ASX CHESS Replacement Application Delivery Review

November 2022

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1. Executive Summary

1.1 Introduction

Since its origination over 25 years ago the current Clearing House Electronic Subregister System (CHESS) system has provided clearing, settlement, asset registration and select post-trade and issuer services paramount to operating an effective market in Australia. In 2015, ASX Operations Pty Ltd (ASX) began a process to evaluate replacement options for CHESS. By the end of 2018, ASX embarked on a transformation journey (CHESS Replacement Program) to modernise and upgrade CHESS utilising Distributed Ledger Technology (DLT) to improve overall availability, reliability, and performance of the system.

1.2 Scope

In September 2022, Accenture was appointed to conduct an independent review (Review) of the CHESS Replacement Application delivery. The Review was conducted for the purpose of bringing external expertise to assess the remaining work required to complete delivery of the CHESS Replacement Application, as well as to identify necessary actions for ASX to communicate a revised timeline to finish the project. To determine this, Accenture:

1. Investigate the CHESS Replacement Application Core Issues as defined by ASX and Digital Asset (DA).

2. Review the delivery partnership between ASX and DA across the software delivery lifecycle for the CHESS Replacement Application - architecture, design, implementation practices, ways of working and project governance to determine current state and define recommendations for a path forward (CHESS Replacement Application Delivery Assessment (Delivery Assessment)).

The findings and recommendations of this report are limited to the CHESS Replacement Application delivery capabilities managed by ASX and DA. This should not be considered a CHESS Replacement Program-wide or ASX organisation-wide assessment.

Figure 1: Accenture's Scope of Activities for Review

As per the figure above, the Review was conducted in three stages:

1. Review of the six Core Issues identified by ASX and DA.
2. The Delivery Assessment consisted of:

i. The Solution Review focused on the solution design and architecture for the CHESS Replacement Application, use of Daml and VMware Blockchain (VMBC), and a code review to develop a set of recommendations.
ii. The Capability Assessment focused on the maturity of the software delivery lifecycle processes managed by ASX and DA.
iii. The draft delivery plan provided by DA was reviewed to understand the remediation activities required to address the Core Issues for the purpose of planning and timeline discussions. Note, this was a draft plan which was reviewed point-in-time to provide feedback and shouldn't considered final or complete.

3. A set of 45 recommendations that were grouped to a set of 12 areas of focus across ways of working, software delivery, quality engineering efficiency, and solution design.

1.3 Core Issues and Underlying Drivers

The CHESS Replacement Application is seeking to replace a 25-year-old legacy implementation with business workflows specific to the Australian market and the desire to avoid disruption to the market participants, which collectively introduces complexity regarding the business requirements and how they can be adopted with a new technology solution.

The six Core Issues identified by ASX, and DA were Holdings, Batch Settlement, Bulk Process Support and Resiliency, Bilateral Matching, Issuer (HIN) Notifications, and Support for Ex-Transactions. Analysis of these Core Issues identified four underlying drivers contributing to the challenges in the current solution design:

- **Latency** – Distributed systems introduces higher latency. In the current architecture, the latency is further increased due to the round-trip data flow of submitting a transaction to the client node through to writing the data to the ledger and distributing back to the client nodes and the CHESS Replacement Application. This design preserves optionality for providing a node to ASX's clients in the future. However, the latency comes at a cost and some workflows needing serial processing may run into challenges meeting the non-functional requirements.
- **Concurrency** – The architecture design supports concurrency which helps allow for scale which is required to meet ASXs non-functional requirements. However, concurrent processing can cause contention when processing multiple in-flight transactions targeting the same dataset (e.g., holdings targeting the same broker, security, and HIN). To remediate this issue, batching/grouping is introduced; however, grouping transactions together does not remove the contention problem forcing serialised processing for some workflows.
- **Batch Processing (Transaction Grouping) –** To solve for concurrency, to achieve scale, and to meet the non-functional requirements with the contention issues noted above, groups of transactions are combined into a single batch for processing. This batch, however, is limited by constraints imposed that need to be configured and tested further.
- **Technical Constraints** – Batching of transactions to process could be constrained by practical limits in Daml Ledger API (size of a Daml object on ledger) and VMBC (total size of a transaction message) which needs to be designed for and tested further. These limits could be a hindrance to extensibility.

The options to remediate the six Core Issues in the Plan addresses the known instances. However, Accenture recommends considering the underlying drivers of the Core Issues in the architecture to comprehensively evaluate other business workflows with similar patterns (e.g., transactions updating the same object on ledger).

1.4 Delivery Assessment

The second component of the Review, the Delivery Assessment, comprised of a Solution Review, Capability Assessment and Draft Delivery Plan Review. Key findings were identified through a series of workshops, artefact analysis, strategic applications to frameworks, and code reviews. Accenture's recommendations to address the key findings are reflected under section 7.

1.4.1 Solution Review

Accenture conducted a Solution Review considering the solution design, use of Daml and its interaction with the VMBC ledger, and code review to understand the quality, modularity, design patterns & reuse, and impact (if any) to maintaining and supporting the code long-term. The Solution Review builds on the Core Issues and their underlying drivers to further highlight issues requiring mitigation in the current design.

The solution design review highlighted the need for greater consideration of how the Australian market business workflows interact with the application and underlying ledger. The current design is contributing to challenges in achieving scalability, resiliency, and supportability:

- Business workflows or requirements were not tailored for a distributed environment.
- The absence of appropriate design artefacts, rigor, or inconsistent design discipline to model the expected behaviour within the constraints of the technology.
- Adding new functionality or changing current functionality will inherently require migrations of existing contracts including recreations of both core system contracts and API contracts.
- High complexity of operations and maintenance to spot fix, long turnaround to evaluate/remediate issues.
- Greater consideration is required regarding the purpose of the consensus layer given ASX's position as the central market operator for the CHESS use case.

Daml is a business-oriented language that provides flexibility for defining business rules and processes in a distributed environment. In the current solution, Daml is used to solve most of the business workflows rather than determining on-ledger vs. off-ledger fit for data, business logic, or calculations. Accenture's review highlighted that while there are benefits of using Daml for distributed processing, further considerations are required:

- From a participant standpoint in the current design and architecture (not withstanding future use cases), there is little value to processing all the business logic on-ledger as ASX maintain data integrity as the market operator and participants receive a point-in-time view via API contracts.
- There is an opportunity to use Daml strategically to maximise its benefits while avoiding the limitations expected with its distributed nature.
- Certain business processes or data models could suffer from performance or scale issues in the future due to design choices (e.g., holdings, ex-transactions, etc.)
- Greater consideration of long-term plans such as bilateral workflows (if any) between parties in Daml should be given to avoid redesigns in the future (e.g., authorisation pattern).

The code review highlighted the existence of a high quality Daml implementation providing considerable efficiencies relative to the current CHESS and is not contributing to the Core Issues, however, introduces potential supportability challenges in the long term due to the skills availability and the interconnectedness of the Daml contracts.

Based on these findings Accenture recommends the following to improve scalability, resiliency, and supportability:

- Review the solution design to meet future growth and ASX's strategic objectives.
- Explore opportunities to simplify the solution design.
- Review Daml use to meet long-term objectives.
- Optimise on-ledger and off-ledger processing for transactions.
- "Shift left" testing to compress long sequential feedback loops.
- Remediate root causes of the (known) Core Issues.

1.4.2 Capability Assessment

Accenture's assessment of the current delivery model and execution plan found deficiencies in execution rigour and the lack of a clear understanding of progress, compounded by misalignment of expectations between ASX and DA.

Execution Rigour and Cross-Team Alignment

- The CHESS Replacement Application's priorities to minimise impact to participants and uphold commitments made to the market are driving solution design and delivery decisions which are inconsistently assessed against strategic objectives for the ASX.
- Siloed execution and reporting between ASX and DA have resulted in misaligned views of status including delivery progress, risks, and issues.
- Insufficiently detailed alignment of scope, delivery plan and resourcing resulting in missed dependencies and opportunities for optimisation.
- Adequate traceability of delivery to business capabilities evidenced; operational readiness capability across business and technology maturing.
- Test and internal release management processes lacking industrialised tooling.
- Management of vendor accountabilities is lacking including inconsistent information obtained regarding the reporting and tracking of execution outcomes and quality-related metrics.
- Functional and non-functional requirements are misaligned, across definitions (at times conflicting), granularity/quality, delivery timing and scope. The Core Issues highlight the consequence of this.

Team Culture and Partnership with Digital Asset

- Misalignment and frustration of current working model expressed by both ASX and DA; common desire to resolve but will require a significant pivot with strong leadership.
- Siloed client/vendor culture observed, rather than driving towards shared business outcomes. Amplified by independent management structures, locations, and tools.
- Requirements and scope definition are a major source of contention leading to inconsistent design artefacts, lack of documented design decisions and impacted change impact assessment capabilities.
- Misalignment on risk and issue management and handling of potential technical implementation challenges to meet functional requirements (FRs) and non-functional requirements (NFRs), resulting in varied perspectives on risk profile and mitigants requiring leadership attention.

1.4.3 Draft Delivery Plan Review

Execution Progress and Robustness of the Draft Delivery Plan

- Whilst 63% of the overall scope has been provided to ASX for testing. Most of the scope delivered for testing is related to functional capabilities and many of the non-functional capabilities are either to be built or in build stages.
- The planned refactoring of batch settlement, holdings and simplification of ex-transactions is expected to impact ~45% of functionality already shipped. This will have a significant impact on testing efforts and program-wide planning.
- The Draft Delivery Plan (v0.2c) proposed by DA is deemed as high risk with low confidence, due to:
    - Additional scope being required to address and resolve underlying drivers for Core Issues leading to significant design changes and refactoring,
    - Not being based on standard, governed methodology for scoping, inventory-based estimation, contingency management, and associated risks,
    - Lack of interim milestones to utilise early testing and validation of functional and non-functional requirements capabilities to build confidence.

1.5 Delivery Assessment Recommendations

Accenture identified 45 recommendations which were grouped to a set of 12 focus areas across ways of working, software delivery, quality engineering efficiency, and solution design.

