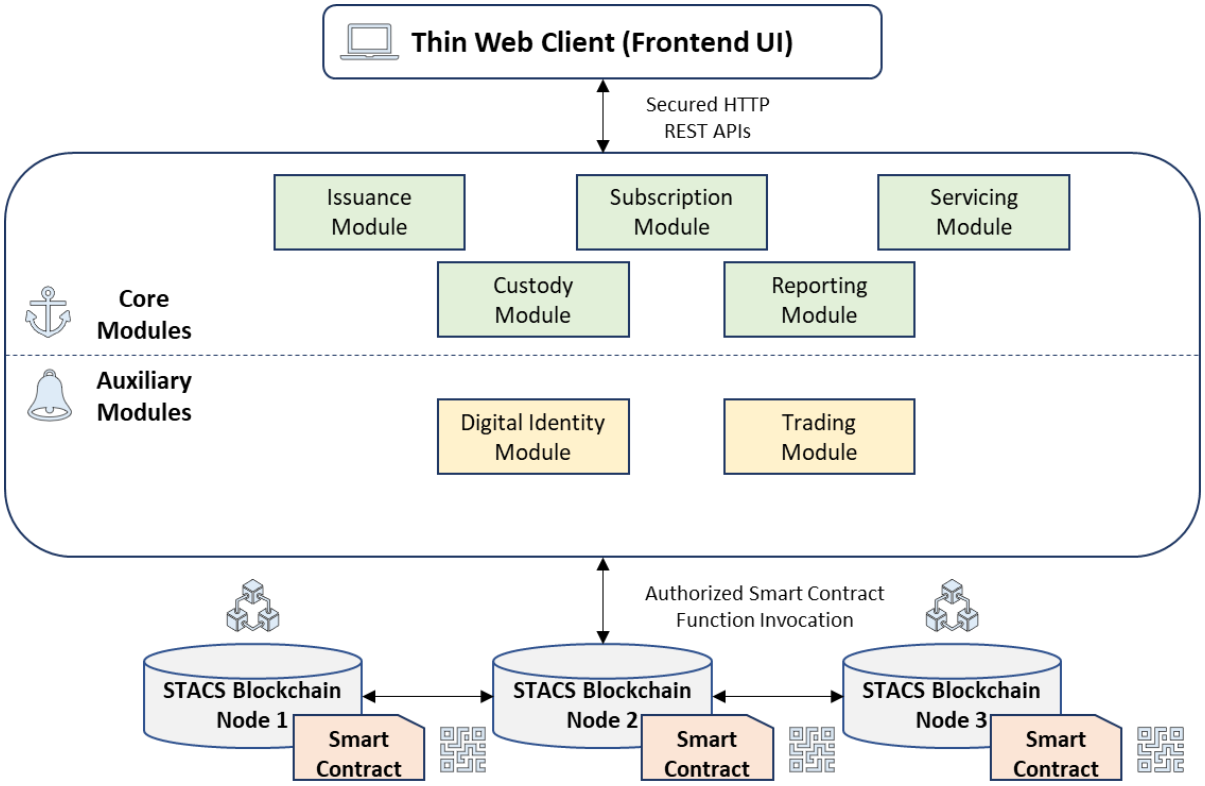


Figure 1: Solution Architecture High-Level Overview

4.3 Application Modules

The Application Modules are separated into core modules and auxiliary modules. The core modules are used for programming of business logic into the digital bonds for downstream benefits, to purchase and trade in primary and secondary markets, to safekeep and administer digital assets, to safekeep private keys, to service corporate actions and finally for corporate reporting.

The auxiliary modules are used to support the operating model as a standalone platform, such as to create a digital profile of an investor, or to enter in price feed of a matched trade. The auxiliary modules will be negated post integration with existing trading and treasury systems to create a hybrid tech stack.

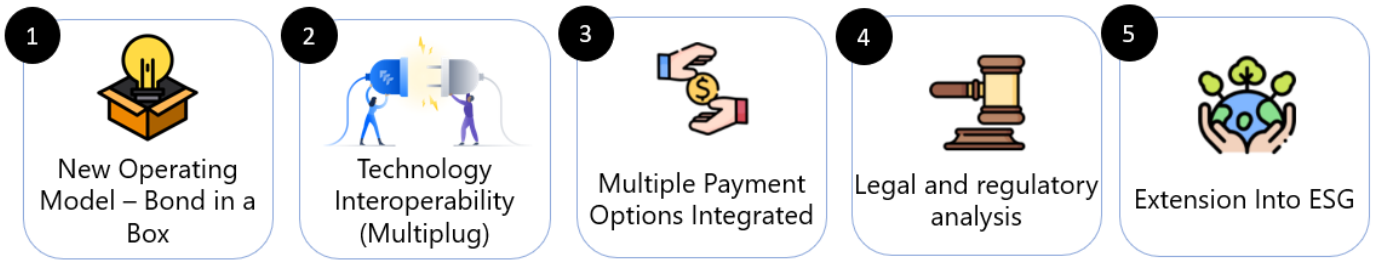
A description of the modules is depicted in Table 1.

Modules	Description
Issuance Module	• Asset tokenization and input of business logic into digital security • Pricing, syndication, and management of orderbook in real time
Subscription Module	• View details and feature of bonds available for purchase • Enforcement of subscription and eligibility rules in real time
Servicing Module	• Track and maintain investor holdings in real time • Administration of corporate actions
Custody Module	• Safekeeping and securing of digital assets and keys • Overview of portfolio holdings in real time • Overview of funds balance in real time
Reporting Module	• Dashboard for exporting transactions and audit log
Trading Module	• Trading of assets with multiple payment options and settlement cycles • Enforcement of trading and eligibility rules
Digital Identity Module	• Creation of digital profile and onboarding of user roles

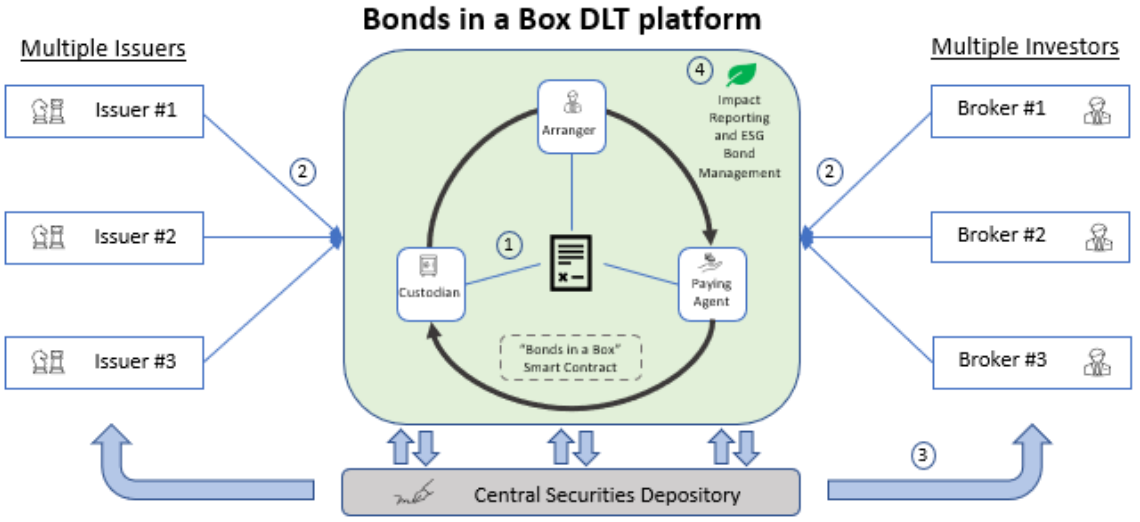
Table 1: Description of the Platform's Core and Auxiliary Modules

5 Project Achievements

5 key achievements were observed throughout the PoC:



5.1 New operating model – Bond in a Box



Trade Lifecycle	1. Issuance/Tokenisation	2. Subscription, Distribution, Trading	3. Asset Servicing, Settlement	4. Impact Monitoring
Blockchain Focus Area	• Service Provider creates preconfigured smart contract bond templates "out of the box" • Issuers and the arranger can launch the "virtual box" bond templates for rapid bond tokenisation efficiently.	• Enforce subscription eligibility • Tracking of orders in an audit trail • Automate movement of funds and proceeds • Maintain integrity of investor holdings with updating of CSD	• Automate coupon and principal payments using up to date ledger of investor holdings • Allow the potential to combine trade affirmation, matching and settlement in a single 'atomic' process	• Impact Reporting on the Blockchain • Tracking and management of proceeds via smart contract • Financial incentives programmed for Sustainability-Linked Instruments

Figure 2: One Stop Issuance & Post-trade Servicing Packaged into a Box

With the *Bond in a Box* operating model (Figure 2), the platform is able to service more with lesser resources, leading to shorter time to market, achieving cost and process efficiencies., Cost-effectiveness is demonstrated via a "intermediary-neutral" platform that can be deployed by

investment banks with custodians for an integrated issuer-to-investor end to end servicing model. The indicative bond pricing is conducted in a simultaneous fashion on the STACS blockchain during the book building process. There is no longer a need for reconciliation and checks due to the ubiquity of shared ledger information where the nature of blockchain and smart contracts remove the need for duplication of multiple reconciliation actions and allows for straight-through processing. The STACS DLT serves as a general-purpose ledger and the CSD fulfils value added functions in addition to fulfilling legal and notary requirements.

Project Benja proposed "to-be" infrastructural setup (origination) has seen a reduction in the number of processes which resulted in greater efficiencies, as shown in the estimates in figure 3, based on STACS analysis. Instead of soft sounding discussions on indicative bond pricing and interests between lead and co-lead arrangers on the bond structuring leg, indicative bond pricing and flex are conducted in a simultaneous fashion on the STACS blockchain, where bond profiles and selling criteria are created alongside the preparation of other relevant information. This means greater transparency and synchronisation in bond structuring and pricing, leading to honest and up-to-date values tagged to every bond being issued.