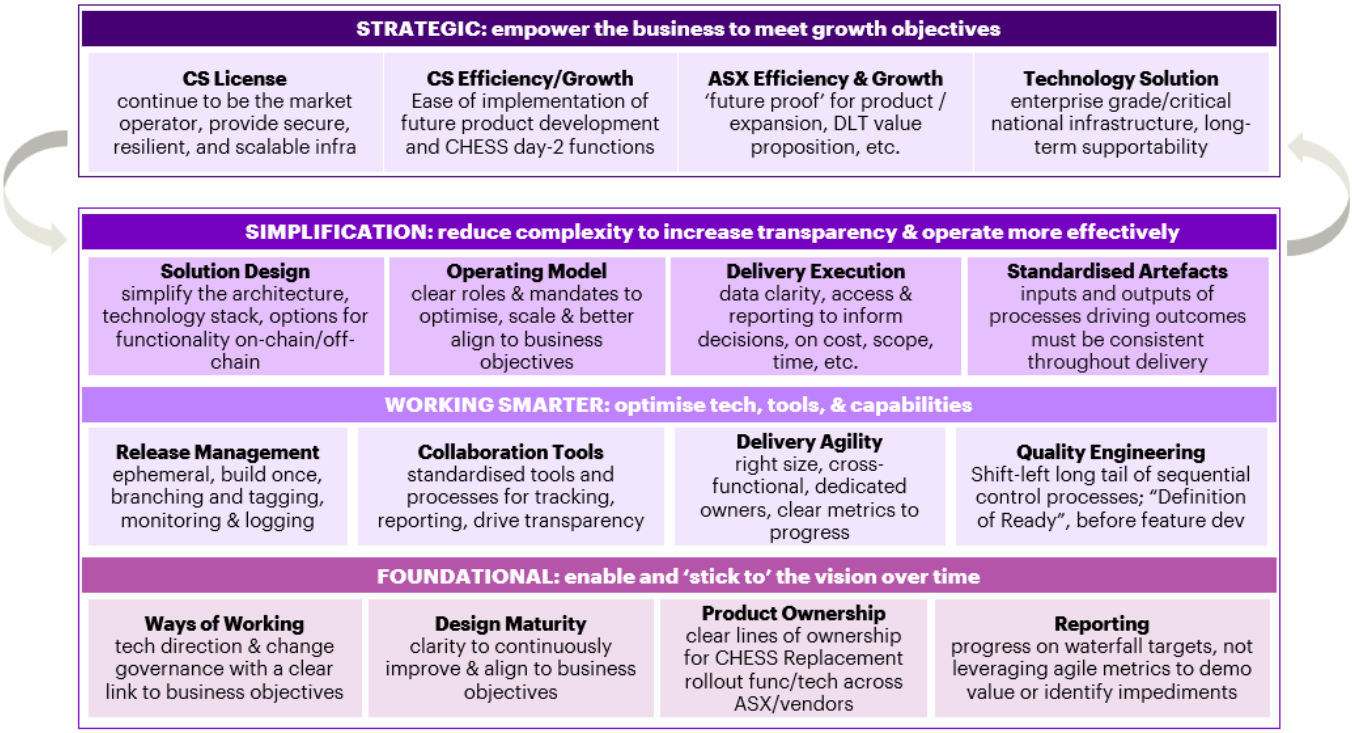


Figure 2: Delivery Assessment Recommendations

2. Scope

ASX sought assistance to understand the current issues with the CHESS Replacement Application delivery and engaged Accenture. In this capacity, Accenture reviewed the current solution for the CHESS Replacement Application along with client node and ledger components, supporting architecture, design, current implementation, and a high-level sample code review to examine practices and levels of technical debt post-deployment. Accenture also reviewed the solution in relation to scalability, resiliency, and supportability.

ASX requested that Accenture assess the current delivery practices and provide actionable recommendations on improvements to the delivery model which could support the remaining work. ASIC and RBA also requested to be kept informed.

Accenture's assessment was constructed as follows:

1. **Core Issues** – Deep dive into the Core Issues identified by ASX and DA and compare against the revised DA delivery timeline; with the purpose of answering key questions raised by ASX.

2. **Delivery Assessment** – Reviewed the delivery partnership across its architecture, design, implementation practices, ways of working and accountability.

The scope of the Review was defined to include the following elements within the ASX Target State Clearing and Settlement Solution:

1. The CHESS Replacement Application that executes the business workflows;
2. Filtered Ledger (Client Nodes) that provides the Daml runtime for smart contract execution; and
3. Relevant interactions with the distributed ledger platform.

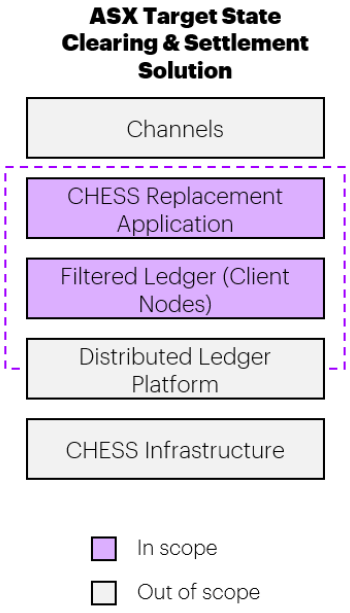


Figure 3: Scope Elements for Review of the ASX Target State Clearing & Settlement Solution

3. Approach

The Delivery Assessment took place over 12 weeks, through a collaborative approach with ASX and DA. The findings and recommendations of this report are limited to the CHESS Replacement Application delivery capabilities managed between ASX and DA and should not be considered as an organisation-wide or program-wide assessment. The following activities were performed across the 12-week timeline:

1. **Artefacts Review** – A detailed review and analysis of documentation related to the CHESS Replacement Application and focus areas related to the Core Issues and Delivery Assessment. All artefacts were provided through a data request process from Accenture to ASX and DA.

2. **Stakeholder Workshops and Interviews** – Accenture identified key stakeholders across ASX and DA and conducted collaborative workshops and interviews to capture additional detail required for the Review. Formal workshops were scheduled with agendas centered around areas of focus for critical review. Additional interviews with stakeholders were conducted on an ad-hoc basis, generally intended as a follow-up or clarification to seek further expertise on focus areas. Upon concluding each workshop/interview, detailed action items and meeting minutes were provided to all workshop attendees for input, clarification and record keeping. Refer to Schedule of Workshops and Interviews for a list of stakeholder workshops and interviews conducted.

3. **Governance Meetings** – Across the 12-week timeline meetings were held across three governance levels: working group, management, and sponsors to understand the status of the Review, key activities occurring and the evolution of focus areas each week. In addition, a tracker was utilised to identify and trace project RAID.

4. **Findings Hypothesis and Validation** – Following stakeholder workshops, interviews and review of the artefacts provided, Accenture formulated key findings and initial hypotheses around the focus areas for critical review. Through further follow-ups and clarification sessions, these hypotheses were validated, grouped into common themes, and documented.

5. **Recommendations** – As part of the Delivery Assessment, Accenture developed detailed recommendations aligned to overarching themes.

The following assumptions and constraints were noted in conducting this review:

- The CHESS Application Core Issues Review is bounded by the six Core Issues provided by ASX and DA.
- Information gathered through project artefacts supplied by the ASX and in workshops (with ASX and DA) was current at the time of discussion.
- The assessment of the delivery plan utilised a snapshot of the document titled "ASX-Snapshot-Spider-Delivery-Tracker-070922" taken on the 7th of September 2022. Changes made after this date have not been considered during this review.
- The assessment focused on the CHESS+ Application and its interaction with the ledger. The evaluation of physical infrastructure, VMware ledger, channels integration,

data migration and reporting, finance, risk, and mailing capabilities were considered out-of-scope.
- Any documents submitted to ASX, in draft form or otherwise, would also be provided to the regulator, as per regulatory directive.
- Post go-live business and architectural roadmaps were not considered as part of this review, in line with ASX's directive.

4. Core Issues

The focus of this part of the engagement was to review, analyse and engage with key stakeholders to understand the Core Issues identified by ASX and DA and determine underlying drivers responsible.

4.1 Core Issues

ASX and DA have jointly identified remediations to address the known Core Issues, which are serving as inputs to the current development of the Draft Delivery Plan provided by DA.

The CHESS Replacement Application Draft Delivery Plan is one of many workstream plans that feed into the broader CHESS Replacement delivery. The Draft Delivery Plan referenced in the following chapters was provided by DA for planning conversations and should not be considered as final or complete.

	Core Issue	Identified Remediation Options	DA's Proposed Timeline	Targeted Uplift
1	**HOLDINGS** Performance and resiliency issues encountered during post settlements processing caused by the current modelling of holdings and settlement locks data.	Refactor the 'holdings' Daml model and introduce batching.	Implementation: 4m Contingency: 4m L	**SCALABILITY** The resolution targets fair scalability for select workflows only; complexity for potential future remediations remains.
2	**BATCH SETTLEMENT** The current implementation of batch settlement introduces challenges in terms of meeting resiliency requirements and the ability to observe the outcomes of intermediate stages, which is required to facilitate Offsetting Transaction Agreement (OTA) reporting.	Refactor and reimplement batch settlement progressively ('commit as you go') for better resiliency and support.	Implementation: 10.5m Contingency: 2.5m XL	**RESILIENCY** The resolution targets an uplift in resiliency compared to the current implementation.
3	**BULK PROCESS SUPPORT & RESILIENCY** Refactoring of the bulk process and batch operations to meet support and resilience, supportability and monitoring requirements.	Refactor complex batch operations with 'Intermediate States' into progressive, to increase supportability and resiliency.	Implementation: 17.5m Contingency: 6m XL	**SUPPORTABILITY** The resolution targets greater supportability compared to the current state by removing interim state complexities during recovery, and better visibility.
4	**BILATERAL MATCHING** The sequential approach to matching bilateral transactions presents scalability and performance problems, particularly in high volume scenarios containing many unmatched transactions with matching fields.	Keep the current business process, avoid FIFO matching to reduce matching concurrency and matching collisions.	Implementation: 1m Contingency: 0.5m S	**SCALABILITY** The resolution enables improved scaling by eliminating FIFO.
5	**ISSUER HIN NOTIFICATIONS** The logic regarding how information is currently disclosed via Issuer HIN notifications such as a change in balance for holders of entrepot accounts vs. direct/sponsored accounts creates complexity in processing and impacts trade registration performance (reads account data).	Implement eventual consistency of disclosure contracts with a minimal impact on customers.	Implementation: 4m Contingency: 4m L	**SCALABILITY** The resolution targets better scalability and performance related to trade registration by introducing asynchronous notifications.
6	**SUPPORT FOR EX-TRANSACTIONS** The cum entitlement balance, and ex/cum basis of movement concepts increase the overall complexity within the system, alongside a high level of past incidents and defects identified in the external test environments.	No change to the current implementation plan for simplification.	Implementation: 6m Contingency: 2.5m L *Schedule is calculated by the sum of implementation and contingency	**RESILIENCY & SUPPORTABILITY** The resolution does not target any uplift on resiliency and supportability capabilities.

Figure 4: Summary of Plan to Address Core Issues

Criticality and Resolvability

The criticality and resolvability of the six Core Issues was also assessed.

Given the Core Issues represent instances of technical limitations within the system and the four underlying drivers have only emerged within the scope of the Core Issues, there is a risk that there may be other thematically related drivers that have not yet been identified.

As such, the criticality and resolvability assessment has considered this risk, and is reflected in the dimension of Impacted Scope.

The criticality of a Core Issue was determined based on two key dimensions:

1. **Impacted Scope:** This was measured by the extent to which the issue relates to functionalities, capabilities or data across the solution, and its span across components.
2. **Severity:** This was measured by scale of problems/outages caused by the issue, and subsequent level of troubleshooting or fixes required.

Based on these dimensions, each Core Issue has been provided a rating corresponding to one of three levels: Low, Medium or High Criticality.

Low Criticality: The issue will require a solution with no changes to the design and minor implementation changes for fixing; the planning can be tactical.

Medium Criticality: The issue will require a solution with changes to the design and implementation; planning can either be tactical and independent, or bundled with a broader strategic roadmap.

High Criticality: The issue will require a solution with significant changes to the design and implementation; the issue will require strategic planning.

Refer to Criticality and Resolvability Assessment Matrix**Error! Reference source not found.** for t he matrix used to determine the criticality of each Core Issue.

#	Issue Title	Criticality	Impacted Scope	Severity
1	Holdings	**HIGH**	**HIGH:** The holdings data model is a common data model used across several business workflows in the system (e.g., settlements).	**HIGH:** Issue may lead to significant outages and performance degradation. Potential impact on core functionality outages (e.g., settlement process).
2	Batch Settlement	**HIGH**	**HIGH:** Issue relates to a core capability across the system, with a large implementation footprint.	**HIGH:** Issue affects core business functionality. Potentially invasive manual fixes may be required in case of failures.
3	Bulk Process Support & Resiliency	**HIGH**	**HIGH:** Issue requires a significant number of bulk processes to be refactored.	**MEDIUM:** Bulk Processes using 'Intermediate States' creates risks of failure. The complexity across bulk processing can lead to potentially long lead times in remediating issues.

#	Issue Title	Criticality	Impacted Scope	Severity
4	Bilateral Matching	MEDIUM	**MEDIUM:** Issue relates to matching capability with limited impact.	**MEDIUM:** Manual fixes will be required in case of matching failures. Unmatched transactions will sit in CHESS to be processed by 'housekeeping'.
5	Issuer HIN Notifications	MEDIUM	**MEDIUM:** HIN notifications may be considered as a satellite capability as the refactoring can be done without impacting the accounts data model.	**MEDIUM:** The current design impacts trade registration performance due to shared account data.
6	Support for Ex-Transactions	MEDIUM	**HIGH:** Widespread impact across the solution design, impacting common functional capabilities (e.g., clearing and settlement activities).	**LOW:** Despite not being associated with a solid defect, it introduces significant complexity for other core functions. The current design regarding ex-transactions may lead to resiliency and supportability challenges.

The resolvability of a Core Issue was defined by two key dimensions:

1. **Impacted Scope:** This was measured by the extent to which the issue relates to functionalities, capabilities or data across the solution, and its span across components.
2. **Remediation Complexity**: This was measured by the extent to which the remediation design has been defined, the maturity of the remediation approach and the impact on inventory required for refactoring.

Based on these dimensions, each Core Issue has been provided a rating corresponding to one of three levels: High, Medium or Low Resolvability.

High Resolvability: The issue will require a solution with a limited impact on the other phases (such as analysis or design) or a capability re-implementation.

Medium Resolvability: The issue will require a solution with a significant impact on the other phases (such as analysis or design); this may involve changing the implementation and capability testing.

Low Resolvability: The issue will require a solution involving refactoring, redesign, and testing. For avoidance of any doubt, Low Resolvability does not imply the issue is not resolvable but rather points to the effort and time required to resolve the issue.

Refer to Criticality and Resolvability Assessment Matrix for the matrix used to determine the criticality of each Core Issue.

#	Issue Title	Resolvability	Impacted Scope	Remediation Complexity
1	Holdings	**LOW**	**HIGH:** The holdings data model is a common data model across the system (settlements).	**MEDIUM:** Remediation approach has fair complexity. Impacted inventory has not yet been clearly identified.
2	Batch Settlement	**LOW**	**HIGH:** Issue relates to a core capability across the system, with a large implementation footprint.	**HIGH:** Remediation approach has been defined at a high-level; the approach requires solid design artefacts to be built.
3	Bulk Process Support & Resiliency	**LOW**	**HIGH:** Issue requires a significant number of bulk processes to be refactored.	**MEDIUM:** Remediation approach has fair complexity. The bulk process inventory has been defined for refactoring.
4	Bilateral Matching	**HIGH**	**LOW:** Issue relates to matching capability with limited impact.	**LOW:** Remediation is simple; solution design and component inventory have been identified.
5	Issuer HIN Notifications	**MEDIUM**	**MEDIUM:** HIN notifications may be considered as a satellite capability as the refactoring can be done without impacting the accounts data model.	**MEDIUM:** Remediation approach has fair complexity. The design requires the impact assessment of 'eventual consistency' approach on notifications and validation of performance uplift in trade registration.
6	Support for Ex-Transactions	**N/A**	**HIGH:** Impacts are widespread across the solution, impacting common functional capabilities (e.g., clearing and settlement activities).	**N/A:** No further remediation is planned on top of ongoing simplification change request i.e., simplifying some of the business rules associated with ex-transactions processing.

The resolvability of Support for Ex-Transactions could not be determined as no further remediation has been planned.

4.2 Underlying Drivers and Implications

The Core Issues revealed the ongoing challenges are symptomatic of technical challenges driving complexity in the current application architecture and design. More broadly, there are four underlying drivers responsible for the current challenges around these components.

These drivers may not cause issues for the CHESS Replacement Application in isolation or with simple transactions. However, they become crucial for complex batch workflows or transactions that require scaling.

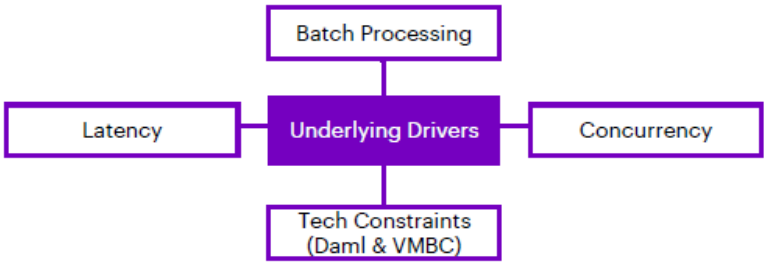


Figure 5: Underlying Drivers

Underlying Driver	Description	Implications on the Solution
Latency	Distributed systems introduce higher latency. In the current architecture, the latency is further increased due to the round-trip data flow of submitting a transaction to the client node through to writing the data to the ledger and distributing back to the client nodes and the CHESS Replacement Application. This design preserves optionality for providing a node to ASX's clients in the future. However, the latency comes at a cost and some workflows needing serial processing may run into challenges meeting the non-functional requirements.	The longer the latency between CHESS Replacement Application and the ledger, the higher the probability of ledger contention due to concurrency. The contention occurs as a conflict with two or more operations updating a single contract at the same time. Latency affects performance by not only delaying commits to the ledger but also limiting the amount of concurrency and batching that CHESS Replacement Application can utilise.
Concurrency	The architecture design supports concurrency which helps allow for scale which is required to meet ASXs non-functional requirements. However, concurrent processing can cause contention when processing multiple in-flight transactions targeting the same dataset (e.g., holdings targeting the same broker, security, and HIN). To remediate this issue, batching/grouping is introduced; however, grouping transactions together does not remove the contention problem forcing serialised processing for some workflows.	Concurrent processing of transactions can lead to contention. When contention occurs, the first transaction to be to be fully sequenced will succeed, but if other transactions are attempted before the first one is fully committed, they will fail and require a retry. Updates to a contract's data may cause subsequent transactions to fail and retry since the state may be different from what was originally observed.

Underlying Driver	Description	Implications on the Solution
Batch Processing (Transaction Grouping)	To solve for concurrency, to achieve scale, and to meet the non-functional requirements with the contention issues noted above, groups of transactions are combined into a single batch for processing. This batch, however, is limited by constraints imposed that need to be configured and tested further.	Boundaries for batches of transactions must be clearly mapped to understand impact from 'unexpected business errors'. Potential supportability issues arise when partial commits from a collection of batch processes succeed. In those situations, manual intervention and potential code changes may be required to bring the ledger into a consistent state. Batch processes may also run into issues with contention or ledger constraints if the batching is not properly created or executed. Some batching designs are particularly complex with a high potential for challenging recoveries from failures.
Technical Constraints	Batching of transactions to process could be constrained by practical limits in Daml Ledger API (size of a Daml object on ledger) and VMBC (total size of a transaction message) which needs to be designed for and tested further. These limits could be a hindrance to extensibility.	Constraints on transaction limits require large transactions or batch operations to be split into smaller chunks with refactoring. Daml contracts must be designed to prevent unbound sizes. Consideration must be given to ensure that a large enough buffer is included. If a size constraint is exceeded, transactions will fail with a potential impact on data integrity and system resiliency.

5. Delivery Assessment Findings

Through a series of workshops, artefact analysis, strategic application to frameworks and code reviews, Accenture found key technical and non-technical findings that provide context to the current state and a basis for the subsequent recommendations.

The Delivery Assessment consisted of:

1. The Solution Review focused on the solution design and architecture for the CHESS Replacement Application, use of Daml and VMBC, and completed a code review to develop a set of recommendations.
2. The Capability Assessment focused on the maturity of the software delivery lifecycle processes shared by ASX and DA.
3. The Draft Delivery Plan provided by DA was reviewed to understand the remediation activities required to address the Core Issues for the purpose of planning and timeline discussions. Note, this was a draft plan which was reviewed point-in-time to provide feedback and should not considered final or complete.

5.1 Solution Review Findings

Accenture conducted a Solution Review considering:

- The overall CHESS Replacement Application architecture and the solution design (Solution Design and Architecture).
- How the smart contract language (Daml), client nodes and distributed ledger (VMBC) are used in the solution (Daml and VMBC Use).
- A code review to assess the code quality, design patterns, reusability, modularity, and long-term supportability (Code Review).

The following chapters provide a detailed view of the findings related to each of the three solution review pillars.

5.1.1 Solution Design and Architecture

The solution design and architecture review assessed the CHESS Replacement Application. The review highlighted a need for greater consideration of how the business workflows interact with the application, ledger, and how the current design contributing to challenges in achieving scalability, resiliency, and supportability.

In particular:

- The absence of appropriate design artefacts, rigour, or inconsistent design discipline to model the expected behaviour within the constraints of the technology.
- Distributed systems inherently introduce latency in the design, this has been exacerbated with multiple layers (CHESS application, client nodes and the ledger) in the current architecture.
- ASX is the central source of truth and final arbiter of outcomes, minimising many of the benefits of a DLT architecture.
- Ledger API would need quality of service changes to enable throttling and control of actions of the participants.
- The need for support tools for recoverability are affecting long-term support and maintenance of the CHESS Replacement Application. Fixing data issues, such as incorrect

data submission, in the ledger will require custom code. The changes will necessitate a contract archival and creation. This will need to be handled by level 3 support to make these changes.

- The ability of the support teams to be able to configure, monitor, debug problems is essential to long term production use. 1st and 2nd level support teams need tools, knowledge base, and guides to ensure system is running well and they can easily mitigate common problems.
- Extending the ability of the platform to handle increased loads may require further design changes. Simple vertical scaling alone of increasing memory/CPU/disk may not be adequate to handle new loads. In the Core Issues, some choices were discussed with potential future scale considerations in the proposed designs. Remediations addressing the Core Issues were proposed for those issues, but further testing is needed to ensure other processes do not face similar scalability challenges.
- Achieving scalability with concurrency is complex and requires appropriate designs. Concurrent processing can cause contention when processing multiple in-flight transactions targeting the same dataset (e.g., holdings targeting the same broker, security, and HIN).
- The CHESS Replacement Application performs to varying levels (e.g., trade registration benchmark); however, settlement under load with 100K+ transactions fail because of data or running out of time. This could require redesign in the CHESS Replacement Application of specific workflows.

5.1.2 Daml and VMBC Use

Accenture assessed the use of smart contracts (Daml) and distributed ledger (VMBC) in the solution to understand how they are associated with the drivers of the Core Issues. The review highlights that Daml is used to solve most of the business workflows and VMBC is a resilient immutable ledger. Simplifying and optimising the use of Daml and VMBC based on the CHESS use cases will allow maximising the benefits of Daml and VMBC while mitigating the issues or risks.