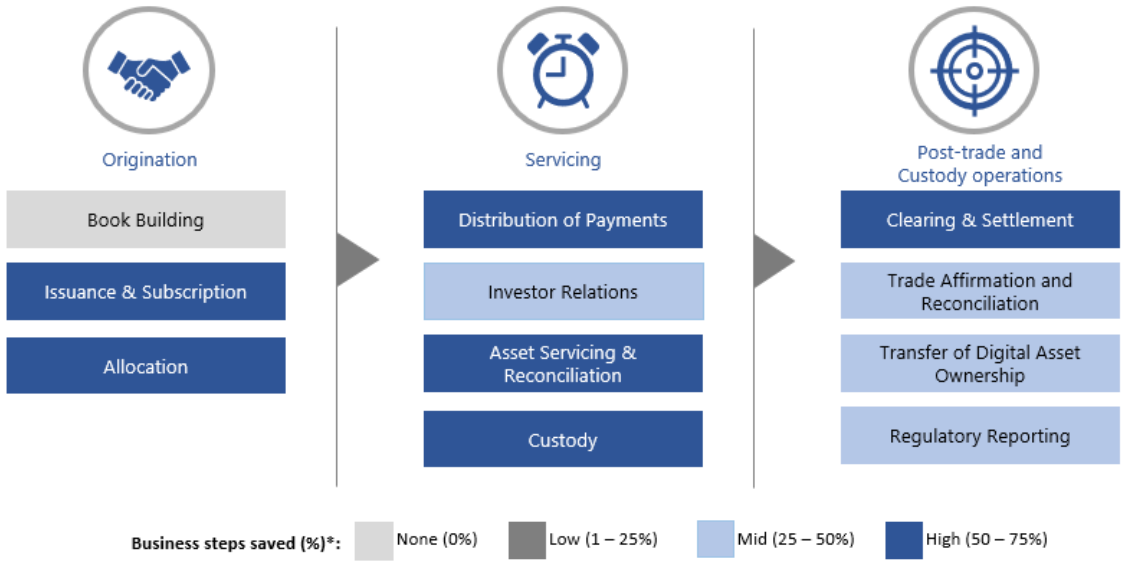


Figure 3: Business Steps Saved Within the Bond Settlement Cycle (%)
[Based on STACS Estimates]

5.2 Technology Interoperability – Systems Use Case

Within Project Benja, DLT and Non-DLT system information flows were also achieved through API connectivity between DB's systems and STACS DLT platform to allow DB to pull DLT-based information into their test environment. For this, the focus was on standardisation of data schema, payload and certificate signing process. The successful connectivity implies potential interoperability with all platform operating users' intermediaries and clients, and other digital platforms (i.e. trading venues/channels) built on different technology stacks. As a "multi-plug gateway", the platform can be a middleware for single access to different digital venues for different digital assets.

5.3 Multiple Payment Options Integrated – Payments Use Case

STACS has successfully integrated blockchain with SWIFT through APIs in the ISO20022 format (as shown in figure 4), such that payments can be triggered on SWIFT via smart contracts, with the SWIFT instructions stored in an immutable blockchain ledger.

Collaborative efforts were made on building connectivity with other payment options such as Diem, and furthering on existing connectivity to the Ubin Payment network (as shown in figure 5 below). Workflows on bank-backed settlement tokens as another payment option were also scoped out, and can now be readily supported technically. Project Benja also explored how the operator of the platform (DB in the context of this project) can have effective control over cross-chain digital assets (i.e. BTC, ETH, Diem, and Ubin This is conducted through leveraging on wrapping and vault mechanism across multiple blockchains with DLT cross-chain custody. The platform's capability to support settlement and custody of cross-chain digital assets was demonstrated.

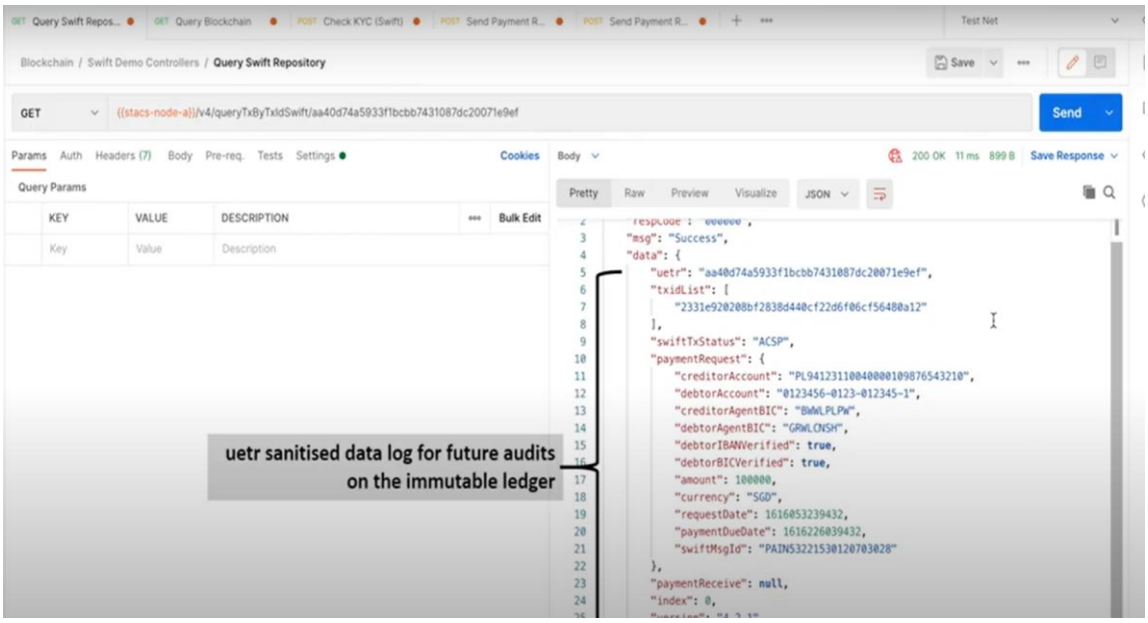


Figure 4: SWIFT Integration via APIs

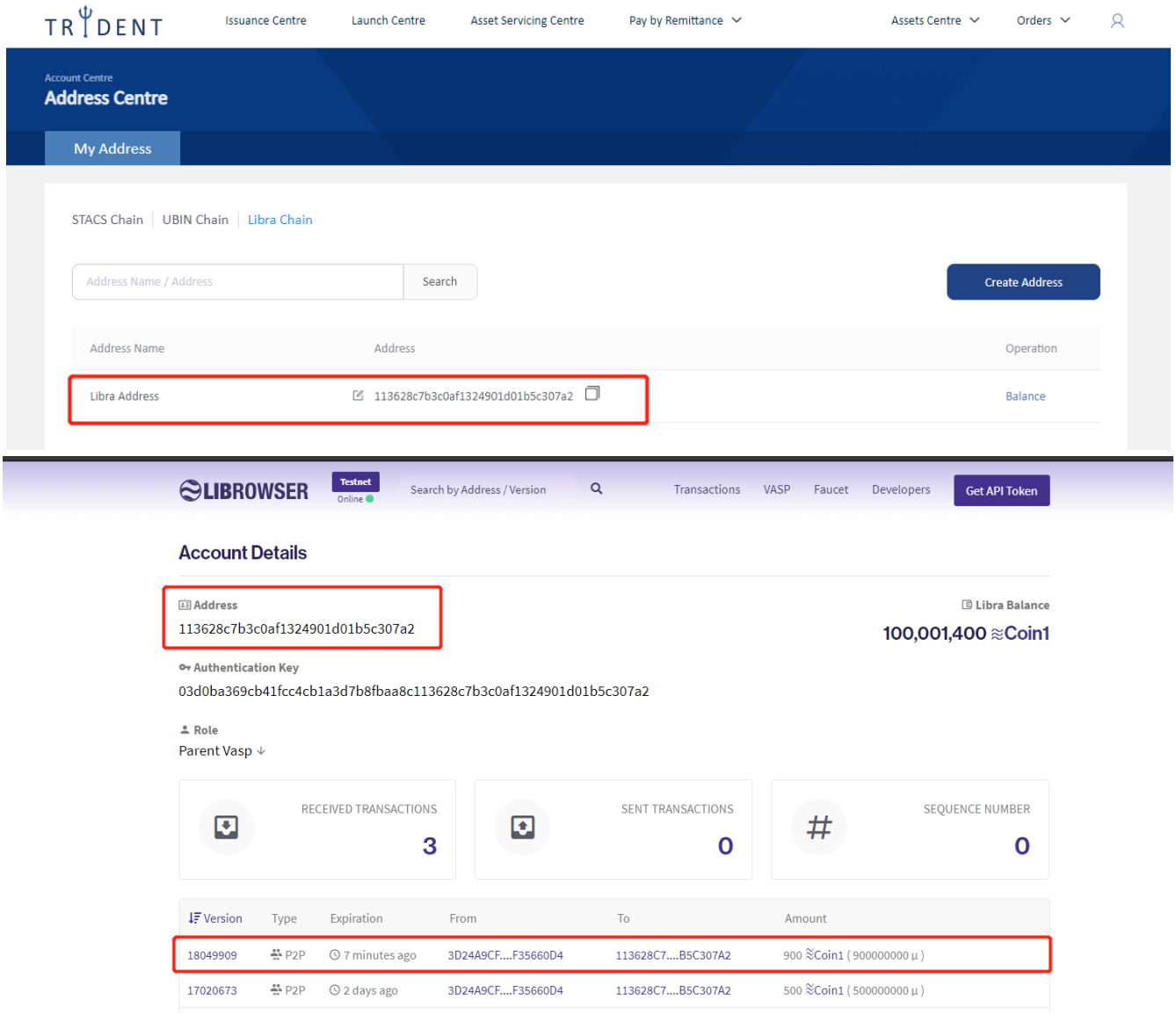


Figure 5: Integration to Diem with STACS

5.4 Legal and Regulatory Analysis

There were several regulatory implications surrounding the adoption of blockchain and digital assets that the participants sought to view clarity on. Working with external legal counsels engaged by the participants, assessments surrounding the legality and compliance of our design within Singapore contexts were carried out to further the usability of the *Bond in a Box* operating model.