- Daml is a capable smart contract modelling language. However, the current design and implementation in the CHESS Replacement Application does not take full advantage of the strengths of the language.
- From a participant standpoint in the current design and architecture, there is little value to processing business logic on-ledger as they receive a point-in-time views via API contracts.
- Daml is used to solve most of the business workflows rather than determining on-ledger vs. off-ledger fit for data, business logic, or calculations.
- Certain business processes or data models could suffer from performance or scale issues in the future due to design choices (e.g., holdings, ex-transactions, etc.).
- Whilst there are benefits of using Daml for distributed processing, it has trade-offs compared to traditional technologies with areas such as aggregating totals, multirow updates, or read/write access without a unique identifier (contract ID in Daml).
- Daml on 'X' (e.g., VMware, Corda, etc.) provides interoperability across ledgers. However, this flexibility comes with trade-offs regarding the optimisation or use of non-functionals of the underlying platforms.
- VMware's VMBC Ledger is built to provide resiliency, immutability, and provability of data. However, CHESS use case primarily uses the ledger for resiliency which adds undue complexity to the solution e.g., the consensus contributes to the round-trip latency.

- Architectural resiliency is well-designed from an infrastructure perspective. However, VMware ledger arriving at consensus via a 'slow path' could impact latency and processing times. The slow path for consensus needs to be tested against the NFRs.
- Adding new functionality or changing current functionality will inherently require migrations of existing contracts including recreations of both core system contracts and API contracts.

5.1.3 Code Review

Accenture conducted a code review on CHESS Replacement Application to understand the quality of the code, modularity, design patterns & reuse, and impact (if any) to maintaining and supporting the code long-term. The code review highlighted existence of a high-quality Daml implementation providing considerable efficiencies relative to the current CHESS and is not contributing to the core issues, however, introduces supportability challenges in post-production due to the potential skills availability (dependent on Daml adoption globally) and the interconnectedness of the Daml contracts.

- **Code Review Overview**
  - The overall quality of the code is high using consistent reusable design patterns.
  - CHESS Replacement Application code consists of Daml, Scala, and Haskell like Daml with ~87% of the code in Daml/Haskell like Daml and 17% in Scala.
  - Some efficiencies gained from the current CHESS with 50% reduction in lines of code for similar functionality. However, the code requires specialised pool of skills to support.
  - The code is not fully covered by unit tests.
  - The testing methodology favours of 'feature style' acceptance criteria testing of business functionality over unit testing.
- **Code Complexity and Coupling**
  - From a functional flow standpoint code is challenging to change or update and code complexity is high, but code is consistent in using specific coding practices and design patterns.
  - Difficulties of operations and maintenance to identify bugs, potential of a long turnaround to evaluate/remediate issues.
  - Interconnectedness of Daml contracts makes it difficult to fully decouple and modularise the CHESS Replacement Application and introduce changes for future needs. Refer to
  - Challenges in the Current Design: Coupling for more detail on coupling.
- **Long-term Supportability**
  - Longer-term, maintaining the code base, or introducing new changes can be difficult with the specialised pool of talent required (Daml, Haskell, Scala) to support the CHESS Replacement Application.

5.2 Capability Assessment Findings

The approach used in the Capability Assessment was based on the Accenture Delivery Architectures (ADA) framework which provides a proven, structured application framework and reusable components to guide program leadership and technology delivery teams in an optimal way to build a robust application. In light of the diversity in platform standards, vendor offerings and client preference to each of these, the Accenture Delivery Architecture focused on establishing a framework within which teams could conceptualise, design and deliver technical and application architecture.

To sufficiently address Accenture's engagement requirements, the framework has been altered with some capabilities reframed or descoped to provide a compressed framework to structure findings and provide meaningful insights to the audience.

The findings and recommendations of this report are limited to the CHESS Replacement Application delivery capabilities managed between ASX and DA and should not be considered as a CHESS Replacement Program-wide or ASX organisation-wide assessment.

Capability Maturity Rating

Each in-scope capability has been assigned a subjective maturity rating based on the definitions below and is designed to highlight key areas that require attention and priority review of recommendations.

Maturity Rating	Definition
Ad Hoc	Inconsistently executed, or only executed in part. Requires significant uplift for the scale and nature of the program. Deviates significantly from industry best practices or approaches adopted for programs of a similar size.
Developing	Some capabilities exist but significant gaps identified and inability to resolve issues evident. Bespoke or ad hoc process may be inconsistently executed and/or lacks effective tooling or automation. Requires major uplift to meet the appropriate capability of a program for this scale.
Emerging	Capabilities exist and effort to improve or uplift current state is evident. Requires further improvement but is trending in the right direction and is almost sufficient for a program of this scale. Elements of industrialised, repeatable processes with elements of automation and/or tooling.
Strategic	Capabilities exist and are mature providing a satisfactory approach to achieve the desired outcome. Still opportunities to optimise and/or industrialise capability.
Leading	Optimised, repeatable and scalable capability with consistent adoption across applicable areas of the program. Leverages tools, automation and industry best practices applicable for a program of this size and nature. Ongoing measurement, refinement and improvement of the process or capability based on learnings and changes within the program.
n/a	Not applicable – capability has been descoped based on applicability or alignment to overall engagement scope.

Capability Assessment

Accenture's analysis of the CHESS Replacement Application delivery found Build, Change Management and Operational Readiness capabilities sufficient, with significant gaps in Test, Analysis and Design, and overall Program and Project Management.

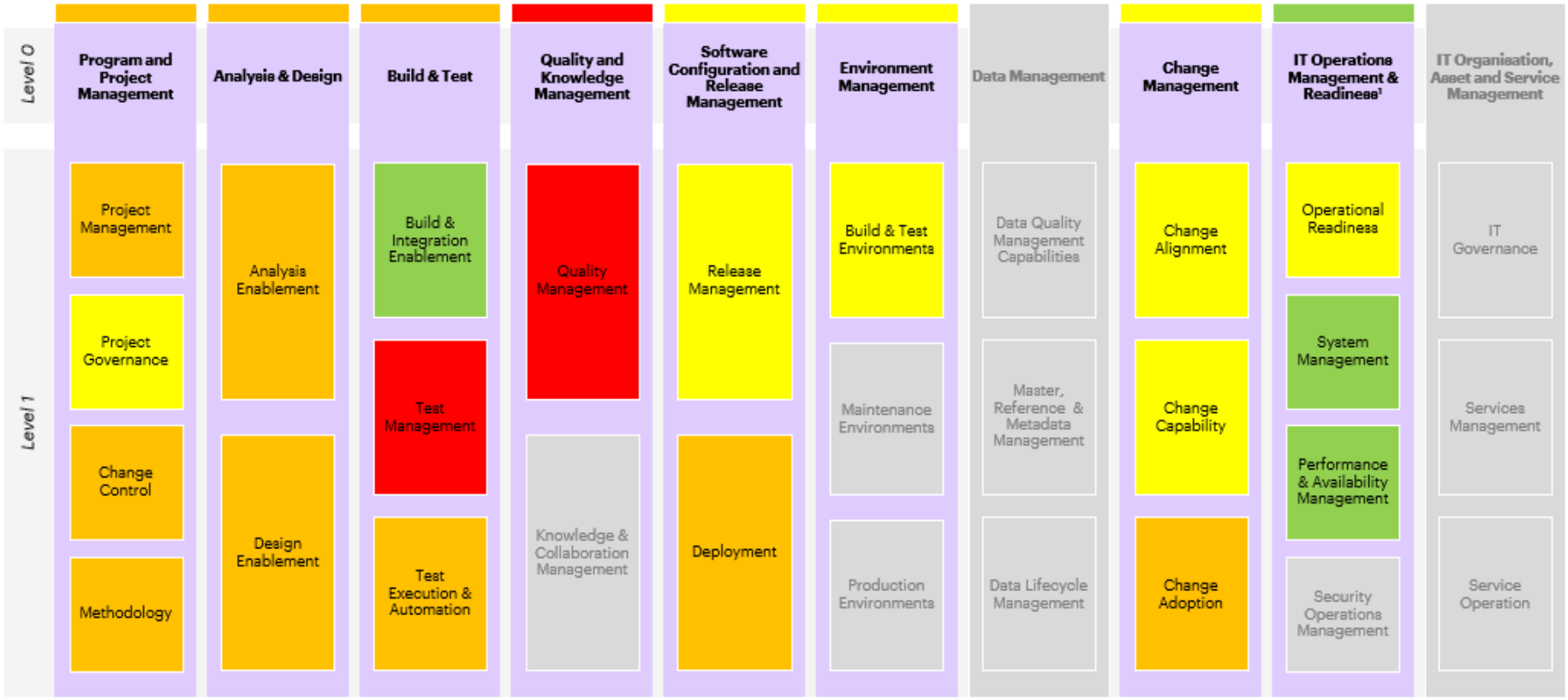


Figure 6: CHESS Replacement Application Delivery Capability Assessment

Program and Project Management

- The Program lacks a holistic, agreed, single view of status with adequate traceability of resources and estimation to the Draft Delivery Plan.
- Evolution to siloed management and execution structures and tooling has impeded collaboration with inefficient escalation- processes that has resulted in friction at the working team level and resulted in misaligned views of accountability.
- Clear definition and management of vendor accountabilities is lacking, with inconsistent information obtained regarding the reporting and tracking of outcomes and appropriate metrics with DA.
- The current hybrid methodology is problematic due to the incompatibility of iterative delivery against locked milestones, and the absence of a defined approach to proactively manage the cadence and execution nuances.
- Deficiencies in the change request process exist due to misaligned definition and usage of a change request/request, including being used to accommodate gaps stemming from assumed DA and/or market capabilities.
- Material discrepancies between ASX and DA regarding risk management practices, evidenced through inconsistent risk rating frameworks and multiple, misaligned risk registers that reflect both program and stream-level risks.

Analysis and Design

- Structured approach to requirement definition; developed top-down based on current CHESS functionality and market consultation but have limited upfront adaption for a DLT-based solution.
- Requirements are traceable to high level capabilities and were the basis for epic and story definition, however overarching capability design documents are not maintained. Retrospective alignment of requirements to features implemented via Jira with opportunity for uplift to enable reporting of scope aligned to a capability and progress toward completion.
- Functional and non-functional requirements are misaligned, across definitions (at times conflicting), granularity/quality, delivery timing and scope. The Core Issues highlighted the consequence of this.
- The CHESS Replacement Application lacks comprehensive design artefacts and processes, and related impact analysis capability. Organisational change impact is not always well understood as design impacts cannot be articulated, including downstream applications.
- There is inadequate visibility of design processes for DA solution components in relation to the CHESS Replacement Application. An absence of architectural guardrails between ASX and DA has created additional complexity to the architecture.

Build and Test

- The overarching strategy and approach have deviated from the effective testing strategy definition/documentation.
- ASX and DA test execution cadence variance (ASX aligned to releases and DA aligned to sprints), resulting in context switching and longer feedback cycles.
- The siloed delivery of functional and non-functional requirements has resulted in significant retest effort due to rework.
- DA system test is not executed on a ledger environment, as a result it is difficult for ASX team to validate and sometimes requires repeat testing.
- The accountability and scope of test data is misaligned between ASX and DA, requiring a focused strategy and path to resolution.
- Test environment preparation and data loading creates material downtime and requires optimisation.
- ASX's test automation is sufficient however, performance monitoring tools are not industrialised.
- Insufficient defect management tooling, inadequate test reports/dashboards and lack of traceability to overarching completeness and readiness has limited the programs visibility and results reporting of top-down progress and quality.