Assuming that operational, legal and compliance considerations were achieved or overcame in entirety as outlined in section 6.2 below, commercial value and opportunities can be achieved by participants of this operating model. The flexibility of this model offers efficiencies and competitive advantages to participants of the model. Moreover, this model could ultimately allow foreign investors to participate in tokenised securities investment opportunities.

5.5 Extension into ESG

Providing a realistic and sustainable solution for the capital markets was a goal of Project Benja. Hence Project Benja has been working on the initial designing of end-to-end flows and scope of work around ESG bonds and social-inclusivity formats, leveraging smart contracts around it, as portrayed in the user journey below (figure 6). Two main aspects were highlighted as pivotal for the management of ESG bonds – (1) real-time impact reporting on-chain; and (2) immutable and transparent management of usage of proceeds.

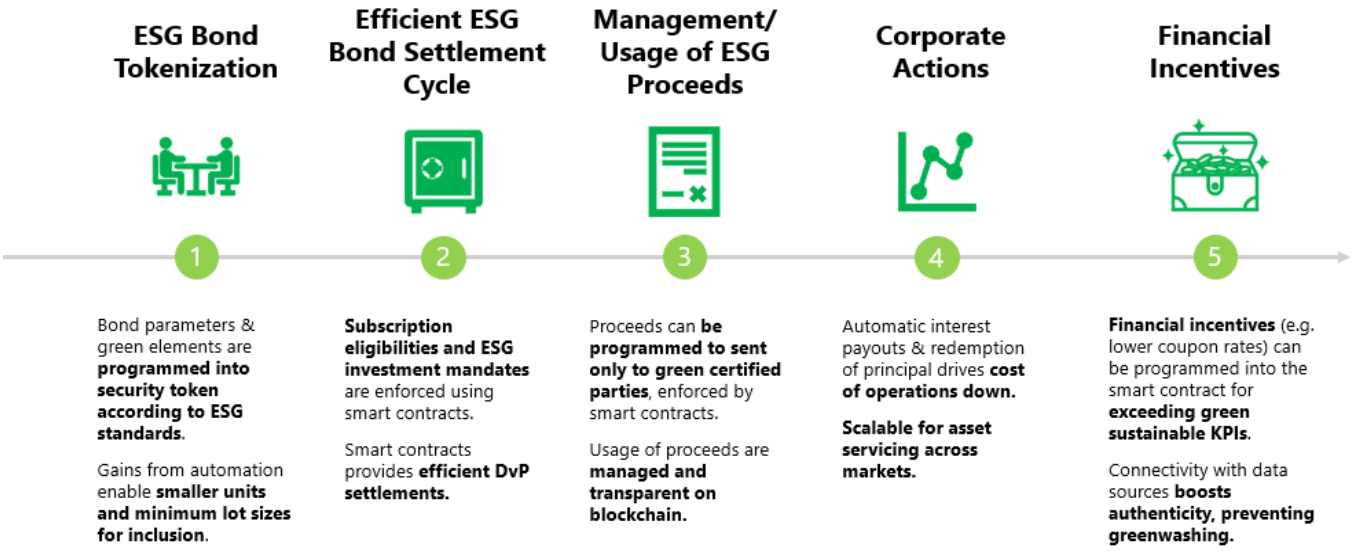


Figure 6: ESG User Journey Business Flow

Discussions around the significance of impact reporting and management of usage of proceeds, in parallel to optimising the efficiencies of a typical bond settlement cycle were held. This prompted efforts towards the agenda of commercialising a *Bond in a Box* model with added sustainability functionality for the financial industry. Project participants highlighted the need for connectivity to primary data sources, like IoT, which could largely contribute to impact reporting on an immutable shared database to further prevent greenwashing. Use of proceeds analytics through on-chain movements, could also provide transparent audit trails (e.g. supply chain tracing, etc.). Combined, these functionalities enhance the quality of data sets useful for actionable insights and better facilitation of investor/banks' ESG financing decision-making.

In particular, sustainability-linked bonds would benefit through enriched ESG data that offers the basis to embed/programme financial incentives or penalties directly into the bond smart contracts, which can also be triggered/executed on a more automated basis. Overall, the *Bond in a Box* model, underpinned by a DLT and smart contract backbone, makes such sustainability-linked products (e.g. bond lifecycle actions linked to sustainability data generated) more cost-effective and efficient to implement. This should help to support broader MAS and ASEAN interests in developing the green and sustainability debt markets.

Further work to develop ESG functionalities will be conducted as a future phase.

6 Additional Considerations

6.1 Integration Considerations

During this PoC, we noted in multiple conversations with the industry participants that there is a need for interoperability between DLT and traditional systems. To achieve this, there needs to be close collaboration with financial market infrastructures to understand evolving functionalities and flows in the Ubin Payments Network towards implementation. Interoperability between industry participants in the ASEAN region and that beyond, would also be key for future phases towards cross-border and local issuances.

For the purpose of this project, DB has worked on the basis where the Custodian will serve as the last mile connectivity to CSD on existing infrastructure by API. Alternatively, the CSD can host a node on the blockchain. In addition, the STACS payments functionality was extended via SWIFT, which enables live transactions, but limits some of the effectiveness envisaged in a fully end-to-end digital platform. These integration considerations will be further explored through the future phases of Project Benja, through discussions with the relevant parties.

The participants saw the need to integrate existing treasury and trade booking systems with the underlying blockchain infrastructure, to provide end-to-end automation and realization of benefits in practice. Participants were also of the view that trading should happen via an off-chain trading system, while the settlement is effected at the blockchain layer. It was also highlighted that not all industry participants will adopt a blockchain based solution immediately due to the potential needs for changes in their current operations. It is realistic that the market would require time to pivot from a long-standing traditional financial market infrastructure to a technology that is trajectorially upcoming. As such, a high-level overview was constructed to showcase how early blockchain and tokenised securities adopters could proceed without penalising subsequent movers.

6.2 Regulatory Considerations

Given the novel nature of this operating model and the usage of new technology in powering the *Bond in a Box* model, we expect potential grey areas that needs to be addressed. As such, we have started off this journey and continue to expect to involve legal counsels (internal and external) from the onset. There were several regulatory implications surrounding blockchain and tokenised securities that the participants sought to view clarity on.

Considerations were examined regarding the legality of digitally native securities registered on the blockchain, the need for papering of bonds and additional disclosures by issuers, the rights and obligations of participants in a distributed ledger system, the existence of production-ready digital cash to facilitate DvP, as well as the custody and securing of digital assets and keys.

6.3 Operating Model

Considerations such as the need to integrate with existing payments and securities settlement rails, the requirements to adopt industry standards such as ISO20022 formats, availability of a trusted DLT network on which securities and other digital asset registrys, can be held. It is also noted that ISO standards are constantly updated, hence the operating model will be ensured to be as up-to-date as possible.

In addition, participants saw the significance of a DLT-powered CSD and Bursa Malaysia provided valuable insights from such a perspective to the project. Considerations around the differences between Singapore and Malaysia's processes were noted. These inputs are significant because there are overlaps in different CSD processes, and new perspectives will lead to the exploration of new ideas and innovation.

6.4 Moving Towards Commercialisation

While there is strong traction in the adoption of a DLT financial market infrastructure, we expect more work around finer details given the intention to scale this into a live environment. For example, some questions have been raised over whether the bond token is a security under the Securities and Future Act, a depository receipt, derivative, or a representation or otherwise of the underlying Global Note deposited with the CSD. As such, we have already engaged with the regulatory and legal divisions of some of the participants involved, along with external legal counsels. We will continue to engage with other participants to have a better understanding on the legal and regulatory framework on the management of tokenised securities.

We also believe that the publication and sharing of this report with these industry associations will also help to promote the adoption of new technology within the Singapore capital markets.

7 Future Phases

7.1 Refinement and Further Exploration of Use Cases

Project Benja's next steps is to further explore the end-to-end management lifecycle of ESG and sustainability-linked bonds.

Secondly, it would be necessary for us to continue work on the interoperability with financial market infrastructures. It would also be highly advantageous to extend the ecosystem with more partners and collaborators.

Finally, engagement with the industry including that of the cryptocurrency field is important to further the advances of tokenised securities in the regulated capital markets environment.

7.2 Commercialisation Efforts

As a next step towards commercialisation, project participants noted the importance to explore live transactions with the broader capital markets ecosystem – initially under controlled conditions, and moving into "natural" live transactions.

In addition, further commercialisation efforts along the ESG theme could consider integration to IoT and other data & analytics providers. This would elevate the possibilities of ESG-related securities, and further combine ESG data and securities in digital formats.

8 Summary

The collaborative efforts in this PoC have established a new *Bond in a Box* operating model that shows commercial potentials.

The end of this project signifies the beginning of a meaningful journey towards the ultimate implementation of DLT as the underlying backbone for an optimised and efficient end-to-end bond lifecycle leading to better profitability. Fragmented liquidity can be overcome through the interoperability between DLT and existing traditional systems. Multiple payment channels with the support of multiple payment/currency options, and extending into the ESG space to achieve a common technology infrastructure that fulfils practicality and sustainability.

9 Project Participants/Acknowledgements

9.1 Deutsche Bank Team (Project Sponsor)

Name	Role	Organisation
Boon-Hiong Chan	Securities Market & Technology Advocacy, Securities Services APAC (Project Lead)	Deutsche Bank
Annita Yeo	Relationship & Transaction Management, Trust & Agency Services	Deutsche Bank
Ernest Lee	Product Management, Trust & Agency Services	Deutsche Bank
Cher Chun Lim	Product Management, Securities Services APAC	Deutsche Bank
Girish Pandit	Business Solutions, Securities Services APAC	Deutsche Bank
Chris Hui	Business Solutions, Securities Services Singapore	Deutsche Bank
Xiuqi Chen	Securities Market and Technology Advocacy, Securities Services APAC	Deutsche Bank
Daniel Koh	Information Technology, Securities Services (IT Lead)	Deutsche Bank
Om Prakash	Information Technology, Securities Services	Deutsche Bank
Wendy Sia	Compliance	Deutsche Bank
Siau-Weei Chong	Legal	Deutsche Bank

9.2 STACS Team (Technology Partner)

Name	Role	Organisation
Benjamin Soh	Managing Director, Founder	STACS
Jin Ser	Solutions Architect, Director	STACS
Nigel Lam	Product and Strategic Partnerships, Senior Manager	STACS
Jace Er	Business Analyst, Senior Manager	STACS
Low Zhi Theng	Business Analyst	STACS
Henry Ng	Technical Solutions Consultant	STACS
Jeanette Some	Strategy and Business Development Associate	STACS

9.3 Participating Partners for Requirements Gatherings and Industry Testing (Contributors and Observers)

Name	Role	Organisation
Andrew Wong	APAC Strategy	UBS
Hugo van Kattendijke	Wealth Management, Head Financial Intermediaries APAC	UBS
Armin Peter	Global Head of Debt Syndicate & Head of Sustainable Banking EMEA	UBS
Xiaonan Zou	Group Treasury DLT Lead	UBS

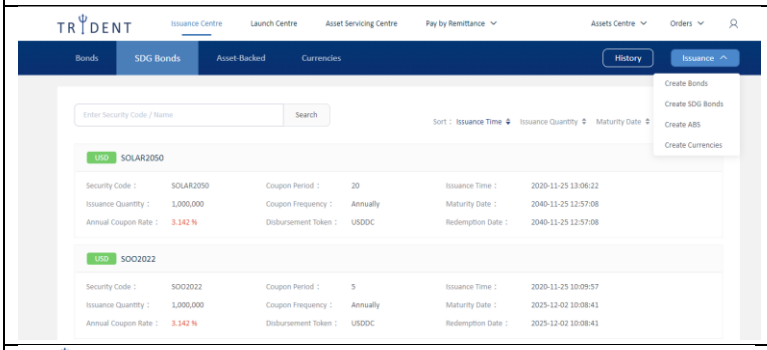
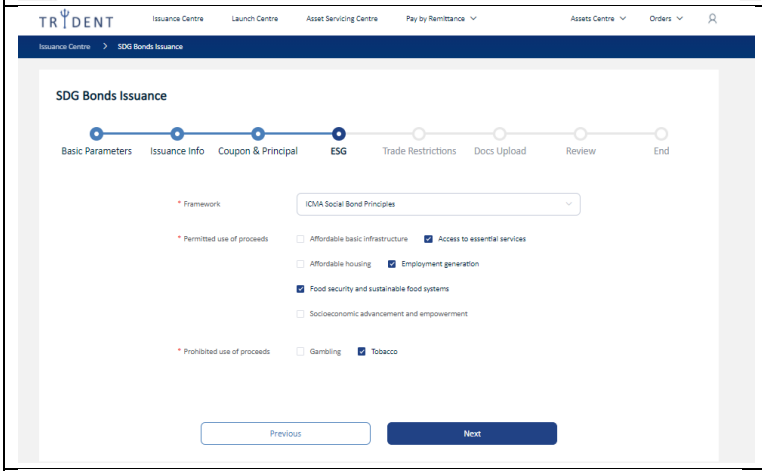
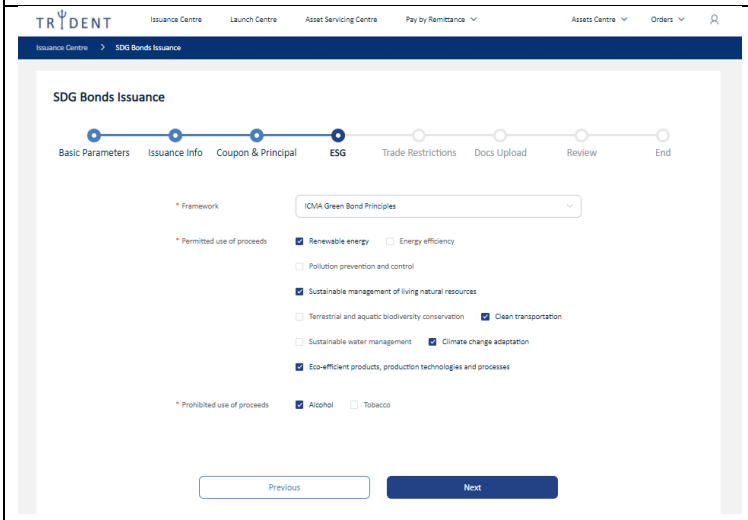
Dane Harris	Debt Syndicate	UBS
Lucas Lemos	Group Treasury DLT Analyst	UBS
Ramon Miguel D. Cervantes	Product Manager, Blockchain Centre of Excellence	UnionBank
Catherine Anne B. Casas	Head of Blockchain Centre of Excellence, First Vice President	UnionBank
Louie Jane M. Marcelo	Senior Product Manager, Blockchain Centre of Excellence	UnionBank
Christy Mae R. Almonte	Head of Derivatives Trading, Vice President	UnionBank
Raquel P. Palang	Treasurer	City Savings, UnionBank Subsidiary
Tay Yu Hui	Director, Market Operations	Bursa Malaysia
Ong Pek Nee	Senior Vice President, Clearing & Settlement	Bursa Malaysia
Lee Kok Leong	Senior Vice President, Issuer Services	Bursa Malaysia
Krishnavenee Krishnan	Executive Vice President, Strategic Innovation & Development	Bursa Malaysia
Lee Kah How	Senior Executive, Strategic Innovation & Development	Bursa Malaysia

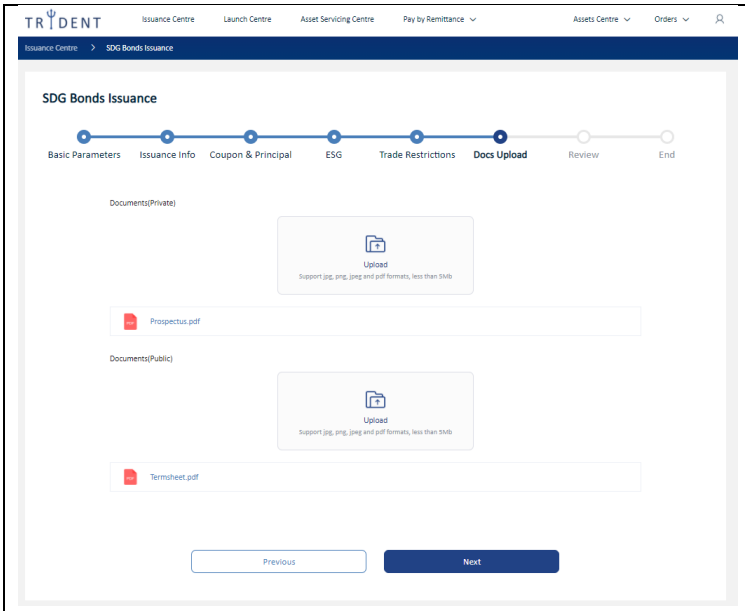
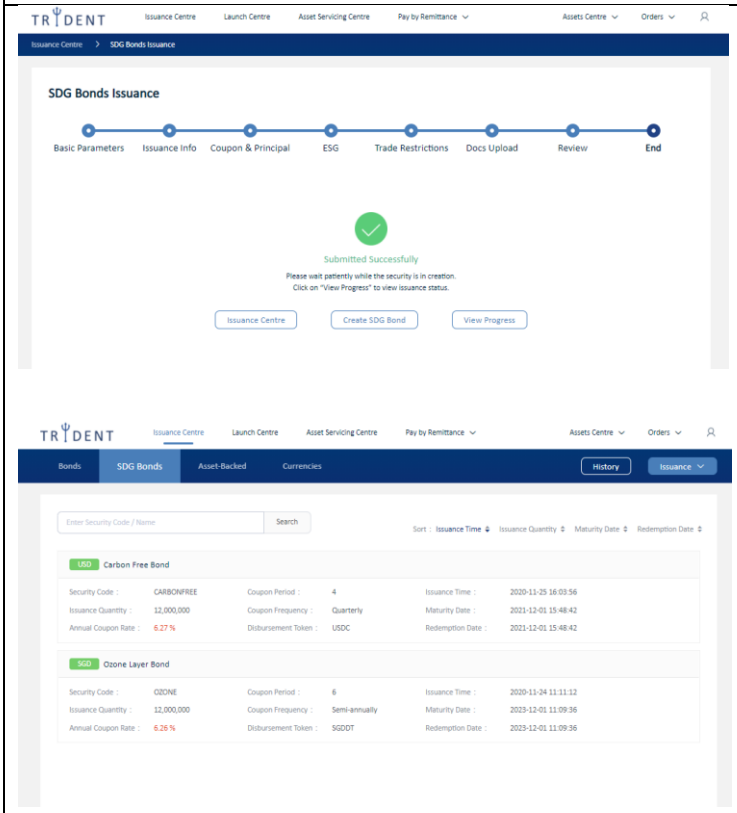
10 Appendices

10.1 Appendix A

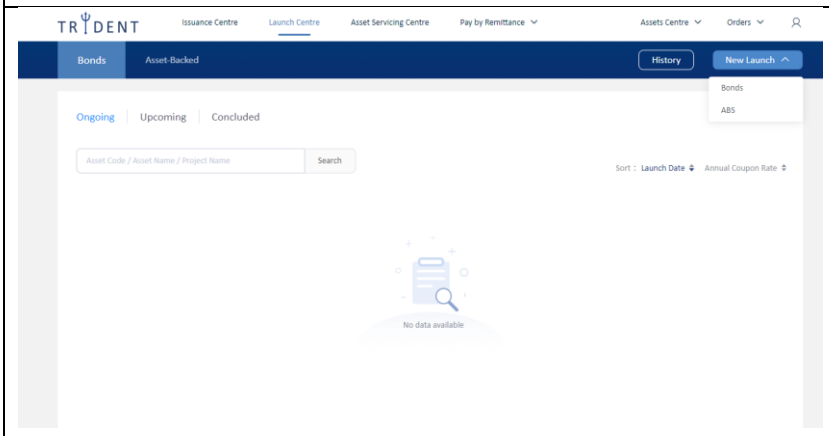
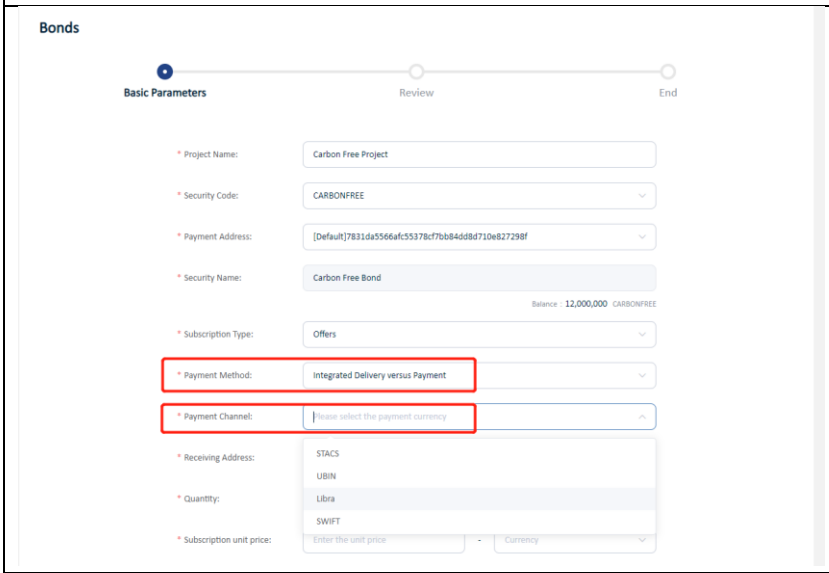
10.1.1 Issuance of an ESG Bond