Quality and Knowledge Management

- Quality management was inconsistently observed throughout workshops and Program artefact reviews. Defects were a key focus area and the key measure of code quality, but further opportunities exist to explore quality processes and measurement across the execution lifecycle including requirements, designs, strategies, and plans, etc.
- No holistic program level reporting on key quality metrics evidenced and no vendor governance metrics are attributed specifically to quality.
- Although defect stages and tracking are defined, teams are siloed so results are not incorporated into program level delivery status.
- The SLA that exists between ASX and DA regarding defect management is no longer enforced. The defect list is tracked in a spreadsheet and requires manual traceability.
- Misalignment observed between DA and ASX on defect identification and resolution.
- Code quality management is only being done on Scala code, there is no static analysis being done on Daml code.

Software Configuration and Release Management

- CHESS Replacement Application configuration enabled however, calibration of batch attributes is required with collaboration between ASX and DA and needs to be defined per environment.
- Manual environment configuration (incl. IAM and data sets) with opportunities for industrialisation.
- Release management (to ITE) has appropriate rigour and governance, however, release planning and scoping deviates from PI commitments to uphold market-committed dates and impacts test timelines.

Environments

- DA development and system test environments are not ledger-based, resulting in additional validation testing at ASX once deployments are received. The impact of this will be amplified with the delivery of non-functional capabilities as these require a ledger to validate at scale.
- The performance environment (NFT) is the only current environment where ledger, application and components are tested (in the context of non-functional capabilities) together (incl. VMBC, Daml, client nodes and channels) and is resulting in the late identification of issues.
- Process and governance for applying urgent fixes into production or production-like environments (e.g., ITE) is not yet defined but is required to ensure they are suitably verified to mitigate against unforeseen impacts.

Change Management

- Adequate change management strategy and plan has been developed and leverages existing change agents within the operations teams. Change management team is currently unstaffed due to recent staff departures.
- Initial change impact assessment has been completed but is not maintained or included as part of ongoing program change impact assessments. There is a lack of overall visibility of the incremental cost of change and the detailed activities are not evidenced in the program plan.
- IT operating model changes are being iteratively developed making it difficult for the Program to complete a comprehensive impact assessment of the technology and process changes on the broader IT organisation.
- Change adoption, feedback and engagement are not measured in a structured or industrialised way via change management tools. This poses a challenge for implementation readiness as a criterion and the ability to measure against such criteria is lacking.
- No scope or changes identified pertaining to leadership and culture or ways of working.

IT Operations Management and Readiness

- Operational readiness for ASX is defined and measured using entry/exit criteria from prior testing phases and completion of activities on the Draft Delivery Plan. Based on the scope and granularity of the current Draft Delivery Plan, there are production readiness activities that need to be considered but are not yet captured.
- Operational agreements and practices are defined and leveraged for ITE1, with plans to create for ITE2 and production (when appropriate). There is no single view of progress toward production readiness (across technology and non-technology scope) which limits the understanding of completion and remaining effort and requires synthesis from disparate sources.
- With regards to requirements and capability required to support platform operations, the strategic monitoring capability is currently in build with DA, with ASX currently performing their own monitoring in ITE.
- The CHESS Replacement Application quits rather than handling certain business errors. There is currently no reusable solution to fix data incidents in production – 'reset and reseed' has been used in ITE but is acknowledged as not viable for production.

5.3 Draft Delivery Plan Findings

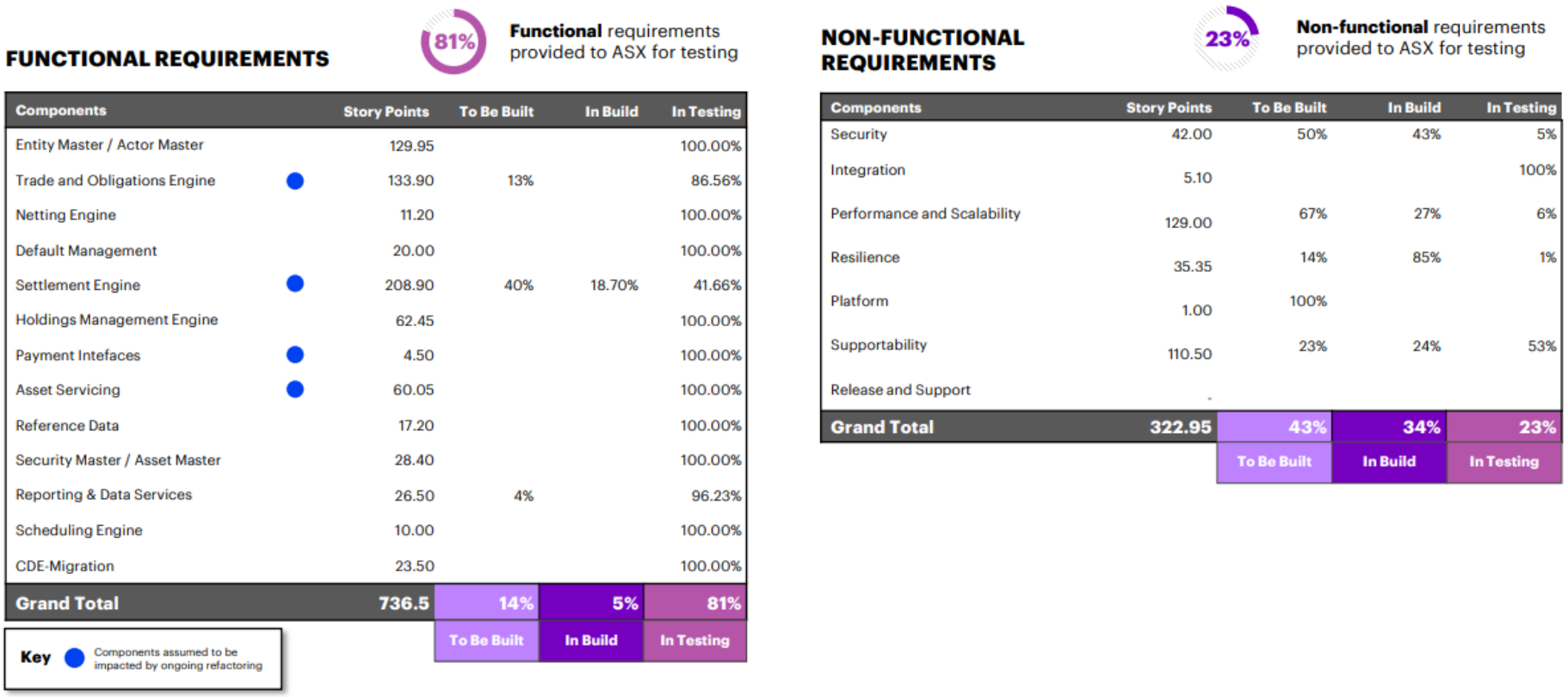
The Draft Delivery Plan Review comprised of an as-is state analysis (by defining the level of completion against the functional and non-functional requirements), a review of scope, assumptions, risks, dependencies, and contingency elements, and recommendations to uplift confidence and predictability.

The Draft Delivery Plan is one of many workstream plans that feed into the broader CHESS Replacement delivery. The draft plan referenced in the following chapters, was provided by DA for planning conversations and should not be considered as final or complete. The progress and completion percentages are based on Jira data considered the source of truth for the application backlog. It includes the additional work estimated by DA to mitigate the Core Issues.

- The current scope of the Draft Delivery Plan is addressing the known issues. However, there is insufficient scope in the Draft Delivery Plan to address underlying root causes and early testing to unlock other potential issues. In addition, the Draft Delivery Plan is not supported by interim milestones to build confidence iteratively, especially in the non-functional areas.
- The Draft Delivery Plan is based on high-level estimates. The estimation in its current form is not supported by a detailed, bottom-up inventory or standard estimation approach for consistency and transparency.
- Approximately 50% of the assumptions recently added to Jira span multiple epics, requiring further socialisation and alignment between ASX and DA.
- The Draft Delivery Plan has a significant amount of contingency associated with epics and schedule. However, the contingency estimation is not supported by a consistent industrialised methodology or approach for calculation, tracking, and contingency release disciplines. The contingency bundled in the Draft Delivery Plan is associated with a set of risks that are not fully agreed upon and aligned between ASX and DA regarding their definitions and classifications.

Completion Status of the CHESS Replacement Application

Based on Jira epic data, 63% of the overall scope has been shipped to ASX for testing. The remaining scope is aligned to implementation of non-functional requirements and has significant changes in key functional areas. Completion is calculated based on data provided by DA on September 12th, 2022.



FUNCTIONAL REQUIREMENTS

81% **Functional** requirements provided to ASX for testing

Components	Story Points	To Be Built	In Build	In Testing
Entity Master / Actor Master	129.95			100.00%
Trade and Obligations Engine ●	133.90	13%		86.56%
Netting Engine	11.20			100.00%
Default Management	20.00			100.00%
Settlement Engine ●	208.90	40%	18.70%	41.66%
Holdings Management Engine	62.45			100.00%
Payment Intefaces ●	4.50			100.00%
Asset Servicing ●	60.05			100.00%
Reference Data	17.20			100.00%
Security Master / Asset Master	28.40			100.00%
Reporting & Data Services	26.50	4%		96.23%
Scheduling Engine	10.00			100.00%
CDE-Migration	23.50			100.00%
Grand Total	**736.5**	**14%**	**5%**	**81%**
		To Be Built	In Build	In Testing

Key ● Components assumed to be impacted by ongoing refactoring

NON-FUNCTIONAL REQUIREMENTS

23% **Non-functional** requirements provided to ASX for testing

Components	Story Points	To Be Built	In Build	In Testing
Security	42.00	50%	43%	5%
Integration	5.10			100%
Performance and Scalability	129.00	67%	27%	6%
Resilience	35.35	14%	85%	1%
Platform	1.00	100%		
Supportability	110.50	23%	24%	53%
Release and Support	-			
Grand Total	**322.95**	**43%**	**34%**	**23%**
		To Be Built	In Build	In Testing

Figure 7: CHESS Application Completion Status

Key Highlights from Completion Status

Despite the overall code completion, the outstanding NFR backlog with the refactoring of core functional capabilities presents widespread program risks requiring close collaboration between ASX and DA. Completion is based on DA data as of September 12th, 2022. The code completion percentage is calculated using DA's weighted functional and non-functional epics for ASX test validation. However, test completion is calculated using story tickets marked by ASX testing as 'Done'.

- Overall, 54% of CHESS Replacement Application components (including functional and non-functional) have been validated by ASX to date.
- Based on the tests there are 2383 DA-related defects; 174 of which are pending resolution.
    - Based on the data received from the ASX test team on September 28th, 2022, 103 defects are with DA, 48 are with ASX testing, and 23 require further clarification.
- 77% of the non-functional capabilities have not yet been delivered for testing to date.
- Based on Accenture's analysis the planned refactoring work related to the Core Issues such as Settlement Engine, Holdings, Payment Interfaces, and Asset Servicing would impact approximately 45% of the functional components that are already in testing. It would impose additional testing efforts for the changed components and additional testing phases (end-to-end, regression etc).
- Seamless collaboration between ASX and DA is identified as a critical path, as the outstanding work is predominantly non-functional requirements.

Figure 8: CHESS Application Completion Status Highlights

The view provides the percentage of the user stories tested and validated by ASX test automation at least once and provides a point in time snapshot based on Jira. It does not indicate overall test completion since user stories are planned to be re-tested as per releases, impacting functional changes or non-functional improvement.