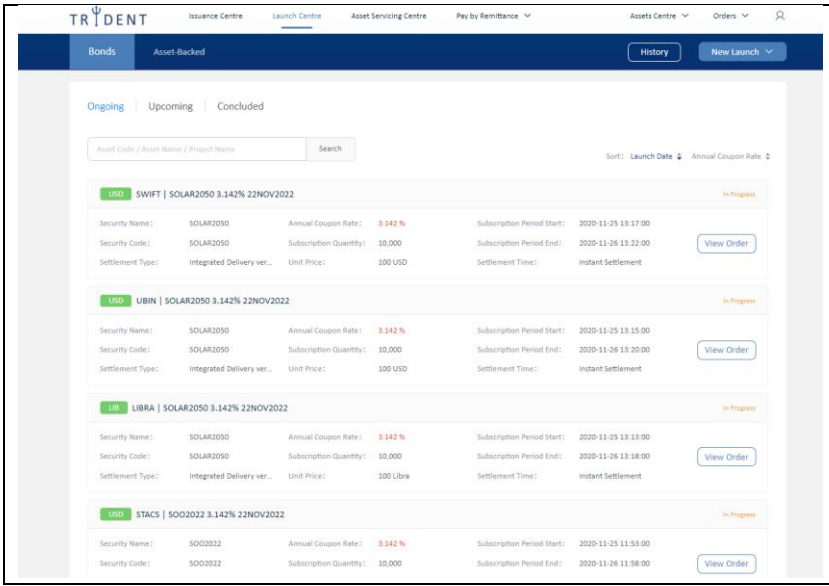
10.1.1.1 Perspective: Trustee/Custodian

Screenshots	Remarks
	Multiple Asset Classes can be issued in the issuance centre
	Ability to configure different security asset parameters. For issuance information, this includes issuance quantity, par value and settlement currencies.
	In the ESG segment, you will be able to choose from ICMA ESG Frameworks to enforce the respective Green Bond or Social Framework onto the smart contract, which will enforce business logic restrictions on the bond on the blockchain.

	Documents can be published onto the blockchain as a public or private document.
 	ESG Bond has now been deployed on the blockchain as a smart contract.

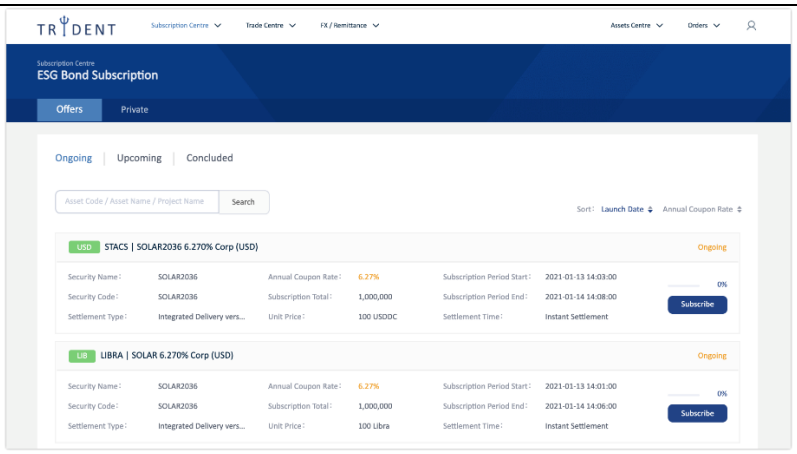
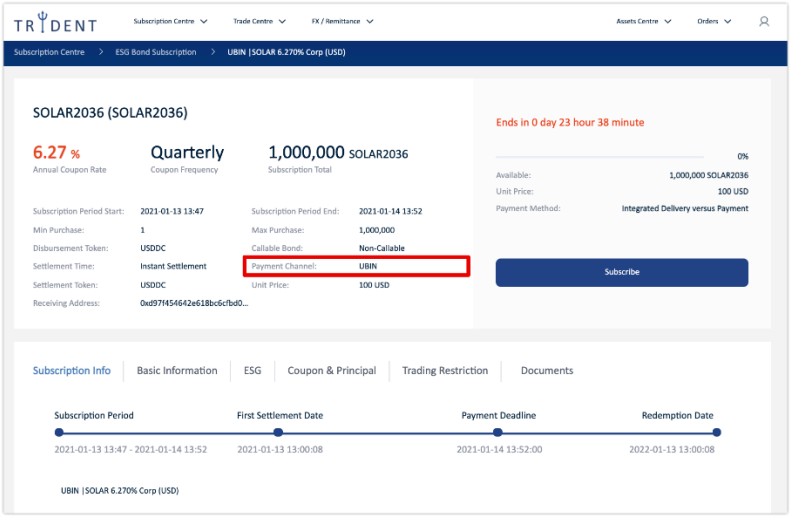
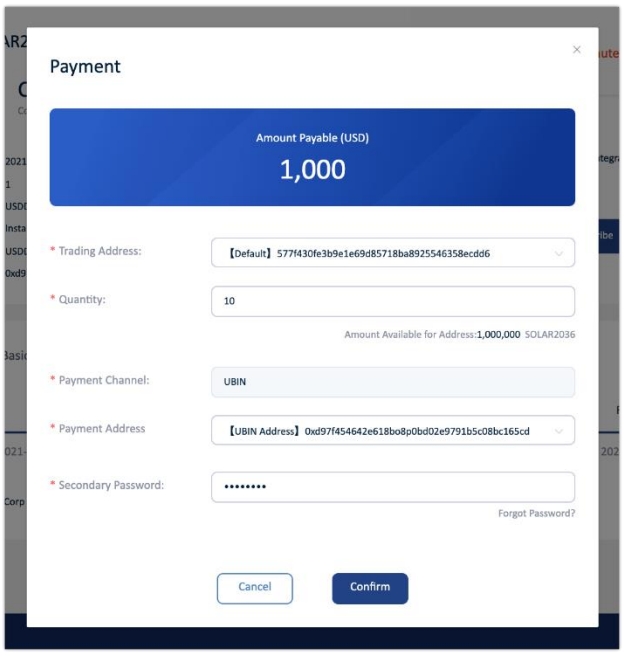
10.1.1.2 Perspective: Arranger

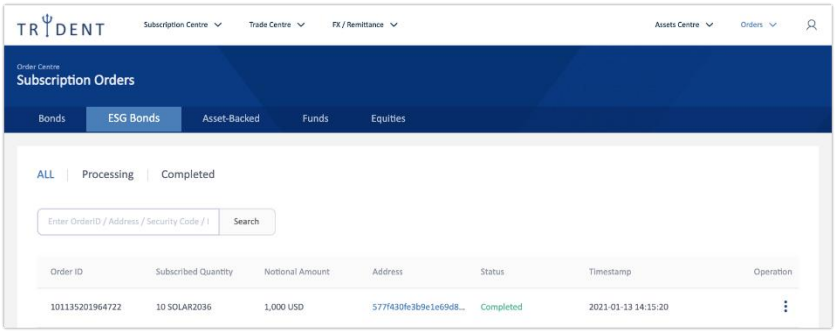
Screenshots	Remarks
	Able to launch assets for sales in the launch centre. Able to do multiple tranches. A smart contract generated for every project launch to facilitate the sales of security assets. Enable rapid launching of security sales digitally, hence, increase efficiency and promotes cost saving.
	You can define the payment method – Integrated DvP Consisting of multiple payment channels: **STACS, Ubin, Diem, Swift**

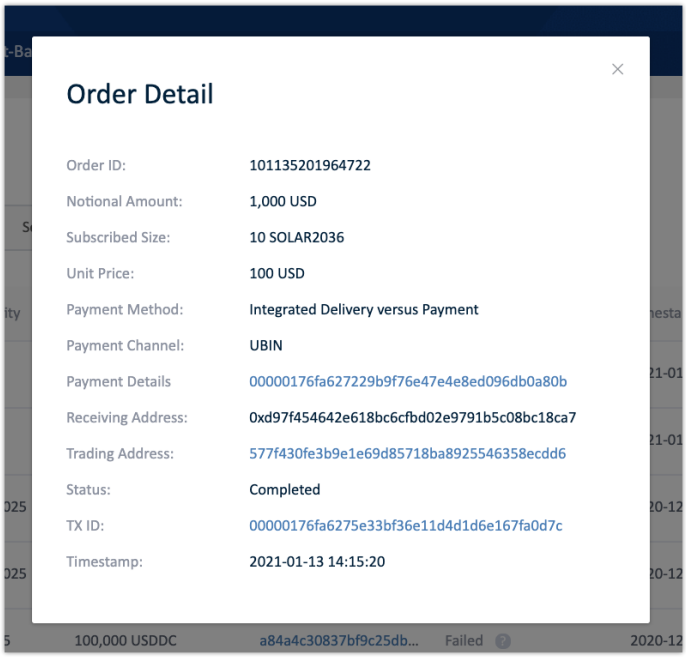


On successful launch, it will appear in your listing.

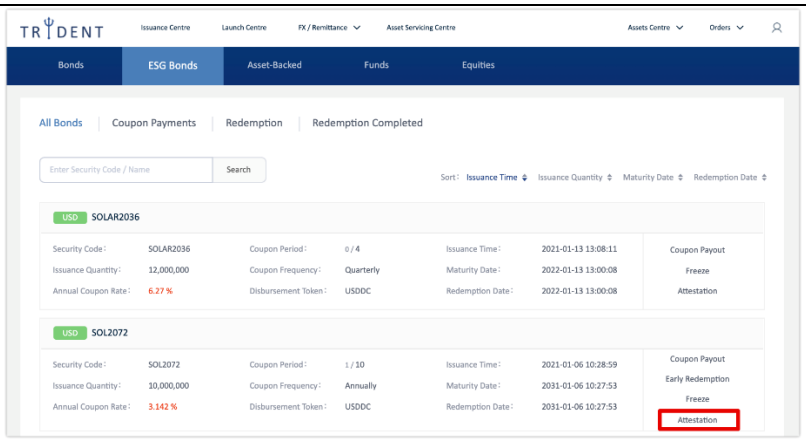
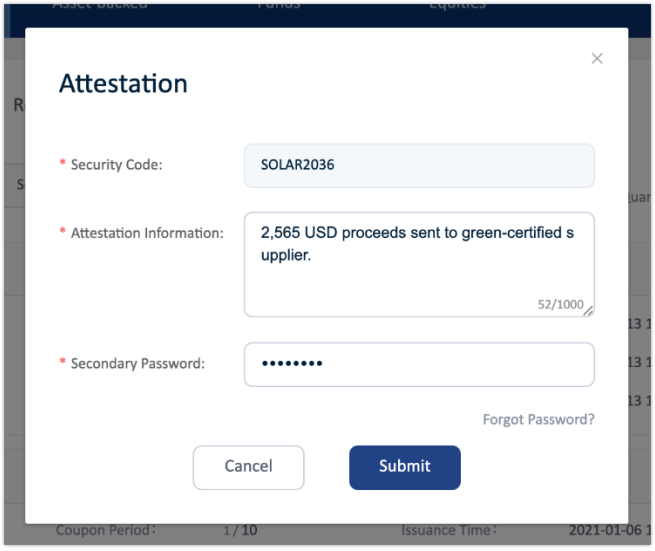
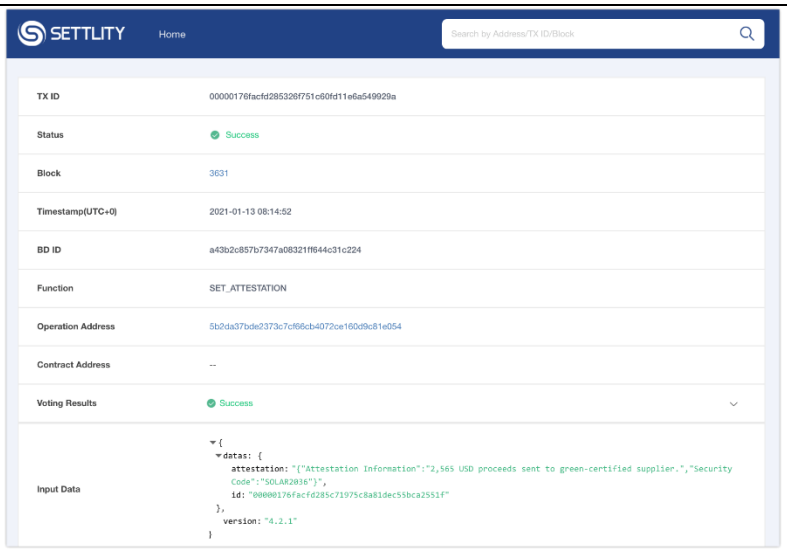
10.1.1.3 Perspective: Investor

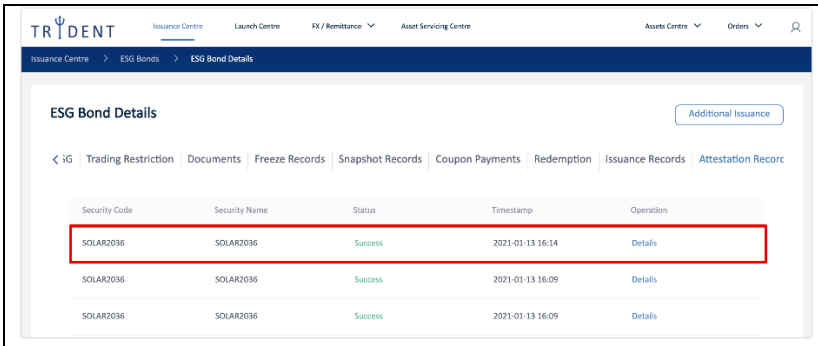
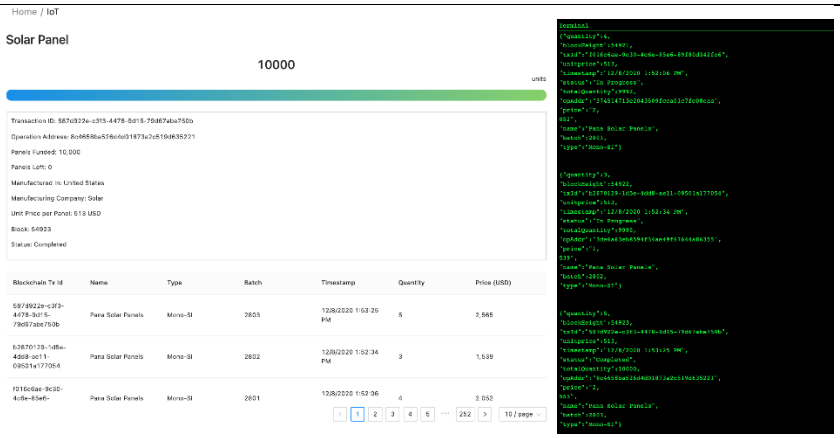
Screenshots	Remarks
	Subscription centre for you to view all the available listing. Select the potential listing and subscribe accordingly.
 	Subscription through Ubin Payment as an example. Diem, SWIFT, STACS payment methods are also available options.


TRIDENT
Subscription Centre
Trade Centre
FX / Remittance
Assets Centre
Orders
Order Centre
Subscription Orders
Bonds
ESG Bonds
Asset-Backed
Funds
Equities
ALL
Processing
Completed
Enter OrderID / Address / Security Code / I
Search
Order ID
Subscribed Quantity
Notional Amount
Address
Status
Timestamp
Operation
101135201964722
10 SOLAR2036
1,000 USD
577f430fe3b9e1e69d8...
Completed
2021-01-13 14:15:20

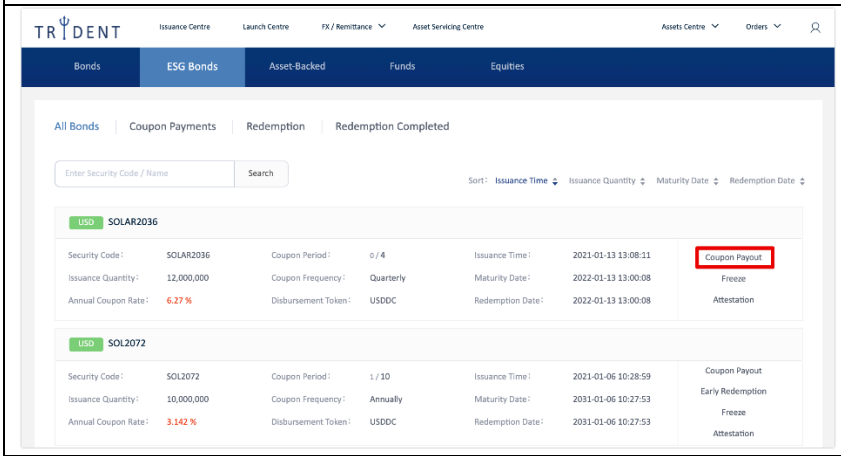

Order Detail
Order ID:
101135201964722
Notional Amount:
1,000 USD
Subscribed Size:
10 SOLAR2036
Unit Price:
100 USD
Payment Method:
Integrated Delivery versus Payment
Payment Channel:
UBIN
Payment Details
00000176fa627229b9f76e47e4e8ed096db0a80b
Receiving Address:
0xd97f454642e618bc6cfbd02e9791b5c08bc18ca7
Trading Address:
577f430fe3b9e1e69d85718ba8925546358ecdd6
Status:
Completed
TX ID:
00000176fa6275e33bf36e11d4d1d6e167fa0d7c
Timestamp:
2021-01-13 14:15:20
100,000 USDDC
a84a4c30837bf9c25db...
Failed
2020-12