Detailed Draft Delivery Plan Assessment Findings

Scope & Backlog	• The current Draft Delivery Plan addresses known Core Issues and other outstanding functional and non-functional requirements. However, it lacks the scope to address resolving underlying root causes for Core Issues driving major design refactoring. • The Draft Delivery Plan includes milestones highlighted for code freeze and VMBC releases, but no interim milestones, particularly for non-functional capabilities, to build stakeholder confidence by iteratively delivering and validating NFR capabilities in the backlog. • The draft delivery plan includes technical and operational support activities. However, there are no considerations regarding migration support to ensure seamless service introduction.
Assumptions & Dependency	• The assumptions and dependencies related to the Draft Delivery Plan were not tracked using Jira until recently. • Some of the assumptions are not mutually exclusive and collectively exhaustive to link specific epic or user stories. • There are inadequate guardrails to define assumptions and dependency leading to inconsistent governance between ASX and DA.
Estimation Method	• The current Draft Delivery Plan is based on non-standard and inconsistent estimation techniques which cannot be converted into actual efforts and serve as the basis for capacity forecasting. • The estimation in its current form is not supported by bottom-up inventory and proven methods based on historical records to assure predictability and confidence.
Risks highlighted in the Draft Delivery Plan	• Some of the documented risks are too broad and overarching without linking to specific epic (FR/NFR) or delivery issues. • DA and ASX currently use different risk scalars to assess and prioritise risks, leading to misalignment and inconsistencies in the mitigation plan. Moreover, 60% of the total risks associated with the current Draft Delivery Plan are pending alignment between ASX and DA. • The Draft Delivery Plan, in its current form, is actively managing fourteen risks. However, several risks associated with the current Draft Delivery Plan have been managed for a long period of time (some of the risks are open since 2019), with some of these risks being reopened after closure with a modified definition. • A significant number of risks associated with the current Draft Delivery Plan can be managed directly with scope management, defect management, and change request process, rather than managing as risks. • Despite having an active risk on migration requirements, there is no evidence of migration support planning in the proposed Draft Delivery Plan provided by DA. • Risk is being highlighted for scope, which is yet to be defined (SPD-20433) and should be managed through the CR process. • There are several risks rated as high or medium without any target schedule for mitigation. This will likely impact project planning and reporting. • Even though the project has had multiple schedule variations in the past, the risk register for the CHESS Replacement Application is

	more active in the past two quarters (as of 10th Oct 2022, 22 out of 35 risks, i.e., circa 63%, were reported in Q2 and Q3 of 2022).
Contingencies highlighted in the Draft Delivery Plan	• The contingency associated with the Draft Delivery Plan is not based on a standard/industrialised contingency management methodology and estimation and is based on risks that are not fully agreed upon between ASX and DA regarding the definition and classification. • Despite the high contingency associated with the current Draft Delivery Plan, the plan is still considered as high risk.

6. Delivery Assessment Recommendations

Accenture has identified 45 recommendations (Figure 10: Delivery Assessment Recommendations Summary and Phasing) through the Solution Review, Capability Assessment, and Draft Delivery Plan Assessments. These recommendations have been aligned to a set of 12 areas of focus (Figure 9: Delivery Assessment Recommendations Theme Alignment) across ways of working, software delivery, quality engineering efficiency, and solution design.

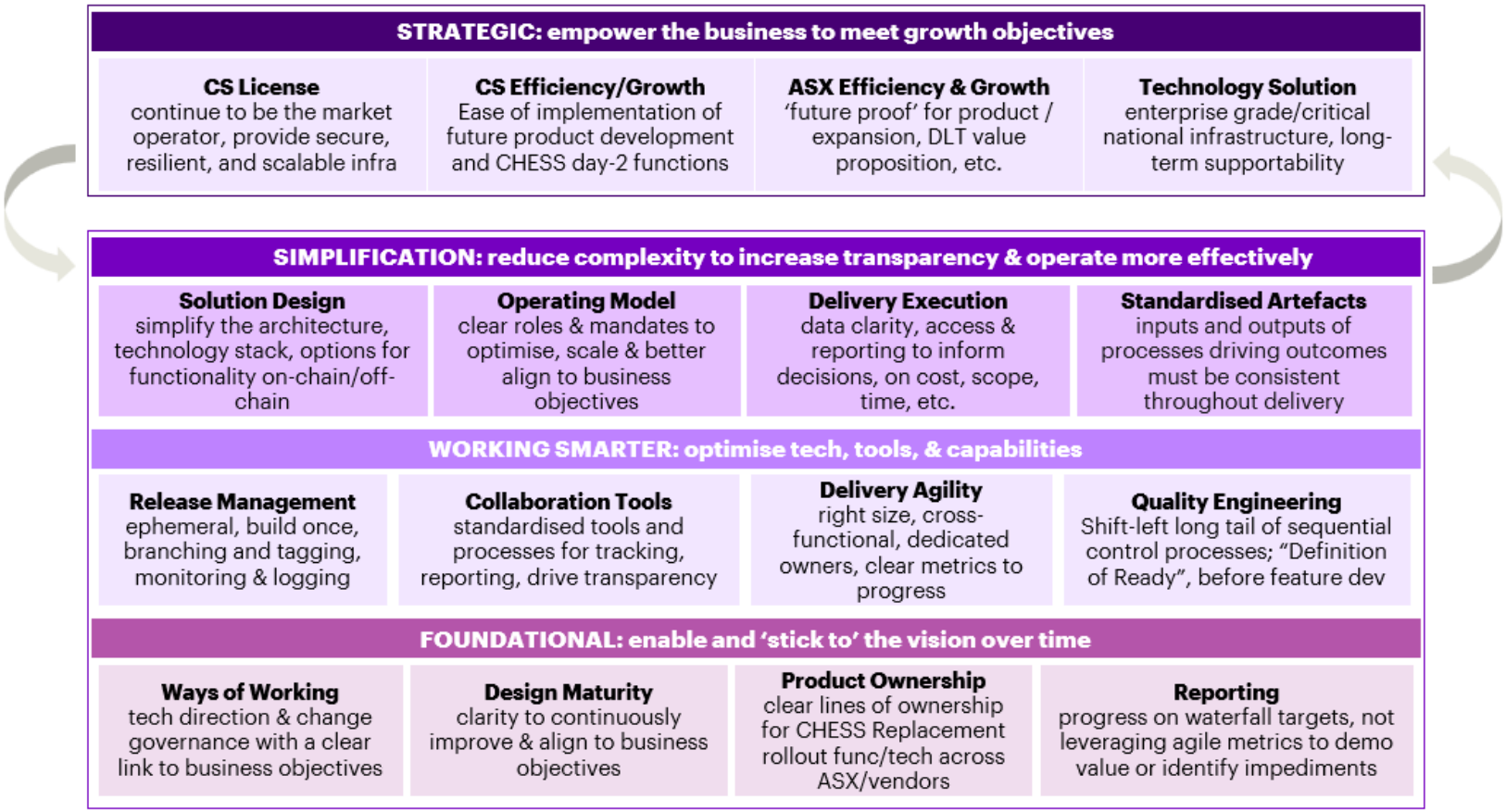


Figure 2: Delivery Assessment Recommendations

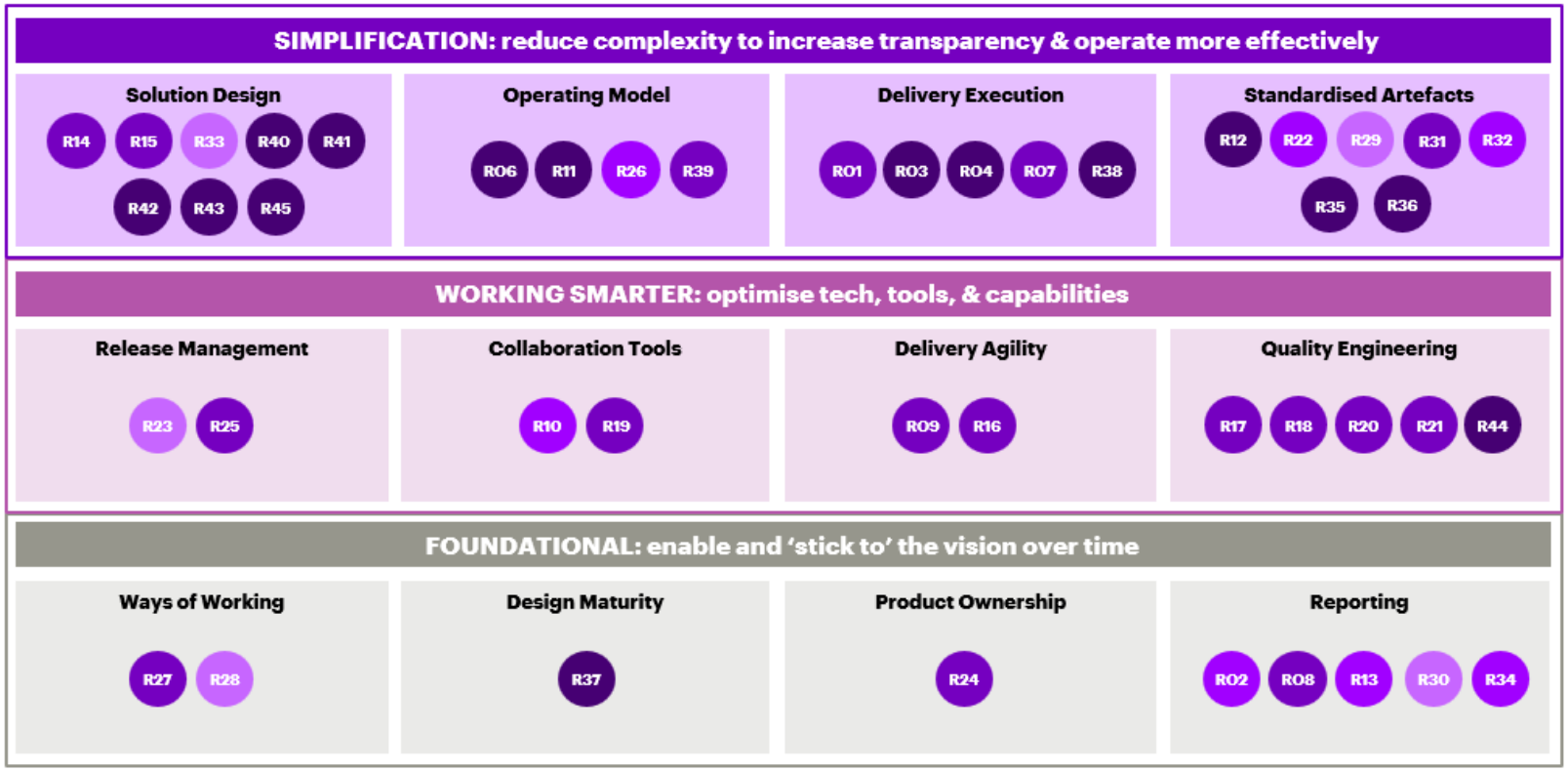


Figure 9: Delivery Assessment Recommendations Theme Alignment

Phase 1 *Implementation of recommendations that are likely fundamental to recalibrating the program or clear precursors to other recommendations.*	Phase 2 *Continued pursuit of high-value recommendations and / or those that are enabled once dependent Phase 1 recommendations are in place.*	Phase 3 *Sustained implementation of recommendations and opportunities for improvement.*	Phase 4 *Long-term recommendations to be evaluated after Phase 2 and 3 precursors are implemented, or at a logical point in program execution where they are deemed necessary.*
RO6. Refine the Program operating model with DA in line with the change in vendor delivery model	**R01.** Refine Change Request Impact Assessment	**R02.** Revise Program (PWG) reporting	**R23.** Remove pipeline backpressure: Pipeline computer capacity & quality gates must be adjusted to prevent opposing completion(success/failure)
R04. Augment the Program plan to provide greater detail and transparency	**R32**. Refine internal communications and engagement approach in line with change requestions and solution design	**R10.** Alignment of tools and data-driven reporting of key information and metrics	**R24.** DA to provide reusable tools that enable greater control of the Ledger and then complement operational processes, driving efficiency and industrialisation
R11. Review of Program Leadership and Culture aligned to ways of working, organisational goals, key roles and responsibilities, including all vendors	**R07.** Clarify definition and purpose of a Change Control and the CR process	**R13.** Implement top-down traceability reporting that presents a capability / component-based view of completeness aligned to the inventory and status of requirements, including technical and non-technical scope.	**R29.** Generate talent and skills map to assess current skills and execute hiring plans in alignment
R03. Calibration of Program Risk Management framework	**R08.** Embed tracking of CR impacts to milestones (post-impact assessment)	**R22.** Consider defining a Program quality management plan and suitable processes, metrics and forums within workstreams to standardise / uplift quality, refine standardised artefacts, and enable visibility of overall quality (including technical and non-technical deliverables)	**R30.** Establish of a training tracker and survey to measure effectiveness of upskilling efforts, the tracker should incorporate
R12. Uplift NFR definition process and template to increase quality and detail, and to align FR and NFR definition timelines	**R09.** Review and define the technology delivery methodology going forward	**R27.** Review of service introduction and IT Operating Model for CHESS Replacement across key areas with the IT organisation	**R31.** Assess change readiness tracking tools and establish appropriate reporting metrics and template
R35. Revisit the project governance approach to establish a standard estimation methodology between ASX and DA including key drivers of the effort like inventory, assumptions, dependencies, associated effort and risks	**R14.** Ensure DA solution design is visible to the ASX, and where relevant, is approved consistently by leveraging established independent design review committee for the purposes of the Program	**R33**. Consolidate and review operational readiness criteria to incorporate activities that are not currently captured and implement dashboard reporting to provide appropriate transparency	
R36. Establish a standard and governed contingency management plan, that includes contingency calculation, mitigation, and contingency release plan associated with the plan	**R15.** Establish a design review of CHESS Application artefacts including creating a design based on FR and NFRs, tailored for best use of Daml documented with appropriate architecture template and reviewed with ASX as a stage gate	**R34.** Build and implement relevant dashboards that allows for monitoring of NFRs against key metrics	
R37. Proactively validate the design against the root causes identified in the Core Issues Report and unpack unknowns early by shifting testing with production-shaped data and volumes early in the delivery cycle (shift-left)	**R16.** Review and enable contemporary engineering practices to optimise delivery efficiency		
R38. Reshape delivery plan with interim milestones to identify potential issues early in the delivery cycle and built-up confidence amongst stakeholders	**R17.** Reassess options to streamline test phases, strategy and accelerate retest		
R40. Solution design review to meet future growth and ASX's strategic objectives	**R18.** Uplift governance on test data creation and management to ensure continuous improvement and right level of test scenario coverage including edge cases, race conditions		
R41. Explore opportunities to simplify solution design	**R19.** Implement a single defect management tool (e.g., Jira) to log and manage defects		
R42. Review Daml use to meet long-term objectives	**R20.** Establish robust test execution and defect reporting including defect template and supporting information		
R43. Optimise on-ledger and off-ledger processing for transactions	**R21.** Refresh Test Strategy to reflect revised approach and communicate to all stakeholders to ensure appropriate visibility.		
R44. "Shift Left" testing to compress long sequential feedback loops	**R25.** Onboard suitably experienced Change Management lead and team to execute revised change strategy		
R45. Remediate root causes of (known) Core Issues	**R26.** Embed business change management activities within Program release and execution plans to ensure traceability of readiness tasks and effort		
	R28. Leadership and culture assessment to define the future needs of the organisation and impacted business units		
	R39. Introduce dedicated teams from DA to support ASX's NFT, and E2E testing phases to speed up testing cycles		

Figure 10: Delivery Assessment Recommendations Summary and Phasing

6.1 Solution Review Recommendation Details

Recommendations on a path forward revisiting strategic objectives tied to technology outcomes.

Solution design review to meet future growth and ASX's strategic objectives

- Revisit or refresh the DLT strategy to determine long-term use.
- Understand DLT use in the technology stack, 3rd party applications, day-2 CHESS features and split between Synfini[1] and CHESS for modernisation.
- (Re)consider modernising business processes to leverage the benefits of a smart contract language and DLT tied to the strategic objectives.

Explore opportunities to simplify solution design

- Revisit design choices of the CHESS Replacement solution with an eye to simplification.
- To meet CHESS Replacement non-functionals, review architecture layers and assess value vs. complexity introduced – ledger, smart contract language, application design, topology.
- The ledger currently as implemented offers resiliency, transaction validation, recording to the ledger with immutability, ability to add client nodes, and increases complexity and overall latency.

Review Daml use to meet long-term objectives

- Consider long-term plans now such as bilateral workflows (if any) between parties in Daml to avoid redesigns in the future (e.g., authorisation pattern).
- Consider simplification of (certain) business workflows that are in contention with the technology stack.
- Daml may not be the most appropriate to solve for all business process, logic, and data.

Optimise on-ledger and off-ledger processing for transactions

- Review trust boundary and data/logic distribution strategy on ledger.
- Refine the on-ledger vs. off-ledger transaction processing based on above.
- Assess the benefits of moving transaction process off-ledger while preserving the results on-ledger to address non-functionals.

"Shift left" testing to compress long sequential feedback loops

- Restructure NFR testing approach and prioritise the NFR testing against the other backlog for early validation of remediations and discovery of other potential issues related to performance, resilience, and supportability.
- Unify NFR testing environments (with or without ledger) and secure dedicated ASX and DA teams for NFR test preparation, execution and defect fixing in an effective manner.

[1] Synfini refers to ASX's DLT as a Service, powered by VMware Blockchain and Daml. It was built initially to underpin the upgrade of ASX's CHESS. Read more at: Synfini DLT as a Service from ASX. (2021, n.d.). Australian Securities Exchange: https://www2.asx.com.au/content/dam/asx/connectivity-and-data/Synfini%20overview.pdf; DLT as a Service – a revolutionary platform for Australian businesses. (2021, November 22). Australian Securities Exchange: https://www2.asx.com.au/blog/from-the-experts/dlt-as-a-service-a-revolutionary-platform-for-australian-businesses.

Remediate root causes of the (known) Core Issues

- Identify current or future workflows requiring concurrent execution tied to performance targets.
- Test concurrent workflows for contention with shared data on ledger.
- Validate transaction context and boundary for batch implementation and resiliency.
- Review solution design accounting for known technical constraints.
- Refactor Daml models with unbounded lists and implement safeguards to avoid technical limits and constraints.

7. Appendix

7.1 Schedule of Workshops and Interviews

The below table describes the schedule of Accenture workshops and interviews conducted with key stakeholders during the CHESS Replacement Application Delivery Assessment.

Date	Attendees		Interview / Workshop
	ASX	DA	
8-Aug-22	• Functional BA	• N/A	Interview
16-Aug-22	• Leadership • Sponsor • Project Manager	• Sponsor	Workshop
17-Aug-22	• Leadership • Sponsor • PMO Director • Program Manager • Assurance	• N/A	Workshop
18-Aug-22	• Project Manager • Technical Product Owner • Architect	• N/A	Workshop
22-Aug-22	• Functional Product Owner • Technical Product Owner • Architect	• Sponsor / Engineering Lead • Project Manager / Product Owner • Architect	Workshop
23-Aug-22	• Functional Product Owner • Technical Product Owner • Architect • Functional BA • Engineering	• Sponsor / Engineering Lead • Project Manager / Product Owner • Architect	Workshop
26-Aug-22	• Program Manager • Project Manager • Testing Lead	• Sponsor • Project Manager	Workshop
29-Aug-22	• Program Manager • Project Manager • Functional Product Owner • Technical Product Owner • Architect	• Sponsor • Architect • Project Manager	Workshop
29-Aug-22	• Project Manager • Functional BA • Architect	• Sponsor • Architect • Project Manager • Relevant SME	Workshop

Date	Attendees		Interview / Workshop
	ASX	DA	
30-Aug-22	• Project Manager • Functional BA • Architect	• Sponsor • Architect • Project Manager • Relevant SME	Workshop
31-Aug-22	• Project Manager • Functional BA • Architect	• Sponsor • Architect • Project Manager • Relevant SME	Workshop
31-Aug-22	• General Manager	• N/A	Interview
31-Aug-22	• Project Manager • Functional BA • Architect	• Sponsor • Architect • Project Manager • Relevant SME	Workshop
2-Sep-22	• Project Manager • Functional BA • Architect	• Sponsor • Architect • Project Manager • Relevant SME	Workshop
6-Sep-22	• Engineering	• Sponsor / Engineering Lead • Architect • Relevant SME	Workshop
6-Sep-22	• PMO Director • Program Manager • Project Manager • Functional Product Owner • Testing Lead • Engineering • Architect	• N/A	Workshop
6-Sep-22	• N/A	• Sponsor • Architect / Product Owner • Project Manager	Workshop
6-Sep-22	• Program Manager • Project Manager • Technical Product Owner • Testing Lead • Engineering • Architect	• N/A	Workshop
7-Sep-22	• PMO Director • Program Manager • Project Manager • Functional Product Owner • Testing Lead	• N/A	Workshop

Date	Attendees		Interview / Workshop
	ASX	DA	
	• Engineering • Architect		
7-Sep-22	• N/A	• Sponsor • Architect / Product Owner • Project Manager	Workshop
12-Sep-22	• Program Manager • Project Manager • Testing Lead • Functional BA • Operational Readiness	• N/A	Workshop
12-Sep-22	• N/A	• Sponsor • Architect / Product Owner • Project Manager • Relevant SME	Workshop
12-Sep-22	• N/A	• Sponsor / Engineering Lead • Architect • Relevant SME	Workshop
21-Sep-22	• Program Manager • Project Manager • Functional Product Owner • Technical Product Owner • Operational Readiness • Technical Readiness • Customer and Technical Ops • CHESS Cutover Replacement Lead • Architect	• N/A	Workshop
27-Sep-22	• PMO Director • PMO Lead • Program Manager • Operational Readiness	• N/A	Workshop
28-Sep-22	• Program Manager • Test Director • Testing Lead • NFR Test Lead	• N/A	Workshop
28-Sep-22	• Procurement	• N/A	Interview
30-Sep-22	• N/A	• Sponsor • Architect / Product Owner	Workshop

Date	Attendees		Interview / Workshop
	ASX	DA	
30-Sep-22	• Program Manager • Project Manager • Functional Product Owner • Functional BA • Architect	• N/A	Workshop
30-Sep-22	• Program Manager • Operational Readiness • Head of Change and Delivery Enablement • Change Analyst	• N/A	Workshop
4-Oct-22	• Test Director • Testing Lead • NFR Test Lead	• N/A	Workshop
6-Oct-22	• Architect	• N/A	Interview
7-Oct-22	• Operational Readiness • CHESS Replacement Cutover Lead • E2E Migration Manager • Architect	• N/A	Workshop
13-Oct-22	• Environments	• N/A	Workshop
17-Oct-22	• Functional BA	• N/A	Interview
17-Oct-22	• CHESS Replacement Cutover Lead	• N/A	Interview
17-Oct-22	• Engineering	• N/A	Interview
18-Oct-22	• Technical Readiness	• N/A	Interview

7.2 Terms of Reference

The below table provides definitions of key terms of references used throughout this document.