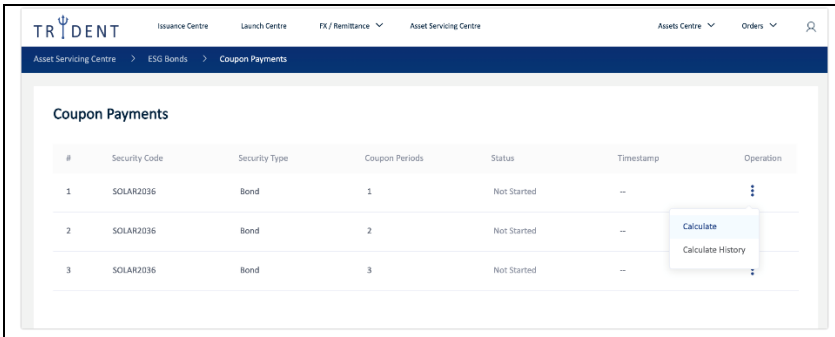
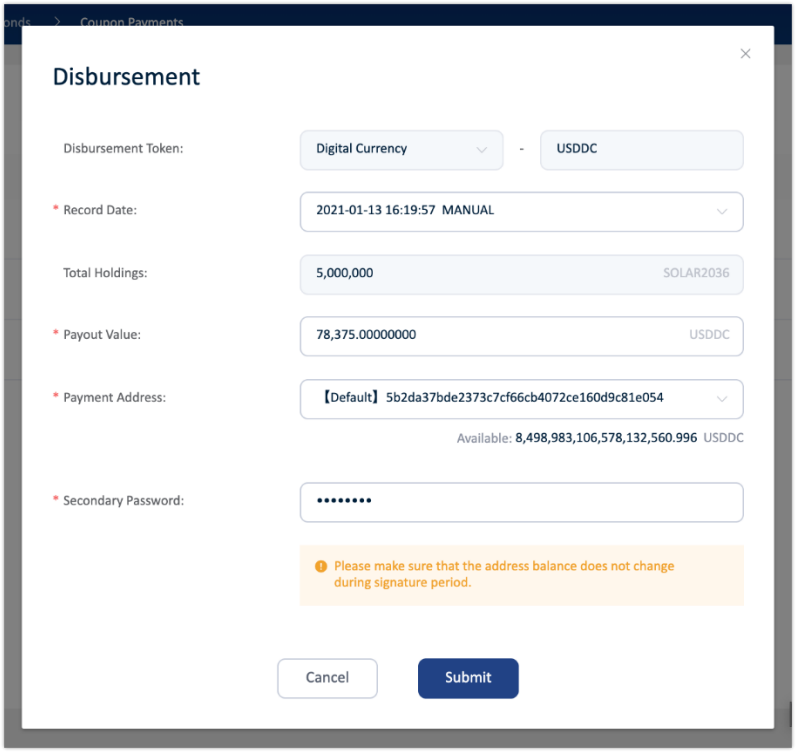
10.1.1.4 Perspective: Paying Agent (Coupon Payment)

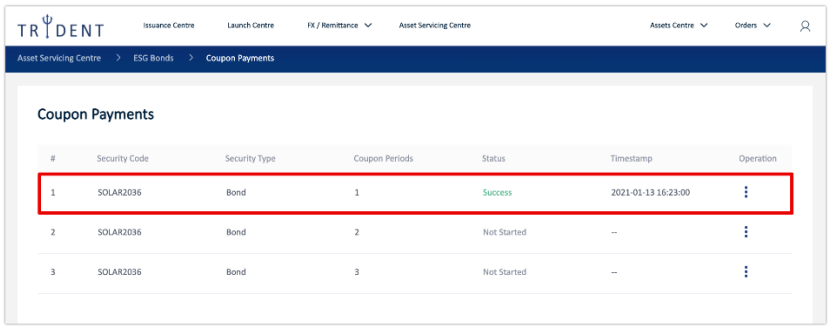
Screenshots	Remarks
 	Proceeds sent to green-certified supplier can be attested to the blockchain. Additional information or announcement can be appended to the security assets.
	Green-certified supplier address whitelisted so they are able to receive from the green funding. Proceeds sent attested and recorded on Blockchain.

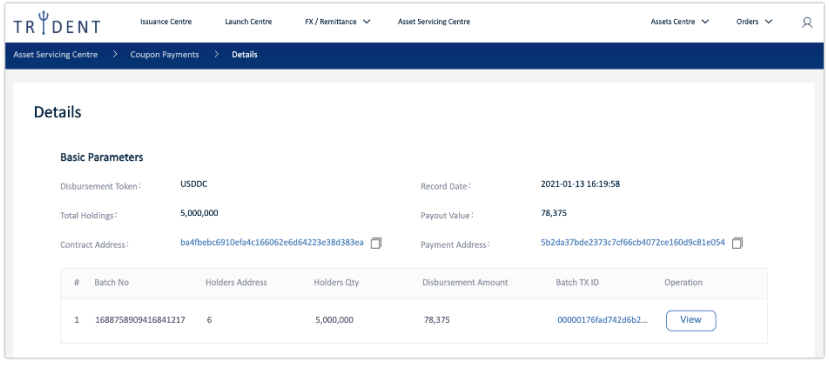
<table>
<tr>
<td> 
</td>
<td></td>
</tr>
<tr>
<td> 
</td>
<td>Proceeds sent attested and recorded on Blockchain.

Pay-out is completed, you will have a report and the corresponding tx id.
Third-party technology can now integrate with STACS to record data onto immutable layer through APIs.

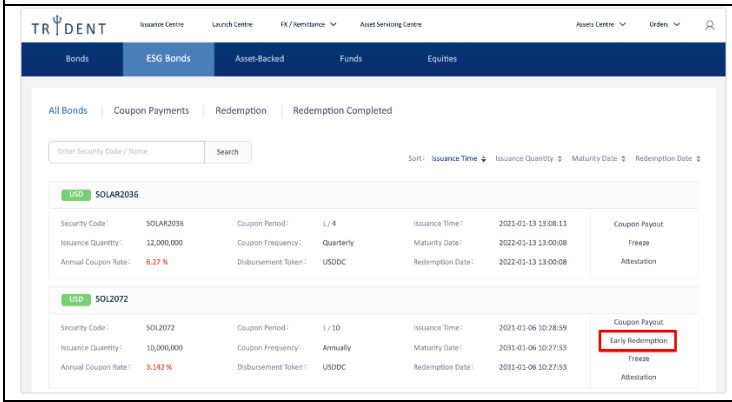
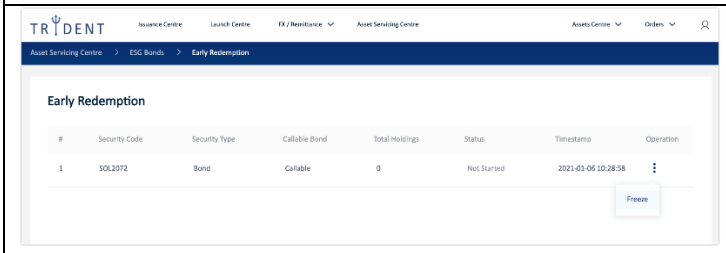
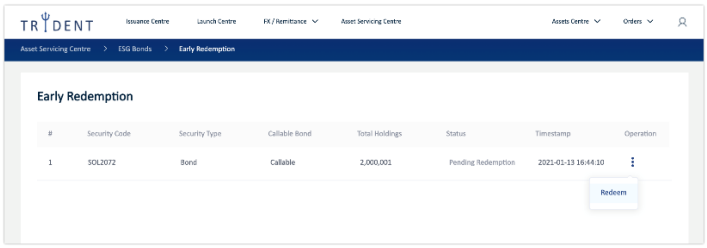
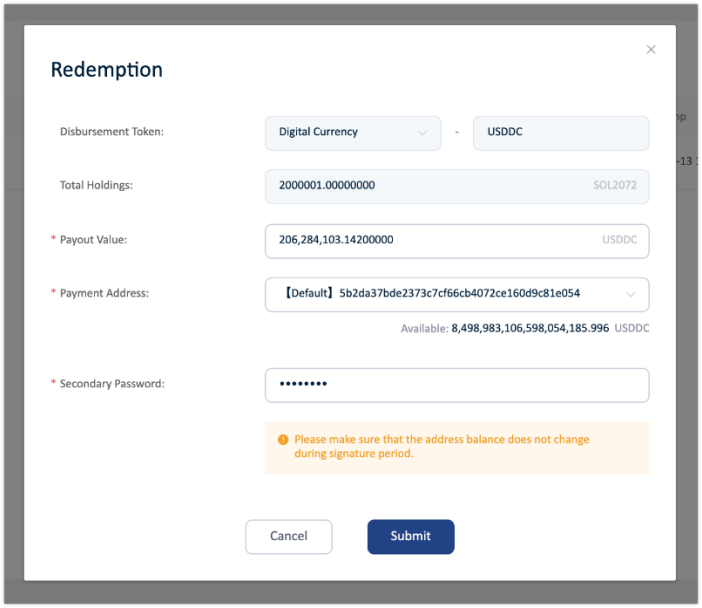
Full range of APIs are available to support multiple business use cases through integration.</td>
</tr>
<tr>
<td> 
</td>
<td>Under the Asset Servicing Segment, able to pay-out coupon payments.</td>
</tr>
</table>

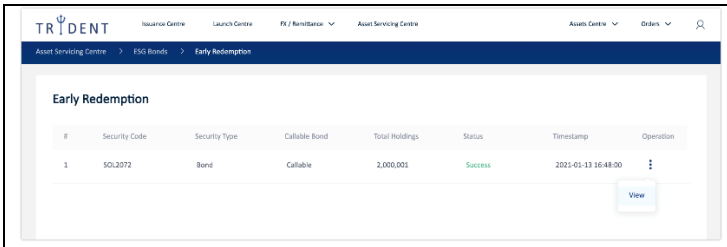
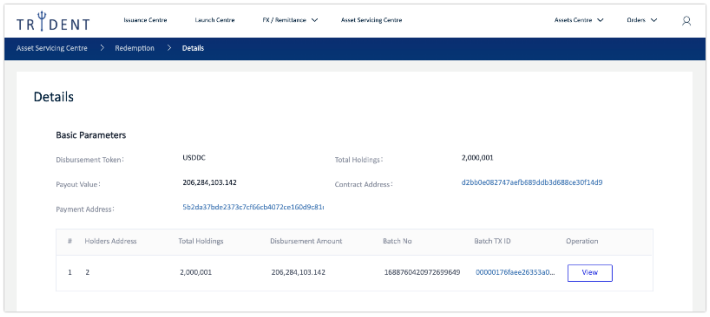
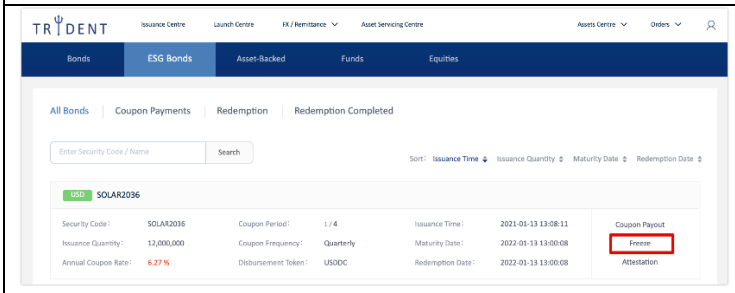
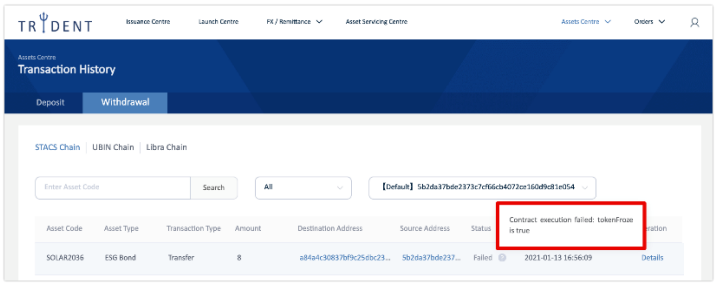
<table>
<tr>
<td> 
</td>
<td>Once snapshot is completed, we are ready to do pay-out.</td>
</tr>
<tr>
<td> 


</td>
<td>You will be notified with the total holders available with the grand total pay-out value.

Once confirmed, you are able to authorise the pay-out.</td>
</tr>
<tr>
<td> 
</td>
<td>Pay-out is completed, a report will be available with the corresponding tx id.</td>
</tr>
</table>

10.1.1.5 Perspective: Paying Agent (Redemption)

Screenshots	Remarks
	Similarly, in the Asset Servicing centre, you are able to conduct redemption.
 	"Freeze" will trigger both a snapshot on the blockchain to capture the current holders with their holdings qty. It also "halt" all the tokens from trading / transfer from 1 party to another. Once above are completed, we are able to proceed with the redemption pay-out.
	Complete list of holders is available with the grand pay-out value. Once confirmed, you are able to authorise the pay-out.

 	A report and the corresponding tx id will be generated once the pay-out is completed.
 	System is able to freeze the tokens from transfer / trading if necessary.

10.2 Appendix B

10.2.1 Platform Architecture (STACS' Trident/*Bond in a Box* Solution)

10.2.1.1 Application Layer

The frontend is a thin web client that is stateless to ensure that users do not need to pre-install any software. Hence, users can simply use an Internet browser with secured access to complete their tasks.

The engine that comprises of all modules is deployed for each participant and connected to a deployed node.

All business processes are isolated at the application engine level for each institution while smart contract access by the applications are agreed upon by all participants at the blockchain level. Each institution has their individual requirements customized at the frontend and application engine layer since the applicable business logic for individual users differ greatly. These applications will be hosted separately for each user, and the segregation of data and business requirements between institutions is thus enforced at this layer.

Every user will also host a node and run the same exact smart contract code that is mapped to their customised workflows. Essentially, each user will execute their business workflows on their own application, which in turn has pre-agreed authorization to only execute specific smart contract functions required by their workflows. At the same time, the design also ensures that all nodes in the network execute each transaction with the same smart contract code since this layer is not exposed to the other users. This allows every user to execute the same business logic for a particular transaction, and the various nodes will independently arrive at the same execution state to maintain the single source of truth of data which is then sent to the blockchain layer.

10.2.1.2 STACS Blockchain

The STACS blockchain architecture is an Enterprise permissioned blockchain solution with a highly modular infrastructure design, enabling for the business logic and smart contract code to be separately designed. This allows for changing business requirements to be mapped at the business logic layer, which is housed at the application layer. This facilitates changing business needs to be fulfilled rapidly, while preserving the inherent immutability characteristics of a blockchain as the smart contract functions are invoked independently by all nodes through the business logic applications. Essentially, this ensures that data state is unified across the network.

10.2.1.3 Access and Control

The STACS blockchain has access control built into the blockchain to authorize which smart contract functions are accessible by specific applications. This access control layer can be pre-agreed upon by the participating institution (which is recorded to the blockchain) and permissions can also be later modified by the institution (also recorded to the blockchain) should there be a future change in business requirements.

The access control layer therefore acts as a modular form of consortium governance of the network. For example, information entered by one participant through a node can require explicit approval from a group of pre-determined participants which is decided prior to the controls being designed on the blockchain.

Finally, for each of the participant's applications catering to their own business needs, additional role-based access control following the principle of least privileges will be provided and built into the APIs that are used by the web client. This ensures that business users in the institution are only provided the minimal amount of permission to perform their specific tasks on their application. Ultimately, this results in a layered approach to data segregation and operational workflow segregation, while preserving the core benefits of the proposed solution.

Contact Us

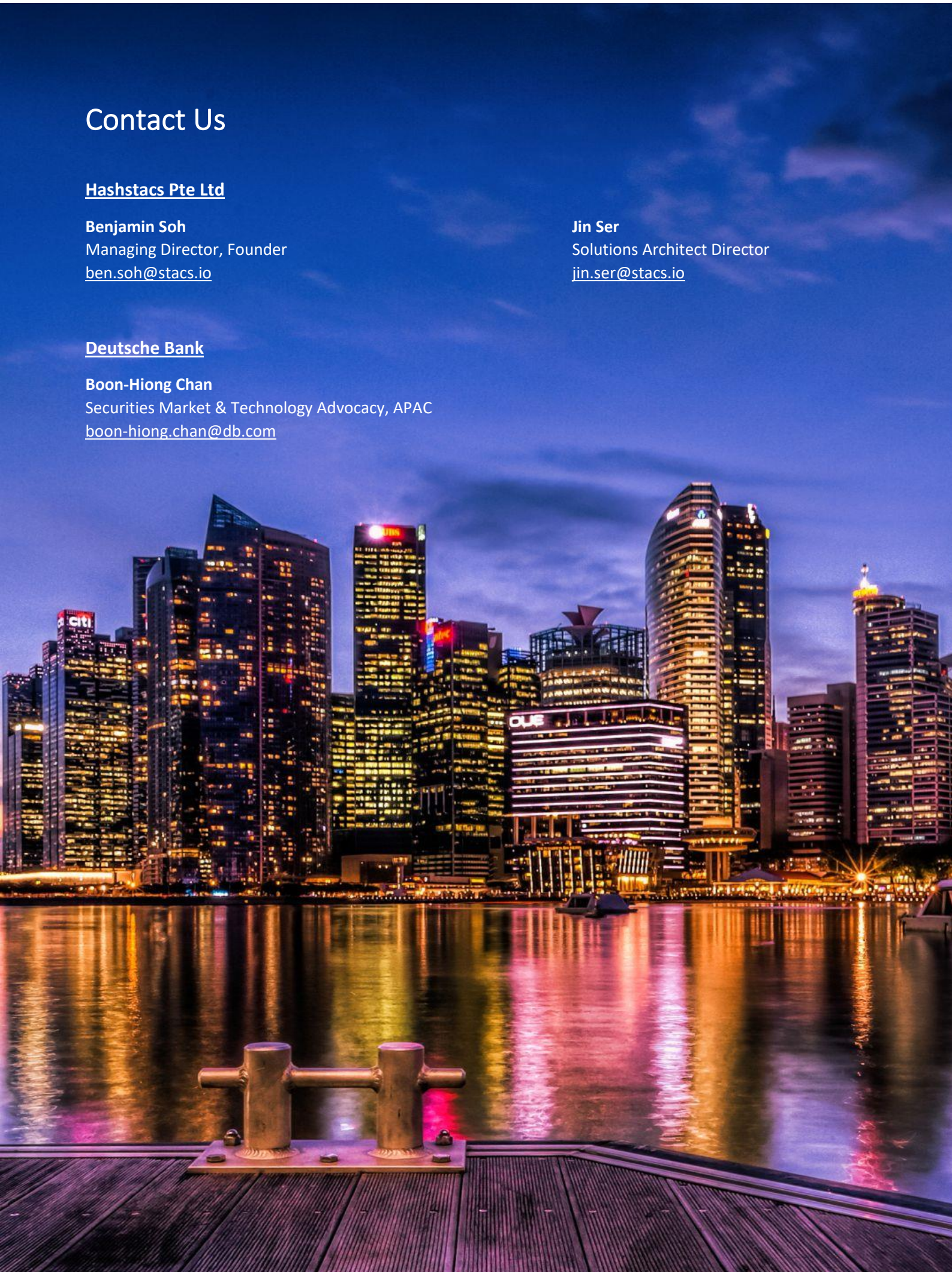
Hashstacs Pte Ltd

Benjamin Soh
Managing Director, Founder
ben.soh@stacs.io

Jin Ser
Solutions Architect Director
jin.ser@stacs.io

Deutsche Bank

Boon-Hiong Chan
Securities Market & Technology Advocacy, APAC
boon-hiong.chan@db.com



About Deutsche Bank

Deutsche Bank provides commercial and investment banking, retail banking, transaction banking and asset and wealth management products and services to corporations, governments, institutional investors, small and medium-sized businesses, and private individuals. Deutsche Bank is Germany's leading bank, with a strong position in Europe and a significant presence in the Americas and Asia Pacific.

About STACS

STACS (Hashstacs Pte Ltd) is a Singapore FinTech development company with a Vision to provide Transformative Technology for the Financial Industry, with its complete infrastructure of live institutional green and ESG-enabling platforms that make global markets simpler. STACS is leading the way forward by digitalizing assets, processes, and documents using its patent-pending STACS Blockchain technology. Its clients and partners include global banks, national stock exchanges, and asset managers. STACS is The Asset Triple A Digital Awards 2021 FinTech Start-up of the Year, an Award Winner of the Monetary Authority of Singapore (MAS) Global FinTech Innovation Challenge Awards 2020, and a two-times awardee of the Financial Sector Technology and Innovation (FSTI) Proof of Concept (POC) grant, under the Financial Sector Development Fund administered by MAS.

Disclaimer

This communication contains general information only, and none of Deutsche Bank, its member firms and related entities, or any other party involved in this project, is by means of this communication, rendering professional advice or services. Before making any decision or taking any action that may affect your finances or your business, you should consult a qualified professional adviser.

No entity involved in the construction and publication of this report (namely Bursa Malaysia, Deutsche Bank, Hashstacs, UBS, and UnionBank, in alphabetical order) shall be responsible for any loss whatsoever sustained by any person who relies on this communication.