Term	Definition
API	Application Program Interface
ASIC	Australian Securities and Investments Commission
ASX	Australian Securities Exchange Limited
BA	Business Analyst
CCP	Central Counter Party
CHESS	CHESS is a system run by ASX Settlement Pty Limited to facilitate settlement and maintain the electronic subregister. CHESS is an acronym of Clearing House Electronic Subregister System. It refers to the current CHESS solution and environment.
CHESS Replacement Application	This refers to those elements of the solution specific to the Daml Architecture and ledger. This includes the bots, CHESS Replacement Application cache, adapters controlled and delivered by DA, Daml code, SDK, Ledger API and Ledger.
Core Issues	This refers to the six priority issues identified by ASX and Digital Asset as part of the CHESS Replacement Application Delivery Assessment performed by Accenture. These issues are Holdings, Batch Settlement, Bulk Process Support and Resiliency, Bilateral Matching, Issuer HIN Notifications and Support for Ex-Transactions.
CPU	Central processing unit
CR	Change request
CS	Clearing and Settlements
CSD	Central Security Depository
DA	Digital Asset Holdings LLC
Daml	Digital Asset Modelling Language
Dev	Development
DLT	Distributed Ledger Technology
E2E	End-to-end
FIFO	First In First Out
FIX	Financial Information Exchange
FR	Functional requirement
Func	Functional
HIN	Holder identification number
IAM	Identity and access management
ID	Identification
Infra	Infrastructure
ISO	International Organisation for Standardisation
IT	Information Technology
ITE	Industry Test Environment
KPI	Key Performance Indicator
NFR	Non-functional requirement
NFT	Non-functional Testing

Term	Definition
OTA	Offsetting Transaction Agreement
Ops	Operations
PI	Program increment
PMO	Project Management Office
RAID	Risks, Assumptions, Issues, and Dependencies
RBA	Reserve Bank of Australia
SDK	Software Development Kit
SIT	System Integration Testing
SLA	Service-level agreement
SME	Subject Matter Expert
Tech	Technical
Underlying drivers	This refers to the four underlying drivers identified by Accenture of the challenges faced in the current solution design: batch processing, latency, concurrency, and technical constraints.
VMBC	VMware Blockchain
XML	Extensible Markup Language
XSD	XML Schema Definition

7.3 Criticality and Resolvability Assessment Matrix

Criticality Assessment Matrix				
Severity	**High** The issue may lead to significant outages involving widespread impact on participants, affecting one or more key business processes, and potentially involves complex manual troubleshooting or extensive fixes	*High Criticality*	*High Criticality*	*High Criticality*
	Medium The issue may lead to outages involving a limited impact on participants, may be related to performance degradation and is potentially solvable with streamlined troubleshooting or fixes	*Medium Criticality*	*Medium Criticality*	*High* Criticality
	Low The issue may lead to complexity or supportability and extensibility limitations, and is unlikely to lead to outages	*Low Criticality*	*Medium Criticality*	*Medium Criticality*
		Low The issue relates only to a specific function, capability and/or data across the solution	**Medium** The issue relates to multiple capabilities and is not used as a shared component or data across the solution	**High** The issue relates to common functionality capability or data across the solution, or spans across an extensive list of components
		Impacted Scope		

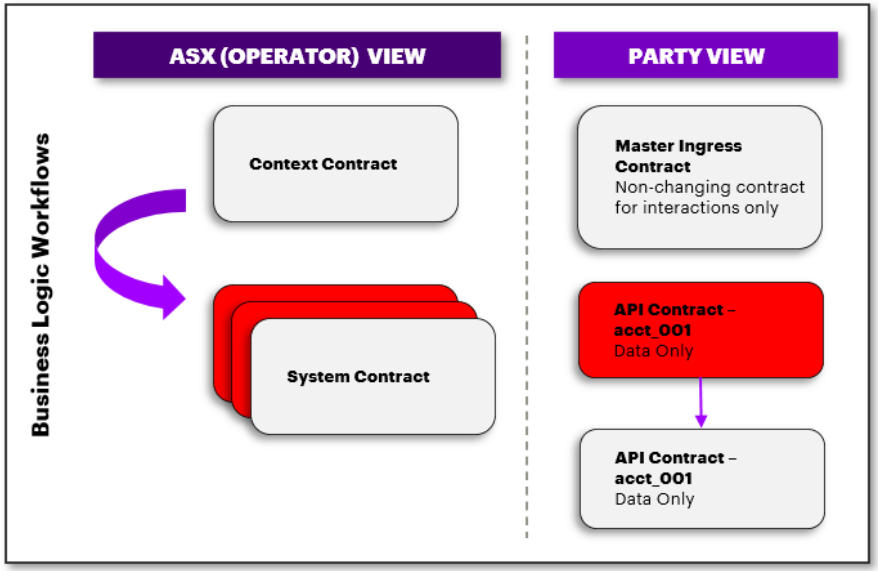
Resolvability Assessment Matrix				
Remediation Complexity	**High** Remediation approach with high complexity or limited or no solution design or component inventory	*Medium Resolvability*	*Low Resolvability*	*Low Resolvability*
	Medium Remediation approach with fair complexity or limited solution design and component inventory definition, inadequate coverage on the problem statement, and pending alignment on solution dependencies	*High Resolvability*	*Medium Resolvability*	*Low Resolvability*
	Low Remediation is simple, solution design and component inventory are identified with impact on current design including key decisions pros/cons	*High Resolvability*	*Medium Resolvability*	*Medium Resolvability*
		Low The issue relates only to a specific function, capability, and data across the solution	**Medium** The issue relates to a few capabilities and is not used as a shared component or data across the solution	**High** The issue relates to a common functionality capability or data across the solution, or spans across an extensive list of components
		Impacted Scope		

7.4 Artefacts

7.4.1 Challenges in the Current Design: Coupling

	Tight Coupling	Loose Coupling
DEFINITION	**Tight Coupling** refers to a design state where components of an application are bound to other components. In other words, software components are highly dependent on each other.	**Loose Coupling** refers to a design pattern where software components are minimally bound to other components. In other words, software components have a reduced knowledge of other software components.
IMPACT ON SOLUTION	Tight coupling (unlike federated microservices) creates challenges around: • **Maintainability:** Maintenance cant be performed in isolation at a single function level. System wide implications may exist even with small changes. • **Supportability:** Root cause of error may not be manifest where the related business logic is, because of tight coupling between components the error may manifest elsewhere. • **New feature/extension:** difficult to introduce new features without systemic impact. • **Ripples down to the business level:** Functions like corporate action processing are commingled with settlements, such that system performance is impaired in one function because of coupling with another.	
CHESS SOLUTION CONTEXT	• **Daml contracts:** Typically within Daml, contracts cannot be queried within the code, but must be referenced using either a contract id or a contract key. CHESS has enabled a unique method using a context contract which allows for very specifically written methods to find a contract based upon a field within the contract. Even so, there are limitations on the amount of decoupling linked contracts can use particularly when the data within those contracts is gathered to produce some dynamic data. • **Traditional design patterns:** Common patterns in traditional n-tier architecture are not possible in Daml. For example, in a traditional application, a single SQL query can be written to query all locks that match a pattern, sum the total number of locks, and return the data in a single element. • **Logic/data:** Within a contract written in Daml, it is not possible to query in this manner. Each custom query must be coded within the smart contract and any updates to the requirements would require an update to the code or the option is to calculate the value and store it within the contract at the time any update is made.	

7.4.2 Suitability of Daml for CHESS

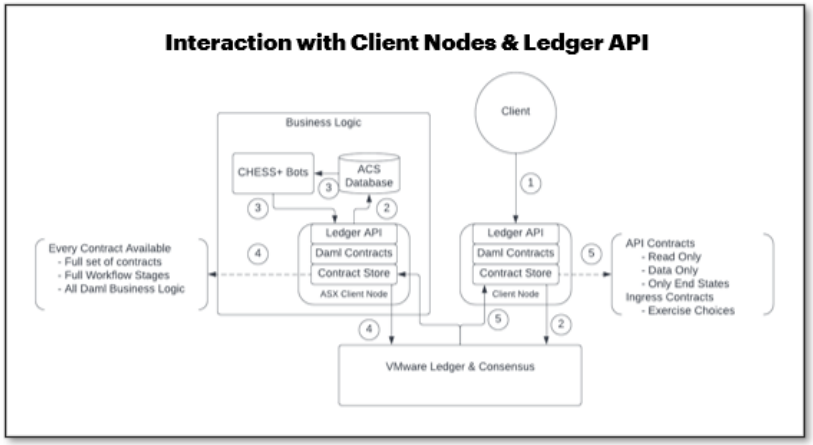


CHESS Replacement Application Implementation

- Only Operator (ASX) has visibility of core contracts.
- Core contracts contain all business logic in Daml.
- Benefits of DLT that CHESS uses are a consistent state and shared data across multiple parties. However, this data is a static point-in-time view of the core contracts.
- Current implementation of Ledger API provides participants with a view of the static data and a messaging-like interface to interact with the system.
- All direct interactions with the core contracts using business logic in Daml are done by the Operator in the CHESS Replacement Application. A single-operator model is not a common design pattern in Daml.
- The CHESS Replacement Application does not utilise common Daml design patterns, such as the Authorisation Pattern, Multi-Party Agreement Pattern, or Delegation Pattern.
- The results of Core Contracts workflows are shared, but participants have no traceability to Core Contracts for verifiability and simply see the results of any business logic.

Current design for the CHESS Replacement Application

- The current design for the CHESS Replacement Application encodes most of the business logic within the Daml contracts and bots
- These core Daml contracts and bots are only visible to the ASX
- Clients are only given a view of the end state which is the result of the business logic and saved as static data in a separate API contract
- Clients cannot see "how" the end state was calculated and so verifiability is only captured around what is stored in the ledger and not the process that was used to get to that state
- With this design, there is little value in having the logic to create those API contracts contained within a Daml contract visible to only one party, ASX
- Currently, Clients can interact with two types of contracts via the Ledger API: ingress/egress contract or API contract. The ingress contract receives an ISO, FIX, or other message type and the bot framework converts them into Daml commands run against the ledger. This implementation of Ledger API mimics a traditional messaging interface and equivalent to sending ISO, FIX, or other messages directly



1. In the diagram, the Client can interact with the ledger by sending a message to the Ledger API on a client node (either via ISO message or exercising a choice on the Ingress Contract)
2. This message is then received by the ASX Client node and a copy is stored in the ACS Database
3. When the CHESS Replacement Application bot sees a specific contract creation, it is able to initiate a workflow in the Daml contracts on the ASX Client node. This workflow can span over one or many steps
4. Within the ASX Nodes, various contracts will be created as part of the workflow, messages are sent out, and a static API contract is created and sent to the Client node
5. The Client is then able to see the resulting API contract, but that view is only a set of data and has no traceability back to the contracts or workflow which is available on the ASX node